aselsan

İhsan Doğramacı Bilkent Üniversitesi

KOÇ ÜNİVERSİTESİ

BİLKENT ÜNİVERSİTESİ NANOTAM

FOTONİKA YARI İLETKEN TEKNOLOJİLERİ

AFL Fujikura

BS TELEKOM

optomek

LUMOS LASER

APPSILON ENTERPRISE

SPARK ÖLÇÜM TEKNOLOJİLERİ MEASUREMENT TECHNOLOGIES

mitra LAZER TEKNOLOJİLERİ

SEMITECH YARI İLETKEN TEKNOLOJİLERİ A.Ş.

LITHORIUM MICROTECH

CÜNAM

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FOTONİK 2025

ULUSAL OPTİK, ELEKTRO OPTİK VE FOTONİK ÇALIŞTAYI

12 Eylül 2025, Koç Üniversitesi

FOTONİK 2025

Ulusal Optik, Elektro-Optik ve Fotonik Çalıştayı

Koç Üniversitesi Sevgi Gönül Kültür Merkezi

12 Eylül 2025

İÇİNDEKİLER

AMAÇ

Bu toplantı, ulusal boyutta optik, elektro-optik ve fotonik konularına yönelik yıllık tek bilimsel toplantı serisi olan Ulusal Optik, Elektro-Optik ve Fotonik Çalıştaylarının 25.'sini oluşturmaktadır. Optik, elektro-optik ve fotonik alanlarının yüksek teknoloji dahilinde ekonomik katkısı büyük, savunma ve sağlık gibi stratejik sanayilerde uygulamaları geniştir. Bu nedenlerden dolayı, bu konularda ulusal düzeyde gelişmemizle birlikte bulunduğumuz düzeyin bilinmesi ve ilerletilmesi önemlidir.

Bu toplantıda, ülke çapında optik, elektro-optik ve fotonik konularında akademide ve endüstride araştırma ve geliştirme çalışması yapan gruplar (bilim insanları, yöneticiler, mühendisler, lisansüstü öğrencileri vs.) bir araya gelecek ve çalışmalarını birbirlerine sunup, tanışma, görüşme ve tartışma olanağı bulacaklardır. Bu, gruplar arası ortak çalışmaların başlatılmasına, karşılıklı destek ve fikir alışverişinde bulunulmasına ve ortak proje başvuruları (örneğin, Avrupa Birliği Çerçeve Programları) için çalışmalar yapılmasına ön ayak olacaktır.

Bu şekilde, bu toplantının optik, elektro-optik ve fotonik konularında ülkemizin bilim ve teknoloji çalışmalarına yarar ve katkı sağlaması beklenmektedir.

Toplantı Konuları

- Fotoalgılayıcılar
- Elektro-Optik Malzeme ve Cihazlar
- Lazerler
- Doğrusal Olmayan Optik Aygıtlar
- Tümleşik Optik
- Optik Lifler
- Modelleme ve Simulasyon Yöntemleri
- Ölçüm ve Değerlendirme Teknikleri
- Kuantum Optiği
- Nanofotonik Aygıtlar ve Sistemler

ORGANİZASYON

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Serkan Ateş, İzmir Yüksek Teknoloji Enstitüsü

BİLİMSEL PROGRAM

08:30-10:00	Kayıt İşlemleri
10:00-10:15	Açılış Konuşmaları
10:15-11:00 11:00-11:30	Koray Aydın, Northwestern Üniversitesi Hakan Altan, ODTÜ
11:30-12:00	Kahve Arası
12:00-12:30 12:30-13:00 13:00-13:30	Ramazan Şahin, Akdeniz Üniversitesi İlkay Demir, Sivas Cumhuriyet Üniversitesi Özgür Karcı, TUSAŞ Havacılık
13:30-15:00	Yemek Arası ve Poster Sunumları
15:00-15:30 15:30-16:00 16:00-16:30	Serhat Tozburun, Dokuz Eylül Üniversitesi Emre Erdem, Sabancı Üniversitesi Safacan Kölemen, Koç Üniversitesi
16:30-17:00	Poster Ödül Töreni ve Kapanış Konuşmaları

DAVETLİ KONUŞMACI BİLDİRİLERİ LİSTESİ

POSTER BİLDİRİLERİ LİSTESİ

DAVETLİ KONUŞMACI BİLDİRİ ÖZETLERİ

Metayüzeylerle Fotonikte Yeni Ufuklar: Görüntüleme, Algılama ve Kuantum Uygulamaları

Koray Aydın
Norhwestwrn Üniversitesi

Günümüzde bilgi işleme, algılama ve iletişim teknolojilerinde yaşanan hızlı dönüşüm, ışığın kontrolünü yalnızca bir mühendislik problemi olmaktan çıkararak, fotonik alanında çok disiplinli bir fırsatlar dünyasının parçası hâline getiriyor. Bu dönüşümün merkezinde yer alan metayüzeyler sayesinde, ışık-madde etkileşimini atomik ölçekte yönlendirebilmek mümkün hâle geliyor. Böylece daha kompakt, hızlı ve çok işlevli optik sistemlerin geliştirilmesinin önü açılıyor.

Bu konuşmada, araştırma grubumuzla birlikte geliştirdiğimiz metayüzey mimarilerini ve bu yapılara dayalı fotonik uygulamaları tanıtacağım. Makine öğrenmesi ve ters elektromanyetik tasarım yaklaşımlarını kullanarak geliştirdiğimiz optik elemanların; görüntüleme, spektroskopi ve bilgi işleme gibi alanlarda nasıl kullanıldığını örneklerle aktaracağım. Özellikle ışığın kendisiyle gerçekleştirdiğimiz gerçek zamanlı kenar algılama gibi görevlerin, düşük enerjili ve yüksek hızlı optik hesaplama sistemleri için sunduğu olanakları tartışacağım.

Sunumun son bölümünde, kuantum yayıcılarla etkileşen rezonant metayüzeylerin kuantum ağlarının kurulmasına yönelik potansiyelini ele alacağım. Klasik ve kuantum fotonik sistemler arasında kurulan bu köprüde metayüzeylerin üstlendiği rolü ve bu alandaki güncel araştırma yönelimlerini paylaşarak, fotonik teknolojilerin geleceğine dair çok boyutlu bir bakış sunmayı amaçlıyorum.

Yenilikçi Sensör Uygulamaları için Karanlık Kiplerin Terahertz Bölgesinde Uyarımı

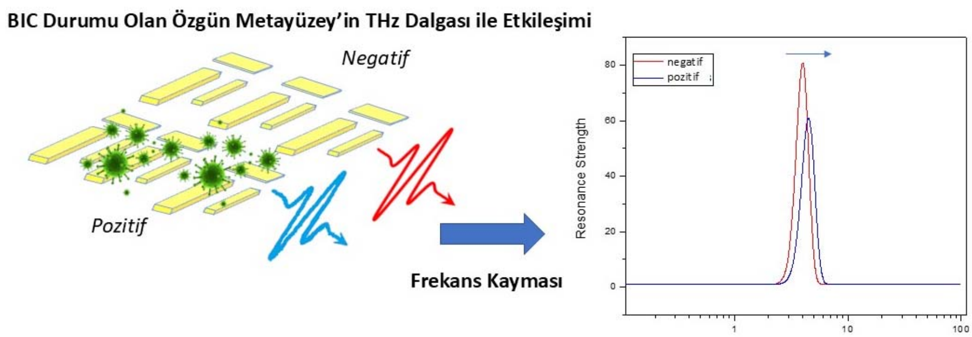
Hakan Altan
Terahertz Araştırma Laboratuvarı, ODTÜ Fizik Bölümü, Üniversiteler Mah. Çankaya Ankara 06800
Eposta: haltan@metu.edu.tr

Özet

Terahertz (THz) dalgaları (0.1-10THz), güvenlikten kablosuz iletişim teknolojilerine kadar birçok farklı uygulamada özgün çözüm önerileri sunabileceği için günümüzde yoğun olarak araştırılmaktadır. THz rejimi elektronik ve fotonik alanların arasında geçiş bölgesi olarak düşünülebilir ve metamalzeme yapıları frekans ayarlı olduğunda kolayca mikrodalgadan THz bölgesine çekilebilir. Metamalzemelerin farklı terahertz frekanslarında gösterdikleri rezonant etkiler, özellikle sensör ve spektroskopi uygulamaları açısından son derece önemli bir yer edinmeye başlamıştır. Mikro fabrikasyon kıstasları nedeniyle 2B düzlemde üretilen metayüzeyler sensör uygulamaları için hem ekonomik açıdan hem de uygulanabilirliği açısından son derece elverişlidir.

Özellikle sensör uygulamaları için metayüzey rezonansların kalite faktörleri (Q) önemli bir unsur olmaktadır. Q-faktörü bir bakıma ışığın o rezonans frekans aralığında ne kadar süre geçirdiğine işaret ediyor ve daha uzun süreler daha yüksek Q-faktörlerine denk geldiği için sensör uygulamalarında tespit sınırları Q-faktörünü arttırarak iyileşebiliyor. Son birkaç yıldır Q-faktörünü arttırmak için birim hücresinin kapasitif ve endüktif yapısına bağlı olan rezonant etkileri görmek yerine kolektif olarak hareket edebilen belli şekle sahip birim hücre yapıları için var olan karanlık kiplerini kullanarak sensör yapıları geliştirmeye çalışan farklı çalışmalar literatürde görülmeye başlanmıştır. THz bölgesinde bu durum yani metal tabanlı metayüzeylerde bulunan karanlık kipler (modlar), simetri korunmalı Süreklilikteki Fotonik bağlı Durumlar (Bound States in Continuum - BIC'ler) olarak adlandırılır ve sonsuz ömürlü optik sistemlerde korunan öz durumu gösterdiği için Q-faktörü de sonsuz olma özelliği gösterir ki bu da sensör uygulamaları için yeni fırsatlar doğurmaktadır.

Simetri korunmalı ideal-BIC modu ile etkileşmek için metayüzey üzerinde simetrisi bozulmamış tek bir birim hücresi yakın-alan THz ölçüm tekniklerine dayanarak uyarılmasına bağlı olarak gerçekleşebilir. Bu radikal yöntem ile teorik olarak çok yüksek Q-faktörlerine ulaşmak mümkün gözükmektedir. Çok yüksek Q-faktörleri sayesinde simetri korunmalı ideal-BIC'in merkez rezonans frekansı etrafında THz ışını uzun sürelere maruz kalacağı için analit ile olan etkileşimi artarak hassas tespit yapabilen bir sensör geometrisi ulaşılabilir olacaktır. Bu kapsamda uzak-alan geometrisi dahil olmak üzere yakın-alan ölçüm tekniklerinin THz bölgesinde özgün metayüzey yapılara uygulanması sonucu elde edilecek yeni algılama yöntemleri dahil olmak üzere bu alanda araştırma grubumuzun yaptığı çalışmalardan bahsedilecektir.



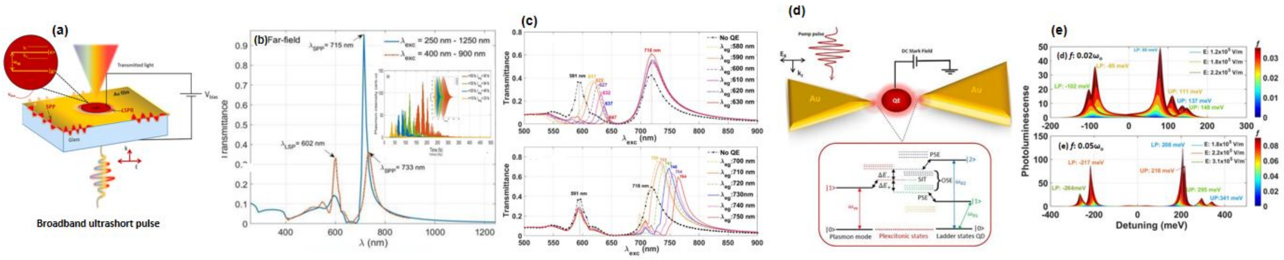
Şekil 1. Yüksek Q-faktörlü özgün metayüzey yapıları ile sensör uygulamaları kapsamında hassas tespit sınırlarına ulaşılması beklenilmektedir.

Görünür Dalgaboylarında Aktif Plazmonik

Dr. Ramazan Şahin[*1,2]
[1]Fizik Bölümü, Akdeniz Üniversitesi, 07058, Antalya, Türkiye
[2]Türkiye Ulusal Gözlemevleri, TUG, 07058, Antalya, Türkiye
rsahin@itu.edu.tr

Özet

Görünür dalgaboyunda plazmonik sistemlerin dinamik kontrolü, yeni nesil nanofotonik aygıtlar ve kuantum teknolojileri için kritik öneme sahiptir. Burada, gerçek zamanlı, yeniden yapılandırılabilir nanofotonik bileşenler elde etmek için plazmon-yayıcı etkileşimlerinin tamamen optik ve elektro-optik kontrolünü birleştirerek, optik frekanslarda çalışan kuantum plazmonik sistemler için aktif ayarlama stratejilerini gösteriyoruz.



Şekil 1: (a) Nanodeliğin içine yerleştirilmiş QE ile EOT yapısının şematik diyagramı (b) Ultrakısa darbenin farklı spektral bant genişlikleri için geçirgenlik spektrumları (c) QE'nin farklı seviye aralıkları (λ_{eg}) için geçirgenlik spektrumları. (d) Au bow-tie nanoanten ve voltaj ayarlanabilir QE'nin hibrit kuantum plazmonik sistemi (e) Zayıf ve güçlü etkileşim rejiminde Stark alanının farklı değerleri için ayar bozma fonksiyonu olarak Stark ayarlı pleksitonların PL spektrumları.

Öncelikle, ultrakısa lazer darbeleri aracılığıyla lokalize ve yayılan plazmon modlarının uyarılmasını sağlayarak olağanüstü optik geçirgenlik (EOT) üzerinde spektral ve zamansal kontrolü sağlayoruz [1]. Ardından, 3B-FDTD simülasyonları ve kuantum osilatör modellemesi aracılığıyla, darbe süresi ve bant genişliğinin değiştirilmesinin EOT şiddetini üç mertebe kadar artırdığını ve plazmon ömürlerini yaklaşık 100 fs'ye kadar uzattığını gösteriyoruz. Ayrıca, plazmonik nanoyapılara voltaj ayarlanabilir kuantum yayıcıları (QE) entegre ederek, sabit dalga boylarında geniş bantlı spektral ayarlama ve EOT sinyallerinin üç mertebe kadar modülasyonunu elde ediyoruz [2]. QE'nin uzun ömürlü yapısı, kısa ömürlü doğrusal olmayan plazmon modlarının ömrünü de 129 fs'ye kadar uzatabilmetedir [3]. Ek olarak, optik Stark etkisini (OSE) kullanarak hem rezonans dışı (off-rezonant) hem de rezonansta etkileştirilen plazmon-yayıcı sistemlerinde pleksitonik modların eş-fazlı kontrolünü teorik olarak gösteriyoruz. Rezonans dışı sistemlerde, Stark alanı üç seviyeli bir QE'deki dejenerasyonu yükselterek, pleksitonik durumları rezonansa doğru ayarlar ve Stark kaynaklı şeffaflığı (SIT) mümkün kılar. Dahası da, küçük Stark kaymaları, vakum Rabi bölünmesinde önemli değişikliklere (350 meV'ye kadar) neden olur ve fotolüminesansın (PL) isteğe bağlı modülasyonuna olanak tanır. Rezonant sistemlerde ise, OSE, Mollow üçlüsü özelliklerini ve yol girişim etkisini tetikler ve gözlenen Stark bölünmesi 491 meV'ye kadar çıkabilir [4].

Sonuçlarımız, nanometre ölçeğinde ışığın dinamik manipülasyonu için dayanaklı stratejiler sunarak, algılama, görüntüleme ve entegre fotonik uygulamalarında ayarlanabilir plazmonik cihazlar için yol açmaktadır.

Anahtar Kelimeler: Yüzey Plazmon Rezonansı, Olağandışı Optik Geçirgenlik, Stark etkisi, Kuantum Yayıcı

R.S., TÜBİTAK'ın 121F030 ve 123F156 numaralı projelerinden sağlanan destek için teşekkür etmektedir.

Referanslar

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Yüksek Performanslı Fotonik Uygulamalar için III-V Yarıiletkenlerde Epitaksiyel İnce Film Mühendisliği

İlkay Demir[1,2]

[1] Sivas Cumhuriyet Üniversitesi Nanofotonik Uygulama ve Araştırma Merkezi-CÜNAM, Sivas, Türkiye

[2] Nanoteknoloji Mühendisliği Bölümü, Sivas Cumhuriyet Üniversitesi, Sivas, Türkiye

III-V yarıiletkenlerin (InP, GaAs, InGaAs, InAlAs vb.) epitaksiyel olarak büyütülmesi, modern fotonik ve optoelektronik teknolojilerin temelini oluşturmaktadır. Metal Organik Buhar Fazı Epitaksisi (MOVPE) ve Moleküler Işın Epitaksisi (MBE) teknikleri ile atomik hassasiyette katman kalınlığı ve bileşim kontrolü sağlanarak kuantum kuyuları, süper örgüler ve gradyan indisli yapılar üretilebilmektedir.

Bu sunumda, optik haberleşme, kuantum teknolojileri, kızılötesi görüntüleme ve lazer sistemleri için epitaksiyel tasarım stratejileri, büyüme optimizasyonu ve ileri karakterizasyon (HRXRD, PL, AFM, ECV vb.) tekniklerinin rolü ele alınacaktır. Ayrıca, sağlık, savunma ve çevresel izleme alanlarında kritik öneme sahip kuantum çağlayan lazer (quantum cascade lasers) aygıtları için çok katmanlı III-V heteroyapıların büyütülmesinde epitaksinin belirleyici etkisi vurgulanacaktır. Bununla birlikte, gerinim mühendisliği, kompozisyon gradyanları ve defekt yönetimi gibi süreç optimizasyonu yaklaşımları aktarılacak; geleceğin fotonik cihaz mimarileri için yüksek performanslı epitaksiyel malzeme geliştirme perspektifleri sunulacaktır.

Referanslar

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Uzay Platformları için Teleskop Tasarımı ve Optik Teknolojileri

Özgür Karcı
TUSAŞ Havacılık

Yer gözlem uyduları, 400-800 km alçak dünya yörüngeden (Low Earth Orbit, LEO) dünyanın farklı spektrumlarda görüntülenmesi için kullanılan uzay platformlarıdır. Teleskop ve elektro-optik kamera sistemleri, yer gözlem uydularında kullanılan asıl faydalı yüklerdir. Kırınım-limitli optik tasarıma ve görüntüleme performansına sahip bu elektro-optik sistemler, fırlatma roketlerinin titreşim koşullarına dayanımlı ve uzay ortamına uygun özelleşmiş malzemeler ve bunlara uygun tasarımlarla şekillendirilmektedirler.

Bir uydu kamerası için teleskop tasarımı, uydu sisteminin görev gereksinimlerinin kırınımıyla başlayan bir sistem mühendisliği çalışmasıyla şekillenen optik tasarımla şekillenmektedir. Geniş görüş açısına sahip kırınım-limitli, aplanatik Ritchey-Chrétien (RC) (Hubble Uzay Teleskobu gibi) ve anastigmatik Three Mirror (TMA) (James Webb Uzay Teleskobu gibi) teleskop mimarileri uydu sistemlerinde öne çıkan modern optik mimarilerdir.

Bu çalışmada, katadioptrik bir RC teleskobun uçtan-uca tasarımı ve realizasyon süreçleri, bu konuda yapılan çalışmalar sunulacaktır. Modern teleskop sistemlerinin optik tasarım süreçleri ve aberasyon teorisi ile ilişkisi, bir teleskobun inşa sürecini kapsayan opto-mekanik ve yapısal tasarımlar ile malzeme seçimleri, bu tasarımları yönlendiren fırlatıcı roket sistemleri ve yörüngedeki uzay koşulları, büyük çaplı hafifletilmiş uzay-kalifiye asiferik optik üretimleri ve bunların interferometre tabanlı metrolojisi (hologram veya null lensler), uzay koşullarına dayanımlı ince film kaplamalar, teleskopların optik olarak hizalanması ve kullanılan nodal aberasyon teorisi (NAT), teleskop performans metrikleri ile bunların ölçümü, gereksinim duyulan time-delay-integration (TDI) tipi CCD ve CMOS sensör teknolojileri çalışmanın ana unsurları olarak öne çıkmaktadır.

Uzay koşullarında çalışacak bir teleskobun yaşam döngüsü, optiğin farklı alanlarının yanı sıra fiziğin de çok farklı disiplinlerini bir araya getirmektedir. Optik metroloji yöntemlerindeki ihtiyaçlar/gelişmeler ise geleneksel simetrik optik mimarilerin yanında serbest form (freeform) optik mimarileri, bunların üretimlerini mümkün kılmakta ve hızlı bir dönüşümü tetiklemektedir.

Gör ve Tedavi Et: Gastroenteroloji için Yeni Teknolojiler

Serdar TOZBURUN
[1]*Izmir Biomedicine and Genome Center, Izmir, Türkiye*
[2]*Izmir International Biomedicine and Genome Institute, Dokuz Eylul University, Izmir, Türkiye*
[3]*Dept. of Biophysics, Faculty of Medicine, Dokuz Eylul University, Izmir, Türkiye*
serhat.tozburun@deu.edu.tr

Özet

Tıbbi teşhis ve müdahalede yeni bir paradigmayı tanımlamak için "gör ve tedavi et" terimi üzerinden yeni teknolojiler geliştiriyoruz. Geliştirdiğimiz teknolojiler, anında ve bilinçli klinik müdahaleyi kolaylaştırmak için gelişmiş optik görüntüleme teknolojilerini akıllı algoritmalarla ve tedavi sondalarıyla birleştiriyor. Tanı ve tedaviyi farklı ve genellikle zaman alıcı aşamalara ayıran geleneksel iş akışlarının aksine, gör ve tedavi et konseptimiz, patolojik durumları tespit etmek ve tedavi kararlarını yerinde yönlendirmek için gerçek zamanlı medikal ve biyomedikal görüntülemeyi (özellikle yapay zekâ destekli görüntülemeyi) entegre ediyor. Görüntüleme ve tedavinin tek bir seansta kusursuz bir şekilde entegre edilmesi, klinik iş akışını reaktif bir modelden proaktif bir modele dönüştürerek tedavi gecikmelerini önemli ölçüde azaltabiliyor ve klinik sonuçları iyileştireceği ön görülüyor.

Bu paradigmamızın temel odak noktası, biyomedikal teknolojilerin (optik görüntüleme, termal tedavi ve termal olmayan tedavi) endoskopi ve yapay zekâ tabanlı gerçek zamanlı analizlerle birleştirilmesinin benzeri görülmemiş bir hassasiyet sağladığı endoskopik müdahalelerdeki uygulamasıdır. Optik Eş-fazlı Tomografi (OCT) ve holografik görüntüleme gibi teknikleri içeren optik görüntüleme hedefimiz, hücresel ve hücre altı düzeyde dokuların yüksek çözünürlüklü, invaziv olmayan görüntülenmesini sağlayarak önemli bir rol oynamaktadır. Geleneksel beyaz ışık görüntülemesinden elde edilen anatomik ve yüzeysel bilgi ileri optik görüntüleme yöntemleri ve makine öğrenimiyle desteklenen hızlı veri yorumlama ile birleştirildiğinde, bu doğrultuda geliştirilen optik araçlar uzman hekimlerin anormallikleri ince ayrıntılarıyla görmelerine ve anında hassas bir şekilde tedavi etmelerine olanak tanır.

"Gör ve tedavi et" yaklaşımımızın dokudan elde edilen yapısal ve işlevsel bilgilere dayanarak müdahalelerin gerçek zamanlı olarak uyarlanabildiği minimal invaziv, görüntü kılavuzlu hassas tıpta yeni ufuklar açacağı düşünülüyor. Biyomedikal mühendisliği, optik görüntüleme, endoskopik termal ve termal olmayan tedaviler ve yapay zekanın güçlü yönlerini bir araya getiren laboratuvarımız, özellikle gastroenteroloji alanında, uzman hekimlerin hastalara daha verimli, güvenli ve etkili bir şekilde teşhis ve birden fazla randevuya gerek kalmadan tedavi etme yöntemlerine yeni teknolojiler sunuyor.

Fon Kaynaklarımız

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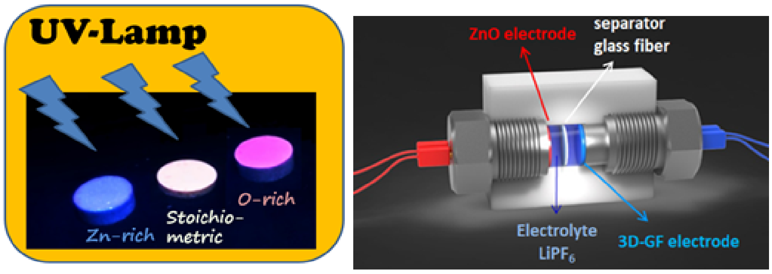
EPR Spektroskopisi ile Kusur Yapılarının İncelenmesi: Fotonik, Nanomalzemeler ve Süperkapasitör Uygulamaları Arasındaki Bağlantılar

Emre Erdem
Sabancı Üniversitesi
Malzeme Bilimi ve Nano Mühendislik Programı İstanbul, Türkiye
email: emre.erdem@sabanciuniv.edu

Elektron paramanyetik rezonans (EPR) spektroskopisi, özellikle oksitler gibi kusurların elektronik, manyetik ve optik özellikleri derinden şekillendirdiği malzemelerde bu yapıları incelemek için güçlü ve çok yönlü bir yöntemdir.

Bu seminerde EPR spektroskopisini katıhal malzeme bilimi ve fotonik çerçevesinde tanıtarak, yarı iletken nanomalzemeler, perovskitler ve yeni nesil 2D malezemelerde kusur ilişkili olguları ortaya çıkarma gücünü vurgulayacağım. EPR, yalnızca kendiliğinden ve dışarıdan oluşan kusur durumlarına duyarlı olmakla kalmaz; aynı zamanda kristal alan parametrelerindeki ufak değişimlere de hassastır. Bu sayede $PbTiO_3$ ve kurşunsuz perovskitlerden ZnO nanomalzemelere kadar farklı malzeme sınıfları arasında karşılaştırmalar yapılmasına olanak tanır. Ayrıca metal iyonlarının elektronik durumları, derişimleri, iyon ikamesi, yük dengelenmesi ve oksijen boşluğu oluşum mekanizmaları hakkında ayrıntılı bilgiler sunar. Yüzey ve hacim kusurlarını ayırt edebilme özelliği ise fonksiyonel uygulamalar için malzeme davranışını doğru şekilde yönlendirmek açısından kritik öneme sahiptir.

Son olarak, ZnO ve kurşunsuz perovskitlerin sürdürülebilir enerji depolama için tümleşik süperkapasitör cihazlarında elektrot malzemesi olarak kullanımına dair devam eden araştırmalarımızı paylaşacağım. EPR'yi fotolüminesans gibi tamamlayıcı tekniklerle birleştirerek kusur durumlarının kontrolünün cihaz performansını doğrudan nasıl etkileyebildiğini göstereceğiz. Bu yaklaşım, enerji ve fotonik teknolojileri için işlevselliği optimize edilmiş yeni nesil elektrot malzemelerinin tasarlanmasına giden yolda önemli fırsatlar sunmaktadır.



Şekil 1: (sol) Stokiyometrik olmayan ZnO'da kusur evriminin şematik gösterimi. (sağ) ZnO ve üç boyutlu grafen köpük elektrotlar kullanılarak geliştirilen süperkapasitör cihazı.

Özgecmiş: Emre Erdem, Sabancı Üniversitesi'nde deneysel fizik ve malzeme bilimi profesörüdür. Araştırmaları spektroskopi ve süperkapasitörler üzerine yoğunlaşmaktadır. Lisans derecesini 1998 yılında Ankara Üniversitesi'nden, yüksek lisans ve doktora derecelerini ise sırasıyla 2001 ve 2006 yıllarında Leipzig Üniversitesi'nden almıştır. Doktora sonrası çalışmalarını Darmstadt Teknik Üniversitesi'nde tamamladıktan sonra Freiburg Üniversitesi'nde işlevsel nanomalzemelerin spektroskopik incelemelerine odaklanan bir araştırma grubuna liderlik etmiş ve 2017 yılında habilitasyon unvanını almıştır. Uzmanlık alanları arasında çok frekanslı EPR, fotolüminesans ve empedans spektroskopisi yer almakta olup, yarı iletkenler ve piezoelektriklerdeki noktasal kusurların anlaşılmasına önemli katkılar sağlamıştır. Prof. Erdem'in güncel çalışmaları 2D malzemeler, sürdürülebilir karbon üretimi ve süperkapasitör tasarımı üzerine odaklanmaktadır. 150'den fazla makale yayımlamış, 50'den fazla davetli konuşma yapmıştır. Experimental Results dergisinin Baş Editörü ve Scientific Reports dergisinin Yardımcı Editörüdür. Ayrıca Sabancı Üniversitesi EFSUN Araştırma Merkezi'nin Direktörüdür ve 2024 yılında Darmstadt Teknik Üniversitesi'nde Mercator Fellow olarak seçilmiştir.

Antimikrobiyal ve Antikanser Fotodinamik Terapi Ajanları

Safacan Kölemen[a]

[a]Koç Üniversitesi, Kimya Bölümü, İstanbul, Türkiye

Fotodinamik tedavi (FDT), klinik olarak onaylanmış bir tedavi yöntemi olup, düşük yan etki profili ve ilaç direncini aşma yeteneği sayesinde kanser tedavisi ve antimikrobiyal uygulamalar için büyük potansiyel taşımaktadır.[1] Tipik bir FDT mekanizmasında, sitotoksik reaktif oksijen türleri (ROS), üç temel bileşenin, fotoduyarlaştırıcı (PS), ışık (lazer) ve oksijen ($^3O_2$), varlığında üretilir.[1] ROS üretimi iki farklı mekanizmayı takip eder. Tip-I mekanizmasında, uyarılmış triplet enerji seviyesinde bulunan bir PS, doku oksijenine ($^3O_2$) olan bağımlılığı oldukça düşük olacak şekilde süperoksit radikali ($O_2{\bullet}^-$) ve hidroksil radikali (•OH) üretir.[1] Tip-II mekanizmada ise, triplet PS, enerjisini temel hal oksijenine aktararak sitotoksik singlet oksijen ($^1O_2$) oluşturur.[1] Tip-I mekanizmanın temel avantajı, doku oksijenine olan minimal bağımlılığıdır.[1] Bu durum, Tip-I PS'lerin katı tümör ortamında bulunan hipoksik koşullarda etkili bir şekilde çalışmasına olanak tanır.[2] Tip-I PS'ler son yıllarda büyük ilgi görse de, kanser hücrelerine seçici olarak etki eden aktivite tabanlı Tip-I PS'ler henüz az sayıdadır.[2]

Aktiviteye dayalı, teranostik fotoduyarlaştırıcıların geliştirilmesine yönelik devam eden çalışmalarımız kapsamında, farklı kanser hücre tiplerinin seçici tedavisini mümkün kılan, kırmızı/yakın kızılötesi ışık absorpsiyonuna sahip çeşitli PS'ler sentezlenmiştir. Bu çalışmalardan birinde, hidrojen sülfür (H_2S) tarafından seçici olarak aktive edilen, hemisiyanin bazlı, organel hedefli tip-I PS'ler geliştirilmiştir.[3] Bu PS'ler, hem normoksik hem de hipoksik koşullar altında kanser hücrelerinde güçlü ve seçici fototoksisite gösterirken, normal hücrelerde ihmal edilebilir düzeyde fototoksik etki oluşturmuştur. Takip eden bir çalışmada ise, hipokloröz asit (HOCl)'e duyarlı, mitokondri hedefli bir tip-I PS ortaya çıkarılmış ve ilgili ajan, hem güçlü bir antikanser ajan hem de endojen HOCl kaynağı olarak görev yapan elesklomol–Cu(II) kompleksi ile birlikte sinerjik bir tedavi yaklaşımında kullanılmıştır.[4] Elesklomol-Cu(II) ve PS'nin birlikte uygulandığı HeLa hücrelerinde terapötik etkinlik anlamlı düzeyde arttığı rapor edilmiştir. Geliştirdiğimiz yenilikçi PS'ler aynı zamanda antimikrobiyal ajanlar olarak da kullanılmıştır. Bu doğrultuda yaptığımız bir çalışmada yapısında polietilen glikol (PEG) grubu taşıyan FDT ajanımız lazer uyarımı altında tüm ESKAPE bakterilerinin ve biyofilmlerin inhibisyonunu sağlamıştır.

TÜBİTAK (Proje No: 121Z662), TÜSEB (Proje No: 32867) ve TÜBA-GEBİP programına desteklerinden dolayı teşekkür ederim.

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POSTER BİLDİRİ ÖZETLERİ

Development of a Near-Field THz Sensing System for Micron-Scale Studies

Öznur Ömrüm ŞAHİN*[1], Hakan ALTAN[2]
[1] Department of Micro and Nanotechnology, METU, Ankara 06800, Türkiye
[2] Department of Physics, Middle East Technical University, Cankaya Ankara 06800
Tel: +90 312 210 3277 Fax: +90 312 210 5099
corresponding author, E-mail: omrum.sahin@metu.edu.tr

Abstract

Investigation of small-scale structures on the micron scale in the THz region is limited by the laws that govern classical THz microscopy due to the Rayleigh and Abbe diffraction criteria. According to these criteria, at 1 THz frequency where the wavelength is 0.3 mm, the minimum resolution limit that can be achieved is 150µm. Consequently, detecting local changes in structures smaller than this is not possible with classical THz microscopy techniques. This limitation has led to the development of near-field measurement techniques. This region is defined as the region where the target to be imaged is placed very near the THz source at lengths $< 2D^2/\lambda$ where D is the source diameter, typically a distance smaller than 10λ, allowing for the investigation of microstructures beyond the Rayleigh and Abbe limits. Near-field measurement techniques can be categorized into five main groups. The first technique is based on the confinement of electromagnetic waves in slits or corrugated apertures, where resolutions down to $\lambda/70$ have been achieved <2 THz range (Mitrofanov et al., 2001) .The second technique involves systems using waveguide-based methods, reaching resolutions of $\lambda/260$ at 0.12 THz (Zhan et al., 2010). The third group includes scattering-based methods such as dynamic scattering, near-field collection with a metallic tip, far-field collection of scattered radiation, and emission scatterers. In our approach, special photo conductive antenna which has an active area of 3µm allows us to achieve a spatial resolution of 40µm at 1 THz (Figure 1). This work aims to contribute to the field of high-resolution imaging in the THz domain.

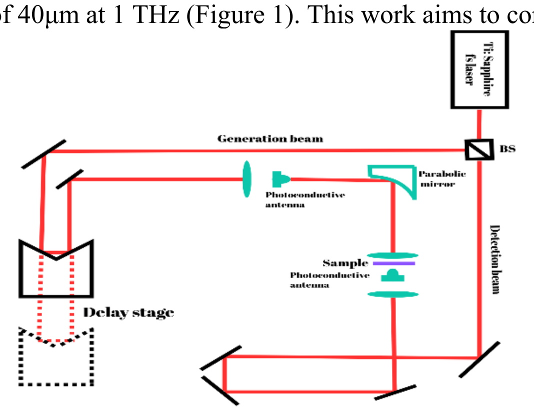

Figure 1a) Near Field THz setup

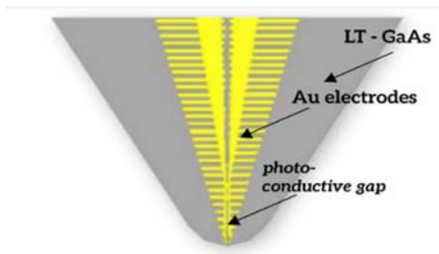

Figure 1b) Photoconductive antenna structure

Keywords: THz near field, Photo conductive antenna

Acknowledgement:
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Development and Validation of an Endoscope for the Real-Time In Situ Ciliary Beat Frequency Analysis in Airways

Amir Mohammad Ketabchi[1], Burak Yükrük[2], Serhat Nas[2], Berna Morova[3], Hasan Bayram[4], Alper Kiraz[1, 2, 4, 5]

[1]*Department of Electrical and Electronics Engineering, KoçUniversity, Istanbul, Türkiye*
[2]*Optofil Inc., İstanbul, Türkiye*
[3]*Department of Physics, Istanbul Technical University, Istanbul, Türkiye*
[4]*KUTTAM-Koç University Research Center for Translational Medicine, Istanbul, Türkiye*
[5]*Department of Physics, KoçUniversity, Istanbul, Türkiye*

Abstract: Ciliary dysfunction in the nasal mucosa is a major factor in the pathogenesis of chronic airway diseases such as primary ciliary dyskinesia, cystic fibrosis, bronchiectasis, asthma, and chronic obstructive pulmonary disease. Accurate evaluation of ciliary beat frequency (CBF) is critical for early diagnosis and disease monitoring; however, current methods rely on invasive sample collection, are time-intensive, and often yield inconsistent results due to environmental or handling factors. This project develops and clinically validates a novel elastic fiber endoscope capable of measuring CBF directly and in real time within the nasal cavity. The device integrates dual optical pathways to provide simultaneous anatomical imaging and motion analysis, enabling precise in vivo quantification of ciliary activity.

The system employs two synchronized imaging channels, one illuminated with a white light source for endoscopic visualization, and another with a defocused laser to generate speckle patterns from the ciliated surface. Frame-by-frame correlation of these speckle patterns allows precise calculation of CBF in the physiological range. Validation is conducted through three complementary approaches: (i) in situ measurement within the nasal cavity of healthy volunteers and patients with ciliopathies; (ii) ex vivo analysis of nasal epithelial brush samples; and (iii) in vitro assessment of cultured epithelial cells from the same donors. Cross-comparison assesses accuracy, reproducibility, and clinical applicability.

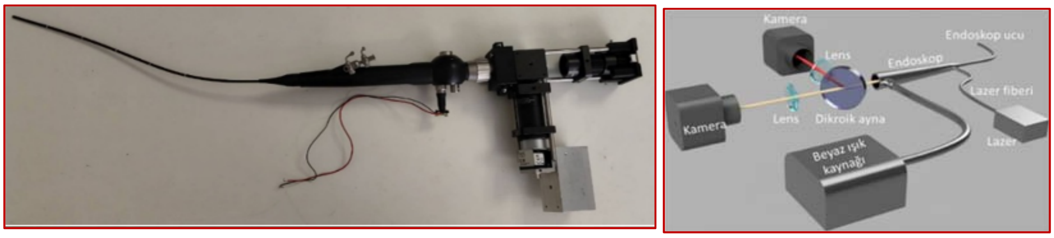

Figure 1: The representation of the optical setup to be used in the investigation of cilia movement. The setup includes an endoscope, laser, imaging system, and the defocus system of the speckle pattern.

The system significantly reduces patient discomfort, improves diagnostic accuracy, and shortens evaluation time from several days to minutes. By enabling rapid, reliable, and non-invasive assessment of mucociliary function, this innovation transforms clinical workflows in respiratory medicine and enhances the management of ciliopathy-related diseases. We thank TÜSEB (Grant No: 35713), TÜBİTAK (Grant No: 9249505) and TÜBA (A. Kiraz) for partial supports.

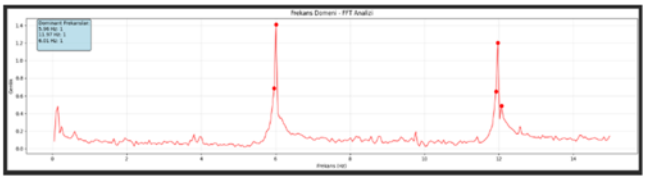

Figure 2: Representative result obtained by moving the sample at 12 Hz using a speaker.

Keywords: Ciliary Beat Frequency, Nasal Endoscopy, Respiratory Diagnostics, In Vivo Measurement.

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TI Growth and Characterization for Single Photon Detector Devices

Mehmet Cengiz Onbasli[1,2]*, Ebrahim Zahrabi[1], Aykut Can Onel[1], Roya Kavkhani[1], Kerem Anar[1], Aahmad El Zatari[1], Arooba Maryyam[1], Hulya Gurcay[1], Berna Agkenc Hanedar[1], Ferhat Katmis[1]

[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye*
[2]*Department of Physics, Koç University, Istanbul, 34450, Türkiye*

*E-mail: monbasli@ku.edu.tr

Abstract

Single photon detectors are essential for quantum photonics, but today's superconducting nanowire devices have limited performance and reproducibility.

A promising direction is TI superconducting single photon detectors (TI-SSPD). Topological insulators offer Dirac surface states for ultrafast electron transport, reduced phonon scattering for lower jitter, and natural topological protection through broken symmetries.

To realize these advantages, epitaxial TI films must be grown with stable crystal phases and high structural quality.

In Bi_2Te_3, the stability of topological surface states is often compromised by stacking faults and secondary phases.

By doping with Sb, we suppress these competing domains, as confirmed by the disappearance of the parasitic (015) peak in XRD.

Raman spectroscopy reveals a strong 24 cm^{-1} downshift of the $A_{1g}^{(3)}$ mode, one of the largest dopant-induced shifts reported in layered TIs.

Together with AFM, these results show a clear transition from disordered growth to a uniform TI phase.

This combination of epitaxial control and Sb stabilization provides the high quality materials needed for reliable TI-based single photon detectors.

Keywords: Single photon detector, topological insulator, phase control

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Linearity Measurement System for High-Precision Radiation Thermometers

***Mücahit Korkmaz[1], Batuhan Ünlü[1], Kaan Erkin Kanatoğlu[1], Nur Erkılıçoğlu[1], *Mehtap ERTURK[1,2], Mevlüt KARABULUT[2], Hümbet NASİBLİ[1]**

[1]National Metrology Institute, The Scientific and Technological Research Council of Türkiye (TÜBİTAK- UME, Ulusal Metroloji Enstitüsü), Gebze, Kocaeli, Türkiye
[2]Gebze Technical University, Gebze, Kocaeli, Türkiye
corresponding authors: mehtap.erturk@tubitak.gov.tr, mucahit.korkmaz @tubitak.gov.tr

Abstract

Radiation thermometers, owing to their non-contact operation, are widely used for reliable measurements of high temperatures in both industrial processes and scientific research. Their accuracy largely depends on the linearity of the photon detectors employed. High-temperature pyrometers operating in the narrow wavelength range of 650–950 nm with Si photodiode detectors have become the standard for ensuring SI-traceable measurements above 1000 °C. However, establishing whether the response of these detectors is strictly linear remains crucial for reducing uncertainties in the metrological chain.

In this study, a high-precision analysis system based on the flux-addition (superposition) method was developed to characterise the linearity of silicon (Si) detectors. Unlike conventional attenuation-based techniques, this method relies on measuring the signals from two independent, stable light sources (L1 and L2), both separately and simultaneously. For a perfectly linear detector, the equality S(L1+L2) = S(L1) + S(L2) must hold; deviations directly indicate nonlinearity. A key advantage of this approach is that it allows detector linearity to be evaluated without requiring absolute calibration of the sources.

The experimental setup employed tungsten ribbon lamps as light sources, with active water cooling to suppress thermal noise and a thermoelectric cooler to stabilise detector temperature. A PID-based electronic circuit, together with dedicated software, was developed to stabilize the lamp intensity with an accuracy of 100 ppm. The photodiode current was converted to voltage using a low-noise transimpedance amplifier and recorded with a high-resolution DAQ system. This configuration effectively eliminated electronic noise and thermal drift, ensuring measurements within a robust metrological framework.

The results clearly demonstrate the detector's linearity performance over the temperature range of 800–1800 °C. In particular, deviations remained at the level of 0.01% between 900 and 1700 °C, indicating near-ideal linear behaviour. At lower temperatures, reduced signal-to-noise ratios led to higher deviations, while at higher temperatures, increased deviations were observed as the detector approached saturation. These findings define the linear dynamic range of the detector together with its physical limitations.

Keywords: Detectors, flux-addition, linearity, high temperature, radiation thermometers

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Improving Contrast in Fiber Bundle-Based Fluorescence Microscopy through the Application of Generative Adversarial Networks

Amir Mohammad Ketabchi[1], Berna Morova[2], Furkan Eren[3], Yiğit Uysalli[4], Musa Aydin[5], Dariusz Pysz[6], Ryszard Buczynski[6,7], and Alper Kiraz[1,3,4,8]

[1] *Department of Electrical and Electronics Engineering, Koç University, Istanbul, Türkiye*
[2] *Department of Physics Engineering, Istanbul Technical University, Istanbul, Türkiye*
[3] *Optofil, Inc., Istanbul, Türkiye*
[4] *Department of Physics, Koç University, Istanbul, Türkiye*
[5] *Department of Computer Engineering, Fatih Sultan Mehmet Vakif University, Istanbul, Türkiye*
[6] *Department of Glass, Institute of Electronic Materials Technology, Wolczynska 133, 01-919, Warsaw, Poland*
[7] *Faculty of Physics, University of Warsaw, Pasteura 5, 02-093, Warsaw, Poland*
[8] *KUTTAM-Koç University Research Center for Translational Medicine, Istanbul, Türkiye*

Abstract: Fiber bundle (FB) based endoscopes are indispensable in biology and medical science due to their minimally invasive nature. However, resolution and contrast for fluorescence imaging are limited due to characteristic features of the FBs, such as low numerical aperture (NA) and individual fiber core sizes. In this study, we improved the resolution and contrast of sample fluorescence images acquired using in-house fabricated high-NA FBs by utilizing Generative Adversarial Networks (GANs). In order to train our deep learning model, we built an FB-based multifocal structured illumination microscope (MSIM) based on a digital micromirror device (DMD), which improves the resolution and the contrast substantially compared to basic FB-based fluorescence microscopes. After network training, the GAN model, employing image-to-image translation techniques, effectively converted wide-field images into high-resolution MSIM images without the need for any additional optical hardware. The results demonstrated that GAN-generated outputs significantly enhanced both contrast and resolution compared to the original wide-field images. These findings highlight the potential of GAN-based models trained using MSIM data to enhance resolution and contrast in wide-field imaging for fiber bundle-based fluorescence microscopy.

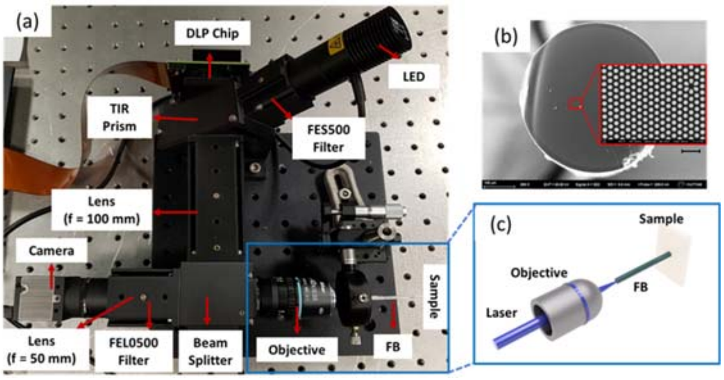

Figure 1. (a) Experimental setup. (b) SEM image of the utilized fiber bundle. Scale bar: 10 µm. (c) The sketch of the system, including the objective, fiber bundle, and sample.

Keywords: Fiber Bundle-Based Fluorescence Microscopy, Deep Learning Model, GAN, Image-to-Image Translation, Multifocal Structured Illumination Microscopy (MSIM), Biological Imaging.

Acknowledgement: This work was supported by TÜBİTAK (Grant No. 118F529). A. Kiraz acknowledges partial support from the Turkish Academy of Sciences (TÜBA). R. Buczynski acknowledges support of the University of Warsaw Excellence Initiative – Research University (2020-2026) program, action I.1.1/IV.1.1 No. BOB-IDUB-662-14/2024.

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Label-free Plasmonic Biosensor for the Pre-diagnosis of Familial Mediterranean Fever

Fatma Kurul[1], Meryem Beyza Avci[1], Seda Nur Topkaya[1], Erbil Ünsal[2], Arif E. Cetin[1]
[1] Izmir Biomedicine and Genome Center, Balcova, Izmir, Türkiye
[2] Division of Pediatric Rheumatology, Faculty of Medicine, Dokuz Eylul University, Balcova, Izmir, Türkiye

Familial Mediterranean Fever (FMF) is a rare autoinflammatory disease caused by mutations in the MEFV gene. These mutations lead to the overproduction of the pyrin protein, triggering an uncontrolled inflammatory response. Early diagnosis of FMF is crucial to prevent irreversible complications such as amyloidosis. However, current diagnostic approaches are often time-consuming, expensive, and lack specificity in early stages. In this project, we developed a label-free plasmonic biosensor platform for the rapid and sensitive detection of pyrin protein levels in serum samples, aiming to facilitate the pre-diagnosis of FMF [1]. The biosensor utilises gold nanoparticles with surface plasmon resonance (SPR) properties integrated into a chip-based detection system. Our results show that the sensor can detect pyrin at concentrations as low as 0.24 ng/mL in less than 10 minutes, offering high sensitivity, specificity, and real-time measurement capability. This platform may provide a promising tool for field-deployable and early-stage screening of FMF, particularly in genetically at-risk populations.

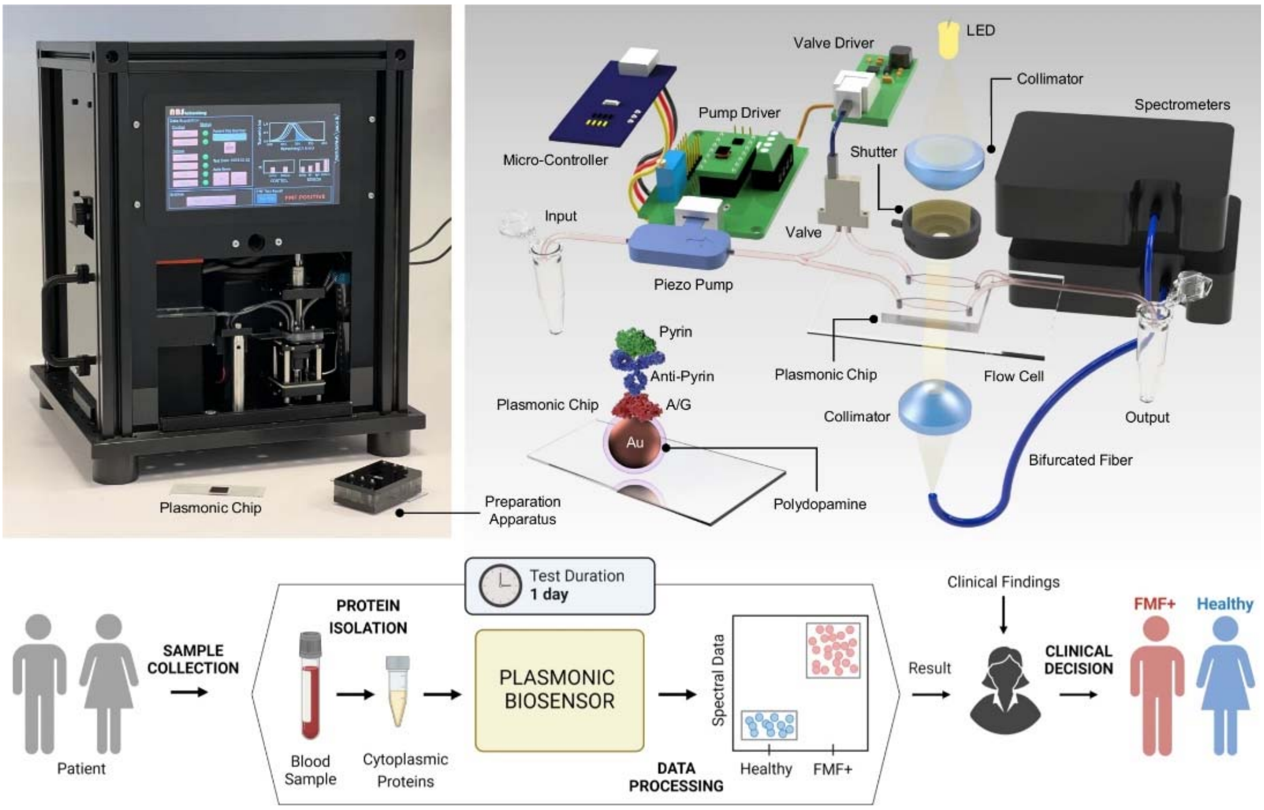

Figure 1. The schematic illustration presents the diagnostic workflow for FMF, integrating test results from the plasmonic biosensor with clinical evaluation findings.

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A Portable Vis-NIR Spectrometer for Developing Turkish Soil Library

***Omer Faruk KADI[1] , Bengu YIGITOGLU[1,2], Can KUMEK[1,3] , Dilem Gokce TUCCAR[1,4] , Eren DEMİREL[1,4], Edanur CARBUGA[1,5], Ahmet Harun ATAG[1,4], *Humbet NASIBLI[1]**

[1]*National Metrology Institute, The Scientific and Technological Research Council of Türkiye (TÜBİTAK- UME, Ulusal Metroloji Enstitüsü), Gebze, Kocaeli, Türkiye*
[2]*Marmara University, İstanbul, Türkiye*
[3]*Karabük University, Karabük, Türkiye*
[4]*Yıldız Tecnical University, İstanbul, Türkiye*
[5]*Kocaeli University, Kocaeli, Türkiye*

corresponding authors: omerfaruk.kadi@tubitak.gov.tr; humbet.nasibli@tubitak.gov.tr

Abstract

Human activities, urban expansion, poor land-use practices, and climate change accelerate the ten key processes of global soil degradation: erosion, organic carbon loss, nutrient imbalance, acidification, contamination, waterlogging, compaction, sealing, salinization, and biodiversity loss[1]. Most of these processes affect the soil surface, making them detectable by remote sensing. Soil mapping is therefore essential for sustainable management in agriculture and ecosystem resilience. In particular, the visible–near-infrared (VNIR) and short-wave infrared (SWIR) spectral ranges (400–2500 nm) are effective for observing soil properties. Optical remote sensing enables rapid, high-resolution, and direct measurements of electromagnetic radiation that capture both chemical and physical characteristics of soils. Extensive studies in laboratory and field conditions have demonstrated strong relationships between soil spectra and soil properties, forming the basis for spectral soil modeling at continental to global scales. The integration of soil spectral libraries (SSLs) from laboratory, field, and global scales into a unified database is crucial for monitoring and managing Earth's surface in the future. Many countries are actively contributing to SSL development at both national and international levels[2].

In this work, we present a portable Vis–NIR spectroscopic system specifically designed to support the creation of the Turkish Soil Spectral Library and its integration into the global SSL. The system follows the *P4005: IEEE SA Standard and Protocol Scheme for Soil Spectral Measurement in Both Laboratory and Field*. It employs a transportable spectrometer covering the 350–2500 nm range, combined with a measurement chamber equipped with fiber-optic light transmission and a lamp-based illumination source[3]. Lightweight and highly flexible, the device can be easily carried for field measurements. We describe the system's optical and mechanical design, as well as its operational algorithms. Representative soil spectra collected at the TÜBİTAK campus (Gebze, Türkiye) and near Foggia (Italy) are presented to demonstrate its performance.

Keywords: Non-Destructive Measurement, Reflectance Spectroscopy, Turkish Soil Spectral Library, Vis-NIR Portable Spectroscopic System

Acknowledgements
This research was funded by the 21GRD08 SoMMet project. The SoMMet project has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States(funder ID: 10.13039/100019599; grant no. 21GRD08 SoMMet; https://www.sommet-project.eu)

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Robust Coupler Grating Design for AR/VR/XR Applications via Sliding-Kernel Tolerancing

Arda Eren*[1,2], Nazmi Yılmaz[2], İbrahim Tuna Özdür[1]

[1] Department of Electrical and Electronics Engineering, TOBB University of Economics and Technology, Türkiye
[2] ASELSAN Inc., Türkiye
Corresponding author, E-mail: a.eren@etu.edu.tr

Abstract
Couplers based on diffraction gratings are critical components in state-of-the-art AR/VR/XR headsets. [1] Manufacturing tolerances often degrade the performance, making purely nominal optimization insufficient. A robust grating-based coupler design framework that evaluates not only peak performance but also tolerance averaged performance is presented. Using a multi-dimensional sliding kernel summation, mathematically equivalent to a local autocorrelation, robustness is efficiently quantified across large grating databases. This allows systematic identification of designs that yield high efficiency under realistic tolerances.

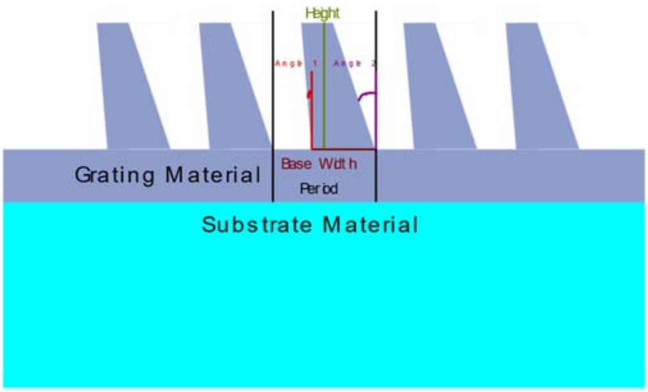

Figure 1: Geometric Dimensions of a Diffraction Grating

Diffraction gratings are characterized by a large number of parameters, namely wavelength, period, refractive indices of constituent layers, structures efficiencies and their geometric dimensions as shown in Figure 1. A database of grating efficiencies was precomputed using RCWA [2][3]. Even this humble database that is computed for a local design space for a single coupler may contain millions of entries, making traditional tolerancing – querying all neighbor points within a $\pm\Delta$ for each element is computationally prohibitive. Instead of traditional tolerancing, a multi-dimensional sliding kernel is used for tolerancing. Boundary handling with zero padding is used to penalize designs near dataset edges, reflecting real fabrication yields.

Keywords: Diffraction Gratings, Waveguide Couplers, Tolerancing

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Idendification of Deep Levels in n-InAlAs Epitaxial Layers Using DLTS

Hasan Efeoğlu[1,2], İlkay Demir[3], Merve Nur Koçak[3], Ömer Çoban[1]
[1]*Atatürk Üniversity, Faculty of Eng. Department of E&E Eng. Erzurum Türkiye*
[2]*Department of Nanoscience and Nanoengineering, Atatürk University, Erzurum, Türkiye*
[3]*Sivas Cumhuriyet University , Nanophotonics Application and Research Center-CÜNAM, 58140, Sivas, Türkiye*
corresponding author: hefeoglu@atauni.edu.tr

Abstract

Deep Level Transient Spectroscopy (DLTS) one of the most powerful characterisation technique for deep levels exist in semiconductors. In this work n-InAlAs epitaxial layers grown on SI-InP grown by MOCVD. Au-Ge based alloy used as omic contact formation and Pt/Ti metallisation used as Schottky barrier. All contacts are made on top of the n-InAlAs films which called as planar fabrication. I-V and C-V characters indicates reasonable rectification. A DLTS system installed in our lab used for detection of possible electrically active defect levels in Schottky diodes. Two trap levels located below conduction band at ~459 meV and ~291 meV detected. Trap concentrations at about 10^{15} cm^3 from capacitance transient values which donor concentration was 10^{17} cm^3.

InAlAs lattice matched on InP substrates is an attractive material for opto-electronic applications and heterostructure applications. In this study detailed electrically active defects presented in n-InAlAs/SI-InP epitaxial layers grown by metal organic chemical vapour deposition (MOCVD) at Sivas Cumhuriyet University: Nanophotonic Research Center (CÜNAM) using an AIXTRON 200/4 system.

N type InAlAs epitaxial layers doped silicon from SiH_4 flow at 24 sccm for InAlAs_03 sample and 33 sccm for InAlAs_05 sample. Corresponding free carrier concentrations were 1.69×10^{17} cm^{-3} and 2.00×10^{17} cm^{-3}. Planar omic contacts on top of the epitaxial films are formed after RTA annealing Au/Ni/Au/Ge multilayer at 385 ºC for 5 min. And then Pt/Ti based Schottky barrier deposited using lift-off technique.

After measurement, this method facilitated the selection of the rate window for data analysis. The transient obtained at 255 K for a 10 ms filling pulse and a -0.5 V reverse bias voltage is shown as an example in Fig. 1.

The temperature-dependent change in ΔC for the three ratio windows is shown in Fig. 2a. Analysis of the raw ΔC(T) transient data yielded trap levels T1 and T2 of 459 and 291 eV, respectively, from the Arrhenius plot, as shown in Fig. 2b.

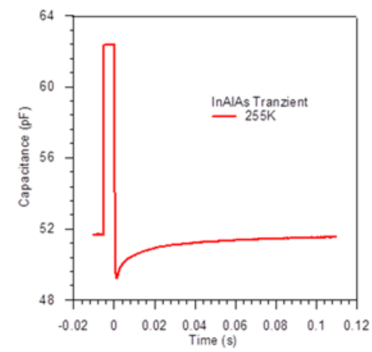

Figure 1. Schottky diode pulsing and capacitance

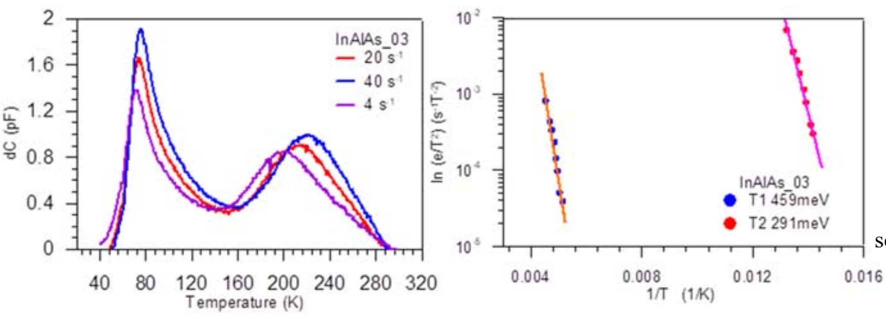

Figure 2. a) DLTS spectra for selected rate windows, **b)** Arrhenius graph for trap energy calculation.

Deep level characterisation of n-InAlAs epitaxial films grown on I-InP substrates are investigated using DLTS technique. Two trap levels were identified below the conduction band. The concentration of these traps, with energy levels of 459 meV and 291 meV, were calculated to be of the order of 10^{15} cm^{-3}.

Keywords: InAlAs, DLTS, Deep Levels, Traps

Acknowledgement: This work was supported by the TÜBİTAK Project No. **22AG073** and **22AG074** within the scope of the *Quantum Cascade Lasers, Devices and Applications (**KUANTAY**)* 1004 project.

AI-Powered Digital Morphology Analyzer for Automated Hematology Imaging and Classification

A. E. Yarıkan[1,5], Can Örer[2], V. Akyıldız[2], Z. Kuş[1], M. Aydin[1], K. E. Palaoğlu[3], S. İncir[2,4], K. Baysal[4], C. Özçelik[5], B. Yükrük[5], S. Nas[5], E. Özgönül[5], B. Kiraz[5,6], and A. Kiraz[5,7,8]

[1] Computer Eng., Fatih Sultan Mehmet Vakıf University, İstanbul, Türkiye
[2] Clinical Laboratory, Koç University Hospital, İstanbul, Türkiye
[3] Clinical Laboratory, VKV American Hospital, İstanbul, Türkiye
[4]Department of Medical Biochemistry, Koç University School of Medicine, İstanbul, Türkiye
[5] Optofil A.Ş., İstanbul, Türkiye
[6] AI and Data Engineering, Fatih Sultan Mehmet Vakıf University, İstanbul, Türkiye
[7]Departments of Physics and Electrical-Electronics Engineering, Koç University, İstanbul, Türkiye

This study introduces an AI-powered digital morphology analyzer designed for automated hematology image analysis. The system integrates a motorized stage, optical imaging, and deep learning-based classification to enable precise identification of blood cells. High-resolution smear images are automatically captured, focused, and processed through an internal pipeline that detects, segments, and classifies target cells into clinically relevant categories. Results are displayed on an intuitive user interface and can be exported as digital reports. By combining advanced optics with artificial intelligence, this platform provides a fast, reproducible, and user-friendly alternative to manual microscopic evaluation, supporting hematologists in clinical decision-making.

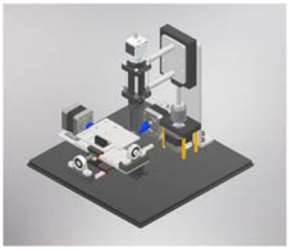

Figure 1. Design of the morphology analyzer.

Figure 2. External view of the morphology analyzer – device enclosure, control panel, user interface screen, and sample loading area.

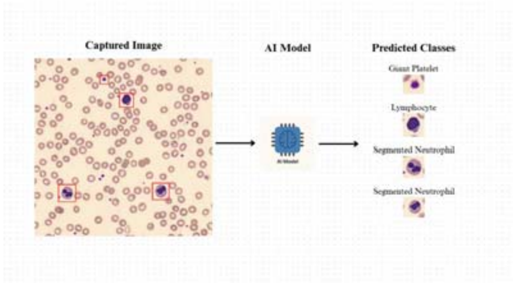

Figure 3. AI-based workflow for blood cell classification. Detected cells are highlighted with bounding boxes, processed by the deep learning model, and labeled with their predicted classes such as Giant Platelet, Lymphocyte, and Segmented Neutrophil.

Figures 1 and 2 show the internal and external design of the morphology analyzer. Figure 3 illustrates the AI-based workflow, where peripheral blood cells (PBCs) are detected, processed, and classified into categories such as Giant Platelet, Lymphocyte, and Segmented Neutrophil. A dataset of 31,476 PBC images, annotated by experts at Koç University Hospital, was used to train the model, achieving 0.8956 accuracy and an F1 Score of 0.8183.

Keywords: Digital Morphology Analyzer, Hematology, Deep Learning, Medical Imaging

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Modeling of Fibrous Insulation with Coated Cylindrical Microfibers

Payam Mashinchi Abbasi[1], Kursat Sendur[*1]
[1]*Faculty of Engineering and Natural Sciences, Sabanci University, Tuzla 34956, Istanbul, Türkiye*
corresponding author, E-mail: kursat.sendur@sabanciuniv.edu

Abstract

Fibrous materials have attracted substantial interest as thermal insulators, predominately because their microstructure excels at suppressing radiative heat transfer. These media are composed of a network of intertwined fibers, as shown in Figure 1, that has low density and high porosity to limit conduction and convection; adjustable fiber diameter and packing to tailor the radiative scattering and extinction; mechanical compliance with good thermal-shock tolerance and ease of formability into blankets, felts, and boards; and compatibility with opacifiers and spectrally selective coatings which could further cut the radiative transport. Thus, these materials are valuable for aerospace thermal protection systems, combustion chambers; industrial furnaces and kilns; petrochemical heaters and hot piping; fire-rated assemblies; and appliance insulation such as ovens and water heaters. The radiative characteristics of these materials are strongly related to the physical and morphological features of the fibers considering their size, orientation, and optical properties.

The optical and radiative transport characteristics of fibrous media have been well studied. Among such studies, work by Lee and Cunnington is very prominent, wherein they conducted an extensive theoretical and experimental effort into fibrous insulation and gave a model to predict radiative properties for very high-porosity, randomly oriented fiber networks [1].

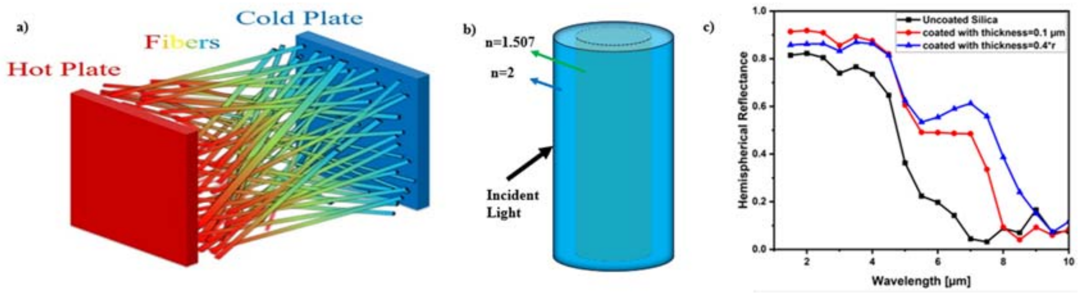

Figure 1: a. Geometry, **b.** Schematic of a coated cylinder,
c. Hemispherical reflectance vs Wavelength for coated and uncoated cylinder.

Thin coating of high reflectivity is applied on fibrous insulation to increase its hemispherical reflectance to suppress radiative heat transfer. Hemispherical reflectance can be determined by solving the radiative transfer equation (RTE) that controls radiative energy transport in participating media such as fibrous materials. A coating that is less absorbing but heavily backscattering diffuse increases effective single-scattering albedo and redirects incoming radiation in the forward direction, thereby increasing hemispherical reflectance and diminishing the net radiative flux into the medium, improvement in overall insulation performance. For this purpose, the use of a coating material with a higher refractive index and a coating-to-core ratio of greater than 0.25 has been suggested [2]. Based on simulations using different materials with optimized thicknesses, it can be concluded that the application of a silicon coating with a thickness ratio of 0.4 with respect to the silica core radius can substantially increase the hemispherical reflectance especially for wavelengths above 5 µm, thereby increasing insulation performance. In addition, introducing a silica coating with a constant thickness of 0.1 µm can further increase hemispherical reflectance for wavelengths below 4 µm. The results indicate that fibrous materials can be customized by proper coatings to enhance their reflectance in a specific wavelength range for a specific application.

Keywords: Fibrous media; Radiative transfer equation; Hemispherical reflectance

Acknowledgements
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Growth of InP: Si structures for quantum cascade lasers by MOVPE

D.H. Unal[1,2], M.N. Kocak[1,3], İ. Altuntaş[1,4], and İ. Demir[1,4*]

[1]Sivas Cumhuriyet University Nanophotonics Application and Research Centre-CÜNAM, 58140 Sivas, Türkiye
[2] Department of Optical Engineering, Faculty of Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye
[3] Department of Metallurgy and Materials Science, Faculty of Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye
[4] Department of Nanotechnology Engineering, Faculty of Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye

corresponding author, E-mail: idemir@cumhuriyet.edu.tr

Abstract

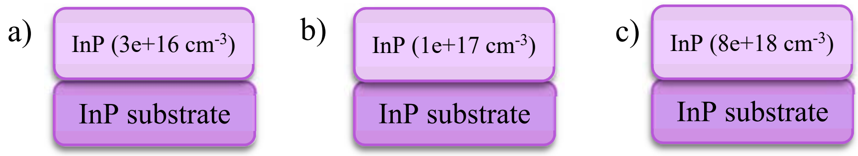

Figure 1: The following schematic illustrates the samples that were grown using different SiH_4 flow rates: (a) Sample A: 0.037 sccm, (b) Sample B: 0.0916 sccm, and (c) Sample C: 6.52 sccm.

Indium phosphide (InP) is a key semiconductor material in photonic integration and was used in the first quantum cascade laser (QCL), which was demonstrated in 1994. Due to its low refractive index and high thermal conductivity, InP-based QCLs achieve high output powers in the 3–12 µm range at room temperature in continuous-wave mode [1]. InP coatings grown by MBE (molecular beam epitaxy) and MOVPE (metal-organic vapor phase epitaxy) reduce optical losses and enhance thermal management through the use of heterojunction designs. In MOVPE, silicon (Si) doping plays a critical role in device performance by precisely controlling carrier density [2].

This study investigated the effect of Si doping on InP-based structures in detail. The samples were epitaxially grown by the MOVPE system. While all growth parameters were kept constant, the flow rate of the silane (SiH_4) gas was varied. Different donor densities were created by selecting SiH_4 flow rates of 0.037 sccm (Sample A), 0.0916 sccm (Sample B), and 6.52 sccm (Sample C), thereby enabling control of the carrier concentration. The grown layers were characterised using XRD to determine their crystal structure, Hall measurements to determine their electrical carrier density and mobility, PL to determine their optical properties, and AFM to determine their surface morphology. The results obtained reveal how changes in the SiH_4 flow rate effect the structural, electrical, and optical integrity of InP.

The results of XRD, Raman, and AFM analyses demonstrate that Si doping has a direct effect on the crystal quality and surface morphology of InP films. The results indicate that the level of Si doping significantly effects the crystal quality and surface morphology of InP films.

Keywords: QCL, InP, MOVPE, XRD, PL

Acknowledgements
This study was supported by The Scientific Research Project Fund of Sivas Cumhuriyet University, Türkiye, under the project number MRK-2024-004, and The Scientific and Technological Research Council of Türkiye (TUBITAK) under the project number 22AG074.

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Investigation of Magnon-Photon Interaction on YIG-SRR Structure

İsmail YARİÇİ*1

1Department of Electrical-Electronics Engineering, Aydın Adnan Menderes University, Aydın, Türkiye

İsmail.yarici@adu.edu.tr

Abstract

With advancing technologies, it is now possible to create compact and fast systems based on the interaction of nanometer-scale magnon structures with photons at GHz-THz speeds [1]. The advantages of these two structures are being harnessed in numerous fields, including quantum signal processing, communications, and multi-mode quantum memories, thanks to the magnon-photon interaction [2]. This interaction involves two sub-components, and the efficiency of the coupling between them is crucial. These sub-components consist of a resonator or cavity and a magnetic material characterized by high spin density and low absorption coefficient [1,2]. In this study, a Vector Network Analyzer-Ferromagnetic Resonance (VNA-FMR) measurement setup operating between 5-9 GHz was developed to investigate magnon-photon coupling, and the results were analyzed. Yttrium Iron Garnet (YIG), known for having the lowest Gilbert extinction coefficient and very high spin density, were used for magnons. Additionally, a coplanar waveguide (CPW) with a split-ring resonator (SRR) on the opposite side was designed with appropriate geometries to influence the photon mode in the measurement system and excite the magnons in the magnetic material. The transmission spectra of the SRRs with YIG as a function of the magnetic field are shown in Figure 1. Consequently, the coupling force constant was determined to be 0,38.

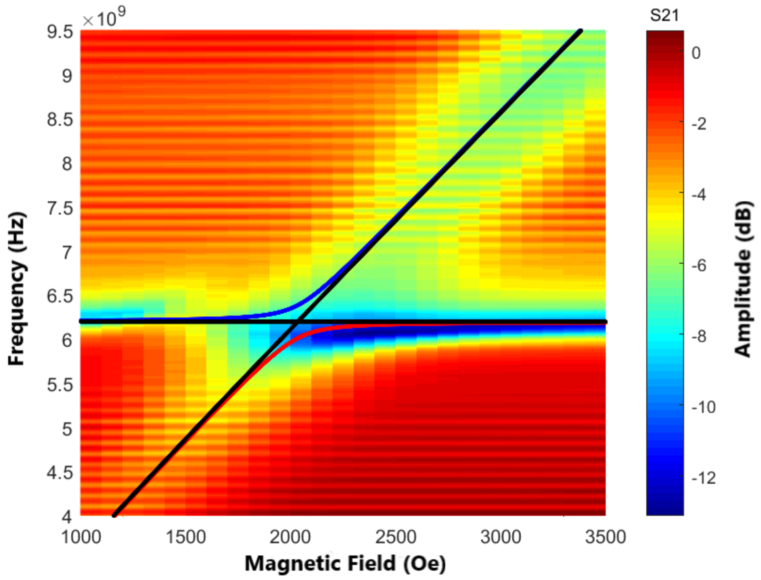

Figure 1: The transmission spectra vs magnetic field for the SRRs with YIG

Keywords: Yttrium Iron Garnet (YIG) , Split-ring resonator (SRR) , Magnon-photon coupling

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Transversely Excited Atmospheric (TEA) Nitrogen Laser

Serhat Nas*[1], Zal Aktaş[2], and Alper Kiraz[1,2]
[1] *Optofil A.Ş., İstanbul, Türkiye*
[27]*Departments of Physics and Electrical-Electronics Engineering, Koç University, İstanbul, Türkiye*
E-mail: Serhat.nas@optofil.com.tr

Abstract

This report presents the development and characterization of a Transversely Excited Atmospheric (TEA) nitrogen laser system. We developed an open-air laser with dimensions of around 25cm x 20cm. The TEA laser, based on transverse electrical discharge in a gas mixture at atmospheric pressure, was implemented using a pulse-forming network (PFN) circuit with capacitors and a spark gap. In the PFN circuit a doorknob storage capacitor with capacitance of C_1=3.4 nF is used together with a peaking capacitor (C_2=1 nF) obtained between two conducting surfaces separated by a mylar insulating sheet. A 100 kΩ charging resistor was used. The laser channel was built with 17 cm long hexagonal rods separated by 1.5 mm. A flyback transformer (15-20 kV DC output) provided high voltage driving the PFN circuit. Pulse repetition rate of 9.9 Hz and pulsewidth <100 ns were measured. Picture of the laser cavity, PFN circuit schematic, laser output beam scattered from fluorescent and normal papers together with pulsewidth and repetition rate characteristics are shown in Figure 1.

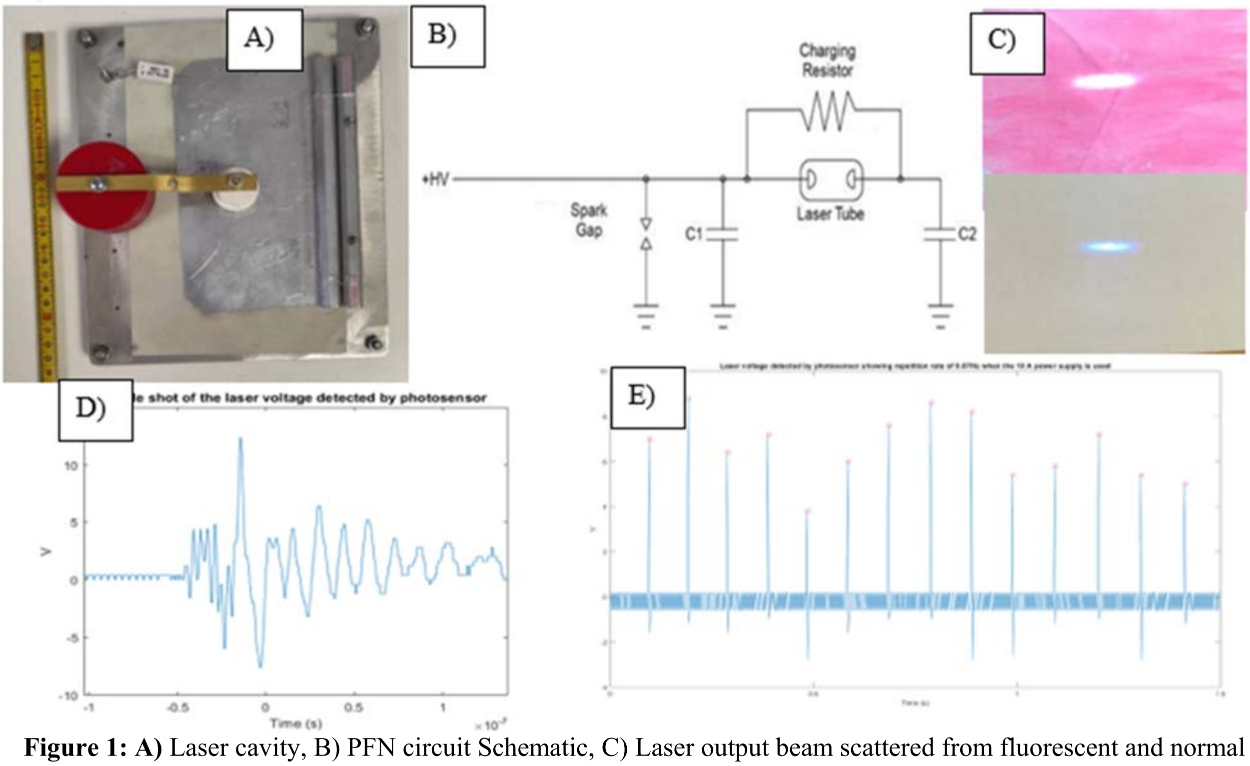

Figure 1: A) Laser cavity, B) PFN circuit Schematic, C) Laser output beam scattered from fluorescent and normal papers, D) A single shot characteristic of 10 ns pulse width and 337.1 nm wavelength, E) 9.9 Hz pulse repetition rate.

Keywords: TEA nitrogen laser, high voltage, gas lasers.

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A Comparitive Study of Fixed-WMS and Scanned-WMS for Remote Optical Gas Sensing

Gülşah Yıldız*[1,2], Atakan Dura[1], Tolga Kartaloğlu[1], Ekmel Özbay[1,3,4], İbrahim Özdür[5]

[1] *NANOTAM, Bilkent University, Ankara, Türkiye*

[2] *Micro and Nanotechnology, Middle East Technical University, Ankara, Türkiye*

[3] *Department of Electrical and Electronical Engineering, Bilkent University, Ankara, Türkiye*

[4] *Department of Physics, Bilkent University, Ankara, Türkiye*

[5] *Department of Electrical and Electronical Engineering, TOBB University of Economics and Technology, Ankara, Türkiye*

gulsahyildiz@bilkent.edu.tr

Abstract

Wavelength Modulation Spectroscopy (WMS) is a widely used technique for trace gas detection due to its high sensitivity and robustness against noise [1,2]. In this work, we present a comparative study of two WMS implementations: Fixed-WMS (FWMS) and Scanned-WMS (SWMS) for methane detection in short-wave infrared (SWIR) region. FWMS utilizes a constant laser wavelength with sinusoidal modulation, while SWMS combines wavelength scanning with modulation to reconstruct absorption features [3, 4]. Both methods were experimentally evaluated in terms of stability, sensitivity, and implementation complexity. Stability was assessed using Allan variance analysis, while sensitivity was quantified through minimum detectable concentration and signal-to-noise ratio. Additional comparisons include computational efficiency, spectral reconstruction capability, and robustness to environmental fluctuations. Preliminary results indicate that FWMS provides higher temporal stability and faster response, making it suitable for real-time monitoring, whereas SWMS offers enhanced spectral information and accuracy in concentration retrieval. This study highlights the trade-offs between the two approaches and provides guidance for selecting the appropriate technique in different application scenarios.

Keywords: Wavelength Modulation Spectroscopy, Remote Sensing, FWMS, SWMS, Stability Analysis.

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IMPACT OF MANDREL DIAMETER AND FIBER WINDING LAYERS ON THE SENSITIVITY OF FIBER OPTIC HYDROPHONES

S. Uluğ[a,d*], F. Uyar[a,b], T. Kartaloğlu[a], E. Özbay[a,b,c] and İ. Özdür[d]

[a]NANOTAM, Bilkent University, Ankara, Türkiye

[b]Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye

[c]Department of Physics, Bilkent University, Ankara, Türkiye

[d]Department of Electrical and Electronics Engineering, TOBB ETU, Ankara, Türkiye

[*]serra.ulug@bilkent.edu.tr

Abstract: Fiber-based underwater acoustic sensors (hydrophones) are increasingly replacing conventional piezoelectric sensors thanks to their compact design, high sensitivity, and superior resistance to electromagnetic interference [1]. These hydrophones are fabricated by winding optical fibers around cylindrical mandrels.

This study explores how mandrel diameter and the number of fiber winding layers influence the sensitivity of fiber-optic hydrophones. Standard single-mode (SM) fibers with a 250 µm diameter were wound onto mandrels in either single or double layers: a 31 mm mandrel was tested with both single and double layers, while a 26 mm mandrel was wound with a single layer only. To assess the role of mandrel diameter, sensitivities of the 26 mm and 31 mm single-layer mandrels were compared, whereas the impact of fiber layer count was evaluated using the 31 mm single- and double-layer configurations. Sensitivity measurements were performed using an optical setup based on a frequency-diversity dual-pulse interrogation scheme, followed by controlled water tank experiments to validate underwater sensing performance.

The results revealed that the 31 mm single-layer mandrel achieved a sensitivity of -139.72 dB re rad/µPa, while the double-layer version improved this to -137.80 dB re rad/µPa, corresponding to a 2 dB gain. Also, the 26 mm single-layer mandrel exhibited a lower sensitivity of -142.53 dB re rad/µPa, about 3 dB below that of the 31 mm single-layer design. Overall, the findings demonstrate that increasing both mandrel diameter and fiber winding layers substantially enhances hydrophone sensitivity, enabling more precise acoustic detection and extending applicability to deeper ocean environments.

Keywords: Fiber-optic hydrophone; Underwater acoustic sensing; Mandrel; Sensitivity; Fiber winding layer.

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Portable and Cost-effective LED-based Moisture Measurement System

***Ahmet Harun ATAG[1,2], Ahmet KIZILAY[1,2], Zeynep Bera BASAK[3], Omer Faruk KADİ[1] ,*Hümbet NASİBLİ[1]**

[1]National Metrology Institute, The Scientific and Technological Research Council of Türkiye (TÜBİTAK- UME, Ulusal Metroloji Enstitüsü), Gebze, Kocaeli, Türkiye
[2]Yıldız Technical University, İstanbul, Türkiye
[3]Fatih Sultan Mehmet University, İstanbul, Türkiye
corresponding authors:harun.atag@std.yildiz.edu.tr

Abstract

An Arduino-based control and measurement system was developed to evaluate the surface moisture of bulk materials. The platform employs 49 LEDs operating at seven characteristic absorption wavelengths of water molecules in the near-infrared region of the electromagnetic spectrum. Independent adjustment of signal frequency, duty cycle, and constant current level for each LED enables precise modulation and intensity control. Reflected radiation from the sample is detected using an InGaAs detector with thermoelectric cooling, coupled to a high-resolution ADS1263 ADC module. To ensure robustness and repeatability, a dedicated algorithm was implemented to control LED modulation and sequencing, providing stable and reproducible signals. The optical geometry of the system was designed such that a standard laboratory Petri dish (9 cm diameter) can serve as the sample holder, facilitating its application both under laboratory conditions and in on-site field tests.

Within the framework of the SoMMeT project, the system was applied to surface moisture measurements of soils. 5 soil types collected from the TÜBİTAK campus in Gebze were investigated, with samples sieved at different mesh sizes to assess system performance across varying soil granule distributions. SI-traceable calibration was achieved using the loss-on-drying method. Finally, a machine learning algorithm was developed to translate reflectance data into surface moisture values. Preliminary results indicate that the model achieves strong predictive performance, with R^2 values reaching up to 0.998.

Keywords: Electromagnetic spectrum, LED, Photodiode, Soil Moisture, Water Absorbtion

Acknowledgements

This research was funded by the 21GRD08 SoMMet project. The SoMMet project has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States (funder ID: 10.13039/100019599; grant no. 21GRD08 SoMMet; https://www.sommet-project.eu

LIGHT MANAGEMENT BY PHOTOCHEMICALLY ETCHED INVERTED STRUCTURES FOR SILICON SOLAR CELLS

Güntuğ Vural*[1,2,3], Alpan Bek[3,4], Reşat Özgür Doruk[2]
[1]*Opsin Electro Optical Systems, Ankara, Türkiye*
[2]*Department of Electrical ve Electronics Engineering, Atilim University, Ankara, Türkiye*
[3]*Environmental Photonics Group, METU, Ankara, Türkiye*
[4]*Department of Physics, METU, Ankara, Türkiye*
guntug.vural@opsin.com.tr

Abstract

Crystalline silicon (c-Si) solar cells dominate the photovoltaic market, but their efficiency is constrained by high reflection losses and limited light-trapping [1]. To overcome these limitations, advanced surface structuring methods have been widely studied, including random pyramids, metal-assisted chemical etching, and black silicon [2,3]. However, these techniques often involve high cost, complex fabrication, or increased surface recombination, which limit their large-scale applicability.

This study presents a single-step inverted nanohole photochemical etching (SS-INH-PCE) technique using a continuous-wave 532 nm laser in HF/H_2O_2/DI water solution to fabricate broadband light-trapping nanostructures on silicon wafers. Unlike conventional approaches requiring sequential steps such as saw damage removal (SDR), the proposed process simultaneously performs surface texturing and defect mitigation in one step, thereby simplifying fabrication.

Experimental results demonstrate that SS-INH-PCE reduces the average reflectance of saw-damaged wafers to 17.5% and SDR wafers to 22.5% across the 300–1200 nm spectrum. Increased haze measurements confirm enhanced scattering, further promoting photon absorption. Scanning electron microscopy revealed randomly distributed, inverted nanohole structures with improved uniformity compared to untreated wafers. The elimination of the SDR step decreases chemical consumption, processing time, and overall cost, while maintaining optical performance.

These findings indicate that SS-INH-PCE provides a reproducible, cost-effective, and scalable approach for industrial solar cell manufacturing. Furthermore, by eliminating additional polishing or etching steps, the method aligns with recent efforts to simplify solar cell processing while maintaining high optical quality [4]. Beyond photovoltaics, the technique's low thermal budget and lithography-free implementation suggest potential applications in photodetectors and MEMS devices.

Keywords: Crystalline Silicon, Single-Step Inverted Nanohole, Laser Assisted Etching, Photochemical Etching, Surface Texturing

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Optical Performance Enhancement Of Cotton Fibers Via Nanoparticle Coating

Efe KURUOĞLU[1], Kürşat ŞENDUR[1]

[1]Mechatronics Engineering, Sabanci University, 34956, Tuzla, Istanbul, Türkiye

Email: efekuruoglu@sabanciuniv.edu , kursat.sendur@sabanciuniv.edu

Abstract

Cotton fibers, with a refractive index of n ≈ 1.53–1.55, exhibit inherently low reflectivity in the ultraviolet (200–400 nm) and infrared (700 nm–1 mm) regions, which restricts their optical functionality. Enhancing the reflective properties of cotton is particularly important for developing functional and protective textiles that combine sustainability with advanced optical performance. Although nanoparticle coatings have been applied in polyester and other petroleum-based materials [1][2], their exclusive application to cotton fibers remains novel. Leveraging cotton's unique ribbon-like morphology, long-standing use, biocompatibility, and sustainability, this study aims to introduce nanoparticle-based enhancements to one of the most widely used natural fibers. To achieve this, ANSYS Lumerical and HFSS are employed to simulate the influence of nanoparticle type, size, and distribution on reflection across UV and IR domains. Initial investigations focus on TiO_2 and silver nanoparticles, while ongoing studies expand toward ceramic nanoparticles (e.g., zirconia) and additional metallic candidates.

Preliminary results show that bare cotton fibers possess high absorbance (A ≈ 0.88–0.95) and low reflectance (R ≈ 0.05–0.12) across most of the 200–900 nm range, with a strong suppression of reflectance near 330–350 nm. When coated with TiO_2 nanoparticles, a sharp UV reflectance peak (R ≈ 0.55–0.57) emerges around 240–250 nm. However, beyond 300 nm, reflectance decreases toward ~0.07–0.10 by 900 nm. These findings demonstrate that TiO_2 coatings selectively enhance UV reflectivity but do not yet yield broadband gains in the visible–IR. Future optimization of particle size, surface coverage, and material selection (e.g., ZrO_2, multi-material stacks) will aim to extend this enhancement across wider spectral ranges. Overall, the study establishes cotton as a promising platform for nanoparticle-driven optical engineering, enabling next-generation functional and protective textile applications.

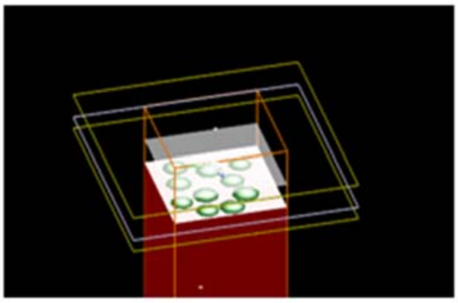

Figure 1: ANSYS Lumerical setup for 200x200nm cotton substrate with 20nm sized, 10 randomly oriented titanium dioxide nanoparticles.

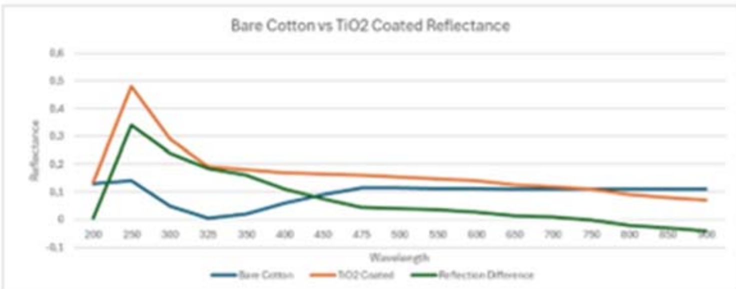

Figure 2: ANSYS Lumerical results

Keywords: Cotton fibers, Nanoparticle coatings, Optical reflectivity, Ultraviolet and infrared spectra

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Optical Computing with Multi-channel Multi-plane Light Conversion

Fatma Nur Kılınç[1], Uğur Teğin[2]
[1]Computational Sciences and Engineering, Koç University, Istanbul, 34450, Türkiye
[2]Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye
Uğur Teğin, E-mail:utegin@ku.edu.tr

Abstract

We introduce a versatile, multichannel optical computing platform using multi-plane light conversion (MPLC) for hardware-accelerated machine learning. This system processes complex data, including multichannel RGB images and structured numerical inputs, directly in the optical domain, bypassing the bottlenecks of conventional digital hardware and single-channel optical processors. Our approach uses a single phase-only spatial light modulator (SLM) to perform sequential, randomized phase modulations, generating a high-dimensional feature representation that is captured and then processed by a simple Ridge classifier.

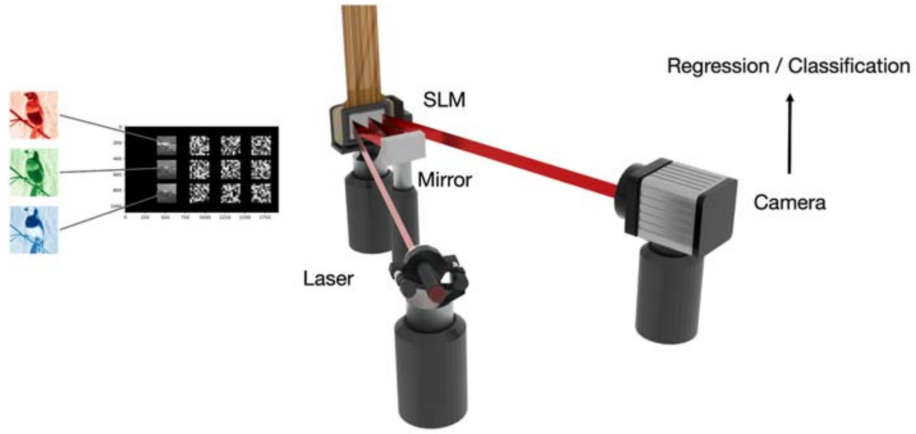

Figure 1: Multi-channel Multi-plane Light Conversion Setup.

Our platform demonstrates significant performance gains across multiple benchmarks. On the HAM10000 skin lesion dataset, our method increases RGB classification accuracy from 68% to 98%, achieving state-of-the-art performance without the need for data augmentation. For the STL-10 dataset, accuracy improves from 30% to 83%, and is further enhanced to 90% through Bayesian-optimized channel mixing. The system's versatility is also confirmed on the Abalone regression benchmark, where it effectively processes tabular data, achieving a normalized RMSE of 0.08. This optical approach paves the way for building general-purpose optical processors. By handling diverse data types with incredible speed and efficiency, our work helps bridge the gap between powerful machine learning software and the next generation of computer hardware.

Keywords: Optical computing, Photonic neural networks

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High-Resolution Night Vision Objective Lens Design for Monocular Fusion Systems

Yusuf Çekerek*[1], Devrim Anıl[2]
[1]Gazi University, Faculty of Applied Sciences, Department of Photonics, Ankara, Türkiye
[2]ASELSAN/MEOS, Ankara, Türkiye
Yusuf Çekerek, E-mail: yusuf.cekerek@gazi.edu.tr

Abstract
Advancements in imaging technologies have enabled the utilization of visual data obtained from diverse sources across various applications, and the integration of these data allows for the generation of richer and more functional images. Fusion refers to the process of combining data from two sensors to create a unified perceptual model, aiming to produce meaningful images with higher information content by leveraging the advantages of different imaging systems. In this context, fusion devices emerge as advanced optoelectronic systems that integrate data from visible and infrared bands onto a single platform, enhancing perceptual performance under low-light and challenging environmental conditions. By combining the detail and color information from the visible spectrum with the thermal contrast provided by infrared sensors, situational awareness is improved, and target detection and recognition capabilities are significantly enhanced in critical applications such as defense, security, and search-and-rescue operations.

This study focuses on the optical design of the night-vision objective lens for a monocular fusion device. A double-Gauss-derived optical configuration was selected as the starting point for the design. The system was optimized using several standard material catalogs and incorporated an image intensifier tube. Image intensifier tubes are vacuum devices that amplify weak optical images, converting them into clear and visible images suitable for the human eye.

The double-Gauss configuration, with its symmetric lens arrangement, allows for the achievement of both wide fields of view and low f/# values. The symmetric design effectively mitigates third-order aberrations, spherical distortions, and chromatic deviations within the optical system, thereby significantly improving image quality and contrast performance. Additionally, a comprehensive tolerance analysis was conducted during the design process to assess the impact of manufacturing and assembly variations on optical efficiency, ensuring the system's stability under practical operating conditions.

Keywords: Night Vision, Optical Design, Gen2+ Image Intensifier Tube

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Magnetic Field Sensitivity Enhancement Through Dual Orthogonal Polarization Method

Başak Çağlayan TOPRAK[1*], İrem DİNÇ[1], Erkut Emin AKBAŞ[1], Aylin YERTUTANOL[1], Ekmel ÖZBAY[1,2,3]

[1]*Bilkent University, Nanotechnology Research Center-NANOTAM, Ankara, Türkiye*
[2]*Bilkent University, Department of Physics, Ankara, Türkiye*
[3]*Bilkent University, Department of Electrical and Electronic Engineering, Ankara, Türkiye*

*corresponding author, E-mail: basak.toprak@bilkent.edu.tr

Abstract
Interferometric fiber optic gyroscopes (IFOGs) obtain angular velocity by detecting the non-reciprocal phase difference caused by the sagnac effect. The navigation system sensitivity is directly impacted by the Fiber Optic Gyroscope's (FOG) performance. Thus, it is essential that the IFOG identify and suppress further environmental non-reciprocal phase errors. Navigation accuracy and angular velocity measurement findings are significantly impacted by the FOG's magnetic error, which changes according on the magnetic field's direction. Magnetic error results from non-reciprocal circular birefringence in the fiber caused by the Faraday effect and the sensitivity of the magnetic field. To enhance the performance of IFOGs and reduce the bias error brought on by the Faraday effect, polarization maintaining fiber (PMF) and magnetic shielding are utilized. These two conventional methods are effective in lowering IFOGs' magnetic sensitivity [1].

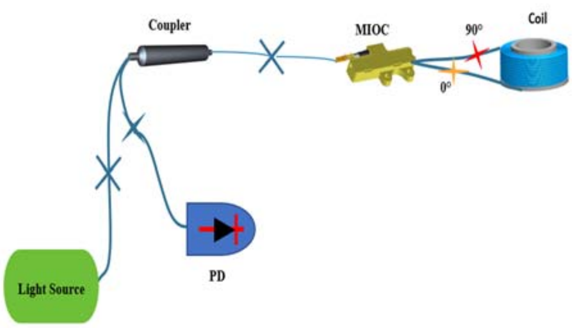

Figure 1: Schematic view of FOG configuration

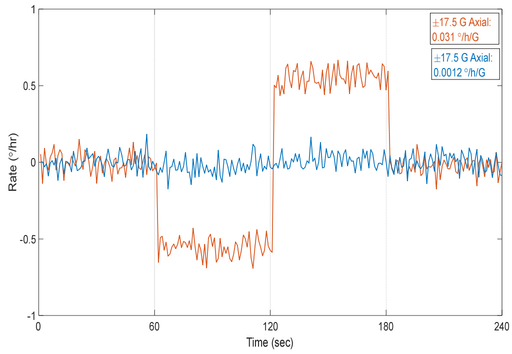

Figure 2: Comparison of the magnetic field induced bias error

Two orthogonal polarization modes are employed by the light beam in single-mode fibers used in IFOGs. Light travel in these two orthogonally polarized modes at the different speed as a result. Consequently, there is a phase difference between the two orthogonal modes when one moves more fastly or more slowly than the other [2]. In this investigation, the two fiber pigtails of MIOC were spliced to each end of PMF coil with 0° and 90° alignment (as stated in Figure 1.) angles to investigate the magnetic field sensitivity. The light beam moves along the slow axis of the PMF coils when both alignment angles are at zero degrees. The light beam also propagates along the fast axis when the alignment angles are 90°. When the two fiber were aligned via 0° and 90° angle difference, the magnetic field induced bias error was measured 0.031 °/h/G and 0.0012 °/h/G, respectively. Therefore, the fast and slow axis' opposing polarity is the cause of the bias error caused by the Faraday effect and magnetic field sensitvity was enhanced ~25 times with dual orthogonal polarization method. These error cancel each other out when the light beam alternates between the PMF coil's two polarization axis, therefore lowering the magnetic field sensitivity.

Keywords: Interferometric fiber optic gyroscopes / magnetic field / polarization / slow and fast axis

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Energy Efficient Smart Glass Design

Cansu Topaloğlu[1], Yağmur Tomruk[1], Kürşat Şendur[*1]
[1]*Faculty of Engineering and Natural Sciences, Sabanci University, Istanbul 34956, Türkiye*
[*] corresponding author, E-mail: sendur@sabanciuniv.edu

Abstract

Reducing global energy consumption is a critical step in mitigating the impacts of climate change. As the growth in global energy demand continues, there is an urgent need to adopt passive, energy-efficient solutions that can reduce reliance on external systems. The building sector holds over one-third of this global energy consumption [1], with heating and cooling demands accounting for an important portion of this usage. In many regions, windows represent a critical area of thermal inefficiency, especially in heating or cooling dominated regions, where they contribute significantly to unwanted heat loss or gain [2]. Traditional glass allows significant infrared radiation to pass through, which leads to increased cooling needs and higher energy consumption during warm seasons. This paper tackles the problem of reducing energy consumption related to indoor heating and cooling by developing a thermochromic smart glass that passively modulates infrared (IR) light transmission. Our design aims to reduce spectral transmission in the infrared range while maintaining transparency in the visible spectrum, ultimately decreasing the reliance on energy-intensive cooling systems.

Our passive smart glass design is based on vanadium dioxide (VO_2), a material that undergoes a reversible phase transition at a critical temperature of 68°C, switching from an insulating to metallic state. VO_2 was studied in two main configurations: VO_2 nanoparticles embedded in a SiO_2 layer, and VO_2 thin films coated on SiO_2 substrates. Ansys Lumerical was used to simulate the temperature-dependent behavior of smart glass structures incorporating VO_2 nanoparticles and thin films at 30°C and 100°C. Ansys Lumerical software operates using the Finite Difference Time Domain (FDTD) method, which numerically solves Maxwell's equations in both space and time domains. The FDTD method was preferred for its robustness in plotting the interaction between electromagnetic waves with materials across a wide spectral range. The results provided transmission and reflection spectra across the visible and near-infrared regions, enabling us to assess the performance of each configuration. After extracting the transmission spectra from Ansys Lumerical, MATLAB was used for post-processing the simulation outputs, especially to compute and compare the performance of different configurations based on their spectral transmission behavior. The differences between the hot and cold states of each configuration were analyzed. These differences were then integrated across the near-infrared wavelength range to quantify the performance of each structure.

The transmission changes between 30°C and 100°C for different VO_2-based designs were compared, and the difference in transmission ($T_{30°C}$ - $T_{100°C}$) over the wavelength range was plotted (Figure 1-2). Our results showed that thin-film structures, especially those with 30 nm and 50 nm thicknesses, outperformed the nanoparticle designs. These thin films were able to block more IR radiation at high temperatures, leading to higher energy gain values. The 50 nm thin film gave the best result, with an energy gain of around 238.78 W/m², meaning it could significantly reduce the energy spent on cooling in buildings. These findings demonstrate the feasibility of incorporating VO_2-based smart coatings into architectural applications, offering a passive and energy-efficient solution for heat management in buildings.

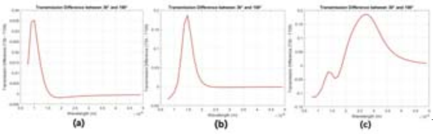

Figure 1: Transmission differences between 30°C and 100°C conditions for the nanoparticle configuration, with nanoparticle radii (a) 30 nm, (b) 50 nm, and (c) 100 nm

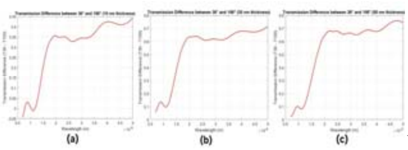

Figure 2: Transmission differences between 30°C and 100°C conditions for the thin film configuration, with thin film thicknesses a) 10 nm, b) 30 nm, and c) 50 nm

Keywords: Thermochromic smart windows, thin-film coatings, energy efficiency, vanadium dioxide

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Fiber-Based Diffractive Deep Neural Network via Mode Coupling Optimization

Bahadır Utku Kesgin[1], Firdevs Yüce[2], Uğur Teğin[1,*]
[1]*Department of Electrical and Electronics Engineering, Koç University, İstanbul 34450, Türkiye.*
[2]*Department of Mechanical Engineering, Koç University, İstanbul 34450, Türkiye*
*corresponding author, E-mail: utegin@ku.edu.tr

Abstract

Modern neural networks rely on outdated computer architectures and demand massive datasets to achieve effective generalization. As neural networks see broader adoption, the environmental footprint of machine learning systems becomes increasingly unsustainable. An old concept, optical computing, has been proposed as a solution to this issue, offering advantages in both energy efficiency and scalability [1]. Multimode fibers operating in nonlinear regimes have demonstrated success as analog information processors, serving as an alternative to resource-intensive digital processors [2]. These fiber-based implementations often incorporate digital optimization of mode coupling, altering the way information is processed as it propagates through the modes [3,4]. Since optical computers in nonlinear regimes require powerful lasers to achieve nonlinearity, diffractive deep neural networks have emerged as another optical computing platform, leveraging diffractive plates such that free-space propagation itself performs computation [5].

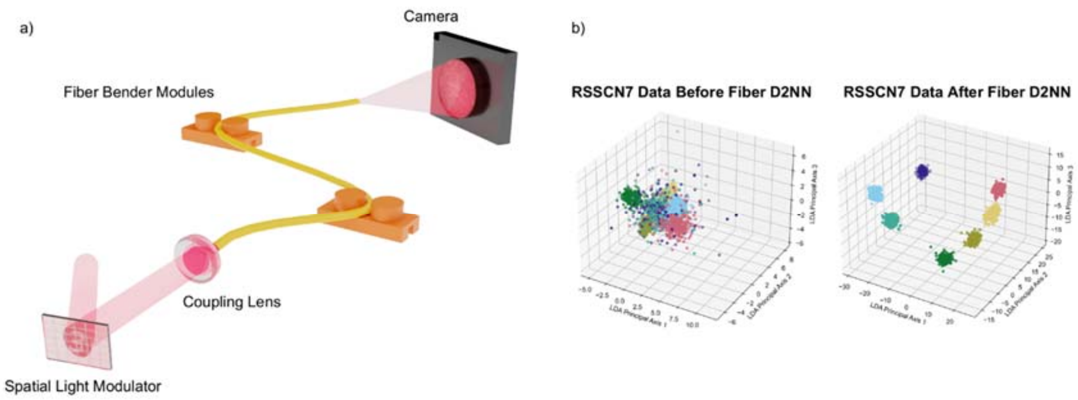

Figure 1: Figure describing our experimental setup and results. a, 3D visualization of our experimental setup. b, Impact of mode coupling optimization for information processing,.

The mechanical perturbation of a graded-index multimode fiber orthogonal to the propagation axis modifies its linear mode coupling matrix. Mode coupling, corresponding to extra information processing, is induced by changes in the effective refractive index. The diffractive neural network is physically trained by adjusting the perturbation strength using Bayesian Optimization. We also examine the scenario in which the digital electronic readout layer is eliminated, allowing the realization of fully optical neural networks through the excited region of the detector, while requiring orders of magnitude fewer trainable parameters than the traditional method, which applies this layer to finish the learning process.

Keywords: Optical computing, Photonic neural networks, Linear mode coupling

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Photonic Neural Network Harnessing Spatiotemporal Chaos in a Multimode Fiber

Bahadır Utku Kesgin, Uğur Teğin*
Department of Electrical and Electronics Engineering, Koç University, İstanbul 34450, Türkiye.
*corresponding author, E-mail: utegin@ku.edu.tr

Abstract
Modern machine learning models, such as artificial neural networks, demand large datasets and are limited by the von Neumann bottleneck, leading to high energy consumption and long training times. Reservoir computing offers an alternative, showing that nonlinear physical systems can achieve similar outcomes with lower power. Optical computing based on nonlinear photonic structures has been shown to enable scalable, sustainable machine learning [1], and chaotic analog nonlinear transformers have further boosted performance [2]. In multimode fibers, strong excitation of higher-order modes induces complex nonlinear coupling, creating chaotic modal energy flows that can be harnessed for computation [3,4].

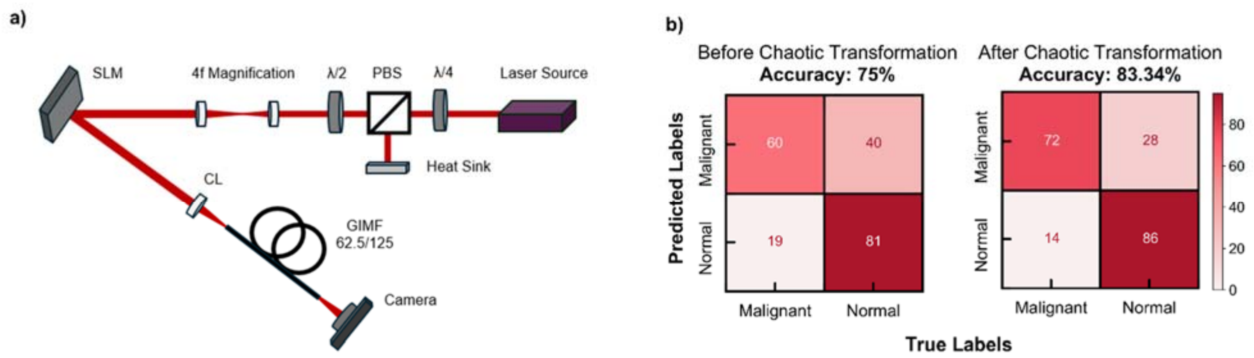

Figure 1: Experimental setup and result of edge of chaotic photonic reservoir computer. a, Experimental setup of the chaotic photonic computer. SLM, spatial light modulator; GIMF, graded-index multimode fiber; PBS, polarizing beam splitter; CL, coupling lens. b, Biomedical image classification results before and after our model.

We present a photonic reservoir computer that exploits the spatiotemporal chaotic dynamics of multimode fibers for machine learning. By exciting high-order modes with a vortex beam carrying an information phase, the input undergoes chaotic transformation during propagation. After chaotic transformation in the fiber, learning is carried out using a lightweight digital layer that requires orders of magnitude fewer parameters than conventional neural networks. As shown in Figure 1, operating at the edge of this chaotic regime enables effective separation of complex geospatial image samples, boosting classification accuracy by nearly 60%. We further achieve high performance on biomedical classification tasks, comparable to state-of-the-art digital neural networks.

Keywords: Optical Chaos, Optical computing, Photonic neural networks

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Yüksek Hassasiyetli Fiber Optik Dönüölçer için Dalga Boyu Kararlılığı Artırılmış ASE Işık Kaynağı

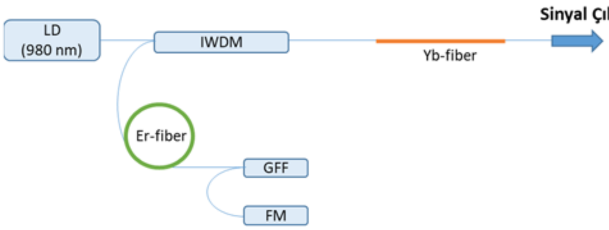
Erkut Emin AKBAŞ[1], Aylin YERTUTANOL[1], Ekmel ÖZBAY[1,2,3]

[1]Bilkent University, Nanotechnology Research Center-NANOTAM, Ankara, Türkiye
[2]Bilkent University, Department of Physics, Ankara, Türkiye
[3]Bilkent University, Department of Electrical and Electronic Engineering, Ankara, Türkiye

corresponding author, E-mail: erkut.akbas@bilkent.edu.tr

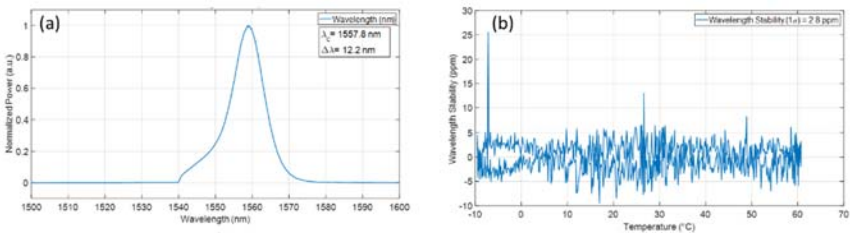
Özet

Bu çalışma, fiber optik dönüölçer (FOD) uygulamaları için geliştirilmiş bir Yükseltilmiş Kendiliğinden Emisyon (ASE) ışık kaynağı konfigürasyonunu sunmakta olup, geleneksel ASE kaynaklarına kıyasla iyileştirmeler sağlamaktadır [1]. Önerilen tasarım, çoklu optik bileşenleri birleştiren yeni bir sonlandırma yöntemi içermekte ve böylece genel sistem performansını artırmaktadır. Özellikle, kazanç ortamı olarak erbiyum katkılı fiber (EDF) kullanılırken, filtreleme amacıyla iterbiyum katkılı fiber (YDF) kullanılmış ve 90 mW yüksek çıkış gücü elde edilmiştir.



Şekil 1. Optik konfigürasyon

Geliştirilen ASE kaynağı, sıcaklık değişimleri altında başarılı bir dalga boyu kararlılığı sergileyerek -10 °C ila +60 °C sıcaklık aralığında 2.8 ppm düzeyinde kararlılık sağlamıştır. Bu iyileştirmeler, önerilen ışık kaynağını yüksek optik güç ve üstün termal kararlılığın kritik gereksinim olduğu yüksek hassasiyetli FOD uygulamaları için son derece uygun hale getirmektedir.



Şekil 2. Optik Spektrum (a) sıcaklığa bağlı dalga boyu kararlılık test sonucu (b)

Artırılmış kararlılık ve güç çıkışı, bu ASE ışık kaynağını, ölçek faktörü doğruluğunun kritik olduğu yüksek hassasiyetli İnterferometrik Fiber Optik Dönüölçer (IFOD) için son derece uygun hale getirmektedir [2]. Deneysel bulgular, önerilen ASE ışık kaynağının yüksek optik güç elde ederken sıcaklık değişimlerine karşı olağanüstü dalga boyu kararlılığı sağlama konusunda etkinliğini doğrulamaktadır. Yiterbiyum katkılı fiberin spektral filtre olarak dâhil edilmesi ve gelişmiş sonlandırma yönteminin uygulanması bu iyileştirmelere bütüncül olarak katkıda bulunmuştur. Sonuçlar, bu tasarımın fiber optik dönüölçerlerin performansını önemli ölçüde artırma potansiyeline sahip olduğunu göstermekte ve yüksek hassasiyetli uygulamalar için ideal bir hale getirmektedir.

Anahtar Kelimeler: Fiber optik dönüölçer, ASE ışık kaynağı, Erbium katkılı fiber

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Optical Design of a Four-Mirror Focal System Folded into a Ball-Shaped Envelope

Görkem Can Karakaya*[1], Devrim Anıl[2]
[1]*Gazi University, Department of Photonics, Faculty of Applied Sciences, Ankara, Türkiye, 06560*
[2]*ASELSAN, Microelectronics & Electro-Optics Systems, Ankara, Türkiye, 06750*
Görkem Can Karakaya, E-mail: gcan.karakaya@gazi.edu.tr

Abstract

This study presents the optical design of a four-mirror catoptric system compactly folded into a spherical envelope. The proposed structure utilises a combination of concave and convex reflective surfaces to fold the light path and provide aberration correction. Such catoptric architectures offer advantages, particularly in applications requiring high optical performance within limited volumes; they stand out for eliminating chromatic aberrations and providing efficient packaging. The intermediate image formed between successive mirrors provides the flexibility of focused or afocal operation, depending on system requirements. Compared to traditional refractive or hybrid designs, the spherical folding approach significantly reduces size while maintaining imaging quality. Such catoptric imaging systems are widely used in electro-optical sensing, surveillance, and reconnaissance platforms due to their ability to combine a wide field of view with minimal distortion. The presented design emphasises the balance between compactness and optical performance, offering a viable approach for next-generation optical payloads where volume constraints and image accuracy are critical.

This work is in the preliminary design phase; the current geometric layout of the proposed four-mirror catoptric configuration has been created for initial evaluations, and optimisation work is ongoing to meet the desired performance requirements. The imaging performance in the current arrangements is not yet at the targeted levels; performance improvements are being implemented incrementally through iterative optimisation, tolerance analyses, and surface parameterisation in the Zemax environment. As achieving the final performance of the design requires steps such as parameter adjustments and production-tolerance compliance, it is planned to proceed with gradual improvements.

The purpose of this study is to evaluate whether the proposed four-mirror top-shaped catoptric design, if deemed suitable, could serve as a gimbal alternative to replace traditional Cassegrain catadioptrics.

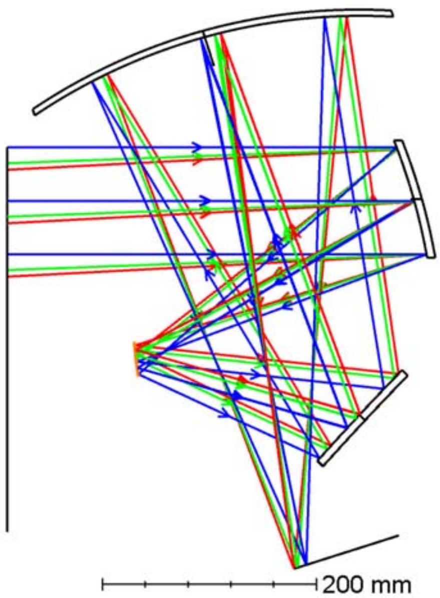

Figure 1: Optical Layout

Anahtar Kelimeler / Keywords: Four-Mirror Optical System, Ball-Shaped Folded Optics, Focal System Design, Compact Optical Architecture, Imaging Performance Optimization

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Machine Learning Assisted Broadband Dielectric Photonic Media

Cevat AÇIKEL*[1], Ecem HELVACI[1], Bilgehan Barış ÖNER[2], İrem ÖNER ALP[1]
[1]Physics Department, Gazi University, 06500, Teknikokullar, Ankara, TÜRKİYE
[2]Department of Physics, Graduate School of Natural And Applied Sciences, Gazi University, 06500, Teknikokullar, Ankara, TÜRKİYE

İrem ÖNER ALP, E-mail: iremoner@gazi.edu.tr

Abstract

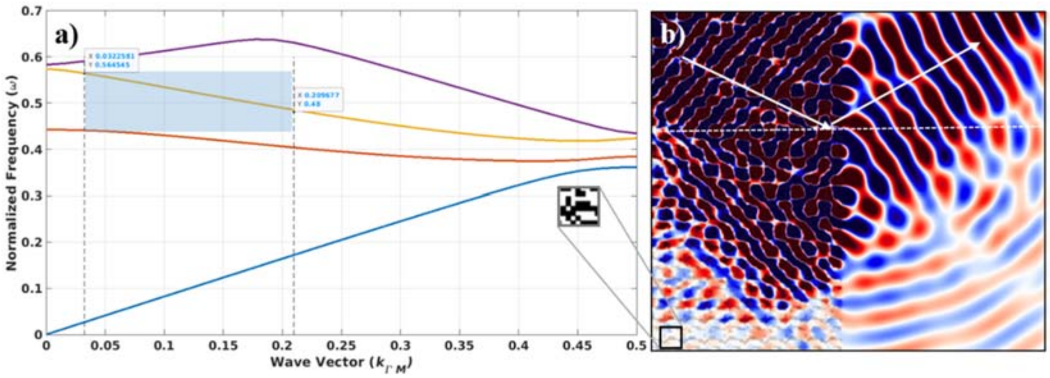

Figure 1: a) An example of effective negative refractive index by a binary-pattern geometry (total size: $1a \times 1a$; black: material; white: no material). In all simulations, material refractive index value was set to 3. b) The steady state spatial distribution of the field reflected by periodic dielectric medium is plotted ($f = 0.55\ \omega a/2\pi c$). The dashed line intersects surface normal.

In this study, an effective negative index photonic medium to enable negative refraction over a broadband frequency range was designed through the assistance of artificial intelligence. Both frequency-domain and time-domain simulation packages were employed [1, 2]. In the first step, a dataset was constructed by generating completely random binary-pattern and all-dielectric photonic crystal geometries and obtaining their corresponding dispersion diagrams ($\omega - k$) (please see Fig. 1a). From this dataset, a subset of bands exhibiting effective negative refractive index characteristics was selected. For each geometry, the negative refractive index value, the degree of isolation of the corresponding band from other bands, and the operational frequency bandwidth were listed as outputs. In this way, the required input (binary pattern) and output data for machine learning were prepared. In the next stage, negative refraction of an inclined plane wave through the photonic medium with a negative effective refractive index was investigated in the time domain (please see Fig. 1b). While a conventional metamaterial designed with metallic unit cells typically operates only within a very narrow frequency range (resonant behavior), the machine-learning-based approach adopted in this study enables the operational frequency bandwidth to be significantly broadened (Δf> 15%). In this way, it would be possible to design a lens composed entirely of dielectric unit cells such that a broadband electromagnetic field waist at the focal region can be confined within subwavelength values.

Keywords: Metamaterials, Broadband Designs, Superlens

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Hücresel Haberleşme Teknolojilerinde Optik Devre Elemanlarının Performans Optimizasyonu

Hamid Ali Mbarak, N. Özlem Ünverdi
Yıldız Teknik Üniversitesi, Elektrik - Elektronik Fakültesi
Elektronik ve Haberleşme Mühendisliği Bölümü, 34220 Esenler, İstanbul, Türkiye
barakisty11@gmail.com , unverdi@yildiz.edu.tr

Özet

Bu çalışmada, 5G ve ötesi haberleşme teknolojilerinin artan bant genişliği gereksinimlerinin karşılanmasında önemli bir yerde bulunan optik haberleşme sistemlerinin potansiyeli incelenmiştir. OptiSystem 22.0 simülasyon programı ile yapılan araştırmada, optik haberleşmenin temel devre elemanları olan kaynak, darbe üreteci, modülatör, kuvvetlendirici ve filtrelerin performansı, farklı sistem konfigürasyonlarında değerlendirilmiştir [1-6].

Analizde, sürekli dalga (Continuous Wave, CW) lazer, uzun mesafeli iletimlerde düşük bit hata oranı (Bit Error Rate, BER) değeri ve gösterdiği optik güç performansıyla ön plana çıkarak LED (Light Emitting Diode, Işık Yayan Diyot) ve sabit ışık kaynağına göre tercih edilmiştir. Sıfıra dönmeyen (Non Return to Zero, NRZ) darbe üretecinin sıfıra dönen (Return to Zero, RZ) darbe üretecinden daha iyi sonuç verdiği izlenmiştir. Mach-Zehnder modülasyonunun (MZM), elektro-absorpsiyon modülasyonu (Electro-absorption Modulation, EAM), genlik modülasyonu (Amplitude Modulation, AM), frekans modülasyonu (Frequency Modulation, FM) ve faz modülasyonuna (Phase Modulation, PM) göre spektral verimlilik açısından daha etkili olduğu belirlenmiştir. Kuvvetlendirici seçiminde, sistem önceliklerine bağlı olarak, erbiyum katkılı fiber kuvvetlendiricinin (Erbium Doped Fiber Amplifier, EDFA) sinyal kalitesinin korunması ve iletim mesafesinin artırılması açısından Raman kuvvetlendirici ve yarıiletken kuvvetlendiriciye göre üstün olduğu gözlemlenmiştir. Gaussian, Dikdörtgen, Butterworth ve Bessel optik filtreler, göz diyagramı, maksimum kalite faktörü, bit hata oranı, optik güç ve spektral analiz gibi performans göstergeleri ışığında karşılaştırılmıştır. Elde edilen bulgularda, Gaussian optik filtrenin incelenen tüm mesafe aralıklarında en yüksek kalite faktörünü ve en düşük bit hata oranı değerini sağlayarak sinyal bütünlüğünün korunmasında en etkin filtre olduğu görülmüştür. Diğer optik filtreler, bazı avantajlar sunmakla birlikte, spektral verimlilik ve sinyal kalitesi açısından sınırlı performans sergilemişlerdir.

Analizlerde, optik devre elemanlarının hücresel haberleşme teknolojisinin genel performansını doğrudan etkilediği ve bu bileşenlerin uygun konfigürasyonunun 5G ve ötesi gibi yüksek hızlı ağ altyapıları için kritik öneme sahip olduğu saptanmıştır. Yeni nesil mobil haberleşme ağlarında, yüksek performanslı optik haberleşme sistemlerinin anahtar konumunda olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Hücresel haberleşme teknolojileri, optik haberleşme, optik devre elemanları, göz diyagramı, maksimum kalite faktörü

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Sürü İnsansız Hava Araçlarında Hibrit Yapıdaki Radyo Frekans Haberleşmesi ile Optik Kablosuz Haberleşmenin Modellenmesi

Şamil Ekrem Şallı, N. Özlem Ünverdi
Yıldız Teknik Üniversitesi, Elektrik - Elektronik Fakültesi
Elektronik ve Haberleşme Mühendisliği Bölümü, 34220 Esenler, İstanbul, Türkiye
ekremsallieast@gmail.com , unverdi@yildiz.edu.tr

Özet

Günümüzde sürü insansız hava araçları (İHA) teknolojileri, sivil, askeri ve endüstriyel uygulamalarda karmaşık görevlerin etkin şekilde yerine getirilmesinde kilit konumda bulunur. İnsansız hava araçlarının kendi aralarında haberleşmesi, görevlerin koordineli yürütülmesi, çarpışmaların önlenmesi, veri paylaşımı ve kapsama alanının genişletilmesi için kritik öneme sahiptir. Bu sistemlerin başarısı, yüksek veri hızı, düşük gecikme süresi ve güvenilir iletişim kapasitelerine sahip olan haberleşme altyapılarına dayanır. Radyo Frekansı (Radio Frequency, RF) tabanlı haberleşme sistemleri, geniş kapsama alanı, engelleri aşabilme ve görüş hattı olmadan haberleşme (Non Line of Sigth, NLoS) gibi avantajlara sahip olmalarına karşın bu sistemlerde, artan talep ve cihaz sayısı nedeniyle RF spektrumunda yaşanan bant genişliği kısıtlamaları, elektromanyetik parazitler ve güvenlik problemleri gibi sorunlar söz konusudur. Bu noktada, Optik Kablosuz Haberleşme (Optical Wireless Communications, OWC) sistemleri, düşük kayıp, büyük kanal kapasitesi, yüksek veri hızı ve düşük gecikme süresi sunmalarının yanı sıra RF haberleşme sistemlerine göre elektromanyetik alanlardan daha az etkilenir. Bununla birlikte, OWC tabanlı iletişim sistemlerinde, özellikle hareketli ve dinamik ortamlarda yer alan sürü insansız hava araçlarında, görüş hattı (Line of Sight, LoS) zorunluluğu, sis, pus, yağmur, kar, dolu, rüzgar ve fırtına gibi atmosferik koşullara bağlı olan zayıflamalar ve tozlu ortamlar gibi engeller nedeniyle haberleşme kalitesinde bozulmalar yaşanır [1-6].

Bu çalışmada, iletişimde karşılaşılan sorunların aşılması ve sürdürülebilir bir haberleşme için gerçek zamanlı haberleşme yapısı göz önünde bulundurularak hibrit yapıdaki RF ve OWC teknolojileri, MATLAB simülasyon programı ile modellenmiştir. Tasarımda, sürü insansız hava araçları, binalar, dağlar, tepeler ve ağaçlar rastgele konumlandırılmıştır. Burada, her İHA'nın, diğer İHA'lar ile LoS ya da NLoS bağlantıları kuracak şekilde haberleştiği kabul edilmiştir. Sistemdeki bağlantı kalitesi sürekli izlenerek LoS durumunun kaybolması halinde tasarlanan anahtarlama mekanizması ile iletişim yükü kesintisiz bir şekilde RF kanalına aktarılmış ve böylece sürdürülebilir bağlantı temin edilmiştir. Söz konusu olan anahtarlama mekanizması ile gecikme süresi, BER (Bit Error Rate, Bit Hata Oranı) değeri ve SNR (Signal to Noise Ratio, Sinyal Gürültü Oranı) değeri hesaplanarak en verimli haberleşme sağlanmıştır. Analizde, RF kanalında serbest uzay kaybı ve Rayleigh sönümlemesi, OWC kanalında ise sis, pus, yağmur, kar, dolu, rüzgar, fırtına ve toz kaynaklı kayıplar dikkate alınmıştır. Sistemin verimliliğini incelemek amacıyla RF haberleşmesi, optik kablosuz haberleşme ve hibrit yapıdaki RF-OWC haberleşmesi olmak üzere üç farklı senaryo üzerinde çalışılmıştır. RF-OWC yapısındaki hibrit sistemlerin daha düşük gecikme süresi, daha düşük BER değeri ve daha yüksek SNR değeri sağladığı görülmüştür. Hibrit sistemde, her iki teknolojinin zayıf yönleri telafi edilerek tek tür haberleşme sistemine göre verimin arttığı belirlenmiştir. Yapılan çalışma, özellikle kritik görev uygulamaları ve afet yönetimi gibi kesintisiz ve gerçek zamanlı haberleşme bağlantısı gerektiren durumlarda, sürü insansız hava araçları iletişimi için bir referans model olarak değerlendirilmiştir.

Anahtar Kelimeler: İletişim teknolojileri, sürü insansız hava araçları, RF haberleşmesi, optik kablosuz haberleşme, hibrit haberleşme

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Investigation Of Spin Dynamics In $Fe_xCo_{(1-x)}$ Magnetic Thin Films

Tuğçe Bozdağ*[1,3,5], Bekir Asilcan Ünlü[1,3], Eyüp Kavak[1,3], Metin Arslan[1,4], Halime Gül Yağlıoğlu[1,2], Eyüp Duman[1,2]

[1]*Department of Engineering Physics, Ankara University, Degol Street, Besevler, Ankara-Türkiye*
[2]*Turkish Accelerator and Radiation Laboratory (TARLA) Golbasi, Ankara-Türkiye*
[3]*Graduate School of Natural and Applied Sciences, Ankara University, Diskapi, Ankara-Türkiye*
[4]*ROKETSAN, Ankara-Türkiye*
[5]*ASELSAN, Ankara-Türkiye*
E-mail: tugcebozdag35@gmail.com

Abstract

Femtosecond laser-induced ultrafast spin dynamics for the magnetic field states of a $Fe_xCo_{(1-x)}$ sample were optically probed. Although numerous experiments have been conducted on various magnetic materials, further detailed research on the dynamics of ultrafast magnetization of materials is needed. This is important not only for understanding the mechanism behind ultrafast magnetization but also for identifying suitable materials and compositions for various applications. In this context, FeCo alloys present research opportunities due to their high magnetic moment, low Gilbert damping factor, tunable Curie temperature and moderate composition-dependent spin-orbit coupling strength. In this work, time-resolved magneto optic Kerr effect (TR-MOKE) experimental techniques and three temperature model (3TM) analysis were used to investigate how compositional tuning affects the efficiency of demagnetization and it's time scales. We found that the demagnetization time for FeCo thin films ranged from 300 to 500 femtoseconds, as determined by fitting the experimental TR-MOKE data to the analytical solution of the 3TM model. Those values are slower than that of other transition metals. This observation was attributed to the low Gilbert damping factor α value of the investigated FeCo thin films. Moreover, the values of both τ_m and τ_E were increased with increasing fluence values. It can be concluded from these two observations that the underlying mechanism responsible for the ultrafast demagnetization in FeCo thin films is predominantly governed by the spin-flip process. Additionaly, experimental results along with their theoretical analysis revealed that, although altering composition of FeCo thin films affect ultrafast demagnetization time profile slightly, it changes demagnetization efficiency significantly, which is one of the important parameters for ultrafast switching applications. Therefore, it can be concluded that among the investigated thin films Fe30Co70 have the potential to be utilised in ultrafast switching applications.

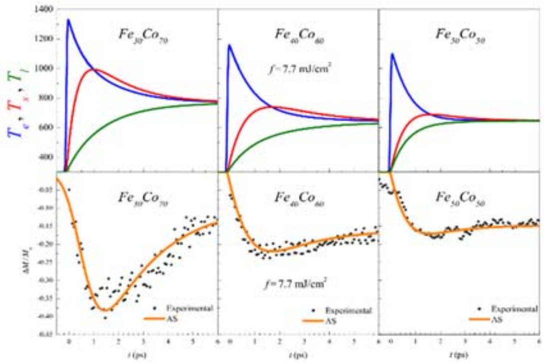

Figure 1: The temporal evolutions of electron, spin and lattice subsystems and 3TM fit results of TR-MOKE data for 7.7 mJ/cm2 fluence for investigated samples.

Keywords: Spin Dynamics, Femtomagnetism, Ultrafast Demagnetization, Time-Resolved Magneto-Optical Kerr Effect, Three Temperature Model (3TM).

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Oda Sıcaklığında $[FeL_2][BF_4]_2$ Spin-Geçiş Kompleksinde Ligand Alanı Destekli Ultrahızlı Yüksek Spin–Düşük Spin Foto-Anahtarlama

Fatime Gulsah Akca* [1,3], Damla Beşe[1], Kübra Gürpınar[2], E. Uzay Karakaya[1], Hasan Nazır[2], Barış Emre[1], Orhan Atakol[2], Eyüp Duman[1,3], Halime Gul Yaglioglu[1,3]

[1] Fizik Mühendisliği Bölümü, Ankara Üniversitesi, Dögol Caddesi, 06100 Beşevler, Ankara, Türkiye

[2] Kimya Bölümü, Ankara Üniversitesi, Dögol Caddesi, 06100 Beşevler, Ankara, Türkiye

[3] Türk Hızlandırıcı ve Işınım Laboratuvarı (TARLA), Bahçelievler Mah. 306 sk. No: 11/N, 06830 Gölbaşı, Ankara, Türkiye

*gakca@tarla-fel.org

Özet

Demir (II) spin-geçiş (SCO) komplekslerinde ışıkla kontrol edilebilen spin durumları, ultrahızlı fotofizik süreçler ve olası uygulamaları nedeniyle son yıllarda yoğun ilgi görmektedir [1-6]. Bu çalışmada, $[FeL_2][BF_4]_2$ (L = 2,6-di(pirazol-1-il)pyridin) kompleksinde ters-'ışık ile indüklenen uyarılmış spin durumu tuzaklanması' (reverse-LIESST) etkisinin foto-fiziğinde ligand alanı (LF) durumlarının rolü, metanol çözeltisinde ve oda sıcaklığında incelenmiştir.

Bu çalışma, dalga boyu ayarlanabilir pompa demeti ve sürekli spektruma sahip beyaz ışık (WL) gözlem demetine dayalı ultrahızlı geçici soğurma (TA) spektroskopisi yöntemi ile gerçekleştirilmiştir. 400 nm dalga boyundaki uyarım ile yüksek spin (HS) temel durumundan uyarılan metal–ligand yük transferi (MLCT) durumları başlangıç HS durumuna geri dönmüştür. Buna karşılık, 435 nm pompalama ile LF durumuna uyarım sonucunda iki ardışık sistemler arası geçiş (ISC) süreci aracılığıyla HS→ düşük spin (LS) geçişi gözlenmiştir. Bu bulgu, çözeltide oda sıcaklığında LF durumu üzerinden ters-LIESST etkisinin doğrudan gözlemlendiğini kanıtlamaktadır. Ayrıca, EADS analizi ile HS→HS veya HS→LS foto-anahtarlamanın dalga boyu ayarlaması ile kontrol edilebileceğini göstermiştir. Elde edilen sonuçlar, ligand alanı durumlarının SCO komplekslerinin foto-fiziğinde kritik rolünü doğrulamakta ve bu sistemlerin oda sıcaklığında kontrollü spin anahtarlama davranışlarının algılayıcılar, moleküler elektronik ve spintronik uygulamalar açısından güçlü potansiyel taşıdığını ortaya koymaktadır [7].

Anahtar Kelimeler: Spin-geçiş; Ters-LIESST; Ultrahızlı spektroskopi, Ligand alanı durumları; Foto-anahtarlama

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GdFeCo İnce Filmlerinin Ultrahızlı Manyetizasyon Dinamiklerinin İncelenmesi

Fatime Gulsah Akca*[1,2], Osman Karlioglu[1], Eyüp Duman[1,2], Halime Gul Yaglioglu[1,2]
[1] *Fizik Mühendisliği Bölümü, Ankara Üniversitesi, Dögol Caddesi, 06100 Beşevler, Ankara, Türkiye*
[2] *Türk Hızlandırıcı ve Işınım Laboratuvarı (TARLA), Bahçelievler Mah. 306 sk. No: 11/N, 06830 Gölbaşı, Ankara, Türkiye*
*gakca@tarla-fel.org

Özet
Son yıllarda manyetik olmayan malzemeler (NM) ile kontak halinde bulunan ferromanyetik (FM) ince filmler şeklinde üretilen NM/FM heteroyapıların, farklı spin-yörünge çiftlenimine bağlı olarak gösterdikleri özellikler nedeniyle, gelecekteki spintronik uygulamaların omurgasını oluşturacağı düşünülmektedir. Bu nedenle NM/FM heteroyapılarda meydana getirilen spin akımları ve arayüzeydeki spin dinamiklerinin araştırılmasına olan ilgi son birkaç yılda çok hızlı bir şekilde artmıştır [1-4].

Bu çalışmada, ultrahızlı lazer darbeleri ile manyetik durumlarının değiştirilebildiği bilinen ve ferrimanyetik özellik gösteren GdFeCo ince filmlerinin Ta arayüzeylerinde spin pompalama dinamikleri ve bu dinamiklerin, film kalınlığı ve uygulan dış manyetik alan ile nasıl değiştiği incelenmiştir. GdFeCo ince filmlerinin homojen bir şekilde büyütüldüğü SEM (Taramalı Elektron Mikroskobu) yüzey analizleri ile görülmüştür. İnce filmlerin oda sıcaklığında alınan VSM (Titreşimli Örnek Manyetometresi) ölçümlerine göre düşük koersif alana sahip ferrimanyetik yapıda olduğu görülmüştür. Yaklaşık 7 mJ/cm2 pompa darbe akısı ile alınan TRMOKE (Zaman Çözünürlüklü Manyeto Optik Kerr Etkisi) analizleri sonucu uzun ömürlü presesyon hareketleri görülmüştür.

Anahtar Kelimeler: Spintronik; Ferrimanyetik; Ultrahızlı spektroskopi; TRMOKE

Teşekkür: Bu çalışma TÜBİTAK 122F440 numaralı proje tarafından desteklenmektedir.

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Innovative Bandstructure Design for High-Power Mid-IR

Merve Nur Koçak[1,3], İlkay Demir [1,2*]

[1]*Sivas Cumhuriyet University Nanophotonics Application and Research Center-CÜNAM, 58140 Sivas, Türkiye*

[2] *Department of Nanotechnology Engineering, Faculty of Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye*

[3] *Department of Metallurgy and Materials Science, Faculty of Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye*

corresponding author, E-mail: idemir@cumhuriyet.edu.tr

Özet / Abstract

Quantum Cascade Lasers (QCLs) are important semiconductor devices for the mid-infrared (mid-IR) spectral region, providing compact, tunable, and wavelength-selective sources for applications such as infrared countermeasure (IRCM) systems. In this work, we present a QCL active region design operating at 4.6 µm.

The proposed structure combines a shallow well at the injector–active interface with a tapered active region. This approach increases the upper-level energy separation, helping to suppress carrier leakage, while the lower levels are optimized for two-phonon resonance, allowing faster depopulation and supporting population inversion [1,2].

Simulation results indicate good optical gain, stable single-wavelength operation, and an improved efficiency compared to conventional designs. The performance trends are in line with state-of-the-art mid-IR QCLs reported in the literature, such as the high-power devices by Bai et al.[3], but with some improvements at the design level.

These findings suggest that combining shallow-well and tapered active-region concepts can be a useful strategy to improve the efficiency and reliability of mid-IR QCLs for defense and sensing applications.

Keywords: Quantum Cascade Laser (QCL), Infrared Countermeasures (IRCM), Band Engineering, Laser Design

Acknowledgements
This work is based on results obtained during the ongoing Ph.D. thesis of Merve Nur Koçak, titled "Development of Short- and Mid-Wavelength Quantum Cascade Lasers". Merve Nur Koçak is supported by the YÖK (Council of Higher Education) 100/2000 Ph.D. Scholarship Program and The Scientific and Technological Research Council of Türkiye (TÜBİTAK) 2211/A Program. This study supported by The Scientific Research Project Fund of Sivas Cumhuriyet University, Türkiye under the project number MRK-2024-004 and The Scientific and Technological Research Council of Türkiye (TUBITAK) under the project number 22AG074.

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Elektriksel Olarak Ayarlanabilen Grafen Pleksitonları ile Bozunma Oranının Dinamik Kontrolü

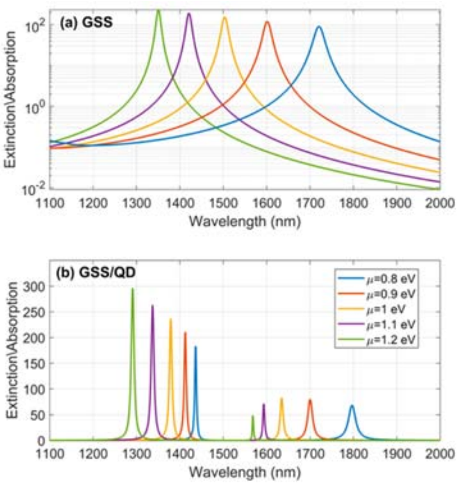
Taner Tarık Aytaş*[1,2], Hira Asif[3], Ramazan Şahin[1,3]
[1]Fizik Bölümü, Akdeniz Üniversitesi, 07058 Antalya, Türkiye
[2]Türkiye Ulusal Gözlemevleri, DAG, 25050 Erzurum, Türkiye
[3]Türkiye Ulusal Gözlemevleri, TUG, 07058 Antalya, Türkiye

Taner Tarık Aytaş, E-mail: taneraytas7@gmail.com

Özet

Sahip oldukları benzersiz elektronik ve optik özellikler sayesinde iki boyutlu malzemeler, Kuantum Yayıcılar (QE'ler) ile aralarında güçlü etkileşim sergilerler. İki boyutlu malzemelerden özellikle grafen; güçlü ışık-madde etkileşimleri için öne çıkan bir materyaldir [1,2]. Bu çalışmada grafen küresel kabuk (GSS) ile kaplanmış bir kuantum nokta sisteminin yakınına yerleştirilen bir dipolün bozunma oranının dinamik modülasyonu gösterilmektedir.

Grafen kaplı kuantum nokta sisteminde, GSS'nin plazmonik modları kuantum noktanın (QD) eksiton modları ile güçlü bir şekilde birleşerek pleksitonik rezonanslar olarak bilinen hibrit modları oluşturur (Şekil 1) [3]. Oluşan hibrit modlar, grafen kabuğa uygulanan voltaj aracılığı ile kimyasal potansiyelinin ayarlanabilmesini, dolayısıyla hassas şekilde modüle edilebilen ve dinamik olarak kontrol edilebilen bozunma oranları sergiler. Elde edilen sonuçlar ışığında bu güçlü birleşmenin ve modülasyonun rezonans dışı koşullar altında bile sürdürülebildiği gösterilmektedir. MNPBEM Toolbox kullanılarak gerçekleştirilen simülasyonlar [4], bu hibrit modların oluşumunu ve ayarlanabilirliğini açıkça göstermekte ve kızılötesi (IR) rejimde önemli ölçüde ayarlanabilir optik tepkilere neden olmaktadır.



Şekil 1: Grafenin farklı kimyasal potansiyeller altında uyarma dalga boyuna bağlı olarak (a) GSS'nin ve (b) GSS/QD'nin soğurma (veya sönümleme) spektrumu.

Anahtar Kelimeler: Grafen, Plazmonik, Decay Rate, Pleksiton, Grafen Plazmonik

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Optimization of NiO Hole Transport Layer for InSb Colloidal Quantum Dot Photodetector

Betül SATILMIŞ[1,2,*], Tuğçe ATAŞER[1,2,3], Süleyman ÖZÇELİK[1,2,3]

[1]Photonics Application and Research Center,
Gazi University, Ankara, Türkiye, 06560 Ankara, Türkiye
[2]Gazi University, Photonics Science and Engineering,
Graduate School of Natural and Applied Sciences, Gazi University, 06560 Ankara, Türkiye
[3]Gazi University, Faculty of Applied Sciences, Department of Photonics,
Gazi University, 06560 Ankara, Türkiye
[*]betul.satilmis@gazi.edu.tr

Abstract

In recent years, non-toxic short-wave infrared (SWIR) photodetectors have garnered increasing attention due to their potential for enabling environmentally friendly and high-performance optoelectronic devices. [1]. Indium antimonide (InSb) colloidal quantum dots (CQDs) are promising materials for SWIR detection due to their narrow bandgap (Eg ~0.17 eV), high carrier mobility, and solution-processability [2]. In InSb CQD-based flexible photodetectors, the optimization of charge transport layers, including hole transport layer (HTL) and electron transport layer (ETL), plays a crucial role in achieving efficient device performance. HTLs in InSb CQD-based flexible photodetectors are typically composed of transition metal oxides and organic semiconductors. Among these, NiO works as a p-type indirect band gap semiconductor with suitable energy band alignment with InSb CQDs, high transmittance in the SWIR region, and environmental friendliness and these properties make NiO a wonderful candidate for application in optoelectronic devices as HTL [3].

In this study, nickel oxide (NiO) was synthesized via the sol-gel method at concentrations of 0.1 M, 0.3 M, and 0.5 M for use as a hole transport layer (HTL) in InSb CQD-based flexible photodetectors and deposited on flexible polyimide (PI) substrates. The sol-gel method not only enables low-cost and low-temperature fabrication but also offers precise control over chemical composition, compatibility with large-area flexible substrates, and the production of high-purity, homogeneous thin films. The structural, optical, and morphological properties of the resulting NiO films were comprehensively investigated to assess their suitability for integration into flexible SWIR photodetector architectures.

Keywords: InSb, CQDs, NiO, HTL, sol-gel, flexible photodetector, IR, SWIR.

Acknowledgements
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Comprehensive Investigation of Multiplication Width and Guard Ring Influence on InGaAs/InP Avalanche Photodiode Performance

Mert Satılmış[1,2], Habibe Keleş[1,2], Çağrı Tok[1,3], Fikri Oğuz[1,2], Ekmel Özbay[1,5]

[1] *Nanotechnology Resarch Center, Bilkent University, Ankara 06800, Türkiye*

[2] *Department of Micro and Nanotechnology, METU, Ankara 06800, Türkiye*

[3] *Department of Materials Science and Nanotechnology Engineering*

[4] *Department of Physics Engineering, Ankara University, Ankara 06800, Türkiye*

[5] *Department of Electrical and Electronics Engineering,Bilkent University, Ankara 06800, Türkiye*

corresponding author, E-mail: mert.satilmis@bilkent.edu.tr

Özet / Abstract

Avalanche InGaAs photodetectors (APDs) attract considerable interest in optical and quantum communication, LiDAR, imaging, and single-photon counting due to their internal gain at short wavelengths. Their narrow bandgap, however, makes them prone to tunneling currents under high electric fields. To address this, the separate absorption and multiplication (SAM) structure was introduced. While InAlAs-based SAM-APDs are typically fabricated in mesa form for ease of processing, their response is limited by charge accumulation at the absorption–multiplication interface. This challenge led to the development of the separated absorption, charge, and multiplication (SACM) design, employing a high–low doping profile in the multiplication region. Nonetheless, interface discontinuities persist, which are alleviated by incorporating graded layers—resulting in the widely adopted separated absorption, graded, charge, and multiplication (SAGCM) structure.

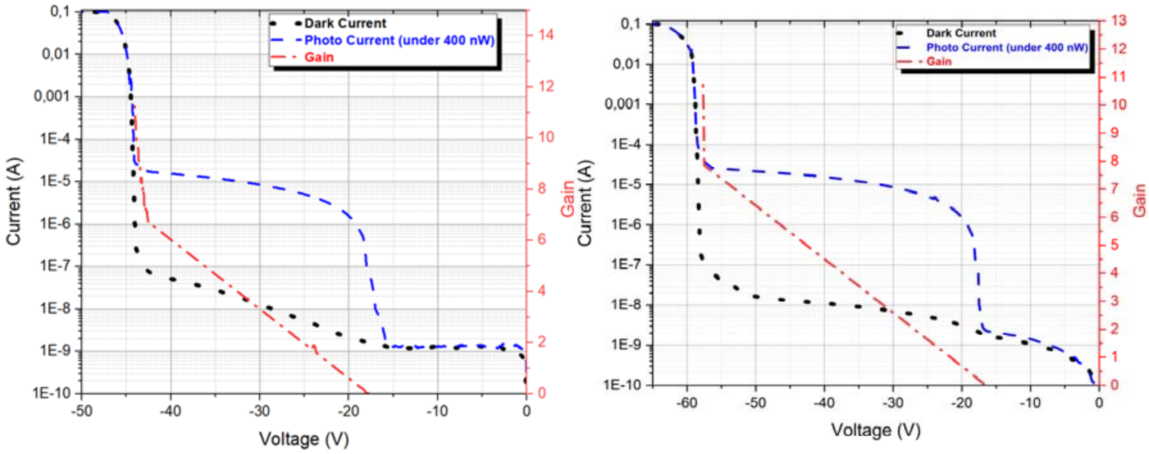

Figure 1: Measured performance of the initial device (left) and the final device (right)

In this comprehensive study, both numerical calculations and experimental analyses were conducted to evaluate the impact of MW, AGR thickness, FGR spacing and thickness, and the number of AFGRs on the performance of SAGCM APDs. A total of 135 device configurations were designed and characterized. The use of a thin MW effectively reduced both the VBR and VPT, thereby lowering power consumption. The optimal configuration was identified as an AGR thickness of 2 μm, FGR spacing of 8 μm, FGR thickness of 5 μm, and two AFGRs, which increased the breakdown voltage from 43.9 V (without AGR/FGR) to 57.6 V. This methodology can be extended to APD devices requiring high breakdown voltages or low-noise operation, and although developed for InP/InGaAs, the design strategies are adaptable to alternative material platforms, offering advantages in process simplicity and device reliability.

Keywords: InGaAs APD, SAGCM, Multiplication width, AGR, FGR, AFGR

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Polimer Malzemeler Üzerine Lazer Kazıma Tekniği ile Mikrooptik Yapılar Oluşturarak Otomotiv Aydınlatma Sistemi Tasarımı ve Üretimi

Kaan TURAN[1,2], Erhan AKMAN[1,3], Ahmet İREN[1], Fatih GÖREN[1,2], Levent CANDAN[4] and Arif DEMİR[5]

[1]*Electro-Optical Systems Engineering, Kocaeli University, Umuttepe, 41380, Kocaeli, Türkiye*
[2]*FARBA Automotive Inc., Gebze/Kocaeli, TÜRKIYE*
[3]*Faculty of Aeronautics and Astronautics, Department of Aviation Electrics and Electronics, Kocaeli University, Kocaeli, Türkiye*
[4]*Laser Technologies Research and Application Center, Kocaeli University, Kocaeli, Türkiye*
[5]*Faculty of Engineering, Department of Nanotechnology Engineering, OSTIM Technical University, Ankara, Türkiye*

corresponding author, E-mail:kaan.turan@farba.com.tr

Özet / Abstract

Günümüzde artan enerji verimliliği bilinci ve LED teknolojilerindeki hızlı gelişmeler, otomotiv aydınlatma sistemlerinde köklü bir dönüşümü beraberinde getirmiştir. Halojen ve xenon lambaların yerini alan LED ve lazer tabanlı ışık kaynakları yalnızca enerji tüketimini azaltmakla kalmamakta; aynı zamanda ışığın yönlendirilmesi, homojen dağılımı ve estetik tasarım gibi yeni gereksinimleri de gündeme getirmektedir.[1]

Bu gereksinimleri karşılamak için otomotiv endüstrisinde ışık kılavuzları, mikro mercek dizileri ve difüzörler gibi mikro-optik yapıların kullanımı giderek yaygınlaşmaktadır. Ancak mevcut üretim yöntemleri (mikro kalıplama, sıcak damgalama, kimyasal aşındırma vb.) karmaşık ve yüksek hassasiyet gerektiren bu yapıların üretiminde yetersiz kalmaktadır.[2] Bu durum, daha esnek ve yüksek çözünürlüklü üretim tekniklerine olan ihtiyacı artırmaktadır.[3]

Bu çalışmada, lazerle doğrudan yüzey işleme yöntemi kullanılarak otomotiv aydınlatma sistemlerine entegre edilebilecek yenilikçi mikro-optik bileşenlerin geliştirilmesi hedeflenmektedir. Önerilen yaklaşım sayesinde LED ve lazer tabanlı ışık kaynaklarında daha yüksek optik verimlilik, homojen ışık dağılımı ve estetik tasarım olanakları sağlanacaktır. Ayrıca lazer mikro-işleme tekniği, geleneksel yöntemlere kıyasla daha düşük maliyet, daha yüksek hassasiyet ve üretim esnekliği sunarak seri üretime uygun bir platform geliştirilmesine imkân tanımaktadır. Çalışma kapsamında, hedeflenen mikro-optik yapıların polimer yüzeyler üzerinde uygun lazer parametreleri (güç, spot büyüklüğü, hız vb.) optimize edilerek başarılı bir şekilde oluşturulması sağlanmıştır.

Sonuç olarak, bu çalışma otomotiv sektöründe enerji verimliliği yüksek, kompakt ve akıllı aydınlatma çözümleri için özgün bir yaklaşım ortaya koymaktadır. Elde edilecek çıktılar, Türkiye'nin yerli optik üretim kapasitesinin artırılmasına ve uluslararası rekabet gücünün yükseltilmesine katkı sağlayacaktır.

a) b)

Şekil 1 / Figure 1: a) Lazer ile polimer malzeme üzerine işlenen mikro optik plaka b) Mikro optik plaka entegre edilmiş aydınlatma ünitesi

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Quantization-aware Training of Optical Random Neural Networks

Bora Çarpınlıoğlu, Uğur Teğin*
Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye
corresponding author, E-mail: utegin@ku.edu.tr

Abstract
Real-time inference is an important requirement for machine learning applications running at the edge e.g., autonomous driving [1]. Quantization-aware training (QAT) is proposed [2] to reduce memory requirements of large models without significant loss in accuracy. Optical computing offers faster processing with parallel computations and reduced power use, enabling neural networks due to dense connectivity and noise resistance. As a prominent technique, linear optical neural networks for large datasets use random projection, reducing the dimensionality of data [3].

Here, we develop and explore optimizable random projection kernels in optical neural networks and incorporate bit depth as a trainable parameter. The scattering medium in Fig. 1 acts as a complex, random matrix that performs the bulk of computation, where different angular positions correspond to different random matrices. We search for an angular position that provides superior classification accuracy for a given task by employing a heuristic search algorithm, genetic algorithm (GA). Using the Breast MNIST dataset to test the effects of two types of quantization on classification accuracy. In post-training quantization, conventionally 8-bit randomly projected features are reduced in bit depth. On the other hand, QAT allows GA search for the optimal random projection kernel under different bit depth regimes, producing higher classification accuracies. We experiment with 8-bit, 4-bit, 2-bit and 1-bit scenarios.

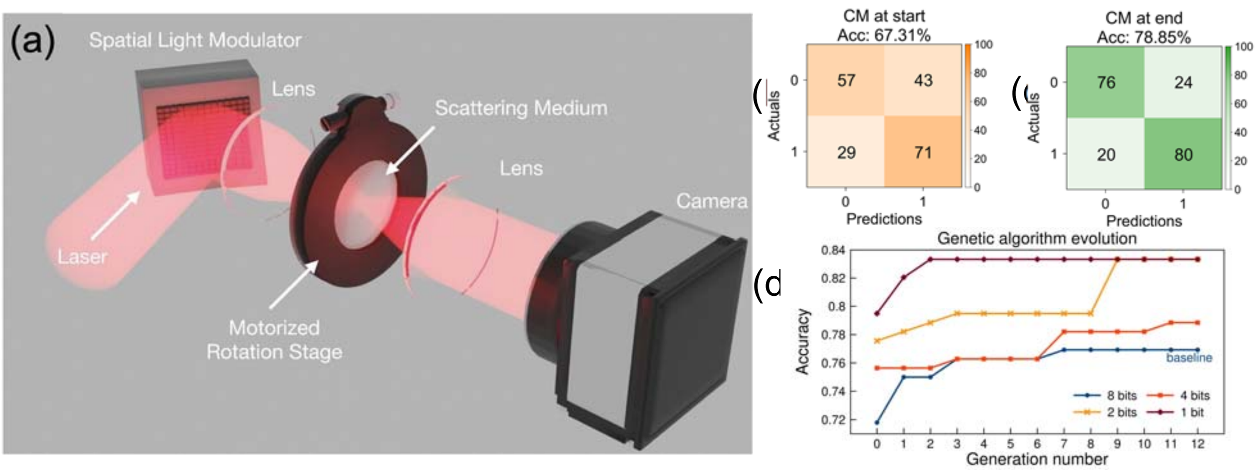

Figure 1: Quantization-aware training (QAT) of an optical random neural network. (a) Illustration of experimental setup, which consists of a modulator, lenses, scattering medium on a motorized disk and a camera. Confusion matrix (CM) at the start (b) and end (c) of GA iterations for the Breast MNIST dataset while training the optical platform with 4-bit captures. (d) Evolution of accuracy through generations for a range of bit depths.

The best classification accuracy of 83.33% was obtained under the 2 bits and 1 bit scenarios using only 1% of the search space. Our approach performs better than ridge classification (66.67%) with only 177 additional trainable parameters. Future work will focus on the processing of high resolution datasets not trainable with conventional, digital hardware because of memory constraints.

Keywords: Optical computing, Photonic neural networks, Quantization-aware training, Complex optics

Acknowledgements
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Controlling Spatiotemporal Nonlinearities in Multimode Fibers with Artificial Intelligence

Bora Çarpınlıoğlu, Bahadır Utku Kesgin, Uğur Teğin*
Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye
corresponding author, E-mail: utegin@ku.edu.tr

Abstract

Fibers are versatile tools in various applications, including imaging, computing, and data transmission. While single-mode fibers are straightforward to work with in simulations and experiments, they lack the rich degrees of freedom that multimode fibers offer. Multimode fibers can support over 100 modes, but understanding the contribution of each mode becomes complex when triggering complex nonlinear interactions.

Out of many complex nonlinear dynamics observed in multimode fibers, spatiotemporal instability (STI) has been studied extensively in the literature [1, 2]. Here, we study STI in multimode fibers and how different mode combinations influence new frequency generation. We adopt a mode-decomposed data-driven approach, generating a dataset of 4250 pairs of input mode coefficients and their corresponding output spectra using beam propagation method (BPM) simulations. We then design and train a simple feed-forward multi-layer perceptron (MLP) to predict the strength of STI peaks in multimode fibers in the spectral region from 515 to 2100 nm. Dataset generation and our simulation pipeline can be seen in Fig. 1.

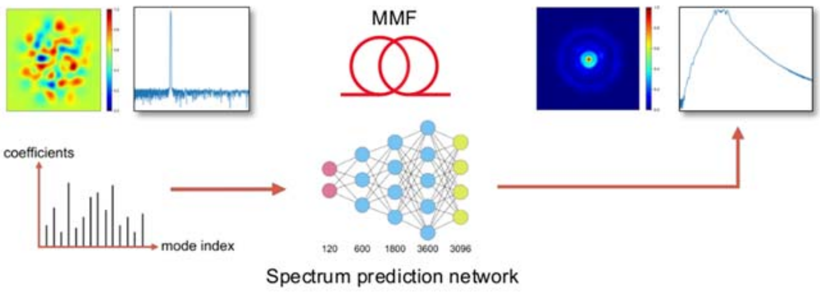

Figure 1: Our dataset generation and simulation pipeline. A spectrum prediction network that effectively replaces a MMF and approximates BPM simulations is trained where 120 random mode coefficients and corresponding spectra are provided as data pairs. The network has a simple feed-forward MLP architecture with batchnorm layers and ReLU activation.

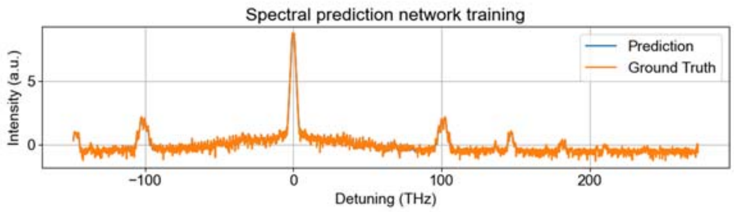

Figure 2: Quantitatively, we obtained a mean-squared error (MSE) of 0.0223 and a mean-absolute error (MAE) of 0.1039 over the test set, evidenced by the perfect fit of predicted spectra with the ground truth.

Our findings show that a fundamental yet effective MLP model can successfully replace the time-consuming BPM simulations for STI generation and peak identification, offering a more efficient approach to understanding the complex and nonlinear dynamics in multimode fibers. We further plan to extend the number of tasks made possible with our method.

Keywords: Multimode fibers, Spatiotemporal nonlinear dynamics, Artificial intelligence

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Photostimulation of Cardiac Explants by Near-Infrared Light using Hydrogel-Integrated Quantum Dot Biointerface

Ömer Faruk Özelçi[1], Humeyra Nur Kaleli[2], Gizem Yıldız[3], Tarık Safa Kaya[4], Sedat Nizamoğlu[*1,3,4]

[1] *Department of Electrical and Electronics Engineering, Koç University, 34450, Istanbul, Türkiye*
[2] *Research Center for Translational Medicine, Koç University, 34450, Istanbul, Türkiye Adress*
[3] *Graduate School of Biomedical Science and Engineering, Koç University, 34450, Istanbul, Türkiye*
[4]*Graduate School of Material Science and Engineering, Koç University, 34450, Istanbul, Türkiye*
corresponding author, E-mail: snizamoglu@ku.edu.tr

Abstract

Cardiovascular diseases (CVDs) have become a major worldwide health concern,[1] and one third of the global mortality is caused by the CVDs.[2] Bradycardia, a clinically significant condition defined by a pathologically slow heart rate, arises from dysfunction in the heart's intrinsic electrical conduction system. As a bioelectronic solution, cardiac pacemakers improve patients' quality of life and lifespan by regulating heartbeats through electrical stimulation. Conventional pacemakers use long leads that extend into the heart for endocardial stimulation. However, lead malfunction, endocarditis, and tricuspid valve regurgitation often require multiple lead replacements over a patient's lifetime, increasing morbidity and reducing quality of life.[3, 4] In addition, they require surgical replacement of the battery, which may have potential negative consequences of infection or psychological stress.[5, 6] Alternatively, photonic stimulation of cardiac tissue offers a wireless, battery-free and minimally invasive control of cardiac activity.

In this study, we present a hydrogel-integrated quantum dot (QD) biointerface for near-infrared cardiac photostimulation. The device incorporates ultrathin $AgBiS_2$ QD layers, which efficiently harvest light and generate charge carriers, with a soft PEDOT:PSS hydrogel that mimics tissue mechanics and enhances ionic–electronic coupling. This hybrid design resulted in a 52.8-fold increase in charge transfer compared to hydrogel-free devices, while ensuring charge balance and negligible thermal effects ($\Delta T \approx 0.2$ K). Using rat embryonic cardiac explants, we demonstrated precise modulation of heart rate across physiological ranges under pulsed near-infrared illumination. A custom-developed video analysis algorithm confirmed precise synchronization between light pulses and tissue contractions.

These findings highlight the synergy between nanomaterials and hydrogels in creating soft, efficient, and biocompatible optoelectronic biointerfaces. The presented platform establishes a promising foundation for the next-generation, minimally invasive, leadless pacemakers that operate wirelessly through near-infrared light.

Keywords: Times Near-Infrared Photostimulation, Leadless Pacemakers, Optoelectronics, Quantum Dots, Hydrogels

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This study was funded by the Scientific and Technological Research Council of Türkiye (TUBITAK) with Project No. 121C301. The authors gratefully acknowledge use of the services and facilities of the Koç University Research Center for Translational Medicine (KUTTAM).

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Gd2O3-ZnO-AC Nanocomposite as an Electrode Material

Ajala Oluwatosin Johnson[1] Emre Erdem[1,2]

1- Faculty of Engineering and Natural Sciences, Materials Science and Nanoengineering, Sabanci University, Tuzla, 34956, Istanbul, Türkiye.

2- EFSUN - Center of Excellence for Functional Surfaces and Interfaces, Sabanci University, Tuzla, 34956, Istanbul, Türkiye.

Abstract

The growing demand for efficient and sustainable energy storage systems has intensified research into advanced electrode materials for supercapacitors. In this study, a novel ternary composite comprising gadolinium oxide (Gd_2O_3), zinc oxide (ZnO), and activated carbon (AC) was synthesized and evaluated for its electrochemical performance as a supercapacitor electrode.

The activated carbon was derived from waste cigarette butts through pyrolysis followed by chemical activation, providing a high-surface-area matrix. ZnO and Gd_2O_3 nanoparticles were incorporated via a wet chemical co-precipitation route to enhance the pseudocapacitive behaviour and conductivity of the composite. The structural, morphological, and textural properties were characterized using EPR, XRD, SEM, BET, and FTIR techniques.

Electrochemical measurements conducted in a two-electrode setup using 1 M KOH as the electrolyte revealed that the Gd_2O_3-ZnO-AC composite exhibited excellent specific capacitance, superior rate capability, and enhanced cyclic stability compared to pristine AC and binary composites. The synergistic effect between the metal oxides and porous carbon framework contributed to improved charge storage through a combination of electrical double-layer capacitance and Faradaic redox reactions. The composite retained over 90% of its initial capacitance after 5000 cycles, demonstrating excellent stability. These findings highlight the potential of Gd_2O_3-ZnO-AC as a promising electrode material for high-performance supercapacitor applications.

Keywords; Gadolinium-oxide, zinc-oxide, activated-carbon, and supercapacitors.

Acknowledgement

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DFB Fiber Lazer Tabanlı Akustik Algılama İçin İkili İnterferometrik Sorgulama

Mehmet Ziya Keskin*[1], Abdulkadir Yentür [1,2], İbrahim Tuna Özdür[1]

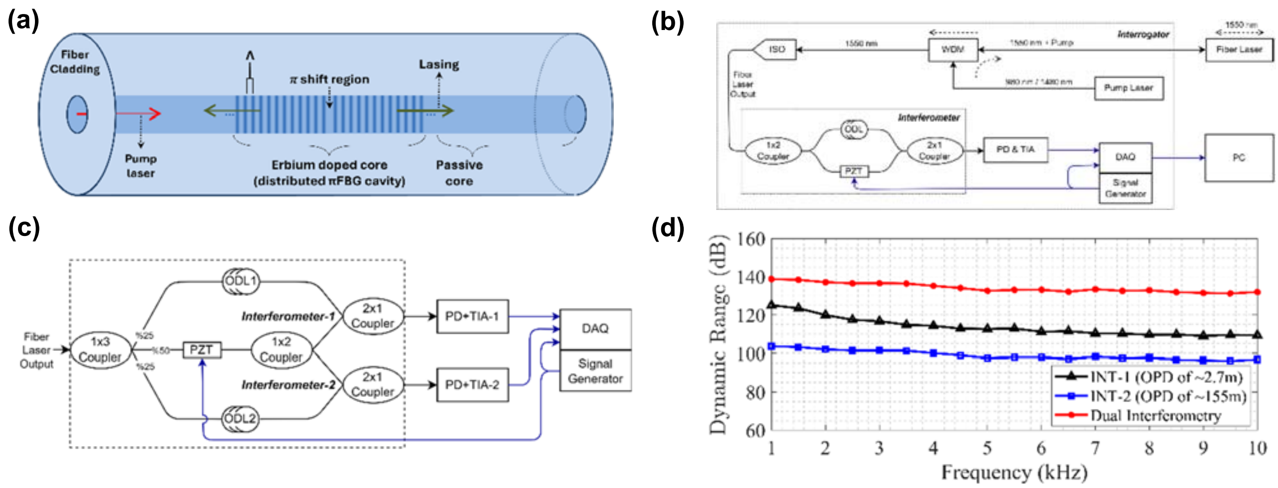
[1]Elektrik ve Elektronik Mühendisliği, TOBB Ekonomi ve Teknoloji Üniversitesi, Ankara, Türkiye

[2]Bilkent Üniversitesi, NANOTAM, Ankara, Türkiye

*corresponding author, E-mail: mehmetziya.keskin@etu.edu.tr

Özet

Mühendislikte akustik algılamanın birçok uygulaması bulunmaktadır ve bunlardan biri de fiber optik hidrofonlardır (FOH) [1]. Geleneksel piezoelektrik hidrofonlar; boyut, elektromanyetik girişim, korozyon ve dar çalışma bant genişliği gibi konularda sınırlılıklarla karşılaşmaktadır. Fiber optik hidrofonlar, özellikle de Şekil 1 (a)'da gösterilen yağıdaki dağıtılmış geri besleme (DFB) lazerleri kullananlar, mekanik esneklikleri, zorlu koşullara karşı dayanıklılıkları ve geniş algılama menzilleri sayesinde çekici bir alternatif sunar. DFB lazerler, sıcaklık ve gerinim gibi harici etkilere karşı oldukça hassastır. Bu özellikleri, lazer dalga boyundaki değişimleri izleyerek su altındaki akustik sinyallerin hassas bir şekilde algılanmasını sağlar [2]. Bu makale, dalga boyu değişimlerini ölçülebilir faz sapmalarına dönüştürmek için Şekil 1 (b)'de gösterilen Mach-Zehnder interferometrelerini kullanan gelişmiş bir sorgulama mekanizması sunmaktadır. Bu mekanizma, uygun maliyetli ve yüksek çözünürlüklü faz tabanlı ölçümler sağlamaktadır. Şekil 1 (c)'de görüldüğü şekilde dinamik aralığı genişletmek için bir kolda ~2.7 metre diğer kolda ~155 metre optik yol farkı olan ikili bir interferometrik kurulum, standart bir demodülasyon algoritmasıyla birleştirilmiştir. Şekil 1 (d)'de sunulan deneysel sonuçlar, performansın önemli ölçüde arttığını göstermektedir. Gürültü tabanı kötüleşmeden, dinamik aralık 1 kHz'de 125 dB'den 139 dB'ye yükselmiştir. Bu gelişme, FOH tabanlı sistemlerin su altı gözetimi, denizaltı iletişimi ve deniz ekosisteminin izlenmesi gibi su altı uygulamalarındaki kullanışlılığını önemli ölçüde artırmaktadır.



Şekil 1: (a) DFB fiber lazer yapısı**, (b)** DFB fiber lazer sorgulayıcı yapısı (WDM: Wavelength Division Multiplexer, ISO: Isolator, ODL: Optical Delay Line, PZT: Piezo Fiber Strecher, PD: Photodetector, TIA: Trans Impedance Amplifier, DAQ: Data acquisition Unit, PC: Personal Computer), **(c)** Mach-Zehnder interferometresine dayalı ikili interferometrik sorgulayıcı yapısı, **(d)** Interferometre-1 (INT-1), Interferometre-2 (INT-2) ve ikili (Dual) interferometre ile elde edilen dinamik aralıklar.

Anahtar Kelimeler: Akustik algılama; fiber lazerler; fiber optic sensörler; hidrofonlar; interferometreler

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High Power–Frequency AlN Schottky Barrier Diodes: Strain–Stress Analysis Influenced by Si-Doping

Izel Perkitel[1,2], Ahmet Emre Kasapoğlu[3], Emre Gür[4] and Ilkay Demir[*1,2]
[1] Sivas Cumhuriyet University Nanophotonics Application and Research Center-CÜNAM, 58140 Sivas, Türkiye
[2] Department of Nanotechnology Engineering, Sivas Cumhuriyet University, 58140 Sivas, Türkiye
[3] East Anatolia High Technology Application and Research Center, Atatürk University, 25240 Erzurum, Türkiye
[4] Department of Physics, Faculty of Science, Eskişehir Osmangazi University, 26040, Eskişehir, Türkiye
corresponding author, E-mail: idemir@cumhuriyet.edu.tr

Abstract
III-nitride semiconductors (GaN, InN, and AlN) play a critical role in advanced electronic and optoelectronic applications today due to their wide bandgaps, high breakdown fields, and chemical stability. This material family stands out particularly in the development of devices such as light-emitting diodes (LEDs), laser diodes (LDs), high electron mobility transistors (HEMTs), high-power p–n diodes, and Schottky diodes [1].
Among the III-nitrides, aluminum nitride (AlN) stands out with its wide bandgap (6.2 eV), high breakdown field (450 kV/cm), excellent thermal conductivity (~590 W/mK), and remarkable thermal stability, making it highly promising for high-frequency, high-power, and optoelectronic applications. Nevertheless, growing high-quality AlN epitaxial films remain challenging. While homoepitaxy ensures superior quality, it is limited by high cost; heteroepitaxy, though cost-effective and scalable, suffers from large lattice mismatch and thermal expansion differences, leading to high dislocation densities. Various approaches, such as buffer layers, ELOG, and PALE, have been used to reduce these defects. Furthermore, Si doping is essential to achieve electrical conductivity in AlN, yet often results in defect complexes that restrict carrier mobility, making doping control highly challenging [2].
In this study, AlN films with three different Si flow rates were grown on sapphire substrates using the Metal-Organic Vapor Phase Epitaxy (MOVPE) technique, followed by device fabrication through lithography (Figure 1). The crystal quality and dislocation densities were evaluated by X-ray diffraction (XRD), while strain–stress analysis was carried out in detail using Raman spectroscopy. Furthermore, temperature-dependent I–V measurements were performed at 400, 500, and 550 °C, revealing Schottky diode-like behavior with improved electrical characteristics at elevated temperatures.

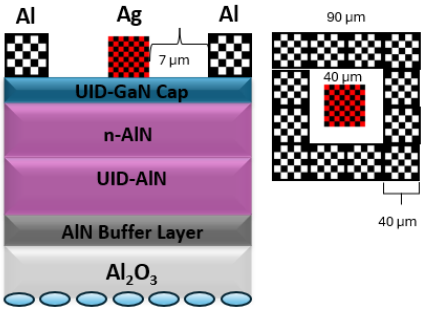

Figure 1: Schematic illustration of AlN Schottky barrier diodes fabricated on c-plane sapphire substrates via MOVPE.

Keywords: AlN, Si-doping, MOVPE, XRD, Raman spectra

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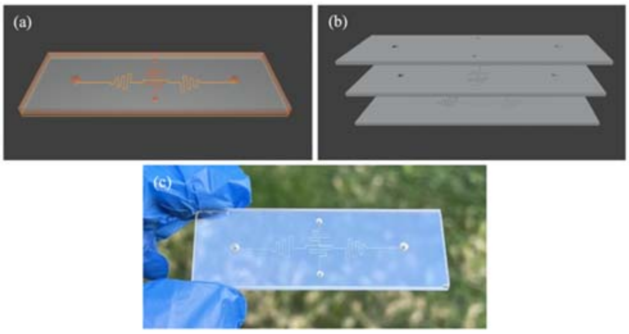
Çok Katmanlı Cam Mikroakışkan Cihazların Tümleşik Femtosaniye Lazer ile Üretimi ve Kaynağı

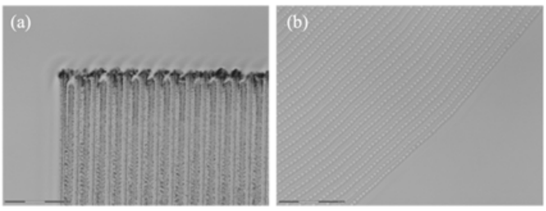
Gizem Alpakut*1, Mehmet Burçin Ünlü[2], Bora Akgün[1], Seydi Yavaş[1,2,3]
[1]Fizik Bölümü, Boğaziçi Üniversitesi, 34342 İstanbul, Türkiye,
[2]Mühendislik Fakültesi, Özyeğin Üniversitesi, 34794 İstanbul, Türkiye,
[3]Lumos Lazer, İstanbul, Türkiye
e-mail: gizem.alpakut@gmail.com

Bu çalışmada, çok katmanlı cam mikroakışkan cihazların üretiminde tek bir femtosaniye lazer sisteminin hem mikroişleme hem de kaynak amaçlı kullanılabildiği bütünleşik bir yöntem sunulmaktadır. 1030 nm dalga boyunda, 300 fs atım süresinde ve 400 kHz–1 MHz aralığında ayarlanabilir tekrar frekansına sahip özel tasarlanmış fiber lazer sistemi, yüksek hassasiyetli mikrokanal açma işlemlerinin ardından spiral tarama yaklaşımıyla cam-cam kaynağı gerçekleştirebilmektedir. Bu yöntem, ek bağlama adımlarına veya temizoda koşullarına ihtiyaç duymadan üretim sürecini sadeleştirmekte ve karmaşık üç boyutlu mikroakışkan mimarilerin üretimine olanak tanımaktadır.

Üç katmanlı prototip cihazda mikrokanallar sert odaklı bir objektif ile translation stage kullanılarak mikrometre ölçeğinde yazılmış, giriş ve çıkış bağlantıları ise Galvo ile f-theta mercek kullanılarak açılmıştır. Kaynak aşaması da yine sert odaklı objektif ve translation stage düzeninde spiral tarama yaklaşımıyla gerçekleştirilmiş, böylece enerji dağılımı homojenleştirilerek klasik yöntemlere göre daha düzgün kaynak arayüzleri elde edilmiştir. Bu sayede, kaynak bölgelerinde optik berraklık korunurken mikrokanal yapıları zarar görmeden sızdırmaz bağlantılarla bütünleşmiş ve optik açıdan şeffaf, hermetik olarak kapatılmış mikroakışkan cihazlar elde edilmiştir.



Şekil 1. (a), (b) Üç katmanlı mikroakışkan çipin 3D tasarımları, (c) entegre kanallar ve giriş/çıkış bağlantıları ile tamamlanmış cihaz.



Şekil 2. Kaynak yöntemine ilişkin mikroskop görüntüleri: (a) raster taramada köşe bölgelerinde görülen homojensizlik, (b) spiral tarama ile elde edilen daha homojen kaynak yapısı.

Anahtar Kelimeler: femtosaniye lazer, mikroakışkan cihazlar, cam kaynak, spiral tarama, mikroişleme

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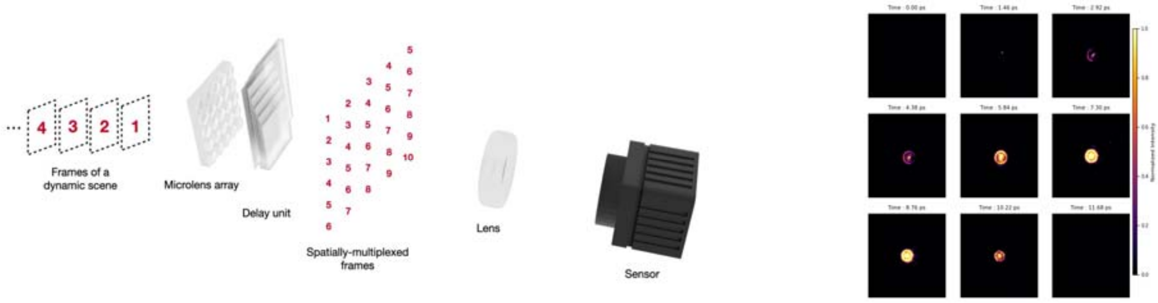
Single-shot spatially-multiplexed ultrafast imaging with 685 billion FPS

Dilem Eşlik, Uğur Teğin*
Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye
E-mail: utegin@ku.edu.tr

Abstract

Capturing rapid events in science, such as the evolution of a laser pulse or fluorescence, is a challenging imaging task due to the limited frame rate of conventional cameras. Using compressed imaging and streak camera, Wang et al. [1] achieved 100 billion FPS with compressed ultrafast photography. To simplify the operation principle and decrease the overall cost of ultrafast imaging systems, Liang et al. [2] introduced a diffraction-gated realtime ultrahigh-speed mapping (DRUM) photography that can capture a transient event in a single exposure at 4.8 million FPS and a sequence depth of 7 frames using a DMD. Mertz et al. [3] introduce single-shot nonsynchronous array photography (SNAP), that uses a DOE, glass echelons for time delays, and a microlens array (MLA) to capture 5.7 trillion frames per second. Here, we present a novel spatially multiplexed low-cost ultrafast imaging technique that can achieve a sequence depth of 10 frames and 685 billion FPS. The experimental setup shown in Fig.1a consists of a 6x6 microlens array (MLA), a spatially varying delay unit, an imaging lens, and a commercially available low-cost sensor. Here, the MLA creates 36 copies of the input image from the dynamic scene, and the spatially varying delay unit provides different latencies for each copy.



b b

Figure 1 : a) The setup of the ultrafast camera. (b) Formation of a pulse.

We designed this delay unit using microscope glasses with a refractive index of 1.44. The delay caused by a 1 mm thick glass is approximately 1.46 picoseconds which is our temporal resolution. Using a simple spatially varying delay for each row and column of the MLA, information from the dynamic scene arrives at different times at the sensor. Since each copy of the dynamic scene created by the MLA arrives at the sensor with different latency, in a single shot image we can obtain the evolution of the dynamic scene with 685 billion FPS and a sequence depth of 10 frames. To observe the evolution of a laser pulse, we performed pulse picking with AOM and sent one pulse to MLA and glass delay lines. We captured the single shot image with a conventional sensor and extracted 10 frames from the same image with increasing order of relative delay from 0 to 10. The formation of a pulse can be seen in Fig.1b. The intensity of each frame is plotted against relative delay, which forms the pulse shape fitted to the Gaussian pulse. The frames are normalized, and the noise floor is subtracted from each frame.

Our novel camera design is validated by experimental observation of a picosecond laser pulse in a single-shot image with 10 frames of depth with a temporal resolution of 1.46 picoseconds. Our method is a low cost, ultrafast and compact imaging setup that can be used to visualize ultrafast events.

Keywords: Ultrafast Imaging, Single-shot Imaging, Temporal delay

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Optical Computing with Multimode Continuous-Wave Laser

Dilem Eşlik[1], Fatma Nur Kılınç[2], Uğur Teğin[1]*
[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye*
[2]*Computational Sciences and Engineering, Koç University, Istanbul, 34450, Türkiye*
E-mail: utegin@ku.edu.tr

Abstract
We present a multimode continuous-wave (CW) Yb-doped fiber laser at 1030 nm incorporating an intracavity spatial light modulator (SLM) for optical computing. The multimode fiber provides a naturally high-dimensional space for information encoding, while the intracavity SLM enables programmable control of the intracavity field, functioning as a reconfigurable weight matrix. Nonlinear intracavity effects, including gain saturation and mode competition, introduce rich dynamics that act as photonic equivalents of neural activation and inhibition. In this way, the system extends foundational work on optical neural models [2], connects with recent advances in scalable photonic learning operators [1], and aligns with contemporary directions in optical computing [3].
The experimental setup (Fig. 1a) consists of a CW Yb-doped fiber laser cavity with intracavity SLM. The 976 nm pump passes through the dichroic mirror and 1030 nm lasing is reflected due to 4% Fresnel reflection from the edges of the fiber. The output of the multimode fiber is collimated, and the beam is expanded onto the SLM, which imposes spatially varying phase masks to shape the intracavity field. This configuration allows direct mapping of input data onto modal distributions of the laser field. The nonlinear cavity dynamics evolve the encoded field with cavity dynamics like gain saturation, which creates the nonlinearity, and mode competition, which is the selective amplification of some modes. The resulting intensity distributions are captured by a camera at the output. A simple digital classifier is applied only at the final stage to interpret the optically processed patterns.

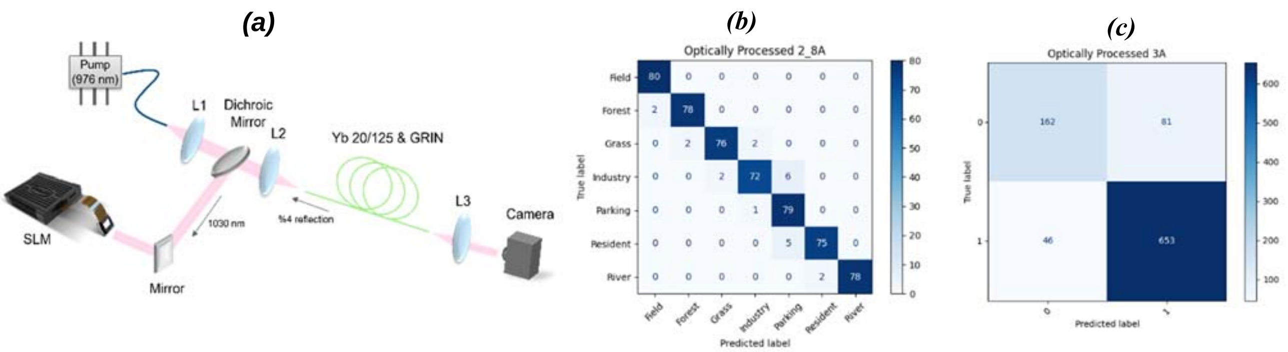

Figure 1: (a) The setup. (b) The confusion matrix of RSSCN7 dataset, achieving 96% accuracy. (c) The confusion matrix of PneumoniaMNIST, achieving 87% accuracy.

The computational capability of the system was evaluated on two benchmark datasets. On the RSSCN7 dataset, which involves scene classification, the system achieved 96% accuracy (Fig 1b), the highest reported to date. On the PNEUMONIA-MNIST dataset, the system reached 87% accuracy (Fig. 1c), outperforming deep learning architectures such as ResNet. These results demonstrate that multimode intracavity lasers are not only competitive with state-of-the-art electronic neural networks but can also surpass them in certain tasks.
In conclusion, our multimode CW Yb-doped fiber laser with intracavity SLM establishes a compact and scalable platform for photonic neural networks. By combining modal richness, programmable intracavity modulation, and nonlinear effects such as gain saturation and mode competition, the system provides a powerful route toward real-time, energy-efficient optical computing. These results validate the potential of multimode intracavity photonic systems as next-generation computational engines, bridging the gap between laser physics and machine learning.

Keywords: Optical computing, Photonic neural networks, Laser dynamics

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Experimental Evaluation of the Thermal Effect of Circumferentially Emitted Laser Irradiance in an In-Vivo Rabbit Esophageal Model

Seval Ünal*[1,2], Merve Türker Burhan[1,2], Serhat Tozburun[1,2,3]
[1]*Izmir International Biomedicine and Genome Institute, Dokuz Eylul University, Balcova, Izmir, Türkiye*
[2] *Izmir Biomedicine and Genome Center, Mithatpasa St. 58/5, Balcova, Izmir, Türkiye*
[3] *Department of Biophysics, Faculty of Medicine, Dokuz Eylul University, Balcova, Izmir, Türkiye*
Email: seval.unal@ibg.edu.tr

Abstract
Barrett's esophagus is a premalignant condition caused by the replacement of normal squamous epithelium with columnar epithelium, typically resulting from chronic acid reflux [1]. This condition increases the risk of developing esophageal adenocarcinoma [2]. Current treatment options, such as endoscopic mucosal resection (EMR), radiofrequency ablation (RFA), and argon plasma coagulation (APC), have several limitations, including organ narrowing and bleeding due to the uncontrolled thermal injury [3].
To address these challenges, we investigated a novel endoscopic cap designed for circumferential laser coagulation using a radial fiber. The cap features a recessed channel for well-confined thermal damage. A motorized stage is used for precise control over longitudinal pullback of the endoscopic cap along the esophageal surface. We conducted in vivo experiments on the rabbit esophagus, evaluating 1540 nm laser irradiation at power levels ranging from 0.9 to 1.8 W and pullback speeds between 0.5 and 2.0 mm/s, with vacuum pressures set between 100 and 300 mmHg. The thermal effects of the treatment were analyzed using histological and histochemical assessments of tissue samples collected immediately after treatment and six hours later.

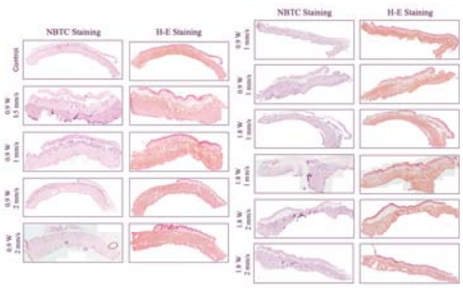

Figure 1: Histological evaluation of the rabbit esophagus demonstrates tissue responses to circumferential 1540 nm laser irradiation at different irradiance levels and withdrawal speeds. Representative NBTC and H&E-stained sections are shown at 4x magnification.

Keywords: Barrett's Esophagus, Endoscopic laser therapy, Radial optical fiber, Vacuum-assisted endoscope, Rabbit esophagus model, Histological evaluation

Acknowledgements
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Hybrid Fractional Fourier Transform to Improve Reconstruction Resolution in Digital Off-Axis Holography

Müge Topcu*[1,2] and Serhat Tozburun[1,2,3]
[1]Izmir International Biomedicine and Genome Institute, Dokuz Eylul University, 35340, Türkiye
[2]Izmir Biomedicine and Genome Center, 35340, Türkiye
[3]Department of Biophysics, Faculty of Medicine, Dokuz Eylul University, 35340, Türkiye
Email: muge.topcu@ibg.edu.tr

Abstract

Digital off-axis holographic microscopy (DHM) is a powerful quantitative phase imaging method that allows label-free and rapid visualization of biological samples [1]. While it offers strong temporal performance, its spatial resolution is limited by the restrictions of the Fourier-domain filtering process. To overcome this, we introduce the use of the fractional Fourier transform (FrFT) as an alternative to the standard Fourier transform within the imaging workflow. The FrFT offers a flexible way to manage information between spatial and frequency domains, enabling the better utilization of the sensor's capacity [2]. By employing this approach, the unwanted background and twin image terms are effectively suppressed, allowing for improved recovery of high-frequency details in the reconstructed images [3]. The technique maintains the speed advantages of DHM while significantly enhancing image clarity. Demonstrations with live cells confirm that this hybrid FrFT-DHM method provides more detailed morphological information, suggesting its strong potential for advanced live-cell imaging where both resolution and rapid acquisition are essential.

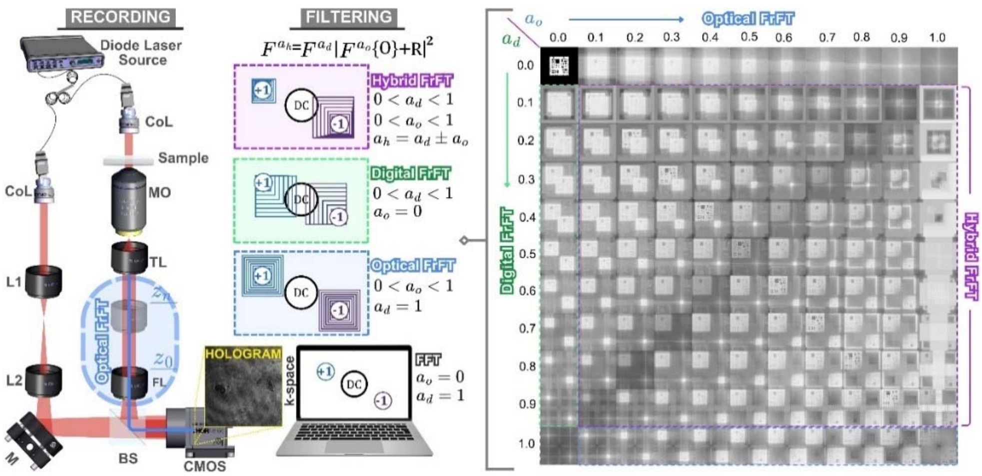

Figure 1: Graphical abstract of the hybrid FrFT-DHM system. Recording stage, filtering stage, and corresponding space-frequency matrix.

Keywords: Fractional Fourier transform, digital holographic microscopy, quantitative phase imaging, live cell imaging

Acknowledgements

This work is supported by the European Research Council (ERC) under the European Union's Horizon Europe funding programme for research and innovation (Grant agreement No. 101171563—CLARISURGE). Müge Topcu was partially supported by TÜBİTAK 2211-A National PhD Scholarship Program.

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VPI Photonics Ortamında TDLAS Tabanlı Metan Algılama Modeli Geliştirilmesi

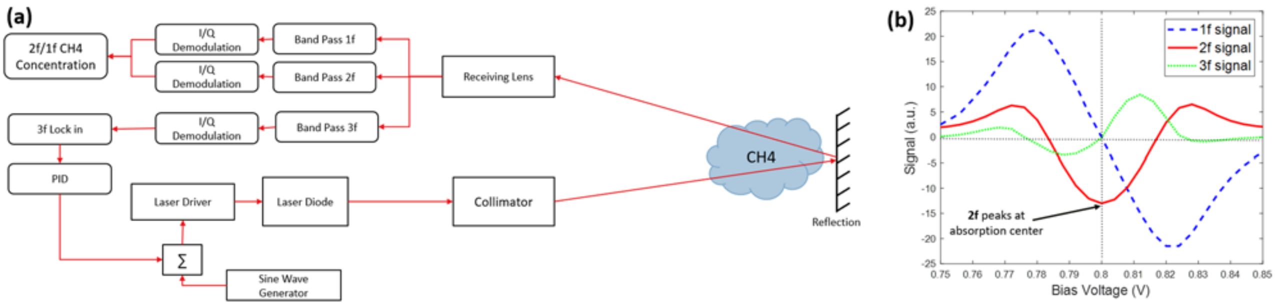
Abdulkadir Yentür*[1,2], Gülşah Yıldız[1], Süheyl Token[1], Tolga Kartaloğlu[1], Ekmel Özbay[1,3], İbrahim Özdür[2]
[1]Nanoteknoloji Araştırma Merkezi (NANOTAM), Bilkent Üniversitesi, Ankara, Türkiye
[2]Elektrik-Elektronik Mühendisliği, TOBB Ekonomi ve Teknoloji Üniversitesi, Ankara, Türkiye
[3]Elektrik-Elektronik Mühendisliği, Bilkent Üniversitesi, Ankara, Türkiye
*corresponding author, E-mail: abdulkadir.yentur@bilkent.edu.tr

Özet / Abstract

Ayarlanabilir diyot lazer absorpsiyon spektroskopisi (TDLAS), gazların seçici ve yüksek hassasiyetli tespitinde öne çıkan bir yöntemdir [1]. Bu çalışmada, VPI Photonics yazılımı kullanılarak 1653,72 nm dalga boyunda metan (CH_4) algılama modeli geliştirilmiştir. Simülasyon modelinde lazer kaynağı, optik yol, metan absorpsiyon hücresi ve fotodiyot gibi temel bileşenler bir araya getirilmiş; ayrıca serbest-uzay (free-space) etkileri de değerlendirilmiştir. Lazer üzerine 10 kHz sinüzoidal modülasyon uygulanarak dalgaboyu modülasyonlu spektroskopi (WMS) gerçekleştirilmiştir [2].

Modelde elde edilen 1f, 2f ve 3f harmonik sinyalleri I/Q demodülasyon ve lock-in amplifier yöntemleriyle analiz edilmiştir [3]. Özellikle 2f/1f normalizasyonunun metan derişiminin güvenilir şekilde belirlenmesini sağladığı görülmüştür. 3f bileşeni ise taban kaymaları ve girişim etkilerinin değerlendirilmesinde ek avantaj sunmakta ve merkez dalgaboyu kilitleme yöntemlerine katkı sağlayabilecek bilgiler üretmektedir.

Simülasyon sonuçları, 30 metreye kadar optik yol uzunluklarında ve 50.000 ppm·m seviyesine kadar geniş bir derişim aralığında güvenilir çıktılar vermektedir. Geliştirilen modelin blok diyagramı Şekil 1-a'da ve simülasyondan elde edilen harmonik bileşen örnekleri (1f, 2f, 3f) Şekil 1-b'de verilmiş olup, yöntemin uygulanışını ve işlenen sinyallerin karakterini göstermektedir. Çalışma, TDLAS tabanlı sistemlerin VPI Photonics ile başarılı bir şekilde modellenebildiği hem laboratuvar ortamında hem de açık-yol koşullarında meydana gelecek etkilerin başarılı bir şekilde incelendiği örnek bir model olmuştur.



Şekil 1: (a) TDLAS yöntemi blok şema gösterimi, **(b)** 1f, 2f ve 3f harmonik bileşenlerin gösterimi

Anahtar Kelimeler: TDLAS, Metan Algılama, VPI Photonics

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Wavelet-Informed Pix2pix Model with an FID-based Loss Function for Confocal Microscopy

Giray Nuri Mavis*[1,2], Berkay Ahmet Durmus[3], Semih Burhan[3], Dilek Nazlı[1,4], Gunes Ozhan[1,4], and Serhat Tozburun[1,2,3]

[1] *Izmir Biomedicine and Genome Center, Mithatpasa St. 58/5, Izmir, Türkiye*
[2] *Izmir International Biomedicine and Genome Institute, Dokuz Eylul University, Izmir, Türkiye*
[3] *Healysense A.S., Mithatpasa St. 56-20/Z P2/E, DEPARK, Izmir, Türkiye*
[4] *Department of Molecular Biology and Genetics, Izmir Institute of Technology, Izmir, Türkiye*
corresponding author, E-mail: giray.mavis@std.ibg.edu.tr

Abstract

Confocal laser scanning microscopy (CLSM) is known for providing high-quality, high-contrast images [1]. Its single-point detection and advanced illumination systems enable precise scanning across the focal plane. Since CLSM scans the specimen through a pinhole, the acquisition time increases due to the point-by-point scan. The drawback of CLSM is that prolonged laser exposure can cause photobleaching. We propose a conditional generative adversarial network, an artificial intelligence model to overcome this challenge [2,3]. A common problem with generative adversarial networks is the realism of the generated content. Failing to maintain realistic content in generated images could lead to misinformation or incorrect conclusions in further research. Our model takes low-quality images as input and generates more realistic high-quality outputs compared to other state-of-the-art models. Our method integrates discrete wavelet transforms and U-Net convolutional deep learning algorithms, which help preserve the real information within our generated images and prevent the creation of unrealistic content. We evaluated our approach using two different biological samples: zebrafish and convallaria. Figure 1 illustrates the proposed workflow, which reduces the time required for acquisition while maintaining image quality comparable to that of high-quality images, thereby offering a significant advancement in confocal microscopy for biological research and beyond.

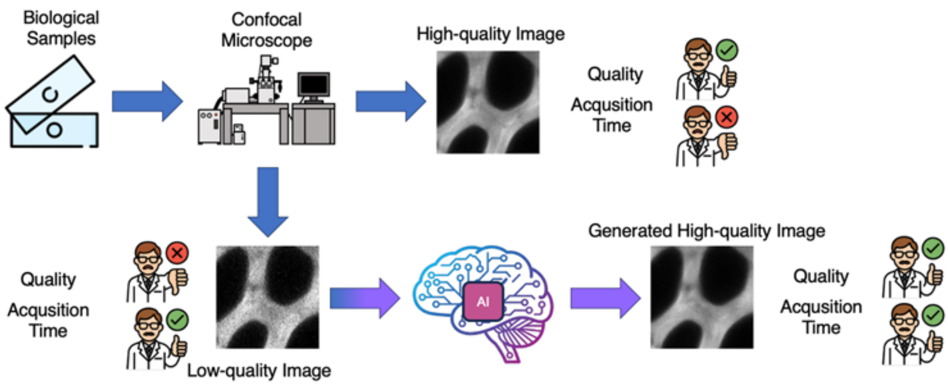

Figure 1: Our proposed workflow to reduce the time required to acquire high-quality confocal images.

Keywords: Artificial intelligence, deep learning, confocal microscopy, image processing, generative adversarial networks.

Acknowledgements
This work was supported by Healysense A.S. (Izmir, Türkiye).

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Freeform Design in Silicon Nitride Waveguides

Gülsüm Yaren Durdu, Azka Iskandar Maula Muda,Uğur Teğin*
Department of Electrical and Electronics Engineering, Koç University, Istanbul, 3440, Türkiye
corresponding author, E-mail: utegin@ku.edu.tr

Abstract

Silicon nitride (Si_3N_4) has emerged as a key material in integrated photonics owing to its broad transparency window, low optical loss, high nonlinear refractive index, and compatibility with CMOS fabrication processes [1]. A major challenge in waveguide design, however, lies in mitigating mode mismatch, scattering, and reflection losses that typically arise in conventional straight waveguides with uniform cross-sections. In this work, we present a data-driven optimization approach for freeform Si_3N_4 waveguides, where the waveguide width is varied along the propagation direction while the height is kept constant, and tapered sections are introduced to ensure smooth mode transitions. Light propagation is modeled using the multimode nonlinear Schrödinger equation, and Bayesian optimization is employed to fine-tune the waveguide geometry. Similar freeform design principles have been demonstrated for nonlinear processes such as coherent supercontinuum generation [2], and here we adapt them for optical computing. Our results show that while conventional straight waveguides achieve 94% classification accuracy, the optimized freeform waveguide design improves performance significantly, reaching 98% accuracy. These findings highlight the potential of freeform waveguides in advancing optical computing applications.

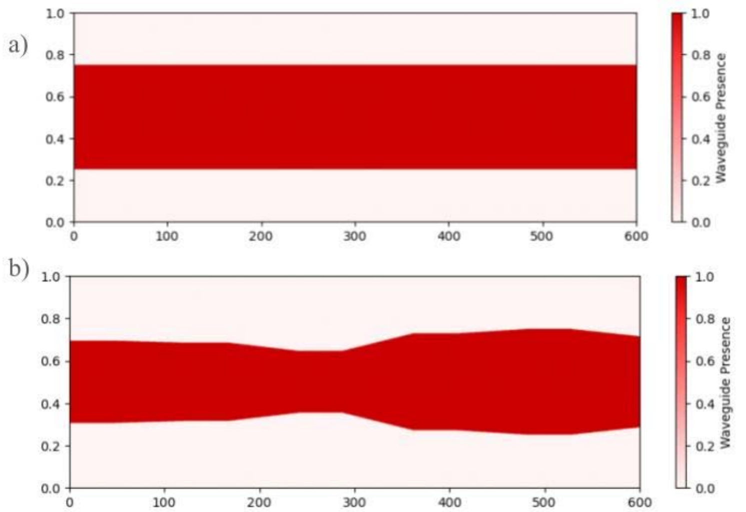

Figure 1: a) Straight Waveguide (b) Freeform Designed Waveguide

Keywords: Freeform waveguides, optical computing

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Rogue Wave Dynamics in Silicon Nitride Waveguides

Gülsüm Yaren Durdu, Uğur Teğin*

Department of Electrical and Electronics Engineering, Koç University, Istanbul, 3440, Türkiye

corresponding author, E-mail: utegin@ku.edu.tr

Abstract

Rogue events in optics are rare and extreme pulses of light that occur more frequently than expected, analogous to rogue waves in the ocean [1]. Such events have been observed in supercontinuum generation within optical fibers [2], and recent studies highlight their relevance in integrated photonic platforms. In this work, we investigate rogue events in silicon nitride (Si_3N_4) waveguides, which support multiple transverse modes and exhibit strong nonlinear effects [2]. The evolution of ultrashort pulses in these structures is governed by the interplay of dispersion and nonlinearities such as self-phase modulation, soliton dynamics, and dispersive wave emission. Using numerical simulations of the generalized nonlinear Schrödinger equation (GNLSE), we analyze how different mode excitations influence the probability and characteristics of rogue events. Our results show that the choice of excited modes plays a critical role: certain mode combinations enhance the likelihood of extreme fluctuations, while others suppress them. Understanding this dependence provides new opportunities for controlling rare, high-intensity events in integrated waveguides and optimizing supercontinuum generation for practical applications.

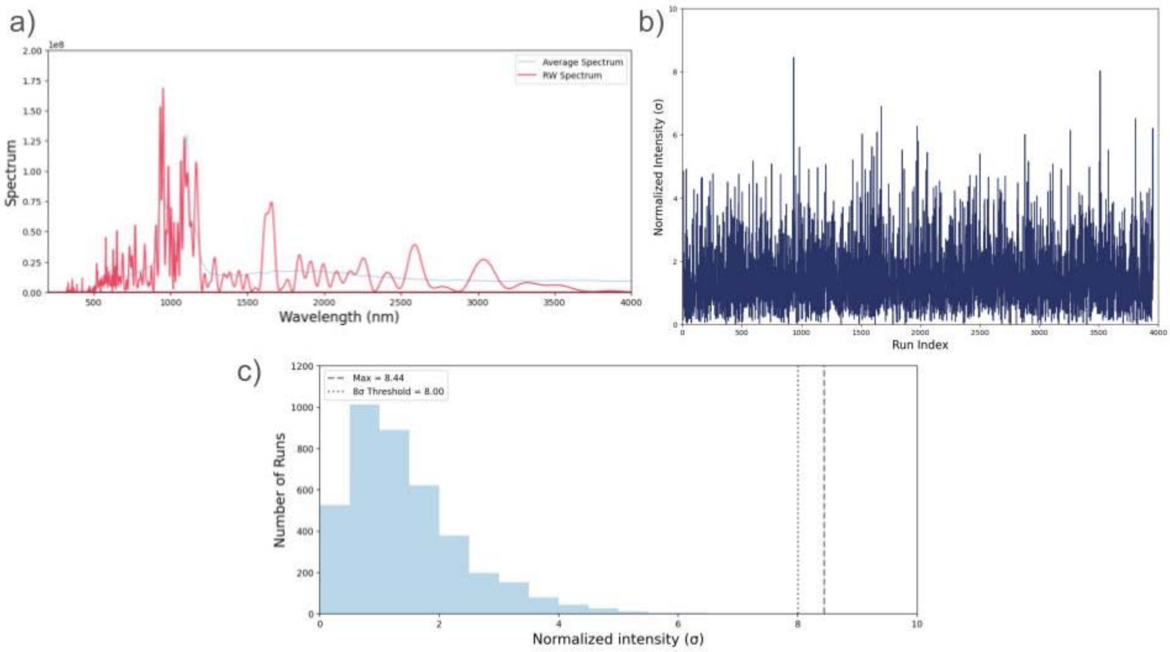

Figure 1: (a) Average and Rogue Wave Spectrum (b) Normalized Intensities Across Runs (c) Histogram of Normalized Intensity

Keywords: Nonlinear Optics, Rogue Wave, Silicon nitride

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Preliminary Design and Simulation of Resonant Gratings via S3NL Method on Platinum-Coated Silicon

Beliz Doğukaya[1], Mehmet Bütün[1], Rana Asgari Sabet[2], Onur Tokel*[1,2]
[1] Department of Physics, Bilkent University, Ankara 06800, Türkiye
[2]UNAM, Bilkent University, Ankara 06800, Türkiye
corresponding author, E-mail: otokel@bilkent.edu.tr

Abstract
Silicon, is the foundational material for both electronics and photonics with its exceptional physical and optical properties. While nonlinear laser lithography with a nanosecond-pulsed Gaussian beam has enabled volumetric (in-chip) modifications with ~1 µm resolution [1], our recent work demonstrates that employing Bessel beams can extend this capability into the sub-diffraction regime, achieving feature sizes down to ~100 nm [2]. We have also extended the subsurface nanostructuring technique to an on-chip nanofabrication method, and introduced Subsurface Seeded Surface Nanolithography (S3NL) for silicon [3]. In the S3NL method, nanosecond Bessel beams generate buried nano-modifications that act as defect-rich precursors; irradiating the regions above these seeds with a spatially modulated laser beam, combined with precise sample scanning, enables the transfer of subsurface patterns into controlled surface nanostructures on pristine silicon. This strategy yields freeform features as small as 150 nm, surpasses the limits of conventional laser ablation while eliminating the need for masks and resists, and provides tunability of lateral dimensions through laser pulse energy and polarization, while the depth is defined by the placement of the in-chip seed layers from ~60 nm to ~300 nm. In this work, we have applied S3NL to fabricate surface nanogratings on metal-coated silicon. We coated 30 nm of platinum on a 1 mm thick p-doped and double-sided polished silicon sample and used the S3NL technique to create the surface nanostructures on the thin metallic layer. The resulting structures, shown in Fig. 1(a), have a feature size of ~900 nm with a 3 µm period. The grating depth could be tuned through controlled positioning of the seed layer or metal-assisted etching. We propose a resonant surface grating for the light sources with a wavelength of 2 µm based on fabricated nanostructures at a depth of 300 nm. This wavelength is of particular interest for LiDAR applications. We have simulated the optical behaviour of the proposed surface nanostructures with the Finite Difference Time Domain (FDTD) method. The proposed surface grating operates in reflection mode and yields a resonance near a 19° incidence at the operating wavelength of 2 µm. The observed resonance behavior is consistent with Mie theory, as shown in Fig. 1(b), with a measured full-width at half-maximum (FWHM) of 2 degrees, corresponding to a Q-factor of ~10.

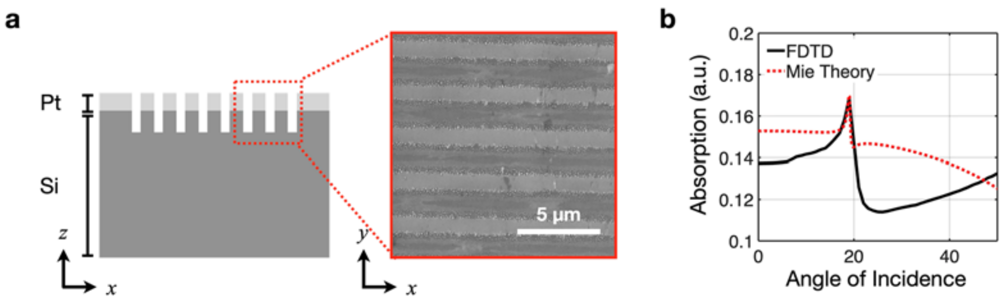

Figure 1: (a) Schematic of the proposed surface nanogratings and SEM image of nanostructures with a 3 µm period and ~950 nm feature size, fabricated on 30 nm Pt-coated silicon using the S3NL technique. (b) FDTD-simulated angular absorption at λ = 2 µm, showing a reflection-mode Mie-type resonance near 19°.

Anahtar Kelimeler / Keywords: laser, lithography, surface, nanostructure, grating.

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A Low-Bandwidth FFT-Based Approach to Brillouin Scattering Signal Analysis in BOTDR Signals

Volkan Türker*[1], Ali Emre Yılmaz[4], Tolga Kartaloğlu[1], Faruk Uyar[1,2], Ekmel Özbay[1,2,3], İbrahim Özdür[4]

[1]NANOTAM, Bilkent University, Ankara, Türkiye
[2]Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye
[3]Physics, Bilkent University, Ankara, Türkiye
[4]Department of Electrical and Electronics Engineering, TOBB ETU, Ankara, Türkiye
volkan.turker@bilkent.edu.tr

Abstract

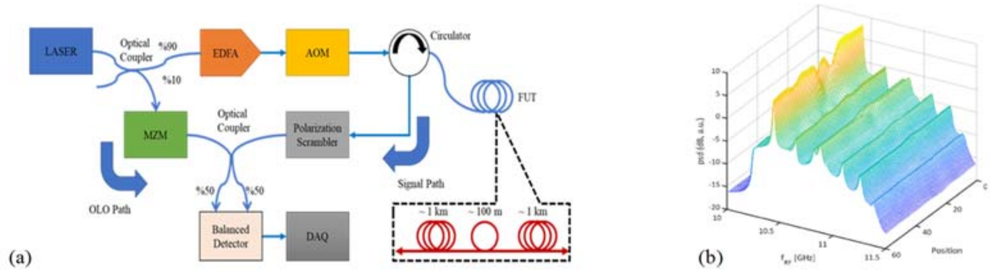

Figure 1: Experimental set-up (FUT (fiber under test), EDFA (Erbium-doped fiber amplifier), AOM (acoustic optic modulator), DAQ (data acquisition unit)), b) PSD concerning OLO frequency and position

In BOTDR systems, temperature and strain variations along the optical fiber are detected using the Brillouin frequency shift, which originates from signals scattered back within the fiber [1-3]. This Brillouin frequency shift, influenced by changes in strain or temperature, spans a broad range of approximately 9–13 GHz with a bandwidth of roughly 20 MHz [2, 3]. It is important to determine the center frequency and track any frequency shifts accurately; however, achieving this within a signal bandwidth limited to 100 MHz requires a novel approach. To overcome these challenges, this study introduces a novel static measurement approach.

The developed approach enables the analysis of Brillouin signals within the 9–13 GHz frequency range using an electronic signal bandwidth limited to 100 MHz. As illustrated in the experimental setup shown in Fig. 1a, this approach is based on FFT data analysis and employs a unique technique. In the optical local oscillator (OLO) path, using a Mach-Zehnder modulator (MZM) radio frequency (RF) scan between 9–13 GHz is achieved. The magnitude values of the FFT at different FFT frequency forms a separate signal trace with changing RF value. For each position (distance in the fiber), a shifted sum of traces is applied to obtain a single trace of Brillouin data. Such a shift allows us to constructively sum data where Brillouin backscattering occurs, while destructive interference reduces noise and unwanted signals where no shift is present. This procedure provides valuable insights into the Brillouin frequency distribution. As depicted in Fig. 1b, this method enables simultaneous observation of both Stokes and anti-Stokes signals while effectively reducing noise, leading to the efficient reconstruction of the Brillouin spectrum.

In conclusion, by shifting the signal frequency in the OLO path, the Brillouin spectrum within the 10–11.5 GHz range was successfully analyzed over the FUT. This study demonstrates that such analyses can be conducted using a system with a low signal bandwidth and a low data sampling rate. Additionally, this method facilitates the simultaneous examination of Stokes and anti-Stokes signals along the entire fiber using the frequency shift of the AOM. A novel averaging technique was introduced to combine different frequency components of FFT analysis, significantly reducing noise in the frequency spectrum. Future research will focus on a more detailed characterization of the noise reduction and extended analysis of the Brillouin spectrum across the broader 9–13 GHz range, particularly over a 50 km fiber span.

Keywords: Brillouin scattering, Brillouin frequency shift, strain, temperature, BOTDR

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Silikon Tabanlı Fotodedektörlerde KOH Kimyasal Aşındırma Prosesi İle Fotocevap Performansının İyileştirilmesi

Elif Cemre Yiğit[1], Cem Alibeyoğlu[1], Ferhat Uçar[1], Levent Özkarayel[1], Akın Aydemir[1], M. Cihan Çakır[1], Ekmel Özbay[1]

[1]Bilkent Üniversitesi, Nanoteknoloji Araştırma Merkezi, Ankara

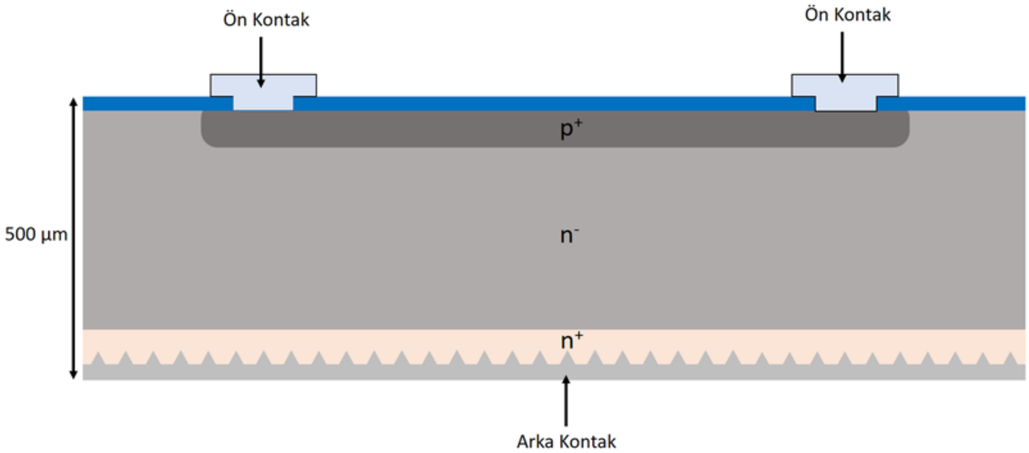
cemre.yigit@bilkent.edu.tr

Özet

Silisyum PIN fotodedektörlerin fotocevap performansı, askeri ve ticari teknolojiler içeren konvansiyonel sistemler gibi birçok uygulama için kritik bir performans parametresidir. Bu çalışmada, arka yüz yüzey dokulandırmasının Si PIN fotodedektörlerin tepkiselliği üzerindeki etkisi araştırılmıştır. Optimize edilmiş ıslak aşındırma teknikleriyle gerçekleştirilen dokulandırma işlemi, özellikle yakın kızılötesi dalga boyu aralığında ışığın aktif bölgede daha fazla yol almasını ve soğurulma olasılığını arttırmaktadır.

Geleneksel metodla, fotodedektör tepkisellik performansı daha kalın soğurma bölgesi ile de artıralabilmektedir. Ancak foton yolunun artırılması dedektörün bir diğer parametresi olan tepki süresini de artırmakta ve dedektörü yavaşlatmaktadır. Arka yüzey dokulandırma tekniğinde ise taşıyıcıların sürüklenme mesafesi uzamadığı için tepkisellik artışı, dedektör tepki süresi etkilenmeden sağlanabilmektedir. Bu sayede piyasada yaygınlıkla bulunan wafer kalınlıklarıyla çalışılarak fotodedektörlerde taşıyıcı geçiş süresi korunarak optik soğurma etkin bir şekilde artırılabilmektedir. Bu bulgular, arka yüz dokulandırma işlemini, yüksek hızlı Si PIN fotodedektörlerde tepkiselliği artırmak için maliyet etkin ve yüksek performanslı bir yaklaşım olarak ön plana çıkarmaktadır.

Bu çalışmada Si alttaş kalınlığı ve arka yüz topografisinin, PIN yapılı silisyum fotodedektörlerin temel performans parametreleri üzerindeki etkisi deneysel olarak incelenmiştir.



Şekil 3: Arka Yüzeyi Dokulandırılmış Si PIN Fotodedektör Yapısı

Anahtar Kelimeler: KOH dokulandırma, fotodedektör performansı, tepkisellik, fotocevap

Kaynaklar

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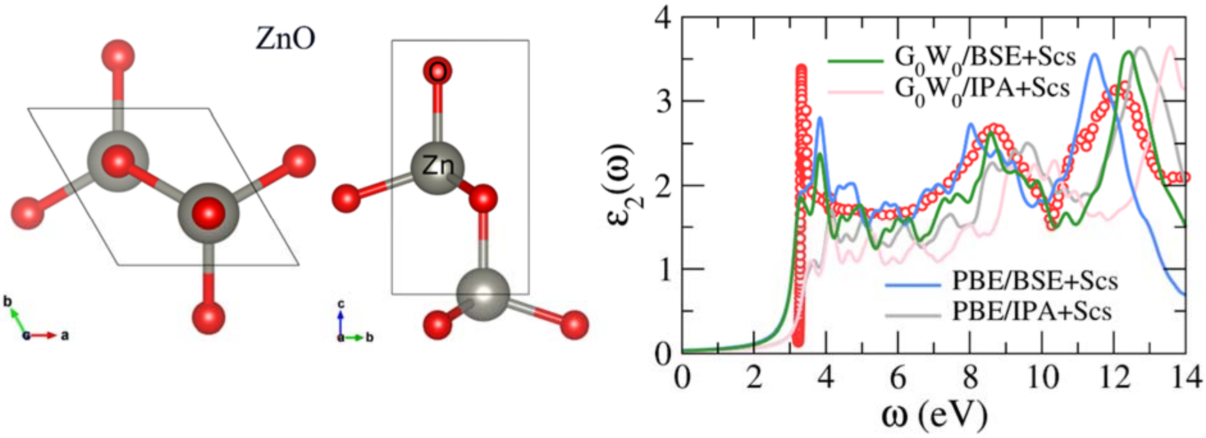
ZnO'nun Elektronik ve Optik Davranışlarının Çok Ölçekli Kuramsal İncelemesi

Zafer Kandemir*[1], Cem Sevik[2], Kürşat Şendur[1]
[1]Faculty of Engineering and Natural Sciences, Sabanci University, 34956 Istanbul, Türkiye
[2]Department of Physics and NANOlight Center of Excellence, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium
corresponding author, E-mail: zafer.kandemir@sabanciuniv.edu

Özet
Çinko oksit (ZnO), geniş bant aralığı, yüksek optik geçirgenliği ve kimyasal kararlılığı sayesinde özellikle ultraviyole (UV) filtreleme, sensör teknolojileri, şeffaf iletken oksitler ve optoelektronik uygulamalarda öne çıkan bir yarıiletken malzemedir. ZnO'nun kuramsal olarak doğru modellenmesi, deneysel verilerle tutarlı bant aralığı ve optik spektrum elde edebilmek için birçok-cisim etkilerinin hesaba katılmasını gerektirir. Bu çalışmada, hekzagonal wurtzit ZnO'nun kristal yapısı yoğunluk fonksiyonel teorisi (density functional theory, DFT) kapsamında Perdew-Burke-Ernzerhof (PBE) fonksiyoneli ile optimize edilmiş ve elektronik bant yapısı ile durum yoğunluğu hesaplanmıştır. DFT'nin bant aralığını küçümsemesini gidermek amacıyla, makas operatörü (Scs) ile desteklenen GW yöntemi uygulanmış ve deneysel değere yakın 3.44 eV bant aralığı elde edilmiştir. Optik özellikler, hem bağımsız parçacık yaklaşımı (IPA) hem de Bethe–Salpeter denklemi (BSE) ile hesaplanmış, iki polarizasyon yönü için dielektrik fonksiyonları elde edilmiştir. Sonuçlar, eksitonik ve birçok-cisim etkilerinin ZnO'nun optik tepkisinin modellenmesinde kritik rolünü ortaya koymakta, deneylerle iyi bir uyum sergilemekte ve gelecekteki fotonik uygulamalar için güvenilir bir kuramsal temel sağlamaktadır.



Şekil 1: Wurtzit ZnO'nun kristal yapısının atomik gösterimi. Çinko (gri) ve oksijen (kırmızı) atomlarının uzaysal düzeni gösterilmektedir. ZnO'nun $\varepsilon_2(\omega)$ dielektrik fonksiyonunun hesaplanan sonuçları ve deneysel veri [1]. Hesaplamalar GW/BSE+Scs (yeşil), GW/IPA+Scs (pembe), PBE/BSE+Scs (mavi) ve PBE/IPA+Scs (gri) yaklaşımları ile elde edilmiştir. Deneysel sonuçlar kırmızı dairelerle gösterilmiştir [1]. GW/BSE+Scs sonuçları düşük enerji bölgesi dahil olmak üzere deneysel spektrumla iyi bir uyum sergilemektedir.

Anahtar Kelimeler: çinko oksit, yoğunluk fonksiyonel teorisi, PBE, GW, Bethe-Salpeter denklemi

Acknowledgements
Bu çalışma, Air Force Office of Scientific Research (Aerospace Materials for Extreme Environments Program, PM: Dr. Ali Sayir) tarafından FA8655-22-1-7023 proje numarasıyla desteklenmiştir. Bu araştırmada yer alan tüm nümerik hesaplamalar Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) ULAKBİM, Yüksek Başarım ve Grid Hesaplama Merkezi'nde (TRUBA kaynaklarında) gerçekleştirilmiştir.

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Entropy Enhancement in Quantum Key Distribution via a Dynamic Polarization Controller

Abdulhay Can Kara*[1,3], Süheyl Töken[1], Muhammed Kaan Yıldız[1,2], Ekmel Özbay[1,2,3], İbrahim Özdür[4]

[1] NANOTAM, Bilkent University, Ankara, Türkiye

[2] Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye

[3] Department of Physics, Bilkent University, Ankara, Türkiye

[4] Department of Electrical and Electronics Engineering, TOBB ETÜ, Ankara, Türkiye

abdulhay.kara@bilkent.edu.tr

Abstract

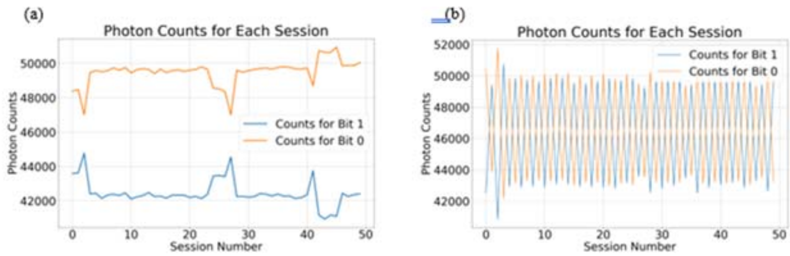

Figure 1: Number of photons detected for each bit value in each session (a) the case where the method is not applied (b) the case where method is applied

Quantum key distribution (QKD) is a method that enables the creation of symmetric keys between two points, whose security is based on quantum physics [1]. Although its security has been proven theoretically; in real life applications, deficiencies in the systems may occur because of the imperfections of devices [2]. One of the problems encountered is the low entropy of the raw key due to detector-efficiency mismatch which increases information leakage in finite-key settings.

In this study, we eliminate the difference in bit counts due to efficiency mismatch by actively directing bits to different SPADs using a dynamic polarization controller. In our QKD setup, we use BB84 and encode bits in polarization. On Alice, key bits are encoded into RC (Right Circular) and LC (Left Circular) states with a POGNAC loop and sent at average photon level of $\mu \approx 0.6$ per pulse. On Bob's side, after the basis selection is made with a passive 50:50 beamsplitter, the distorted polarization is compensated with the dynamic polarization controller. For this projective measurement, RC and LC are actually mapped to H and V states to ensure that the bits are correctly separated by PBS and thus detected with different SPADs. Theoretically, after minimizing QBER, we add an extra $V\pi$ on the DPC's Z-axis channel; this π step flips the X-axis mapping and directs photons to the other SPAD. In practice, because the QBER minimum is slightly offset from an exact H/V mapping, we also apply a small correction voltage to the DPC's Y-axis channel to fine-tune the mapping. In Fig. 1a (no scrambling), the 0 bit has more counts because it is detected by the higher-efficiency SPAD. In Fig. 1b (with scrambling), the mapping is constantly changed between the two SPADs, the counts reach similar average values. As a result, the min-entropy increases from 0.91 to 0.985.

A shortcoming of this work is that scrambling is session-based, meaning it's slow. If scrambling is done on a bit-by-bit basis, it not only increases entropy but also provides security against man-in-the-middle attacks like time shift attacks [3].

Keywords: Quantum Key Distribution (QKD), dynamic polarization controller, detector-efficiency mismatch, min-entropy

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Effect of Oxygen Parameters on Optical and Electrical Properties of ITO Coatings on Polycarbonate and Glass Substrates

Tuğba BİLGİN*, **Özlem EKER**
Volo Composite and Engineering LTD.STI.,
06980 Kahramankazan Ankara Türkiye
*corresponding author, E-mail: tugba.bilgin@volo.com.tr

Abstract

Transparent materials used in aerospace applications are required to simultaneously provide high optical transmittance and low electrical resistance. Therefore, transparent conductive oxide coatings such as indium tin oxide (ITO) applied on polycarbonate (PC) and glass substrates offer a critical solution. In this study, ITO coatings deposited under varying oxygen partial pressures and process conditions are investigated.

The effects of deposition parameters on coating morphology, optical transmittance, surface electrical resistance, and adhesion were analyzed. Results indicate that increasing the oxygen content improves optical transmittance for both PC and glass substrates; however, this improvement is accompanied by an increase in surface resistance. Coating adhesion and stability were also found to be strongly influenced by the optimization of process gas composition and pressure.

Therefore, to achieve the goal of "minimum resistance – maximum optical transmittance," the optimum deposition conditions were determined to be controlled oxygen levels combined with balanced process parameters.

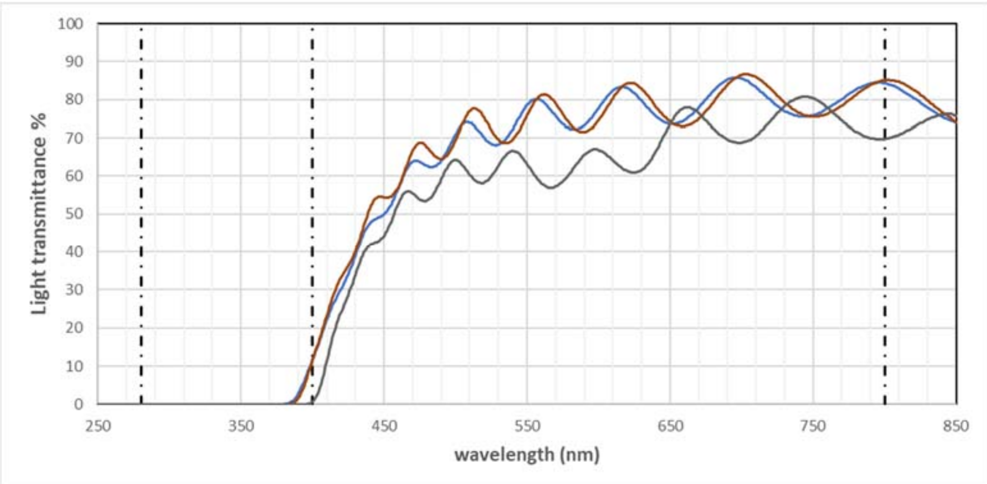

Figure 1: Optical transmittance spectra of ITO films deposited under different coating parameters (oxygen partial pressure and etc.)

Keywords: TCO (transparent conductive oxide) coating, ITO (indium tin oxide), polycarbonate, glass, optical transmittance, electrical resistance

Acknowledgements : This study was carried out at Volo Composite and Engineering Ltd.

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Efficient Continuous-Wave (2W) and Passively Q-switched Operations of a Femtosecond Laser Inscribed Tm,Ho:YLF Waveguide Laser at 2.05 μm

Berke Ayevi[1], Yağız Morova[1,2,3], Eugenio Damiano[4], Mauro Tonelli[4] and Alphan Sennaroğlu[*1,2]

[1]*Laser Research Laboratory, Department of Physics and Electrical-Electronics Engineering, Koç University, Istanbul 34450, Türkiye*

[2]*Koç University Surface Science and Technology Center (KUYTAM), Rumelifeneri, Istanbul 34450, Turkiye*

[3]*Physics Department, Istanbul Technical University, Maslak, Istanbul 34469, Türkiye*

[4]*Mega Materials srl and Dipartimento di Fisica dell'Università di Pisa, Largo B. Pontecorvo 3, 56127 Pisa, Italy*

Corresponding author, E-mail: asennar@ku.edu.tr

Abstract

In recent years, compact coherent light sources around 2 μm have received significant attention. Ho^{3+}-doped gain media have been widely used to generate 2 μm laser radiation through the $^5I_7 \rightarrow {}^5I_8$ transition. Co-doping with Tm^{3+} ions enables the use of common 800-nm pump sources and provides efficient energy transfer from Tm^{3+} to Ho^{3+}. Waveguide lasing in Tm^{3+}/Ho^{3+} co-doped gain media, including fluoride hosts[1, 2], has been demonstrated using femtosecond laser inscription [1] or liquid phase epitaxy[2] . In this study, we demonstrated efficient 2-W CW operation of a femtosecond-laser-inscribed Tm,Ho:YLF depressed-cladding channel waveguide laser at 2.05 μm with a high slope efficiency of 50%. Moreover, passively Q-switched operation with a Cr:ZnSe saturable absorber was achieved, generating pulses as short as 19.6 ns.

The inscription of the depressed cladding (Type-3) waveguide was performed by using a regeneratively amplified, 1 kHz Ti:sapphire laser outputting 120-fs, 1 μJ pulses at 800 nm (MKS Newport Spectra Physics, Spitfire Ace). As the gain medium, a YLF crystal (11 mm × 4.2 mm × 4 mm) doped with 5.2% Tm^{3+} and 0.5% Ho^{3+} (Tm,Ho:YLF) was used. The waveguide tracks were created along the 11-mm long side (a-axis) using a 40X objective lens (NA = 0.65). A total of 56 uniformly distributed tracks were written at a depth of 150 μm to form a 70-μm-diameter waveguide shown in Fig 1(a,b). Laser-written waveguides were characterized by using a CW Ti:sapphire laser at 830 nm to minimize resonant absorption losses. A lens (f = 5 cm) was used to couple light into the waveguide. The propagation loss, measured as 0.14 dB/cm, was determined by comparing uncoupled and coupled power transmission. The spot size variation of the output beam was measured using the knife-edge method, yielding a beam divergence angle of 0.05 rad and a refractive index contrast of 8.3×10^{-4}. The CW Tm,Ho:YLF waveguide laser was pumped with a Ti:sapphire laser tuned to 780 nm. The slope efficiency was determined to be 50%, with an incident threshold pump power of 68 mW and a maximum output power of 2 W at 2051 nm under 4.14 W incident pump power, as shown in Fig. 1(c). We further investigated PQS operation of the 2.05 μm Tm,Ho:YLF waveguide laser. A Cr:ZnSe saturable absorber was placed after the waveguide. PQS operation showed a slope efficiency of 18.9%. With 1.46 W pump power, an average output power of 251 mW was achieved. The shortest pulse duration was 19.6 ns at 58 kHz repetition rate.

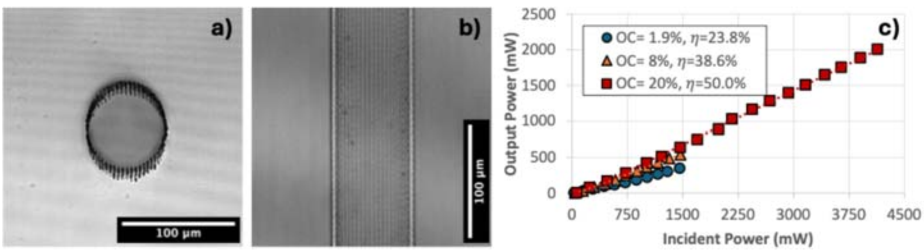

Figure 1: Confocal images of the (a) side and (b) top views of the 700-μm-diameter waveguide in Tm,Ho:YLF crystal. (c) Power efficiency curves of CW operation.

Keywords: Solid-state lasers, Infrared lasers, Tm,Ho lasers, Channeled Waveguide lasers, Pulsed Lasers

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Watt-level Co-lasing Operation of a Tm^{3+}:$LiYF_4$ Channeled Waveguide Laser at 1.9 and 2.3 µm

Berke Ayevi[1], Yağız Morova[1,2,3], Melih Kayra Kadıoğlu[1], Eugenio Damiano[4], Mauro Tonelli[4], and Alphan Sennaroğlu[*1,2]

[1]*Laser Research Laboratory, Department of Physics and Electrical-Electronics Engineering, Koç University, Istanbul 34450, Türkiye*

[2]*Koç University Surface Science and Technology Center (KUYTAM), Rumelifeneri, Istanbul 34450, Turkiye*

[3]*Physics Department, Istanbul Technical University, Maslak, Istanbul 34469, Türkiye*

[4]*Mega Materials srl and Dipartimento di Fisica dell'Università di Pisa, Largo B. Pontecorvo 3, 56127 Pisa, Italy*

*Corresponding author, E-mail: asennar@ku.edu.tr

Abstract

Femtosecond laser writing has been demonstrated as an effective method for fabricating low-loss depressed-cladding, channeled waveguides in Tm^{3+}-doped laser hosts [1, 2]. Although significant progress has been made in thulium waveguide laser development, watt-level co-lasing has not been previously demonstrated in femtosecond laser written channeled waveguides. In this work, we report, for the first time to our knowledge, continuous-wave (CW) co-lasing at 1.9 µm and 2.3 µm with watt-level output power using a femtosecond-laser-inscribed depressed-cladding waveguide in Tm^{3+}:$LiYF_4$, achieving a combined output power of 1.8 W with an incident threshold pump power of 42 mW and a measured slope efficiency of 46.7%.

In the experiments, a depressed-cladding (Type-3) waveguide was inscribed in a 1 at.% Tm^{3+}:$LiYF_4$ crystal with dimensions of 17.3 × 4.1 × 3.7 mm^3. Inscription was performed using 800-nm, 1-µJ, 120-fs pulses at 1 kHz from a regeneratively amplified Ti:sapphire laser (Spitfire Ace, MKS Newport Spectra-Physics). The pulses were focused with a 40X objective (NA = 0.65), and 80 tracks were inscribed along the a-axis over the 17.3-mm crystal length to form a depressed-cladding structure. The resulting waveguide exhibited a cylindrical geometry with a diameter of 100 µm. Microscope images of the fabricated depressed-cladding Tm^{3+}:$LiYF_4$ waveguide are shown in Figs. 1(a) and (b). The device was pumped with a CW Ti:sapphire laser near 780 nm, and the pump light was coupled into the waveguide with a plano-convex lens (f = 5 cm). The laser resonator consisted of a flat high reflector at 2.3 µm and a flat output coupler. The HR mirror had partial transmission at 1.9 µm, and a tilted dichroic mirror was used to collect the backward 1.9 µm laser output. Residual pump radiation was blocked with a silicon filter, while a bandpass filter was inserted to isolate the 2.3 µm emission. Using this configuration, the output coupling transmissions were 30.2% at 1.9 µm and 3.2% at 2.3 µm. Power slope efficiency measurements (Fig. 1(c)) demonstrated watt-level co-lasing performance with a combined slope efficiency of 46.7%. The individual slope efficiencies were measured as 29.1% at 1.9 µm and 17.6% at 2.3 µm. With 4 W of incident pump power, the maximum output powers reached 1.12 W at 1.9 µm and 692 mW at 2.3 µm, corresponding to a combined output power of 1.8 W. The lasing threshold was measured as 42 mW for both the 1.9 µm and 2.3 µm emissions, and the emission spectrum recorded at 4 W of incident pump power is shown in Fig. 1(d).

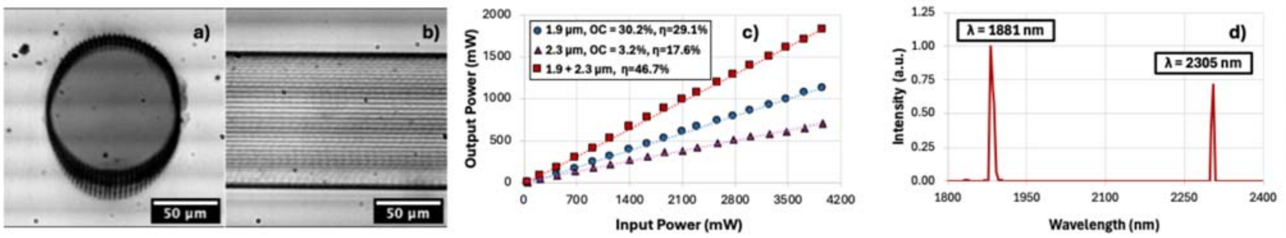

Figure 1: Microscope images of the (a) side and (b) top views of the 100-µm-diameter waveguide in Tm^{3+}:$LiYF_4$ crystal. (c) Power efficiency curves of CW operation and (d) corresponing co-lasing output spectrum.

Keywords: Solid-state lasers, Infrared lasers, Tm lasers, Channeled Waveguide lasers.

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Simultaneous measurement of Curvature Magnitude and curvature Direction with a Compact Hybrid FBG–V-Groove Structure

Gökçe DÜNDAR*[1], Mustafa ERYÜREK[2], Şekip Esat HAYBER[3]

[1]Department of Information Security Technology, Istanbul Gedik University, 34876, Türkiye

[2]Institute of Information Technology, TÜBITAK BILGEM UEKAE, Gebze 41400 Kocaeli, Türkiye

Adress (Department, University, Company, Adress, Country)

[3]Department of Electrical-Electronics Engineering, Bursa Uluda˘g University, 16059 Bursa,Türkiye

corresponding author, E-mail: dundargokce90@gmail.com

Abstract

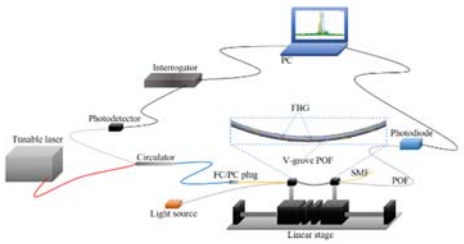

Figure 1: Experimental setup for dual-parameter curvature sensing, showing optical flow through the SSR and analog voltage acquisition via the DOP.

Conventional fiber Bragg grating (FBG) sensors provide high spectral sensitivity for curvature measurement but cannot distinguish bending direction. Conversely, polymer optical fibers (POFs) with structured surfaces offer directional sensitivity but lack spectral resolution. To overcome these limitations, we propose a hybrid sensor that integrates a spiral-wound FBG with a V-grooved POF. The FBG was inscribed by the phase mask method and wrapped around a PMMA-based POF featuring mechanically carved V-grooves. Experimental tests in the 0–14.5 m^{-1} curvature range demonstrated dual-parameter sensing: wavelength shifts of ~86.6 pm/m^{-1} for curvature magnitude and analog voltage outputs above or below 2 V for direction discrimination. Unlike conventional FBG-only designs, the proposed hybrid sensor delivers stable, repeatable, and low-noise performance while maintaining a simple and compact structure. Its capability to simultaneously detect curvature magnitude and direction makes it highly suitable for real-time applications in structural health monitoring, robotics, and wearable systems.

Keywords: Curvature detection, Directional sensing, Fiber bragg grating (FBG), Hybrid optical sensor, V-groove structure

Acknowledgements

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NH_3 Flow Control in PALE–MOVPE: High Quality AlN Films on c-Plane Sapphire

Gamze Yolcu[1,2], Merve Nur Koçak [1,2], Dudu Hatice Ünal [1,3], Ismail Altuntas[1,3], Sabit Horoz[1,4], Ilkay Demir[1,3*]

[1] Nanophotonics Application and Research Center, Sivas Cumhuriyet University, 58140, Sivas, Türkiye
[2] Department of Metallurgical and Materials Engineering, Faculty of Engineering Sivas, Cumhuriyet University, 58140 Sivas, Türkiye
[3] Department of Nanotechnology Engineering, Faculty of Engineering Sivas Cumhuriyet University, 58140, Sivas, Türkiye
[4] Department of Metallurgical and Materials Engineering, Faculty of Engineering and Natural Sciences, Sivas University of Science and Technology, 58140, Sivas, Türkiye
corresponding author, E-mail: idemir@cumhuriyet.edu.tr

Abstract
Thin AlN films (~250 nm) were deposited on c-sapphire by PALE-MOVPE to assess how ammonia flow governs growth mode and material quality. Four NH_3 flow rates (750, 900, 1050, 1200 sccm) were examined. Growth was monitored by in situ 880-nm reflectance and evaluated ex situ by AFM, HRXRD (002/102 rocking curves), Raman spectroscopy, and UV–VIS–NIR transmittance. AFM revealed a transition from rough, three-dimensional islanded surfaces at 750 sccm to a coalesced, quasi-two-dimensional morphology at 900 sccm with sub-nanometer roughness; further increasing the flow (≥1050 sccm) produced dense small-island textures consistent with reduced lateral diffusion and gas-phase parasitic reactions, accompanied by degraded structural and optical properties. In the UV–VIS–NIR transmittance spectra, well-defined interference fringes indicated a sharp AlN/Al_2O_3 interface [1]; shifts of the absorption edge reflected quality variations, whereby increased surface roughness and defect density enhanced scattering and reduced transmittance [2–4]. All samples exhibited a sharp absorption edge, and the spectrophotometry trends aligned with AFM; sample B, having the smoothest surface, showed the highest transmittance. Raman spectroscopy was used to quantify strain via shifts in the E_2 (high) phonon wavenumber: downshifts indicate tensile strain, whereas upshifts indicate compressive strain. Among the four specimens, sample B exhibited tensile strain, whereas the others were under compression. The co-occurrence of stress and increased roughness degraded spectral quality and activated otherwise forbidden modes.

These results established NH_3 flow as a deterministic control parameter for switching between 2D and 3D regimes and identified 900 sccm as optimal for high-quality AlN/sapphire films. Placed against prior studies, the structural and optical properties are competitive for MOVPE/PALE-grown AlN/sapphire: despite the ~250 nm thickness, RMS = 0.22 nm and threading-dislocation densities of $D_S = 7.86 \times 10^7$ cm^{-2} and $D_E = 1.68 \times 10^{10}$ cm^{-2} match the best ranges reported for much thicker films.

Keywords: AlN, sapphire, PALE-MOVPE, NH_3 flow, 2D/3D growth, AFM, HRXRD.

Acknowledgements
The authors acknowledge the usage of the Nanophotonics Application and Research Center (CUNAM) facilities at Sivas Cumhuriyet University. This work was supported by the Scientific and Technological Research Council of Türkiye (TÜBİTAK, project number 118F425) and the Cumhuriyet University Scientific Research Projects (CUBAP, project number M-2022-827). This poster was derived from and informed by the studies reported in the article “High-quality AlN growth: a detailed study on ammonia flow.”

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Silindirik Elektromanyetik Dalga Saçılma Problemleri için Matematiksel olarak Güçlü ve Sayısal Olarak Kararlı Modeller: Düzlemsel Katmanlı Ortamlarda Tek, Çoklu, Periyodik Saçıcılar ve Hızlandırılmış Çözümler

Fatih Dikmen*[1], Aytaç Alparslan[2], Murat Enes Hatipoğlu[1] , Mehmet Emin Geçer[1]

[1] *Elektronik Mühendisliği Bölümü, Gebze Teknik Üniversitesi, Kocaeli, Türkiye*

[2]*Elektrik-Elektronik Mühendisliği Bölümü, Trakya Üniversitesi, Edirne, Türkiye*

İrtibattaki Yazar, E-posta: dikmen@gtu.edu.tr

Özet

Silindirik cisimler ile modellenebilecek fotonik kristaller gibi optik rejimdeki elektromanyetik saçıcı düzenekleri için sınır integral denklemlerine dayalı matematiksel olarak güçlü ve sayısal olarak kararlı modellerin kullanımı ile elde edilen formülasyon ve sonuçlara yer verilecektir. Modellerin düzlemsel katmanlardaki periyodik de olabilecek keyfi kesitli çoklu cisimlerden saçılma problemlerini ele alacak esneklikteki kurguları, çeşitli uygulamaların hızlı optimizasyonları için elverişli bir araç sunmaktadır. 3 Boyuttaki ticari yazılımların talep ettiği zamandan çok daha kısasında anlamlı fiziksel verilere erişim sağlama imkanı önemli bir kazanç olarak nitelenebilir.

Helmholtz denkleminin integral gösterilimler ile varılan çözümlerine dayalı sınır integral denklemleri ile uzayın tümünden ziyade sadece bir boyut eksiği olan alt uzayda verimli çözümlere erişmek mümkün olmaktadır. Bu çözümler eşdeğerlik ilkesine göre sınır kaynaklarını bulmayı hedefler ve direkt çözümlere ek olarak, ötelenmiş sınır koşulu (ÖSK) ilkesine uygun bir alternatif de sunar. 2.5 ve 2 Boyutta anılan bu iki yordam ile de çözümler birbirini sağlar bir biçimde elde edilebilmiş, uygulamada karşılaşılan bazı güçlüklerin aşılması mümkün olmuştur [1]. Özellikle ÖSK temelindeki çoklu saçılma problemleri için uygun olduğu bilinen T-Matrisi yönteminin kararlı bir sayısal düzeneğe kavuşturulması için analitik regülerleştirme esasları kullanımıştır [2]. Bu söz konusu yöntemin lineer denklem sistemlerini iyi koşullu olarak kurmayı mümkün kılar ve hızlı çok kutup yöntemi (HÇY) gibi hızlandırma imkanlarını verimli biçimde uygulama fırsatı yaratır. Ayrıca sınır integral denklemlerinin arka plan ortamı Green fonksiyonlarının hesaba katılmasına bağlı olarak çözümlerini çeşitleyebildikleri iyi bilinmektedir. Green fonksiyonu homojen bir uzaydaki silindirik cisimlerden oluşan 1 boyutlu periyodik yapılar için verimli bir hesapla elde edilebilmektedir [3]. Ayrıca Green fonksiyonu düzlemsel katmanlı bir ortamda sınır düzlemlerinin sağladığı sınır koşullarını hesaba katacak biçimde formüle edilmiş haldedir [4]. Bu yeteneklerin bileşimi fotonik fiziğinin modellenmesi için özgün bir çözüm paleti oluşturmaktadır.

Anahtar Kelimeler: Çoklu silindirik saçılma, fotonik kristaller, optimizasyon

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- Hızlı çok kutup yöntemiyle hızlandırmayı konu alan kısım Gebze Teknik Üniversitesi Bilimsel Araştırma Projeleri Koordinatörlüğü'nce desteklenmiştir. Proje Numarası: 2024-A-102-02.

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Enhancing Jones Matrix Reconstruction in Polarization DHM via Phase Bias Equalization

M. T.R. Hussein*[1,2], M. Fatih Toy[1,2]
[1] Department of Biomedical Engineering, Istanbul Medipol University, 34810 Beykoz, İstanbul
[2] Biophotonics and Computational Imaging Laboratory (Phi - X), Biotechnology and Bioengineering Research Center, Research Institute for Health Sciences and Technologies (SABITA), Istanbul Medipol University, Istanbul
*mohammad.hussein@std.medipol.edu.tr

Abstract
Polarization digital holographic microscopy (PDHM) enables quantitative reconstruction of polarization-resolved complex optical fields [1,2], providing complete characterization of anisotropic samples via Jones matrix analysis. Conventional PDHM systems often rely on separated path configurations and require sequential acquisitions [2], which remain sensitive to environmental instabilities compromising the accuracy of the reconstructed Jones matrix [3]. Inaccurate Jones matrix reconstruction leads to incorrect characterization of how optical elements or samples modify the polarization state of fully polarized light. We implement a practical dual-shot PDHM scheme based on a modified off-axis system using two orthogonal input polarizations with a motorized half-wave plate and a polarization-sensitive CMOS sensor to retrieve whole-field Jones matrices. To enhance the reconstructed Jones matrix, we introduce a phase bias equalization strategy that uses non-birefringent reference regions to correct unstable phase offsets. We validated our approach using diverse anisotropic samples including biaxially oriented polypropylene (BOPP) film, birefringent USAF-1951 resolution test target, mouse brain slice, and human cornea section. The phase bias equalization strategy significantly improves Jones matrix fidelity, validated by comparing two Jones matrix calculation methods for anisotropic samples, demonstrating both theoretical and experimental agreement. Our compact, efficient approach offers superior stability compared to conventional sequential acquisition methods.

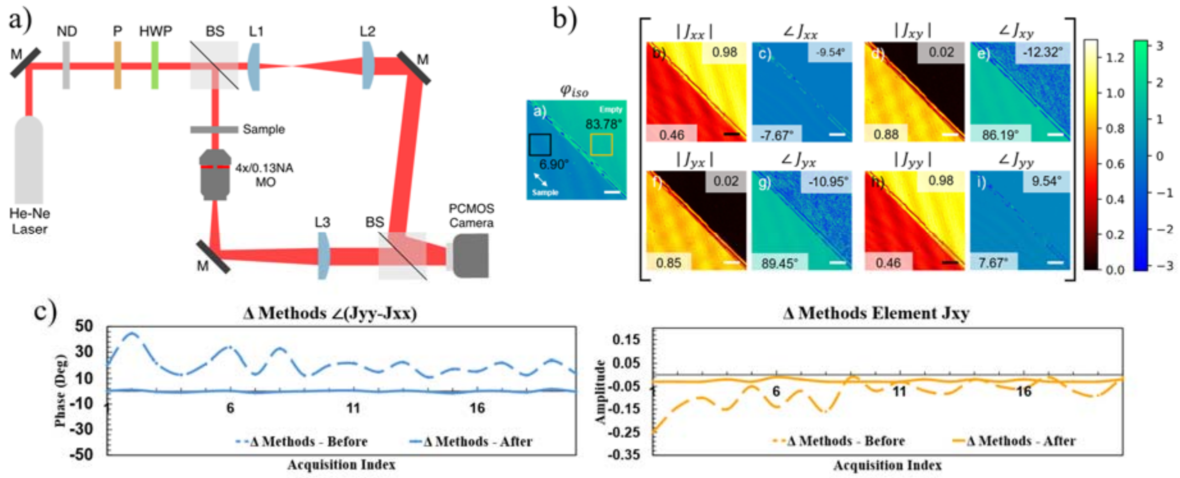

Figure 1: (a) Optical setup. **(b)** Results for the BOPP sample with the principal axis aligned diagonally. **(c)** Comparing two Jones matrix calculations before and after phase equalization.

Keywords: Polarization Imaging, Birefringence, Digital Holographic Microscopy, Jones Matrix

Acknowledgements
This work was supported by TÜBİTAK under project number 123N774.

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Spiral Phase Plate Based Optical Edge Enhancement

Maha Sahloul[1,3], M. Fatih Toy[1,2,3]
[1]*Department of Biomedical Engineering, Istanbul Medipol University, Türkiye*
[2]*Department of Electrical and Electronics Engineering, Istanbul Medipol University, Türkiye*
[3]*Biophotonics and Computational Imaging Laboratory (Phi-X), Research Institute for Health Sciences and Technologies (SABITA), Istanbul Medipol University, Türkiye*

maha.sahloul@std.medipol.edu.tr

Abstract
Optics provide a wealth of opportunities in computing by mitigating extensive reliance on digital post-processing. By manipulating and filtering the wavefront, operations such as differentiation, convolution, and edge detection can be performed physically in real time. Preserving good resolution and contrast while reducing the computational strain of image reconstruction is a major research challenge in optical imaging [1, 2].

The Spiral Phase Plate (SPP) is one optical component that has drawn interest in this regard. The SPP creates a phase singularity object by applying a helical phase distribution to the beam, which results in a continuous phase spanning from 0 to 2π and an undefinable phase at its center. The SPP behaves as a spatial filter when it is integrated into an image system, enhancing high frequency components and suppressing low frequencies, which is advantageous for the edge detection method [3]. In this work, we built an optical system including Zeiss Axio Observer 7 microscope to explore the use of SPPs for real time image enhancement and demonstrate their capability with a USAF resolution test target. We have proved the effect of the SPP on the imaging system both numerically and experimentally. We found that our optical method completes the process in 48.6 ms, while the corresponding software-based implementation takes almost 300 ms. Our work suggests spiral phase plates could be a noticeable candidate for optical image processing, decreasing the requirements for digital post-processing.

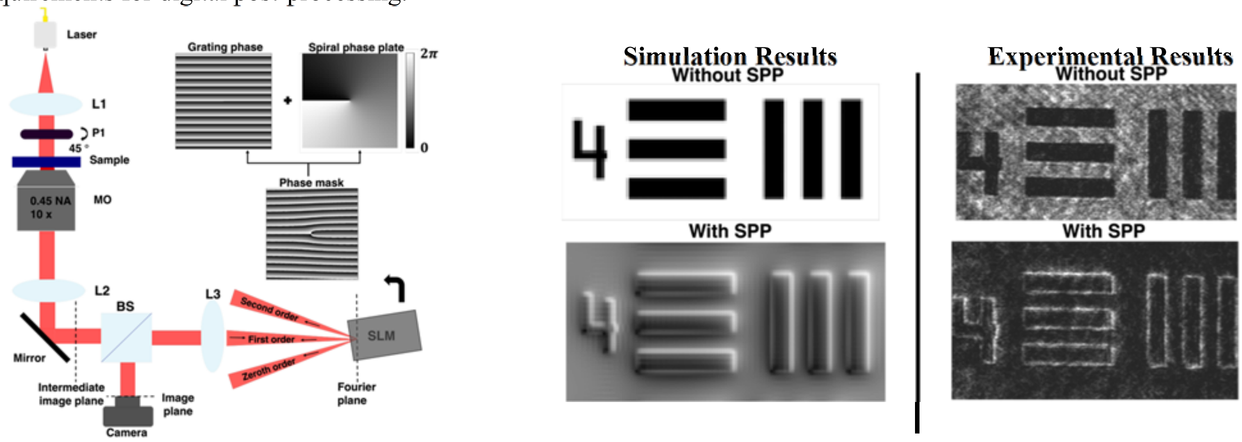

Figure 1. Left: Experimental setup including L1 (collimating lens), P1 (polarizer), MO (microscope objective), L2 (tube lens), BS (beam splitter), L3 (f = 300 mm lens), and SLM (spatial light modulator). **Right:** Simulated and experimental results with a USAF resolution test target, showing the effect of applying an SPP to the input object.

Keywords: Spiral phase plate (SPP), edge enhancement, optical imaging

Acknowledgements
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Geniş Spektral Bantta Çalışan Hibrit Mimarili Yerli Optik Güç Ölçer

Ahmet İREN*[1], Erhan AKMAN[2], Çağrı Kaan AKKAN[3],
[1]*Elektro-Optik Sistem Mühendisliği, Kocaeli Üniversitesi, İzmit, Kocaeli, Türkiye*
[2] *Havacılık Elektrik ve Elektroniği, Kocaeli Üniversitesi, Kartepe, Kocaeli, Türkiye*
[3] *Ulusal Metroloji Enstitüsü, TÜBİTAK- UME, Gebze, Kocaeli, Türkiye*
E-mail: Ahmet İREN, ahmetirn@gmail.com

Özet

Optik metroloji, ışığın fiziksel özelliklerinin hassas biçimde ölçülmesini konu alan ve bilimsel araştırmalardan endüstriyel uygulama süreçlerine kadar geniş bir alanda kritik önem taşıyan uygulamalı optik disiplinlerden biridir[1]. Lazer teknolojileri, telekomünikasyon, yarı iletken üretimi ve tıbbi cihazlar gibi güncel fotonik uygulamalarda sistem performansı, kullanılan optik gücün doğru bir şekilde karakterize edilmesine doğrudan bağlıdır[2]. Bu bağlamda, optik güç ölçerler metrolojik zincirin temel unsurlarından birini oluşturmaktadır. Mevcut ticari optik güç ölçerler, genellikle belirli güç aralıkları için özelleşmiş çözümler sunar ve bu durum özelleştirilmiş çözümlerde belirgin bir teknolojik ayrıma yol açar. Günümüzde, bu ayrım doğrultusunda, düşük optik güçlerin (pW–mW) ölçümünde yüksek hassasiyetli fotodiyotlar, yüksek optik güçlerin (mW–W) ölçümünde ise termopil tabanlı dedektörler tercih edilmektedir. Bu iki teknolojik uygulama ise farklı ürün grupları olarak kullanıcıya sunulmaktadır. Bu durum, geniş bir optik güç aralığında çalışma yapma ihtiyacı duyan araştırmacı ve mühendisleri birden fazla cihaz kullanmaya zorlamaktadır. Bu da hem maliyeti artırmakta hem de deneysel düzeneklerde karmaşıklığa yol açmaktadır.

Bu çalışmada, söz konusu boşluğu gidermeyi hedefleyen hibrit bir optik güç ölçer mimarisi sunulmaktadır. Geliştirilen cihaz, düşük optik güç seviyelerinde fotodiyot teknolojisini, yüksek optik güçlerde ise termopil dedektörünü tek bir kompakt gövde içerisinde birleştirmektedir. Geliştirilen bu hibrit tasarım sayesinde tek bir cihaz kullanılarak 190 nm ile 20 µm dalga boyu aralığında, nanowatt (nW) seviyesindeki hassas ölçümlerden, watt (W) seviyesindeki yüksek optik güç ölçümlerine kadar uzanan geniş dinamik bir aralık sunmaktadır. Çift dedektörlü mimariden elde edilen analog sinyaller, dijital bir kontrol ünitesi tarafından işlenerek kullanıcıya modern ve etkileşimli bir arayüz aracılığıyla sunulacaktır. Bu kapsamda 1 nW–5 W arasındaki optik güç tek cihazla, izlenebilir ve tekrarlanabilir şekilde kapsamak mümkün olacaktır. Dolayısıyla ölçüm zincirinin (optik–mekanik–elektronik–yazılım) tüm bileşenlerini güncel metrolojik ilkeler doğrultusunda uçtan uca işletilebilecektir. Bu hedef doğrultusunda geliştirilen cihaz, bütünleşik mimarisiyle uygulama alanlarında önemli bir yenilik ortaya koymaktadır.

Şekil 1. Prototiplemesi tamamlanan çift açıklı optik güç ölçer

Anahtar Kelimeler : Optik Metroloji, Optik Radyometri, Lazer Güç Ölçümü, Hibrit Optik Güç Ölçer, Optik Metroloji

Teşekkür : Bu çalışma ***TÜBİTAK BİDEB 2210-C Yurt İçi Öncelikli Alanlar Burs Programı*** ve ***Kocaeli Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimi (FYL-2024-4248)*** tarafından desteklenmektedir.

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Enhanced Detection and Monitoring of Unauthorized Activities in High-Voltage Power Grids Using Distributed Acoustic Sensing (DAS) in Turkish Transmission Grid

Faruk Uyar*[1,2], Volkan Türker[1], Tolga Kartaloğlu[1], Barış İyidir[1], Tolga İpek[1], Ümit Aktaş, Mete Uzar, Ceyhun Cengiz, Ekmel Özbay[1,2,3]

[1]NANOTAM, Bilkent University, Ankara, Türkiye
[2]Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye
[3]Turkish Electricity Transmission Corporation (TEIAŞ), Ankara, Türkiye
[4]Department of Physics, Bilkent University, Ankara, Türkiye
*faruk.uyar@bilkent.edu.tr

Abstract

This study presents the implementation and evaluation of a fiber-optic Distributed Acoustic Sensing (DAS) system for monitoring overhead high-voltage transmission lines in the Turkish Transmission Grid. The DAS system, deployed on a 154-kV transmission line spanning 40 km, utilizes existing optical ground wires (OPGW) for real-time acoustic and vibrational sensing. The study outlines the fundamental principles of DAS technology, detailing how optical fiber functions as a distributed sensor to detect mechanical disturbances along the transmission line [1].

Signal processing algorithms and feature extraction techniques were developed to analyze recorded acoustic signatures associated with different types of activities, including structural impacts, mechanical tampering, and environmental stressors such as wind-induced vibrations and icing effects. Key signal features, including root mean square (RMS) amplitude, crest factor, zero-crossing rate, spectral centroid, power spectral density (PSD), and wavelet entropy, were extracted and analyzed for their suitability in activity classification [2]. Extensive field tests were conducted, including controlled experiments such as hammering, mechanical and manual unscrewing, and metal cutting at various distances from the interrogation unit. A signal processing pipeline was implemented to enhance detection accuracy, utilizing noise reduction, spectral analysis, and feature-based classification. The developed detection algorithm processes real-time acoustic data and assigns an activity score based on extracted features, enabling efficient identification of anomalies and security threats along the transmission line. The system demonstrated high sensitivity to impulsive events, reliably detecting 22 out of 23 activities with a near-zero false alarm rate.

The results indicate that DAS technology is capable of accurately monitoring and detecting unauthorized activities around high-voltage transmission towers and it can serve as an effective non-intrusive monitoring solution for power transmission infrastructure. The DAS technology presented herein has the potential to become an essential tool in ensuring the safety and reliability of Türkiye's energy infrastructure, enabling rapid response to both human-made and natural threats.

(a) (b)

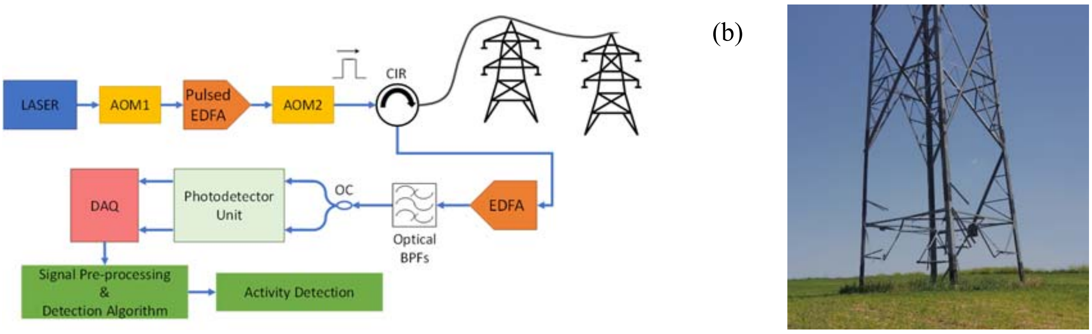

Figure 1: a) DAS configuration (EDFA: Erbium-doped fiber amplifier, AOM: Acoustic-optic modulator, CIR: Cırculator, DAQ: Data acquisition card), b) 154-kV transmission tower with removed iron components and structural weakening

Keywords: Distributed acoustic sensing (DAS), optical ground wire (OPGW), transmission line, power grid

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A Compliant Mandrel-Based Fiber Optic Hydrophone for Underwater Acoustic Sensing

Faruk Uyar*[1,2], Serra Uluğ[1,3], Tolga Kartaloğlu[1], Ekmel Özbay[1,2,4] İbrahim Özdür[3]

[1]NANOTAM, Bilkent University, Ankara, Türkiye
[2]Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye
[3]Department of Electrical and Electronics Engineering, TOBB ETU, Ankara, Türkiye
[4]Department of Physics, Bilkent University, Ankara, Türkiye
*faruk.uyar@bilkent.edu.tr

Abstract

This study presents the design, numerical modeling, and experimental validation of a mandrel-based fiber-optic hydrophone (FOH) tailored for underwater acoustic sensing. The hydrophone leverages a compliant mandrel structure to transduce radial pressure-induced strain into axial strain along an optical fiber wound around the mandrel, with acoustic signals retrieved via interferometric techniques [1-3].

A comprehensive three-dimensional finite element model is developed to evaluate the mechanical response and sensitivity characteristics of the hydrophone. Experimental validation is conducted in a water tank using a calibrated piezoelectric transducer, confirming the simulated predictions. The designed FOH exhibits a mean acoustic pressure sensitivity of −135.28 dB re rad/μPa over the frequency range of 250 Hz to 8 kHz, which is competitive with state-of-the-art FOH designs reported in recent literatüre [2-4]. The pressure noise floor characterization yielded a value of 43.28 dB re rad²/Hz at 1 kHz, demonstrating the hydrophone's capability to detect weak acoustic signals below Deep-Sea State 0 (DSS0) up to frequencies above 1 kHz.

The results suggest that this mandrel-based FOH design offers a robust, scalable, and cost-effective solution for large-scale underwater acoustic monitoring systems, with strong potential for integration into fiber-optic sensor arrays used in oceanographic, industrial, and defense applications.

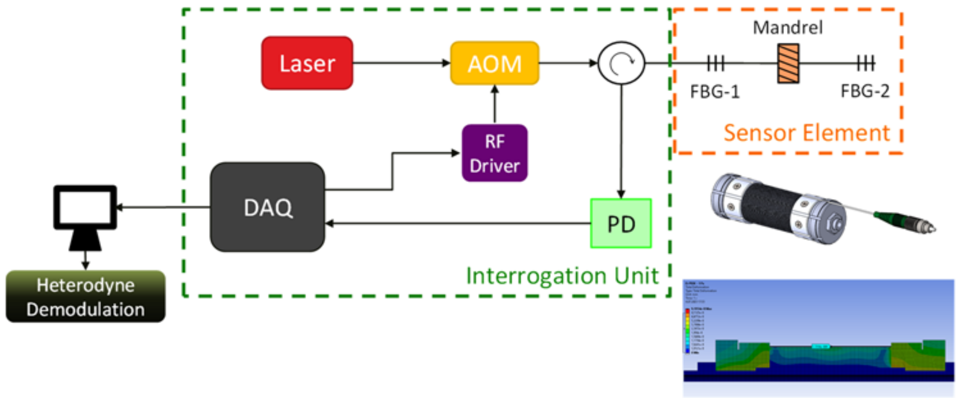

Figure 1: a) Experimental set-up of the FOH system, 3D model and simulation of the designed FOH

Keywords: Fiber optic hydrophone, underwater acoustics, mandrel, finite element modeling, acoustic sensitivity, interferometric sensing, noise-equivalent phase, minimum detectable pressure, mechanical resilience

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Arka Sinyal Lambasında Lens Çerçevesi ve Lens Malzemelerinin Simülasyon Bazlı Optik Performans Karşılaştırması

Gülistan ASLAN TEMEL[1], Kaan TURAN[1,2], Sinan İNGİN[1], Fatih GÖREN[1,2]

[1]*FARBA Automotive Inc., Gebze/Kocaeli, TÜRKIYE*
[2]*Electro-Optical Systems Engineering, Kocaeli University, Umuttepe, 41380, Kocaeli, Türkiye*

Corresponding author: gulistan.temel@farba.com.tr

Özet

LED tabanlı ışık kaynakları, enerji verimliliği sağlamasının yanı sıra, optik malzeme seçimi ve ışığın homojen dağılımı açısından önemli avantajlar sunmaktadır. Bu avantajlar, otomotiv dış aydınlatmalarında hem yönlendirme hem de estetik tasarım gereksinimlerinin karşılanmasında kritik bir rol oynamaktadır.[1] Dolayısıyla, dış aydınlatma tasarımında kullanılan malzemeler, optik performansın belirlenmesinde ve tasarım sürecinin optimize edilmesinde stratejik bir unsur olarak ön plana çıkmaktadır.[2]

Kullanılan malzemeler yalnızca ışığın geçirgenliğini değil, aynı zamanda dağılım ve renk bütünlüğünü de doğrudan etkiler. Yanlış veya yetersiz malzeme seçimi homojenlik kayıplarına (ışığın yüzeyde eşit ve dengeli dağılmaması) ve parlaklık düzensizliklerine yol açabilir. Buna karşılık uygun polimer veya akrilik tabanlı malzeme kombinasyonları, optik performans ve estetik algı açısından daha dengeli ve verimli çözümler sunmaktadır.[3] Bu durum, malzemenin yalnızca üretim maliyeti değil, tasarım güvenilirliği ve rekabet gücü açısından da stratejik bir unsur olduğunu göstermektedir.

Bu çalışmada, üç farklı lens çerçevesi (Milky White, DF White, Milky Red) ve dört farklı lens malzemesi (Combine Lens [Inner Lens: Red Lens, Outer Lens: Clear Lens], Clear Lens, Grey Lens, Red Lens) kullanılarak oluşturulan kombinasyonlar üzerinden optik performans değerlendirilmiştir. Her kombinasyonun ışık geçirgenliği, ışık şiddeti (cd) ve açısal dağılım üzerindeki etkileri ölçülmüş ve grafiklerle karşılaştırılmıştır.

Elde edilen bulgular, lens çerçevesi ve lens malzemesi seçiminin yalnızca ışık verimliliğini değil, aynı zamanda estetik bütünlük ve yasal uygunluğu da doğrudan şekillendirdiğini göstermektedir. Çalışma, tasarım sürecinde malzeme seçimi ve optimizasyon kararlarını destekleyerek, otomotiv aydınlatma tasarımında daha bilinçli ve verimli uygulamalara katkıda bulunmayı hedeflemektedir.

Anahtar Kelimeler: LED, lens malzemesi, otomotiv, optik performans, malzeme seçimi, simülasyon

Acknowledgements
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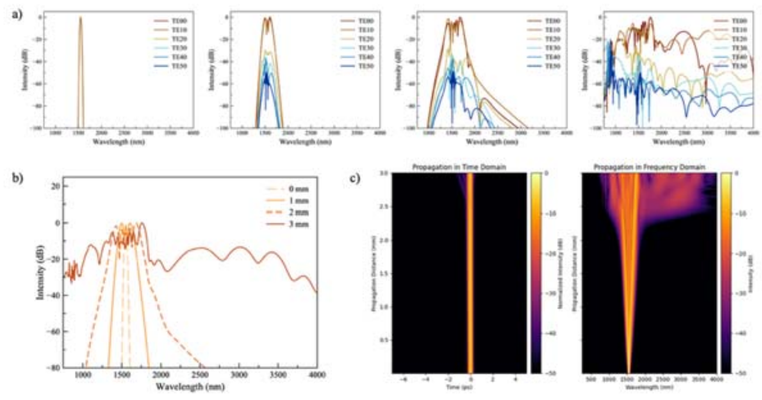
Spatıotemporal Nonlinear Dynamics in Silicon Nitride Integrated Waveguides

Azka Maula Iskandar Muda, Uğur Teğin
[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul*
corresponding author, E-mail: utegin@ku.edu.tr

Özet / Abstract

Silicon nitride (SiN) has become a leading platform for integrated nonlinear optics due to its strong Kerr nonlinearity and CMOS compatibility. While spatiotemporal nonlinear effects have been extensively studied in multimode fibers, their potential within integrated SiN waveguides is an emerging field of research. A systematic understanding of how initial pulse conditions influence these complex dynamics remains limited. In this work, we present a comprehensive numerical study on spatiotemporal pulse propagation in a multimode SiN waveguide, demonstrating that engineering the input modal excitation is a powerful strategy for tailoring nonlinear outcomes.

Our investigation is based on an open-source simulation framework that solves the multimode nonlinear Schrödinger equation (MM-NLSE). We model the propagation of a 250 fs, 25 kW peak power Gaussian pulse at a 1550 nm central wavelength through a 3 mm long, 800-nm-thick, and 6-µm-wide SiN waveguide that supports six TE_{x0} modes. By systematically varying the initial power distribution among these modes, we analyze the resulting spectral and temporal evolution, driven by processes like self-phase modulation, intermodal energy transfer, soliton fission, and dispersive wave generation



Şekil 1 / Figure 1: Mode-pair excitations with TE00 and TE10, to generate optimal flat supercontinuum.

Our results reveal a strong dependence of the nonlinear dynamics on the excitation symmetry and power distribution. For example, co-exciting odd mode (e.g., TE_{00} and TE_{10}) enables coupling across all guided modes, resulting in a significantly broader and flatter spectrum (Fig. 1). Conversely, distributing power evenly among all modes suppresses nonlinear interactions due to rapid temporal walk-off, leading to minimal spectral broadening. This work demonstrates that the careful selection of input mode combinations and power allocation provides a powerful means to control spatiotemporal interactions on-chip. These findings establish a pathway for designing compact, integrated light sources with tailored spectral properties, with applications ranging from broadband supercontinuum generation to programmable nonlinear optics and neuromorphic computing. Our open-source simulation tool is available on GitHub to facilitate further research in the community

Anahtar Kelimeler / Keywords: Nonlinear Optics, Integrated Optics, Supercontinuum Generation

Acknowledgements
This project is supported by Optica Foundation Challenge Grant.

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Inverse Designed Mode Converter with Accelerated FDTD

Asude Sarı, Azka Maula Iskandar Muda, Uğur Teğin

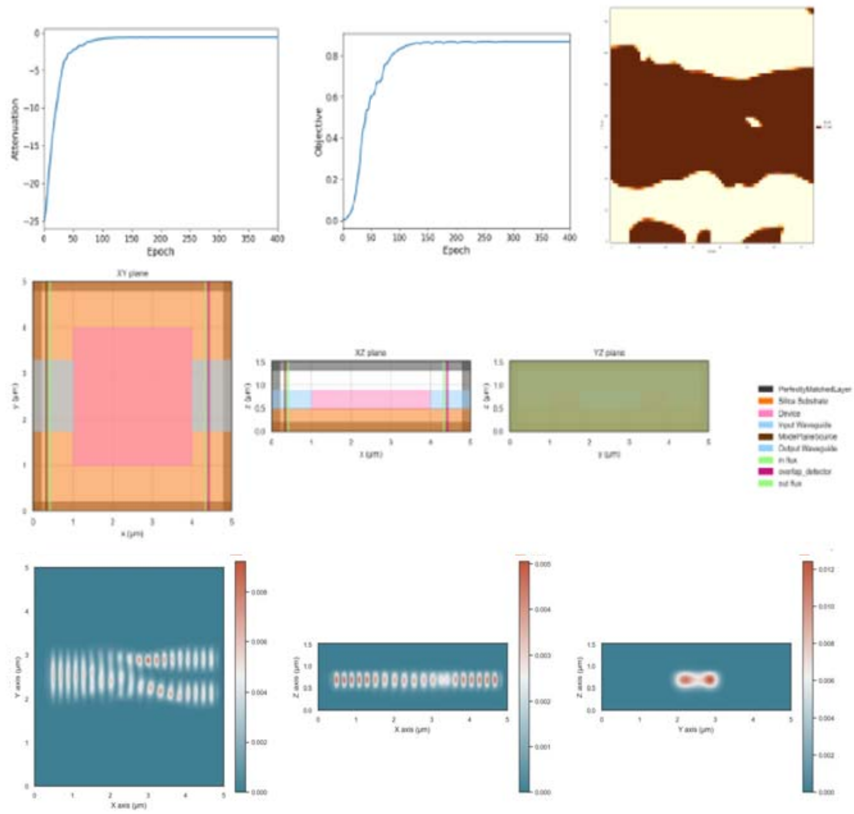
[1]*Department of Physics Engineering, Istanbul Technical University,*

[2] *Koç University, Department of Electrical and Electronics Engineering, Istanbul, Türkiye*

corresponding author, E-mail: utegin@ku.edu.tr

Özet / Abstract

The design process utilizes here is a full-wave three-dimensional finite-difference time-domain (FDTD) solver coded in JAX (fdtdx). To facilitate inverse design, the solver is expressed in a differentiable form to enable gradient-based structure optimization of the device. The simulation environment includes a silica substrate, input/output silicon nitride waveguides, flux as well as overlap detectors, and an active region device that is 3 µm × 3 µm × 0.4 µm in size, surrounded by perfectly matched layers (PML = 5 cells). Device optimization is done utilizing the Nadam algorithm from Optax, with the learning rate schedule being a start-up warm phase accompanied by cosine decay. This approach provides stable convergence. To additionally improve the device geometry as well as increase fabrication viability, we incorporate a β-continuation technique to enhance sharpness in the projection. The excitation is introduced through the fundamental TE_0 mode from the input waveguide. Inside the device section, the same is effectively converted into the TE_1 mode, which is later measured from the output waveguide. The efficiency in mode conversion is estimated from overlap integral calculations.



Anahtar Kelimeler / Keywords: Inverse Design, Differentiable FDTD, Mode Conversion, Integrated Photonics

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Optical Computing with Nonlinear Dynamics in Photonic Crystal Fibers

Azka Maula Iskandar Muda[1], Uğur Teğin[1]
[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye*
Uğur Teğin, E-mail:utegin@ku.edu.tr

Abstract

Neuromorphic computing based on photonic nonlinear dynamics is gaining popularity, due to its low power consumption, as well as their scalability [1]. However, how nonlinearity scales with the network performance are rarely investigated. Here, we numerically investigate the performance of neuromorphic computing, using photonic crystal fiber as a reservoir media [2]. Photonic crystal fiber has a high nonlinearity and thus, capable to produce spectrum that ranges from linear propagation, up to octave spanning supercontinuum generation. Using beam propagation method, we solve the generalized nonlinear Schrodinger equation in the following form:

$$\frac{\partial A}{\partial z} = \sum_{k\leq 2}^{10} \frac{j^{k+1}}{k!} \beta_k \frac{\partial^k A}{\partial T^k} + j\gamma\left(|A|^2 A + \frac{j}{\omega_0}\frac{\partial}{\partial T}(|A|^2 A) - T_R A \frac{\partial |A|^2}{\partial T}\right)$$

where A(z, T) is the time-domain envelope of the electric field, z is the propagation distance, T is the time, β! are the dispersion coefficients, γ is the nonlinear coefficient, ω is the central frequency, and T' is the Raman response time of the fiber. Utilizing the parameters from Dudley, et al [2]. we use the algorithm proposed by Hult [2] to accurately simulate the propagation of 50 fs pulse in a 15 cm long photonic crystal fiber.

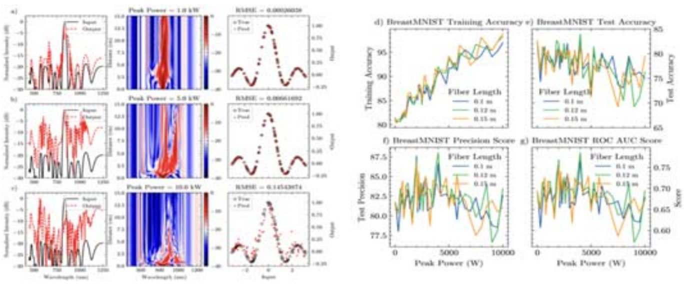

Figure 1: Average spectrum, spectrum evolution plot, and sinc regression with (a) 1.0 kW, (b) 5.0 kW, and (c) 10.0 kW peak power. (d) Training accuracy (e) test accuracy (f) precision score (g) ROC AUC score of BreastMNIST dataset

From figure 1, we tested the photonic crystal fiber against nonlinear regression task. Through regression of sinc function, the RMSE increases when the peak power also increases. The worse performance occurs at 10 kW peak power, when octave spanning supercontinuum is formed. We expect this is due to many to one mapping, since in supercontinuum, the spectrum has high similarity between different inputs. Results from BreastMNIST further strengthen our conclusion, since when peak power is increased, the training accuracy has steady increase, but test accuracy decreases, which signifies that the model overfits the dataset.

As a conclusion, we numerically investigate the nonlinear dynamics in photonic crystal fiber for neuromorphic computing. We found that high nonlinearity does not correspond to increased performance in the model, as evident from both sinc regression and BreastMNIST classification task. Our work further enhances our understanding in harnessing photonic nonlinear dynamics for neuromorphic computing.

Keywords: Optical computing, Photonic neural networks

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2.3-μm Continuous-Wave Laser Operation of a Tm^{3+}:Lu_2O_3 Ceramic Laser with Ultrabroad Tunability Between 1845 nm and 2328 nm

Yağız Morova[1,2,3], İdil Şimşek[1,2], and Alphan Sennaroğlu[*1,2]

[1]Laser Research Laboratory, Departments of Physics and Electrical-Electronics Engineering, Koç University, Istanbul 34450, Türkiye

[2]Koç University Surface Science and Technology Center (KUYTAM), Rumelifeneri, Istanbul 34450, Türkiye

[3]Department of Physics, Istanbul Technical University, Ayazağa, Istanbul, Türkiye

*Corresponding author, e-mail: asennar@ku.edu.tr

Abstract

Thulium lasers around 2.3 μm have been demonstrated in a variety of host materials, including crystals both oxides [1] and fluorides [2,3] as well as glasses [4]. Using Tm^{3+}:YLF as the gain medium, broad tunability was further demonstated in the optical ranges of 1772–2145 nm [5] and 2.20–2.46 μm [6] separately. In the case of ceramic hosts, laser operation near 2 μm has been extensively explored. Nevertheless, to date there has been no report of 2.3 μm laser operation from a Tm^{3+}- doped ceramic host.

In this study, we have demonstrated continuous-wave (CW) operation of a broadly tunable Tm^{3+}:Lu_2O_3 ceramic laser near 2.3-μm having an ultrabroad tuning range between 1845 and 2328 nm [7].

Figure 1(a) shows the tunable Tm^{3+}:Lu_2O_3 ceramic laser setup. A 797 nm Ti^{3+}:sapphire laser served as the pump and was focused into a 2.8-mm-long, 1.5 at.% Tm^{3+}-doped Lu_2O_3 ceramic (Konoshima Chemical) using a 50 mm focal-length lens (L). Pump power was adjusted with a half-wave plate (HWP) followed by a polarizing beam splitter (PBS). The gain element, positioned at Brewster's angle, was placed between two curved mirrors (C1 and C2, ROC = 50 mm). For double-end pumping, a second curved high reflector (C3, ROC = 75 mm) sent the residual pump light back through the crystal. The resonator was completed with a flat high reflector (HR) and a flat output coupler transmitting 1% at 2.3 μm (OC). Wavelength tuning was achieved by inserting a 1.5-mm-thick quartz birefringent tuning plate (BTP) in the HR arm of the cavity. Under this cavity configuration, lasing at the 2.3 μm band ($^3H_4 \rightarrow {}^3H_5$ transition) was optimized at 2309 nm with the BTP, yielding a maximum output power of 134 mW at 4 W of incident pump power, corresponding to a slope efficiency of 7% (Fig. 1(b)).

The tuning characteristics of the laser were further examined using two sets of mirrors spanning 1.8–2.5 μm in combination with the 1.5-mm BTP. The resulting tuning curves were merged, as shown in Fig. 1(c). A continuous tuning range from 1845 to 2328 nm was achieved, representing, to the best of our knowledge, the broadest continuous tuning ever reported for a thulium-doped laser.

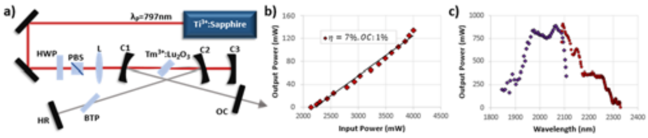

Figure 1: (a) Experimental setup, (b) measured measured power efficiency and (c) tuning curves curves of the 797 nm pumped Tm^{3+}:Lu_2O_3 ceramic laser.

Keywords: Solid-state lasers, Infrared lasers, Thulium lasers, Broadly tunable lasers

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Laser Stabilization by Saturation Absorption Spectroscopy

Turgay Özkan[1], Berfin Muhlise Caklı[1], Mehmet Hüseyin Sevim[1], Enes Günay[1], Büşra Can[1], Hüsnü Şahin[1], İsa Araz[1]

[1]*Atomic Sensors Laboratory, TUBITAK National Metrology Institute, Gebze, Kocaeli 41470 Türkiye*

corresponding author, E-mail: turgay.ozkan@tubitak.gov.tr

Abstract

We report on the stabilization of a diode laser frequency using Doppler-free saturation absorption spectroscopy (SAS) in a Caesium vapor cell. Two counter-propagating laser beams derived from a single source were employed to eliminate Doppler broadening, allowing for the observation of narrow sub-Doppler resonance features. These features were used as frequency references to generate an error signal through laser modulation and electronic feedback, enabling precise frequency locking of the diode laser. The stabilized system demonstrated improved frequency stability, as confirmed by Allan deviation analysis, which quantified the short- and long-term performance. The results highlight the effectiveness of SAS-based frequency locking as a robust method for achieving high-resolution frequency stabilization, with potential applications in atomic physics experiments, precision spectroscopy, and quantum sensor technologies.

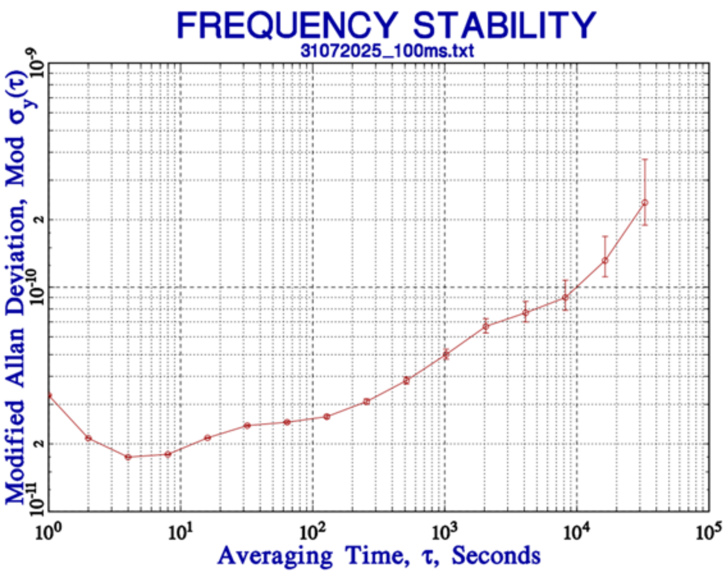

Figure 1: Allan Deviation Plot

Keywords: Saturation Absorption Spectroscopy, Laser Stabilization, Atomic Vapor Cell

References

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Saturation Absorption Spectroscopy

Turgay Özkan[1], Berfin Muhlise Caklı[1], Mehmet Hüseyin Sevim[1], Enes Günay[1], Büşra Can[1], Hüsnü Şahin[1], İsa Araz[1]

[1]*Atomic Sensors Laboratory, TUBITAK National Metrology Institute, Gebze, Kocaeli 41470 Türkiye*

corresponding author, E-mail: turgay.ozkan@tubitak.gov.tr

Abstract

Precise laser stabilization is a fundamental aspect of modern metrology, directly influencing the accuracy of fundamental measurements in fields such as high-precision metrology, atomic sensor applications, and quantum technologies. Saturation absorption spectroscopy (SAS) is one of the most effective techniques for achieving high spectral stability, as it enables laser frequencies to be locked to atomic resonances. This technique exploits the nonlinear interaction between a weaker probe beam and a stronger pump beam within an atomic vapor cell. By eliminating Doppler broadening, SAS allows well-defined hyperfine transitions to be resolved, providing a reliable optical frequency reference. This study aims to optimize laser frequency stabilization using the SAS technique by investigating the effects of temperature of Caesium (Cs) atomic vapor cell and pump-probe power adjustments.

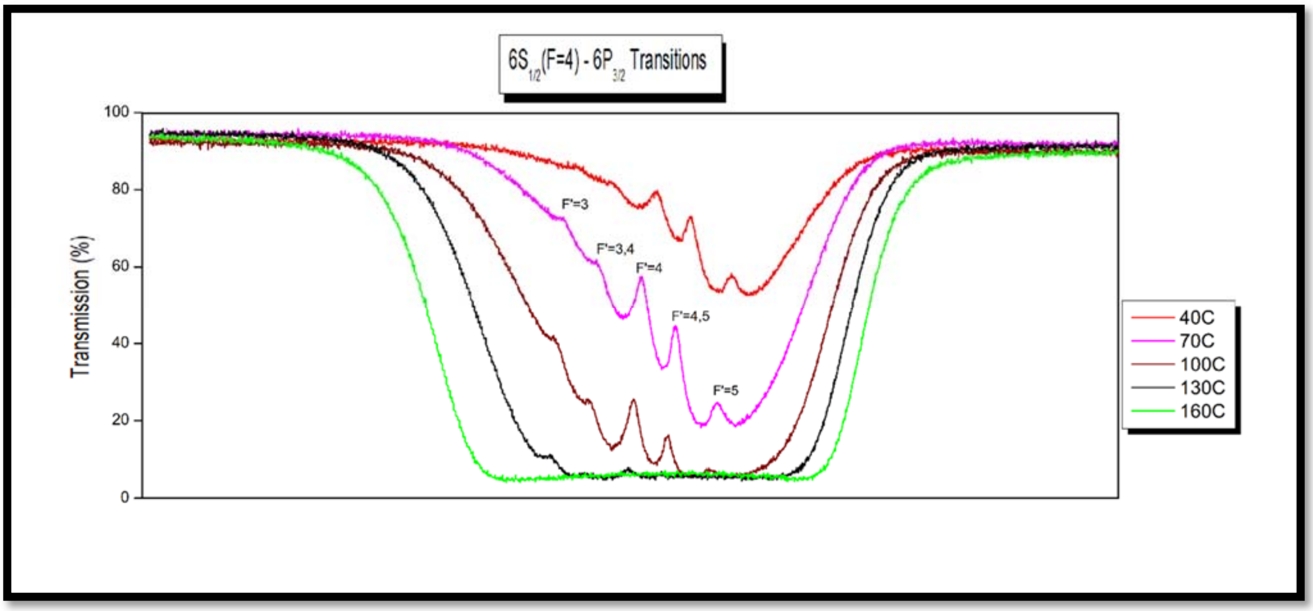

Figure 1: Absorption Spectra Observed at Different Temperatures in $6S_{1/2}$(F=4)-$6P_{3/2}$ Transitions

Keywords: Saturation Absorption Spectroscopy, Laser Stabilization, Atomic Vapor Cell

References

[1] [1]Araz, İ., Yorulmaz, İ., Meraki, A., Kaçar, B., Topal, K., & Kubanaliev, B. (2019, June). Fabrication and Characterization of Miniature Glass-blown Cs Vapor Cells. In 2019 IEEE International Symposium on Medical Measurements and Applications (MeMeA) (pp. 1-6). IEEE.

Bağımsız Detektörlü Kuantum Anahtar Dağıtımında Optik Kayıp ile Verim Artışı

Muhammed Kaan Yildiz[1,2]*, Tolga Kartaloglu[1], Ekmel Ozbay[1,2,3] and Ibrahim Ozdur[4]
[1]*Nanotechnology Research Center, Bilkent University, Ankara, Türkiye*
[2]*Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Türkiye*
[3]*Department of Physics, Bilkent University, Ankara, Türkiye*
[4]*Department of Electrical and Electronics Engineering, TOBB University of Economics and Technology, Ankara, Türkiye*
Sorumlu yazar, E-mail: mkaan.yildiz@bilkent.edu.tr

Özet

Kuantum Anahtar Dağıtımı (KAD) güvenli veri iletişim donanımları için simetrik anahtar oluşturulmasını sağlar [1]. Kuantum mekaniğinin kopyalanamazlık ve herhangi bir ölçümün kuantum durumu bozması ilkeleri nedeniyle bu anahtar oluşumuna müdahale edilemez. Müdahaleler, anahtar istatistiğini etkileyerek dağıtım sisteminin müdahaleyi algılayıp oturumu iptal etmesine neden olur. En yaygın KAD protokollerinden BB84 protokolü, bir fotonun kuantum durumuna dağıtıcı düzenekte kuantum bilgisi kodlar [2]. Kodlanan foton tek-modlu fiber gibi bir kuantum kanalı üzerinden alıcıya gönderilir. Alıcı seçtiği bir bazda fotonun kuantum durumu ölçer. Bilgi kodlama ve ölçüm sırasında kullanılan rassallık kaynakları ve kuantum mekaniği prensipleri BB84 protokolünün güvenliğini sağlar. Ancak protokol uygulaması sırasında kullanılan ölçüm yöntemi oluşturulan simetrik anahtarın entropisini azaltarak BB84 protokolünün verimini azaltabilir. Örneğin; bağımsız ölü zaman verilen detektörler nedeyle belirli bir zaman aralığında bir detektörün ölçüm ihtimali diğerinden daha fazla olabilir. Bu durum oluşturulan anahtarın entropisini azaltır. Bu azalış güvenlik artırımı adımında daha fazla bilginin elenmesini gerektirerek sistemin verimini azaltır. Bu çalışmada BB84 protokolünde optik kayıpların dedektörlerin bağımsız kontrolünü gerektiren durumunda protokol verimini artırdığı simülasyonlar ve deneyler ile gözlenmiştir. Simülasyonlarda python ortamında rassal veri dizisi üretilerek farklı ölü-zamanlar ve kuantum verimliliği durumlarında BB84 protokolü çalıştırılıp elde edilen anahtarın entropisi hesaplanmıştır. Sonrasında, formül (1) kullanılarak protokol verimi hesaplanmıştır [3]. Deneyde ise kuantum rassal sayı üreticisi kullanılarak BB84 protokolü farklı kuantum verimlilikleri ile çalışıtırılarak oluşturulan anahtarın entropisi hesaplanmış, formül (1) kullanılarak BB84 prokolünün verimi hesaplanmıştır. Fig.1'de gösterildiği gibi, sisteme optik kayıp eklendiğinde protokol verimi entropi artışından dolayı önce artmakta, bir tepe noktasına ulaştıktan sonra düşmektedir.

$$l = nH_{min}(Z) - H(Z_A|Z_B) - nf_{EC}\big(H(Z_A|Z_B)\big)H(Z_A|Z_B) + log_2(5)\sqrt{3nlog_2\left(\frac{2}{\varepsilon_{EC}}\right)} - log_2\frac{2}{\varepsilon_{cor}} - 2log_2\frac{1}{2\varepsilon_{PA}} \qquad (1)$$

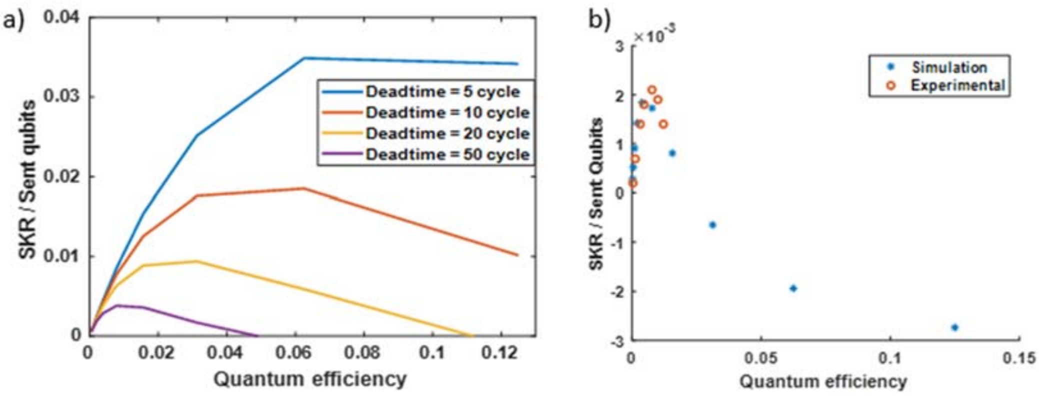

Fig 1 farklı ölü-zamanlarda BB84 verimi (a); 100 tetiklik ölü-zaman uygulandığında BB84 veriminin simülasyon ve deney kıyaslaması (b).

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Effect of Erbium and Ytterbium Concentration on Laser Performance of Er^{3+},Yb^{3+} Co-doped Glasses at 1.5 µm

Eylül Nihan Kamun[1], Ahmet Caner Kayaalp[2], Ayşenur Yılmaz[1], and Alphan Sennaroğlu[*1,3]

[1]Laser Research Laboratory, Departments of Physics and Electrical-Electronics Engineering Koç University, Istanbul 34450, Turkiye

[2]Şişecam Science, Technology and Design Center, Çayırova, Şişecam Yolu St., Kocaeli 41420, Turkiye

[3]Koç University Surface Science and Technology Center (KUYTAM), Rumelifeneri, Istanbul 34450, Turkiye

*Corresponding author, e-mail: asennar@ku.edu.tr

Abstract

Erbium/ytterbium (Er^{3+}/Yb^{3+}) co-doped glass lasers operating near 1.5 µm are suitable for eye-safe applications such as rangefinding [1] and eye surgery [2]. Therefore, investigating the effect of active ion concentration [3] and determining the optimum concentration are essential steps for the development of 1.5 µm laser sources.

In this study, we examined the absorption and laser characteristics of phosphate glasses with constant 0.25 mol % Er^{3+} and varying Yb^{3+} concentration (2, 4, 6, 8, and 10 mol %) in order to determine the optimum Yb^{3+} concentration. Transmission spectrum of each sample near the laser pump wavelength of 976 nm was measured. Morover, maximum generated laser output powers at the fixed input pump power of 420 mW were compared with 976-nm diode pumping.

From the transmission spectra of each phosphate glass shown in Fig 1(a), the absorption cross-section of the Er^{3+}/Yb^{3+} co-doped phosphate glass was determined as $1.15x10^{-20}$ cm^2 at 976 nm.

In the lasing experiments, the glass samples were operated in continuous-wave (CW) regime and the maximum output power generated with each sample was measured at the constant input pump power of 420 mW. Each sample had a constant 0.25 mol. % Er^{3+} concentration. As can be seen from Fig. 1(b), the maximum output power of 45 mW was obtained with the phosphate glass sample containing 6 mol. % Yb^{3+}. Power efficiency data of this phosphate glass are given in Fig 1(c) and shows nearly 12% of power slope efficiency at the output wavelength of 1544 nm.

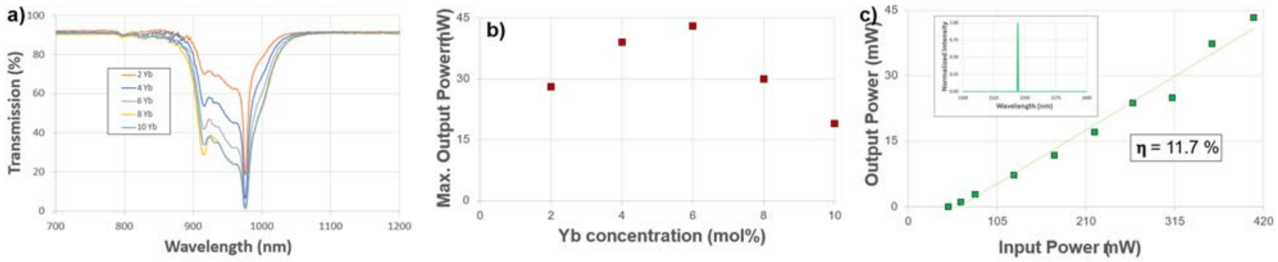

Figure 1: a) Transmission spectra of 0.25 mol % Er^{3+} doped dehydrated phosphate glasses near 976 nm as a funciton of Yb^{3+} concentration, b) measured variation of the output power of phosphate glass lasers at a constant Er^{3+} concentration of 0.25 mol % as a function of Yb^{3+} concentration at constant input power of 420 mW, and c) measured power efficiency of the phosphate sample with 6 mol. % Yb^{3+}, 0.25 mol. % Er^{3+} (inset: output spectrum at 1544 nm).

Keywords: Er^{3+}:Yb^{3+} Glass spectroscopy, Phosphate glass lasers, Solid-state lasers, Near infrared lasers.

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EXPERIMENTAL AND THEORETICAL INSIGHTS ON SEED-LAYER-DRIVEN STABILIZATION OF HEXAGONAL KAGOME FEGE VIA MOLECULAR BEAM EPITAXY

Ahmad El Zatari*[1], Aykut Can Onel[1], Ebrahim Zahrabi[1], Kerem Anar[1], Roya Kavkhani[1], Hülya Gürçay[1], Berna Akgenc Hanedar[1], Ferhat Katmış[1], Mehmet Cengiz Onbaşlı[1,2]

[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye*
[2]*Department of Physics, Koç University, Istanbul, 34450, Türkiye*

Mehmet Cengiz Onbaşlı, monbasli@ku.edu.tr

Abstract

FeGe-based compounds are emerging as promising platforms for topological spintronic devices, as the hexagonal kagome phase can host skyrmions, flat bands, and van Hove singularities. Although metastable compared to the thermodynamically favored cubic B20 structure, the kagome lattice offers opportunities to realize magnetic topological semimetals and explore correlated electron behavior. Stabilizing this phase in thin films, however, remains challenging due to competing growth dynamics and interfacial sensitivity.

Here, we demonstrate a reproducible method to possibly stabilize hexagonal FeGe on Si (111) using molecular beam epitaxy (MBE) with metallic seed layers. Fe was supplied by e-beam evaporation and Ge by a K-cell, with growth optimized for near-stoichiometric 1:1 Fe:Ge ratios. Energy-dispersive X-ray spectroscopy (EDS) confirmed stoichiometry control with minimal clustering. Systematic variation of Fe seed layer thickness (0–6 nm) revealed a transition from B20-dominated diffraction patterns to new reflections consistent with the P6/mmm kagome phase. Films grown with 2–3 nm seed layers produced ~9 nm thick layers with sharp FeGe (111) peaks, Kiessig fringes, and peak shifts indicative of compressive strain from lattice mismatch.

Magnetometry showed room-temperature ferromagnetism with low coercive fields (50–100 Oe), while spin-polarized DFT (PBE+U with SOC) predicted an antiferromagnetic ground state and electronic features characteristic of kagome systems, including flat bands, van Hove singularities, and SOC-induced topological gaps.

These results demonstrate that interface engineering enables stabilization of the kagome FeGe phase on silicon substrates, providing a pathway for exploring correlated and topological phenomena in thin-film form and advancing integration into spintronic and neuromorphic platforms.

Keywords: *Composition & Microstructure/Features/quantum surfaceSynthesis & Processing/Deposition/molecular beam epitaxy (MBE)Performance/Functionality/ferromagnetic.*

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Design of SWIR nBn-InGaAs with AlGaAs Barrier

Çağrı Tok*[1,2], Habibe Keleş[1], Mert Satılmış[1], Fikri Oğuz[1], and Ekmel Özbay[1,3,4]

[1]*Nanotechnology Research Center, Bilkent University, Ankara 06800, Türkiye*
[2]*Department of Physics Engineering, Ankara University, Ankara 06800, Türkiye*
[3]*Department of Physics, Bilkent University, Ankara 06800, Türkiye*
[4]*Department of Electrical and Electronics Engineering, Bilkent University, Ankara 06800, Türkiye*

cagri.tok@bilkent.edu.tr

Abstract

InGaAs-based short wavelength infrared (SWIR) photodetectors are widely used today across various technological fields such as defence industry, medical diagnostics and space exploration [1]. Although p-n InGaAs detectors operating in the SWIR region exhibit sufficiently low dark current at room temperature, they are not fully adequate for the demands of emerging advanced applications. In particular, mesa-structured detectors suffer from limitations such as insufficient suppression of surface leakage currents and increased dark current due to larger active area requirements in quadrant detector configurations [2,3]. These drawbacks have led to a growing interest in the implementation of nBn-type detectors, which inherently offer lower dark current. In an ideal nBn design, the barrier layer should be engineered to block only majority carrier transport. Moreover, eliminating the valence band offset is critically important for a successful design; otherwise, reduction in the contribution of minority carriers to the photogenerated current, thereby degrading the detector's responsivity and overall efficiency. Thus, in this study, we have designed an nBn SWIR detector incorporating a ternary AlGaAs barrier layer, which effectively minimizes the valence band offset.

The article discusses the simulation of an nBn-InGaAs photodetector using Silvaco TCAD at 300 K, focusing on optimizing the barrier performance and reducing the valence band offset. It explores the device's electrical and optical behaviors, including dark current, photocurrent, and capacitance. The results show a peak responsivity of 0.91 A/W at 1.55 µm and a junction capacitance of 9 pF at −5 V. Adding an anti-reflection coating notably improved the optical performance, highlighting the structure's potential for efficient infrared photodetection.

Keywords: Infrared Photodetectors, nBn-SWIR, SWIR Photodiodes, nBn Technologies

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2D Topological Superconducting Single Photon Detector Devices

Mehmet Cengiz Onbasli[1,2]*, Arooba Maryyam[1]

[1]*Department of Electrical and Electronics Engineering, Koç University, Istanbul, 34450, Türkiye*
[2]*Department of Physics, Koç University, Istanbul, 34450, Türkiye*

*E-mail: monbasli@ku.edu.tr

Abstract

Superconducting nanowire single-photon detectors (SNSPDs) have quickly become one of the most promising technologies for photon counting in the infrared range, providing high detection efficiency, low dark count rates, and outstanding timing resolution.[1]

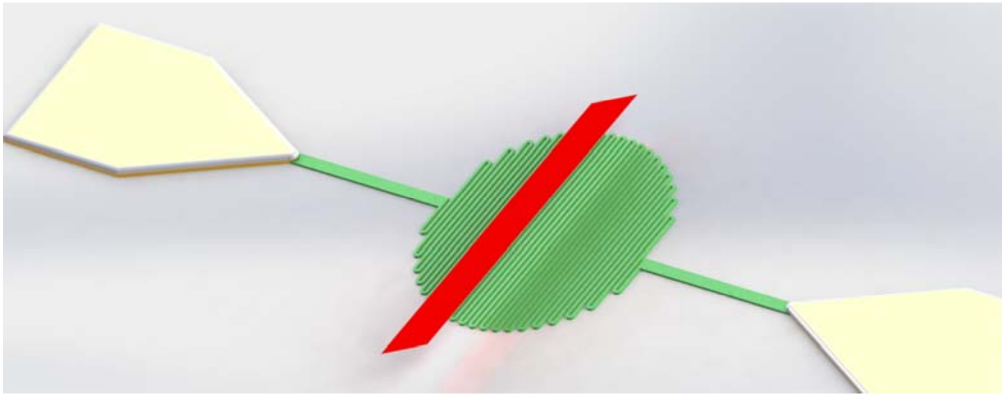

Figure 1: Schematic of a SNSPD in a meander structure

Commercial SNSPDs using NbN and NbTiN face limitations due to the lack of models that integrate material properties, geometry, and detection physics. Current models treat thermal, optical, and superconducting effects separately, restricting progress toward next-generation devices with novel materials like topological insulators. TI-based superconducting single-photon detectors (TI-SNSPDs) represent a compelling advancement, leveraging the unique properties of topological insulators.

In this work we introduce TI based SNSPD device. The architecture involves meander like structure. Bismuth telluride, grown by molecular beam epitaxy (MBE), was employed as the active material. The device was fabricated using a PMMA mask defined via electron beam lithography (EBL), achieving critical dimensions of approximately 50 nm. For proof-of-concept studies, the design was subsequently scaled up and realized using µMLA fabrication techniques. At the µMLA scale, the structures were etched using inductively coupled plasma reactive ion etching (ICP-RIE) with Argon & Methane gas. Gold contacts consisting of a Ti/Au bilayer were fabricated to ensure reliable electrical interfacing. Device performance is currently under detailed characterizarion.

SNSPD Modeling: We present a multi-physics modeling framework for SNSPDs that integrates photon absorption, thermal dynamics, TDGL superconducting dynamics, circuit response, and stochastic effects. The model links key performance metrics detection efficiency, timing jitter, dark counts, and pulse response to design parameters including geometry, material, bias, and cooling. Photon detection is modeled via hotspot formation, with TDGL and circuit dynamics governing pulse evolution. Simulations for NbN, NbTiN, and topological insulator nanowires reveal the influence of kinetic inductance, electron–phonon coupling, and superconducting gap on device transients.

Keywords: Superconducting nanowire single-photon detector, topological insulator.

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BALANSLI FOTODEDEKTÖR TASARIMI

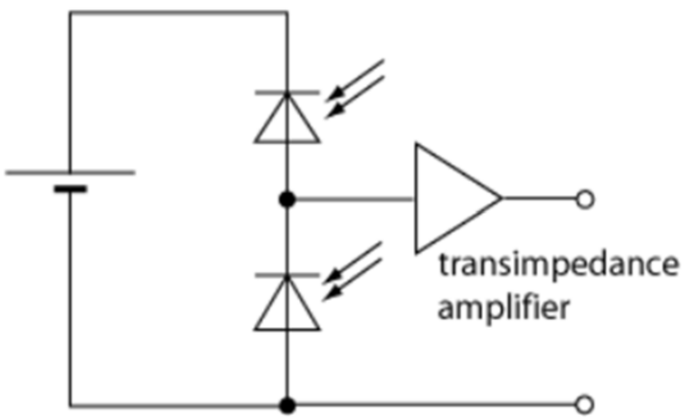
Turgay Özkan[1], Hüsnü Şahin[1], Berfin Muhlise Caklı[1], Mehmet Hüseyin Sevim[1], Enes Günay[1], Büşra Can[1], Kamil Tanır[1], İsa Araz[1]

[1]Atomic Sensors Laboratory, TUBITAK National Metrology Institute, Gebze, Kocaeli 41470 Türkiye

corresponding author, E-mail: kamil.tanir@bursiyer.tubitak.gov.tr

Özet

Bu çalışmada, optik sinyallerdeki ortak mod gürültüsünü azaltmak amacıyla kullanılan balanslı fotodedektörün (balanced detector) temel çalışma prensipleri ve deneysel tasarımı incelenmiştir. Seri bağlı iki fotodiyot kullanılarak, giriş fotokayımlarının eşit olduğu durumda sinyallerin birbirini iptal ettiği ve yalnızca fark sinyalinin çıkışta elde edildiği gösterilmiştir. Transimpedans amplifikatör devresi kullanılarak düşük gürültü seviyesinde, geniş bant yanıtlı ve yüksek hassasiyetli bir dedektör tasarlanmıştır. Ortak mod gürültüsünde yaklaşık 15 dB azalma, SNR'de yaklaşık 15 dB iyileşme, 47 dB dinamik aralık elde edilmiştir.



Şekil 1: Dengeli fotodedektör için basit bir elektronik devre.

Anahtar Kelimeler: Dengeli Fotodedektör, Fotodedektör Dinamik Aralık,

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DESIGN AND CHARACTERISTICS OF HIGH PERFORMANCE LONG WAVELENGTH TYPE-2 SUPERLATTICE SENSORS

Habibe Keleş[1,2], Mert Satılmış[2], Çağrı Tok[2,3], Fikri Oğuz[2], Ekmel Özbay[2,4]
[1] *Department of Material Science and Nanotechnology Engineering, TOBB ETU, Ankara, 06530*
[2] *Nanotechnology Reserch Center (NANOTAM), Bilkent University, Ankara, 06800*
[3] *Department of P*hysics, Ankara University, Ankara, 06930
[4] Department of Electrical and Electronics Engineering, *Bilkent University, Ankara, 06800*
corresponding author, E-mail: habibe.keles@bilkent.edu.tr

Abstract

Interest in InAs/GaSb type-II superlattices (T2SLs) has been steadily increasing for long-wave infrared (LWIR) detection, with applications ranging from military and space systems to emerging civilian technologies. These structures offer key advantages, bandgap tunability through layer thickness engineering, suppression of Auger recombination, and relatively large carrier effective masses that enable low dark current and enhanced performance in cooled IR detectors [1]. Despite the challenges associated with their theoretical design and epitaxial growth, T2SLs provide substantial flexibility for tailoring device properties to meet specific performance requirements. In recent years, significant progress has been made in the development of type-II InAs/GaSb superlattices. To enhance both their operational temperature range and overall performance, a deeper understanding of the electrical-electonics properties of T2SL photodiodes is essential [2]. In this study, focal plane arrays (FPAs) with a 640×512 format and 15 µm pixel pitch were fabricated and characterized. Various fabrication strategies like dry etch, wet etch, ohmic metal combinations by investigating effects of etch depth, ohmic behavior, stress were explored to maximize performance in terms of dark current, response, noise-equivalent temperature difference (NETD), and overall operability. The pixels having same size with FPA pixels that has 9.3 um cutoff yield 10 nA dark current at 100 mV reverse bias while FPAs hybridized with readout integrated circuits (ROICs) demonstrated a NETD of 24.1 mK with 98 us corresponding to %50 ROIC well-fill and 98% operability. The imaging results and diode characterizations are reported.

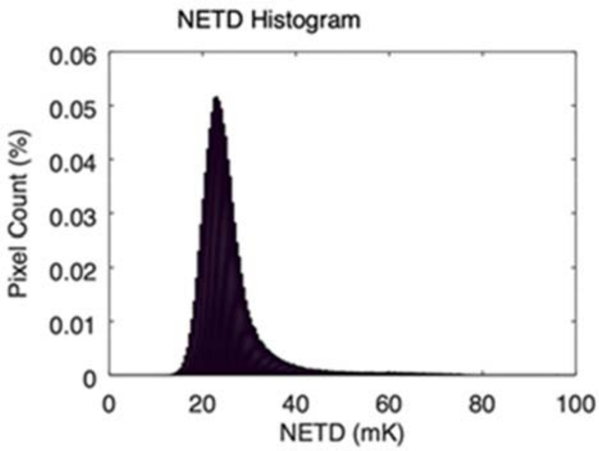

Figure 1: The NETD results of 640x512 FPA with 15 um pitch

Keywords: IR Imaging, Type 2 Super Lattice, InAs/GaSb T2SL, LWIR FPA

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Design of a Portable Vis–NIR Spectrometer for Soil Moisture Assessment

Dilem Gokce TUCCAR[1,2], Eren DEMİREL[1,2], Can KUMEK[1], Bengü YİGİTOGLU[1,3] , Edanur CARBUGA[1,4] , *Ahmet Harun ATAG[1,2], *Omer Faruk KADI[1], Hümbet NASİBLİ[1]

[1]*National Metrology Institute, The Scientific and Technological Research Council of Türkiye (TÜBİTAK- UME, Ulusal Metroloji Enstitüsü), Gebze, Kocaeli, Türkiye*
[2]*Yıldız Technical University, İstanbul, Türkiye*
[3]*Marmara University, İstanbul,Türkiye*
[4]*Kocaeli University, Kocaeli, Türkiye*
corresponding authors: harun.atag@std.yildiz.edu.tr ,omerfaruk.kadi@tubitak.gov.tr

Abstract

Remote sensing of land surface scaled from UAV, aero and satellite based technologies gains its role day by day due to the increasing of the sensitivity (both, in temporal and spatial domains) of the optical and mıcrowave sensors from Visible to millimeter wave region of the electromagnetic spectrum. In this context, proximal sensors play an increasingly important role by providing ground-truth data directly from land surface measurements. Beyond their laboratory use, field-deployable devices serve as essential tools for the calibration and validation of remote sensing sensors.

In this work we presented a proximal sensor, named as a "Mini-ASPAVA" this device is a portable spectroscopic measurement device designed to determine the spectral reflectance of soil surfaces under laboratory conditions with high accuracy and repeatability, enabled by a fixed measurement geometry and an integrated illumination system. In contrast to conventional systems, the new system inverts this geometry: the sample surface is illuminated perpendicularly (90°) to provide homogeneous lighting, while the detector is positioned at a 45° inclination, ensuring a wide field of view with high representativeness. This reversed configuration enhances the detection of non-Lambertian reflections from soil surfaces, resulting in more stable and repeatable spectral data. Subsequently, the device is placed directly on the target soil surface while maintaining the same optical–geometrical configuration. The soil reflectance spectrum is derived by normalizing measurements to a white reference, ensuring wavelength-dependent properties are independent of device or lighting conditions. After SI-traceable calibration, the system is applied to soil surface moisture measurements. Following successful laboratory tests, future work will extend to in situ characterization of undisturbed soils with field-scale validation.

Keywords: Proximal sensors, Portable Transfer Standard, Soil Moisture Sensor, Vis-NIR spectrum, SI-traceability

Acknowledgements
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Electric-Field-Assisted Facile Growth of Aligned ZnO Nanowires on Flexible Substrates for High-Performance Piezoelectric Nanogenerators

Eminenur Sarıtaş[1], Ayşegül Demircioğlu[2], Murathan Kabak[2], Kuzey Kaya[3], Mohamad Aleinawi[2], Omid Mohammad Moradi[2], Emre Erdem[2]

[1]Department of Electrical and Electronics Engineering, Middle East Technical University, 06800, Çankaya, Ankara, Turkey

[2]Faculty of Engineering and Natural Sciences, Sabancı University, 34956, Tuzla, Istanbul, Turkey

[3]Francis College of Engineering, University of Massachusetts Lowell, Lowell, Massachusetts, USA

Ayşegül Demircioğlu, E-mail: aysegul.demircioglu@sabanciuniv.edu

Özet / Abstract

Zinc oxide (ZnO) nanowires (NWs) have emerged as promising building blocks for next-generation energy harvesting devices due to their semiconducting and piezoelectric properties (Wang & Song, 2006). The alignment and aspect ratio of ZnO NWs are critical factors in determining their efficiency in piezoelectric nanogenerators (PENGs) (Xu et al., 2010). Conventional synthesis techniques like chemical vapor deposition (CVD) or hydrothermal growth often face trade-offs between crystallinity, scalability, and compatibility with flexible substrates (Vayssieres, 2003) . In particular, scalable, low-voltage approaches enabling simultaneous vertical alignment and high aspect ratio growth on flexible, non-crystalline substrates remain underexplored.

Here, we demonstrate a facile electric-field-assisted synthesis method that enables the direct growth of highly aligned ZnO NWs on polyethylene terephthalate (PET) substrates at a comparably low electric field (10 V/cm). The approach integrates a sol–gel-derived ZnO seed layer deposited on Au–Pd-coated flexible substrates, followed by hydrothermal growth in an equimolar zinc nitrate hexahydrate ($Zn(NO_3)_2 \cdot 6H_2O$) and hexamethylenetetramine (HMTA) precursor solution under mild conditions (80 °C). The application of a modest electric field across parallel substrates effectively guided nanowire orientation, eliminating the need for templating or high-temperature processing.

We systematically investigated the effect of growth duration on nanowire alignment and morphology. Our findings revealed that the synthesis carried out for 4 hours resulted in the most uniform and highly aligned nanowire arrays, demonstrating the effectiveness of the electric field in promoting ordered growth over a longer period.

Morphological analyses using scanning electron microscopy (SEM) revealed vertically aligned ZnO NW arrays with uniform diameters and enhanced aspect ratios. Complementary photoluminescence and electron paramagnetic resonance (EPR) studies provided insights into defect structures and crystallographic order, confirming the role of the applied electric field in reducing structural disorder. The technique offers significant advantages in terms of simplicity, low cost, and compatibility with flexible electronics, opening new opportunities for scalable integration into wearable energy systems and roll-to-roll manufacturing platforms.

Our findings establish a novel, energy-efficient pathway to synthesize aligned ZnO NW arrays while elucidating the interplay between electric fields and nanowire orientation. This work contributes to the rational design of advanced piezoelectric materials and expands the potential of ZnO nanostructures for energy harvesting, sensing, and flexible optoelectronic applications.

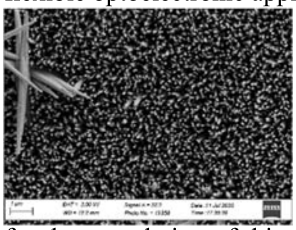

Figure 1: SEM image of ZnO nanowires with 4 hour synthesis duration

Keywords: ZnO nanowires, electric-field-assisted growth, flexible substrates, piezoelectric nanogenerators, hydrothermal synthesis

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Smart Glasses for Intra-Ocular Pressure Measurement

Nergis Saraçbaşı [1], Parviz Zolfaghari [1,2] , Arda Deniz, Yalçınkaya[3], Onur Ferhanoğlu [1]
[1] Electronics and Communications Eng., Istanbul Technical University, Istanbul, TURKIYE
[2] Electrical and Electronics Eng., Koç University, Istanbul, TURKIYE
[3] Electrical and Electronics Eng., Boğaziçi University, Istanbul, TURKIYE

E-mail: saracbasi22@itu.edu.tr

Abstract
In this study, we designed smart glasses to measure of intra-ocular pressure (IOP) for glaucoma patients [1]. The optic nerves can be damaged and irreversible vision loss could be happened as a result of the high intraocular pressure. Nowadays, tonometry, contact lens-based and glasses-based [2] measurement methods are being utilized. Our design is a new approach to real-time non-invasive IOP measurement, comprising a laser, miniaturized lenses, two 3D-printed cantilevers [2] to steer the light on the cornea, and a miniaturized CMOS camera. One cantilever operates in its mechanical resonance to generate a laser line upon eye while the other operates at low frequency to steer the laser beam based on the positioning of the eye. The generated laser line is detected by the miniaturized camera. The captured images are post-processed to deduce the radius of curvature of the scanned beam, which happens to correlate with internal pressure. Initial tests were conducted on an eye phantom.

Figure 1: Illustration of the designed glasses

Keywords: Intra-ocular pressure, glaucoma, smart glasses, cantilevers

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A novel silicon photonic integrated circuit for MRI data transmission

Sajjad Habashi Youvalari [*1], Hamed Asadi[1], Onur Ferhanoğlu [1], Arda Deniz Yalçınkaya [2]
[1] *Electronics and Communications Eng., Istanbul Technical University, Istanbul, TURKEY*
[2] *Electronics and Communications Eng.,Boğaziçi University, Istanbul, TURKEY*

E-mail: youvalari23@itu.edu.tr

Abstract

We propose a silicon photonic solution for MRI data transmission that replaces conventional metallic cables with an optical-domain approach. Built on CMOS-compatible silicon photonics, the system integrates directional couplers, Bragg gratings, and MEMS-based optical modulators to enable compact, safe, and interference-free communication inside MRI environments. Metallic cables in MRI face challenges such as heating, cross-talk, and patient safety risks, whereas fiber optics offer immunity to electromagnetic interference, reduced heating, lightweight design, and support for optical wavelength-division multiplexing (OWDM).

In the proposed architecture, a 1550 nm broadband source couples into a photonic chip via a grating coupler. Directional couplers split the light across phase-shifted Bragg gratings, which act as demultiplexers by mapping distinct optical frequencies to digital bits.

MRI coil signals are amplified, down-converted, and digitized by an ADC, with each bit driving a MEMS-based optical amplitude modulator implemented in a suspended directional coupler. Actuation via the Lorentz force vertically displaces the coupler, altering its coupling coefficient and routing light between bar and cross ports.
The modulated signals are recombined and coupled out through an output grating into fiber, then decoded outside the MRI room using a spectrometer. Simulations confirm 4-bit transmission over a 20 nm optical bandwidth, highlightingthe promise of silicon photonics for safe and scalable MRI data links.[1]

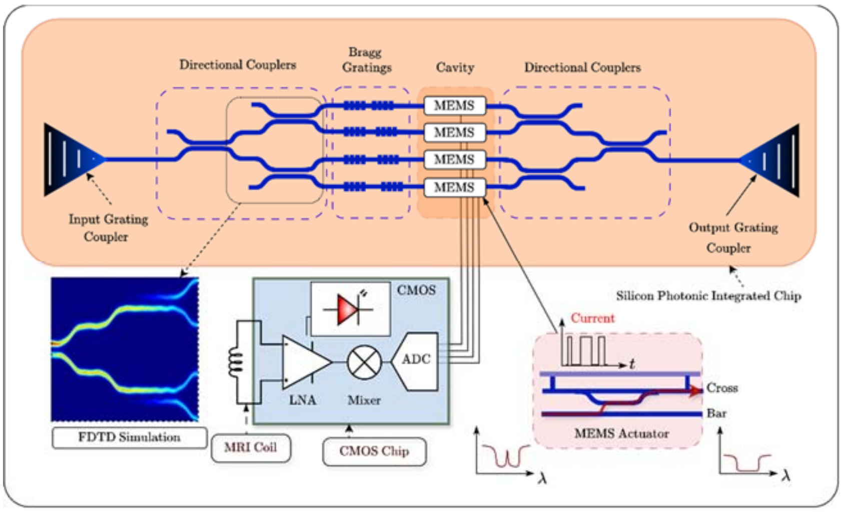

Figure 1: Conceptual illustration of the proposed silicon photonic chip for MRI signal transmission s

Keywords: MRI,CMOS,MEMS,Interferometry,fiber,optics, wavelength division multiplexing

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