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Liquid crystals for ultrafast photonics and neuromorphic optical computing applications

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Abstract:

Liquid crystals possess many physical attributes such as extraordinary large birefringence and ultrafast optical nonlinearities, susceptibilities to external stimuli/fields for reconfiguration, and compatibility with almost all technologically important materials such as plasmonic, metasurfaces/metamaterials, quantum dots, 2-D materials, and inorganic crystalline thin films. They are now widely used in display screens of ubiquitous devices, bio-sensing and diagnostic instruments, spatial light modulation, and imaging devices as well as in advanced optical devices for ultrafast pulsed laser modulations, quantum, and neuromorphic optical computing studies [1, 2]. The talk here will review all recent developments with perspectives on future possibilities.

First, I will present the results of recent studies on using linear light scattering in liquid crystals for nonlinear optical learning and computing applications. Nonlinear activation function, a necessary element in nonlinear neural network operation is enabled by data reverberation via multiple (linear) scatterings with liquid-crystal-polymer composites or partially transmitting/reflecting LC spatial light modulator. It is found that using low power laser or incoherent light, one can perform image/character recognition with accuracy as good as or better than nonlinear digital neural network.

Next, I will delve into ultrafast nonlinear optics using liquid crystals. In centrosymmetric liquid crystals, the first non-vanishing contribution comes from the third order susceptibility which among many other processes, result in laser intensity dependent index modulations. In chiral liquid crystalline materials such as cholesteric liquid crystals (CLC), the birefringence of the constituent molecules gives rise to a spatially varying index, i.e., a Bragg grating or 1-D photonic crystal. Near the band edges of the photonic bandgap, the optical nonlinearity is greatly enhanced and enables many ultrafast nonlinear optical processes, including polarization switching of complex vector beams, self-compression and pulse modulations. Compact all-optical devices made with mm-thick CLC cells are capable of performing operations that otherwise need a tabletop full of optical and electronics instrumentations. In another development, CLC's made of polar molecules such as Ferroelectric liquid crystals have shown high promises as tunable entangled photon pair generation with high efficiency – an important ingredient for quantum optical computing and other applications.

1. I. C. Khoo. Liquid Crystals, 3rd edition (Wiley, NY 1/2022).
2. B. Liu et al., Nonlinear Optical Extreme Learner via Data Reverberation with Incoherent Light. Science Advances 12, eaeb4237 (2026). DOI: 10.1126/sciadv.aeb423

Notes:

Fs laser induced new phenomena in transparent dielectrics---mechanisms and applications

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Abstract:

Femtosecond laser is an extreme physical condition which can be realized in normal laboratories. It has been widely used for microscopic modifications to materials due to its ultra-short laser pulse and ultrahigh light intensity. When a transparent dielectric e.g. glass is irradiated by a tightly focused femtosecond laser, the photo-induced reaction occurs only near the focused part of the laser beam inside the glass due to the multiphoton processes. In this talk, we will describe what happened during the fs laser irradiation in dielectric, some observations of interesting phenomena, e.g. formation of polarization and light intensity dependent dislocation, precipitation of bandgap tunable nanocrystals and formation of periodically distributed nanocrystals etc. The mechanisms and promising applications of these phenomena are also discussed.

References

[1] D. Tan, K. Sharafudeen, Y. Yue, J. Qiu, Prog. Mater. Sci., 76 (2016)154.
[2] K. Sun, D. Tan, X. Sun, J. Song, Z. Liu, M. Gu, Y. Yue, J. Qiu, Science, 375 (2022) 307-310.
[3] Z. Wang, B. Zhang, Z. Wang, J. Zhang, P. G. Kazansky, D. Tan, J. Qiu , Adv. Mater., 35 (2023) 2303256..
[4] B. Zhang, Z. Wang, D. Tan, J. Qiu, PhotoniX. 4(2023) 24.
[5] D. Chen, Z. Chen, Y. Yang, Y. Wang, X. Han, K. Lau, Z. Wu, C. Zou, Y. Zhang, B. Xu, X. Liu, Z. Ma, G. Dong, G. Barillaro, L. Zhong, J. Qiu , Adv. Mater., 36 (2024) 2404493.

Notes:

Laser R&D Experiences Since 1968 – Liquid Laser to Ceramic Laser

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Abstract:

Laser research and development in 1960's was a golden time for young students. Early time of laser was open for everybody to understand what is the real understanding of power of coherent generation by stimulated emission processes. I will talk about the brief history of laser science and technology using my personal experiences. I developed Nd:POCl3 inorganic liquid laser for the laser fusion project in 1969. The idea of ceramic laser was created in the gravitational wave detection project in Japan in 1990. The relation between big projects and crazy ideas in laser technology will be discussed in this lecture.

Notes:

Ultrafast laser volume and 3D processing of transparent materials

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Keywords: ultrafast laser, 3D processing, transparent materials

Abstract:

The rapid development of the ultrafast laser has revolutionized materials processing due to its unique characteristics of ultrashort pulse width and extremely high peak intensity. In particular, the extremely high peak intensity associated with ultrashort pulse width of ultrafast laser allows nonlinear interactions such as multiphoton absorption and tunneling ionization to be induced in transparent materials such as glass, which provides versatility in terms of the materials that can be processed. More interestingly, focusing the ultrafast laser beam inside the transparent materials confines the nonlinear interaction only within the focal volume, enabling three-dimensional (3D) micro- and nano processing by scanning the focused laser beam inside the transparent materials. We applied this 3D fabrication capability of ultrafast laser to fabricate 3D functional micro and nanodevices for chemical and biological applications. Specifically, 3D printing of CYTOP, which is amorphous fluoropolymer commercially available from AGC Inc. and has almost the same refractive index as water, allowed us to fabricate 3D micro and nanofluidic systems for super-resolution live imaging of living cells to elucidate not only mechanism of cancer cell metastasis and invasion in the human body but also many other biological systems. The tailored ultrafast Bessel pulses enabled formation of glass through holes by single shots, which were utilized for rapid manufacturing of diagnostic microchips based on advanced digital nucleic acid amplification technique (d-NAAT), such as digital polymerase chain reaction (d-PCR). The fabricated d-PCR chips consisted of an array of more than 10,000 micro-through-holes on glass substrates. This technique is also expected to be utilized for ultrahigh-speed fabrication of glass through vias with ultrahigh aspect ratio for manufacture of next-generation semiconductor devices. Hybrid ultrafast laser 3D processing, in which different schemes of 3D processing were combined, was applied to fabricate 3D microfluidic surface enhanced Raman spectroscopy (SERS) chips enabling real-time sensing and attomolar level sensing of chemical and biological samples.

Notes:

Efficient laser drilling using low-energy long pulses of a conventional Nd:YAG laser

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Abstract:

Introduction:
Shimane Prefecture, particularly the Oku-Izumo region, has long been famous for its iron production (the traditional Tatara ironworks). As a result, the metal industry remains one of the most important industries in Shimane today. Laser is one of the key tools for metal machining. However, laser machining has not yet become a mainstream manufacturing method, because of its lower machining rate compared to conventional methods such as punching. Although the use of femtosecond lasers must be a promising solution, it has not been widely adopted in the industrial sector. For this reason, the development of more conventional laser machining methods is still necessary. Here we demonstrate that low-energy long-pulses of a conventional Nd;YAG laser can achieve drilling of metal foils with much higher efficiency compared to nanosecond pulses. Additionally, it was suggested that higher drilling efficiency of long-pulses can be attributed to lower plasma generation by long-pulses compared to nanosecond pulses [1].

Materials and Methods:
Laser ablation was conducted using a Nd:YAG laser (GCR-200). This laser generates nanosecond (ca. 40 ns) pulses (NSP) when Q-switch is turned on and long pulses (LP) when Q switch is turned off. The temporal pulse profile of a long pulse is shown in Fig. 1. Focused laser beam was conducted onto a Ni foil of 25 μm thickness set on a X-Y motorized stage. The morphology of the target after laser ablation was observed using a SEM and a three-dimensional optical interferometer. To observe the plasma shielding, a pump-probe system was used [2]. In this system, a probe beam, obtained by extracting a portion of the laser beam, was transmitted through the ablation plume from a perpendicular direction.

Results and Discussion:
Figure 1 shows SEM images of Ni foils after laser drilling. Remarkably, LPs achieved drilling with much higher efficiency than NSPs. At 10 mJ, the depth of craters formed by an NSP was approximately 4 μ m, whereas the depth of holes formed by an LP reached 280 μm. It was also demonstrated that an LP at 5 mJ produced drilling to a depth of 180 μm, indicating that an LP can produce through holes across 7 foils. Results of further investigation suggested that the markedly higher drilling efficiency of an LP would be attributed to the characteristic temporal profile of an LP. As shown in Fig. 1, an LP is composed of a train of sub-pulses with lower peak energy than that of an NSP with the same total energy. It is suggested that the lower peak energy can suppress the plasma generation, thereby reducing plasma shielding, and that repeated irradiation by sub-pulses can promote continuous material melting.
To investigate the effects of plasma shielding on the drilling efficiency of NSPs and LPs, we conducted observations using a pump-probe system. As shown in Fig. 3a, the intensity of the probe beam was reduced by 60% due to the ablation plume generated by an NSP at 10 mJ. In contrast, the probe beam attenuation caused by the ablation plume generated by an LP at 10 mJ was 20%. These results strongly suggest that the lower plasma generation by LPs enables more efficient drilling.

References

[1] T. Tsuji, S. Yamamoto, S. Ikemoto, H. Hara, M. Ohta, D. Nakamura, Int. J. Adv. Manuf. Technol., 120 (2022) 4139.

[2] S. Nammi, N.J. Vasa, B. Gurusamy, A.C. Mathur, J. Phys. D: Appl. Phys., 50 (2017).

Notes:

Ultrafast laser microprocessing of transparent materials for cancer research

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Abstract:

Lab-on-a-chip platforms are miniaturized transparent devices that accommodate cell cultures and enables observation of cell behavior in tridimensional (3D) spaces that mimic in-vivo relevant environment. Such systems with complex configurations are useful for single-cell detection, controlled manipulation and time lapse monitoring of cells for cancer research.

Herein, we applied subtractive 3D processing technologies including femtosecond laser assisted chemical etching (FLAE) and picosecond laser assisted chemical etching (PLAE) to develop 3D microfluidic networks embedded in photosensitive glass microchips [1,2]. We have then developed hierarchical configurations with dimensions from hundreds of micrometers to hundreds of nanometers as relevant platforms to mimic cancer cell intravasation-extravasation processes. The fabricated biochips provided 3D hierarchical architectures with nanoscale geometries and ultrathin chip base for high-resolution live cell imaging. They allowed both observation of collective prostate cancer cells migration over long time periods and individual visualization at unicellular and subcellular levels on the target cell [3].

Miniaturized biochips were further advanced to simultaneously perform dosimetry measurements and evaluation of biological effects of ionizing radiation on cancer cells [4]. We designed and fabricated a tumor-on-chip model platform consisting of co-cultures of melanoma and melanocytes cells grown in a laser processed glass microenvironment that allowed to discriminate the radiation effect on cancer cells vs. normal tissue cells [5]. This is of interest to validate potential benefits of new irradiation strategies over conventional radiotherapy methods.

References

[1] F. Sima, H. Kawano, A. Miyawaki, L. Kelemen, P. Ormos, D.. Wu, J. Xu, K. Midorikawa, K. Sugioka, 3D biomimetic chips for cancer cell migration in nanometer-sized spaces using “Ship-in-a-Bottle” femtosecond laser processing, ACS Applied Bio Materials 1 (5), 1667, 2018;
[2] F. Jipa, S. Iosub, B. Calin, E. Axente, F. Sima, K. Sugioka, High repetition rate UV versus VIS picosecond laser fabrication of 3D microfluidic channels embedded in photosensitive glass, F Jipa, S Iosub, B Calin, E Axente, F Sima, K Sugioka, Nanomaterials 8 (8), 583, 2018;
[3] F. Sima, H. Kawano, M. Hirano, A. Miyawaki, K. Obata, D. Serien, K. Sugioka, Mimicking Intravasation–Extravasation with a 3D Glass Nanofluidic Model for the Chemotaxis-Free Migration of Cancer Cells in Confined Spaces, Advanced Materials Technologies, 2000484, 2020;
[4] C. E. Staicu, F. Jipa, I. Porosnicu, A. Bran, E. Stancu, C. Dobrea, B. M. Radu, E. Axente, I. Tiseanu, K. Sugioka, F. Sima, Glass lab-on-a-chip platform fabricated by picosecond laser for testing tumor cells exposed to X-ray radiation, Applied Physics A: Materials Science and Processing, 128, 77, 2022;
[5] S. Orobeti, L. E. Sima, I. Porosnicu, C. Diplasu, G. Giubega, G. Cojocaru, R. Ungureanu, C. Dobrea, M. Serbanescu, A. Mihalcea, E. Stancu, C.E. Staicu, F. Jipa, A. Bran, E. Axente, S. Sandel, M. Zamfirescu, I. Tiseanu, F. Sima, First in vitro experiments using laser-induced very high energy electron FLASH irradiation – potential for anti-cancer therapeutic strategies, Scientific Reports, 14 (1), 14866, 2024.

Notes:

High-throughput industrial-scale glass microreactors manufactured by femtosecond laser microfabrication

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Keywords: ultrafast laser 3D printing; industrial-scale glass microreactor; flow-chemistry

Abstract:

Introduction

Over recent decades, ultrafast laser internal modification has enabled three-dimensional (3D) micromachining of transparent materials, facilitating the fabrication of intricate structures and advanced devices with high precision. However, despite these technological advances, the direct application of ultrafast laser 3D fabrication to industrial-scale processing of hard and brittle materials—such as glasses—remains a significant challenge.

Materials and Methods

We report a high-resolution, high-throughput ultrafast laser 3D printing method for fabricating glass micro-reactors at an industrial scale. This approach is based on extreme spatio-temporal control of laser–material interactions deep within transparent materials [1].

Results, Discussion and Conclusions

The fabricated glass micro-reactors incorporate complex 3D microchannels and exhibit a large liquid holding capacity. They demonstrate outstanding performance in high-throughput continuous-flow synthesis of advanced pharmaceutical and chemical products, representing a notable advancement in flow-chemistry applications [2–4].

References

[1] Cheng, Y., Zhang, H., Wang, P., et al., In: Ultrafast Laser Nanostructuring, Springer Series in Optical Sciences, vol 239, Springer, Cham (2023). p. 379-410.

[2] J. Ren, F. Wang, M. Wu, et al., Chem. Eng. J., 476, 146758 (2023).

[3] A. Zhang, J. Xu, L. Xia, M. Hu, et al., Light: Adv. Manuf., 5, 10 (2024).

[4] M. Wu, X. Li, D.-F. Yin, et al., Lab Chip, 23, 3785–3793 (2023).

Notes:

High-Speed Copper Welding by Blue and Infrared Hybrid Laser

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Abstract:

The rapid expansion of electric-vehicle manufacturing has increased the demand for high-quality and high-productivity welding of copper components, particularly motor hairpin conductors. Achieving spatter-free and defect-free joints is essential for ensuring reliability in large-scale production. Although laser welding offers high precision and process flexibility, the inherently low absorptivity of copper at infrared wavelengths limits the stability of conventional IR-based approaches. High-power blue lasers provide substantially higher absorption and therefore offer a promising pathway for improved copper welding. In this study, we developed a hybrid blue–IR laser welding system and investigated its capability for fast and reliable copper hairpin welding.

A hybrid laser welding system was constructed by coaxially integrating a 445 nm blue diode laser (3 kW) with a 1070 nm fiber laser (2 kW) and incorporating a galvanometer scanner. Welding experiments were performed on flat copper hairpin wires with a 2 × 4 mm2 cross section. Thermal-radiation imaging was implemented with the aim of enabling weld quality monitoring.

Blue laser-only welding produced spatter-free joints and exhibited stable molten-pool dynamics over a broad range of scanning speeds. By optimizing the scan speed, the required weld-cross-sectional area of 8 mm2 was achieved within approximately 0.48 s per location. In contrast, hybrid irradiation combining blue and IR lasers yielded a substantial improvement in processing efficiency, enabling completion of the target hairpin weld in approximately 0.16 s [1]. Although minor spatter was observed under hybrid conditions, the weld morphology satisfied the requirements for hairpin fabrication. Furthermore, thermal radiation imaging applied during the welding process enabled the estimation of transient temperature distributions at the weld zone, demonstrating the potential of this method for weld-quality monitoring [2].

References

[1] T. Kikuchi, R. Kokubo, T. Kondo, H. Kaminaga, M. Watanabe, H. Ikenoue, D. Nakamura, J. Laser Appl. (submitted)

[2] T. Kikuchi, K. Muro, R. Kokubo, H. Ikenoue, D. Nakamura, J. Laser Appl. 37, 042030 (2025)

Notes:

Femtosecond laser direct writing of non-enzymatic flexible sensors for D-glucose detection

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Key words: Femtosecond laser direct writing, reductive sintering, flexible sensor

Abstract:

Non-enzymatic flexible sensors composed of three electrodes were fabricated for monitoring D-glucose by green femtosecond laser direct writing. A working electrode, a counter electrode, and a reference electrode, were formed using femtosecond laser reductive sintering of copper (II) oxide nanoparticles, carbonization of the polyimide substrate, and Ag/AgCl paste printing, respectively. The sensitivity of the sensor was 30 µM, which was the same as that of the working electrode prior to integration. The wide range of the linearity of the sensor was achieved from 30 µM to 1.0 mM.

Notes:

Control of optical forces using molecular photoresponses

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Abstract:

Nanometric mechanical motions induced by photo-irradiation can potentially be utilized for realizing remote-controlled mechanical systems in nano-space. As an approach to achieving such photomechanical nanosystems, we have been developing methodologies to control the optical force through molecular photoresponses including photochemical reaction, transient absorption, stimulated emission, and fluorescence emission.

We demonstrated the photoswitching of optical forces using P-type [1,3] and T-type [2,3] photochromic reactions. Single polymer microparticles containing photochromic molecules (e.g. diarylethene derivative, DAE) was optically trapped in water with a CW 532-nm laser. At this stage, the absorption force was negligible because most of the DAEs were in the colorless form. UV (355 nm) exposure to the article induced the photoisomerization, resulting in the color change of the DAEs. As a result, the optical force, mainly absorption force, acting on the particle increased and, the particle shifted towards the light propagation direction. After stopping the UV irradiation, the particle went back to the original position due to the back photo-isomerization induced by the 532-nm laser. The trapped particle thus underwent reciprocal motion synchronizing with the photochromic reactions. By using T-type photochromic reactions, we demonstrated similar reciprocal motions.

We have also demonstrated the control of optical forces using 'transient absorption' of molecules in the excited state [4]. We trapped a polymer microparticle containing dye molecules using focused near-infrared (NIR) pulses and subsequently excited the dyes with visible laser pulses to generate their excited states. When a perylenediimide derivative, exhibiting excited-state absorption at the NIR wavelength, incorporated into the particle, the formation of the excited state led to the generation of absorption force pushing the particle toward the propagation direction of the NIR light. On one hand, when styryl 9M, exhibiting stimulated emission at the NIR region, incorporated into the particle, the particle experienced optical pulling (negative absorption) force towards back to the light source. Thus, we demonstrated optical pushing and pulling forces using positive and negative transient absorption.

We further developed a novel photomechanical microsystem by using optical force due to molecular fluorescence [5]. We fabricated cylinder-shaped polymer micro-objects (PMOs) containing dyes with gold thin films on their top surfaces. Single PMOs in water were photoexcited using a continuous-wave laser at 532 nm. The dyes in the PMOs exhibited anisotropic fluorescence emission mainly from the uncoated bottom ends due to reflection by the gold thin films on the tops. Analysis of the individual motions of the PMOs confirmed that the anisotropic fluorescence emission resulted in their directional movements.

We have thus demonstrated several novel concepts for controlling optical forces acting on micro-objects by utilizing photochemistry.

References

[1] S. Ito, at al., J. Phys. Chem. Lett. 2018, 9, 2659.
[2] K. Setoura, at al., J. Phys. Chem. C 2018, 122, 22033.
[3] K. Setoura and S. Ito, J. Photochem. Photobiol. C: Photochem. Rev. 2022, 52, 100536.
[4] S. Ito, et al., J. Phys. Chem. C 2024, 128, 5206.
[5] S. Ito, et al., Adv. Opt. Mater. 2025, 13, 2403546.

Notes:

Origin of Fano resonances in excitonic nanostructures

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Abstract:

Introduction In recent years, excitonic materials such as transition metal dichalcogenides, perovskites and J aggregates of dye molecules have attracted great interest, as they support strong exciton transitions at room temperature and offer potential applications in a variety of optical devices. Several experimental studies demonstrated the emergence of asymmetric line shapes in light scattering spectra of their nanostructures, characteristics of Fano resonances. Despite these observations, the origin and full implications of such resonances are still not comprehensively explored. This work aims to establish a general formalism of describing Fano resonances in 0D, 1D and 2D nanostructures of excitonic materials, enabling elucidation of underlying physical origin.
General Formalism
We discuss the optical spectra of a single excitonic nanostructure characterized by a dielectric function ε(ω), embedded in a surrounding medium with a dielectric constant εεm. The dielectric function of the excitonic material is given by

$$\varepsilon(\omega) = \varepsilon_b - \frac{f\omega_{exc}^2}{\omega^2 - \omega_{exc}^2 + i\gamma_{exc}\omega_{exc}}, \qquad (1)$$

where ε_b is the background dielectric constant, $\hbar\omega_{exc}$ the exciton transition energy, γ_{exc} the damping rate, and f the oscillator strength. The optical spectra of the nanostructure can generally be expressed as

$$S(\omega) = P(\omega)|F(\omega)|^2, \qquad (2)$$

where $P(\omega)$ is a prefactor independent of ε_m and $\varepsilon(\omega)$, and $F(\omega)$ is a spectral function describing excitonic responses in terms of ε_m and $\varepsilon(\omega)$. The background spectrum generated by ε_b is denoted as $S_{back}(\omega)$, obtained from Eq. (2) by setting $f = 0$. The spectrum normalized to the background :

$$NS(\omega) = \frac{S(\omega)}{S_{back}(\omega)} = |1 + \Lambda(\omega)|^2, \qquad (3)$$

where $\Lambda(\omega) = [F(\omega) - F_{back}(\omega)]/F_{back}(\omega)$, with $F_{back}(\omega)$ obtained from $F(\omega)$ by setting $f = 0$. When $\Lambda(\omega)$ behaves like a Lorentzian, it follows that $NS(\omega)$ can be described by a generalized Fano function. The Lorentzian function is expressed as $L(\omega) = A/(\Omega^2 + 1)$, with a complex number $A = A' + iA''$, and $\Omega = (\omega^2 - \omega_F^2)/\omega_F\Gamma$ with the resonance frequency ω_F and the linewidth Γ. Substituting $\Lambda(\omega)$ by $L(\omega)$, we can derive the following generalized Fano function:

$$NS(\omega) = \frac{(\Omega + q)^2 + b}{\Omega^2 + 1}, \qquad (4)$$

where q is the asymmetry parameter given by $q = A'$ and b is the screening parameter given by $b = (1 + A'')^2$.

Application to 0D, 1D and 2D excitonic nanostructures
Applying the general formalism introduced above, we analyzed the light-scattering spectra of an excitonic sphere (0D), an excitonic infinite circular cylinder (1D), and the reflection spectra of an excitonic slab (2D). For a sufficiently small sphere, the spectral function F(ω) in Eq. (2) is governed by the lowest-order Mie coefficient aa1. Similarly, for a cylinder under normal incident light, F(ω) is determined by a1 (TE polarization) or b0 (TM polarization). In the slab geometry, F(ω) is set by the Fresnel reflection coefficient. In numerical calculations of the spectra, we employed parameters of ε(ω) that describe the optical properties of a PVA film doped with J-aggregates of TDBC molecules. The oscillator strength f was taken as f = 0.10, ensuring that the excitonic material remains nonmetallic. For all nanostructures considered, the spectra of Λ(ω) obtained from numerical calculations exhibited resonant behaviour that can be well reproduced by the Lorentzian function

$L(\omega)$. This observation is consistent with the fact that the normalized spectra can be accurately fitted by the generalized Fano function. Since Eq. (3) indicates that the normalized spectra arise from interference between the constant background term and the excitonic term $\Lambda(\omega)$, we can finally conclude that Fano resonances universally originate from the interference between the nonresonant background component and resonant excitonic component in the optical response.

Notes:

III-nitride-Based super-resolution and multi-focal metalens

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Abstract:

Dielectric metalens have novel applications in imaging, nano-fabrication, and quantum optics. Among all dielectric materials, III-nitrides epitaxial film, GaN and AlN, attracted much attention for metalens working in the visible to ultraviolet spectral region for their high transparency and high refractive index. In this report, we'll introduce how we design and fabricate metalenses with super-resolution and multiple focus with AlN and GaN epi layers. According to the accumulated phase difference between the extraordinary ray and ordinary ray, two special classes of III-nitride nano-fins are assembled by theoretical simulations: the half-wavelength plate (HWP) and quarter-wavelength plate (QWP) meta-atoms.

The HWP meta-atoms with full 2π phase coverage provide independent control over light with opposite spins. Therefore, a bifocal metalens that focuses photons with opposite spins to different points can be fabricated using a single metasurface. (ACS Photonics 12, 1235 (2025)). In this report, we further integrate a Fresnel zone plate composed of alternately opaque and transparent rings into the bifocal meta-lens to create the third focus. Based on the polarization states of the incident wave, the photons will be focused to two or three points with orthogonal polarization states. After further manipulation by conventional passive matrix elements, the intensity at three foci can be independently turned on and off simultaneously, thereby enhancing the information density of a single laser shot by fourfold.

QWP meta-atoms can transform a circularly polarized photon to an arbitrary linearly polarized one. Therefore, we can transform a circularly polarized ray into a radially or azimuthally polarized beam. In this report, we will integrate four passive elements, which are the azimuthal polarizer. spiral phase plate, ring aperture, and a Fresnel lens into one metasurface to overcome the Rayleigh diffraction limit. We will demonstrate a GaN-based super-resolution ring-shaped meta-lens working at 450 nm with a numerical aperture (NA) of 0.4. The measured spot size at the focal plane is 544 nm, which is lower than what Rayleigh's criterion predicts (686 nm). The simulation predicted that the spot size could be narrowed to 181 nm with a high NA of 0.9.

Notes:

Optical levitation and dynamics of a microsphere above LIPSS

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Abstract:

Introduction

Optical tweezers are widely used for non-contact manipulation of microscopic objects, typically in liquid environments where particles remain suspended and stable trapping is readily achieved. In contrast, optical trapping in air faces a critical challenge: microspheres strongly adhere to solid substrates due to van der Waals and electrostatic forces. This adhesion prevents reliable detachment and controlled manipulation, making airborne trapping significantly more difficult than trapping in solution. To overcome this limitation, we propose a substrate-assisted trapping approach based on Laser-Induced Periodic Surface Structures (LIPSS). By engineering the surface morphology at the submicron scale, LIPSS modifies both the optical near-field distribution and particle–surface interactions, enabling stable trapping of a microsphere in air.

Materials and Methods

Periodic nanostructures were fabricated on a solid substrate using laser-induced periodic surface structuring. The resulting LIPSS provides a spatially modulated surface profile with periodicity comparable to the trapping wavelength. A single laser beam was focused onto the structured substrate under ambient atmospheric conditions. A microscale spherical particle was placed on the surface, and the interaction between the focused beam and the LIPSS-modified substrate generated localized field enhancement and strong intensity gradients near the surface. The periodic morphology reduces the effective contact area and alters adhesion conditions, facilitating particle detachment and confinement.

Results, Discussion and Conclusions

Stable trapping of a microsphere in air was successfully demonstrated using the LIPSS-engineered substrate. Compared with flat surfaces, the structured substrate significantly improved trapping reproducibility. The combination of modified adhesion and structured optical near-fields enables reliable confinement under atmospheric conditions. Moreover, a trapped microsphere exhibited dynamical behaviors distinct from conventional single-beam optical tweezers. The particle showed anisotropic and position-dependent motion influenced by the periodic surface structure. These results indicate that trapping is governed by a hybrid mechanism involving optical gradient forces and surface-modulated near-field effects. In conclusion, LIPSS-assisted optical tweezers provide a simple and effective platform for airborne particle manipulation and reveal new dynamical regimes beyond traditional liquid-phase trapping systems.

References

[1] Masaki Michihata, Tadaaki Yoshikane, Terutake Hayashi, Yasuhiro Takaya: "New technique for single-beam gradient-force optical trapping in air," International Journal of Optomechatronics, vol. 7 issue 1 (2013) pp.46-59.

[2] Masaki Michihata, Terutake Hayashi, Yasuhiro Takaya: "Measurement of vertical and lateral trapping stiffness of optical tweezers in air using radially polarized beam," Applied Optics, vol. 48, no. 32, (2009) pp.6143-6151.

Notes:

Optical Tweezers Using Nano-Structured Silicon Crystals

Yasuyuki Tsuboi

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Abstract:

Optical manipulation refers to methodologies for controlling the motion of objects—namely trapping and manipulation—using light, and the technique that enables this is known as optical tweezers. This field represents a remarkable area of science, rich in both fundamental and technological potential, and has been recognized by two Nobel Prizes in Physics over the past three decades.

The trapping force decreases rapidly as the size of the target particle becomes smaller. For nanomaterials with sizes below approximately 10 nm, the gradient force can no longer overcome thermal fluctuations, making stable trapping extremely difficult. This is the fundamental reason why optical trapping of biomolecules such as proteins and functional nanomaterials such as quantum dots (semiconductor nanocrystals) is challenging. In other words, it is inherently difficult to "grasp" objects as small as molecules, and achieving this requires some form of physical "mechanism" or enhancement.

To overcome these limitations of conventional optical tweezers, we have focused on silicon substrates possessing surface nanostructures composed of densely integrated nanoneedles—so-called black silicon. Such nanostructures can be readily fabricated by simple surface treatment of silicon wafers using dry etching (reactive ion etching), and large-area fabrication at the inch scale is straightforward. In black silicon, the nanospike structures create a steep refractive index gradient, significantly reducing reflectivity and allowing incident light to be transiently confined near the silicon surface. Furthermore, effects such as Anderson localization of light and Mie resonances are expected to enhance the electromagnetic field in the vicinity of the surface. Importantly, this system does not require real electronic excitation in silicon, thereby avoiding photothermal effects that would otherwise hinder trapping.

Using this platform, we have conducted extensive optical trapping experiments. As a result, we have demonstrated that black silicon substrates strongly assist optical trapping. We refer to this new type of optical tweezers as Nano-Structured Semiconductor-Assisted (NASSCA) optical tweezers. Although the intrinsic trapping force of NASSCA optical tweezers is more than an order of magnitude weaker than that of plasmonic optical tweezers, our systematic studies reveal that NASSCA tweezers are entirely free from thermal disturbances. Consequently, they enable more stable and robust trapping compared to plasmonic systems. Moreover, NASSCA optical tweezers can achieve functionalities that are unattainable with conventional or plasmonic optical tweezers, such as trapping of polymer chains in aqueous environments and large-scale trapping of microparticles.

These findings suggest that this entirely new class of optical tweezers has the potential to open up a new frontier in chemistry based on optical manipulation.

Notes:

Ultrafast single-element beam switching using nanocomposite liquid crystal holographic optical elements

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Abstract:

Introduction
Liquid-crystal-based holographic optical elements (LC-based HOEs) can arbitrarily shape optical wavefronts for specific polarization states through designed alignment patterns. Exploiting this polarization selectivity enables switching of the beam's diffraction direction, and thus LC-based HOEs combined with a half-wave plate have been applied to beam-steering devices. For compactness and low fabrication cost, however, it is desirable to operate beam steering using only an LC-based HOE. In conventional LC-based HOEs employing nematic LCs, electric-field driving often deforms or destroys the imposed alignment pattern due to competition between dielectric torque and elastic restoring torque.[1] This instability limits diffraction efficiency, operational robustness, and response speed. Here, we realize deformation-free electro-optic switching on a tens-of-microseconds timescale by adopting an alignment-preserving nanocomposite nematic LC.

Materials and Methods
A mixture of nematic LC (E-47, Merck), reactive mesogen (RM82, Merck), and photoinitiator (Irgacure 819, BASF) with a weight ratio of 87:12:1 was UV-polymerized at 0 °C to form a nanocomposite LC. A sinusoidal photoalignment pattern with a 72 μm period was fabricated on ITO glass substrates, and an LC cell with a thickness of approximately 4 μm was assembled.

Results, Discussion and Conclusions
Under a 1 kHz square-wave electric field, polarized optical microscopy confirmed that the initial alignment pattern was maintained while the birefringence was uniformly modulated, without noticeable scattering. Consequently, the power distribution between the 0th and 1st diffraction orders for a 532 nm probe beam was continuously tuned with increasing field strength, showing good agreement with numerical analysis based on Jones matrix and Fresnel diffraction theory. The device exhibits fast 0th/1st-order beam switching dynamics with an 84 μs rise time and a 64 μs decay time. These results indicate that nanocomposite-LC-based HOEs provide a promising route to stable, high-speed, electrically tunable holographic diffraction gratings for advanced wavefront-control and beam-steering systems.

[1] J. Kim et al., Proceedings of SPIE, 7093, 709302 (2008).

Notes:

Optical Mobius strips topology distribution in random electromagnetic fields

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Abstract:

Introduction

In nonuniformly polarized electromagnetic fields, polarization structures arise in which the axes of polarization ellipses, traced along small closed contours, form topologically nontrivial surfaces [1]. These are known as optical Mobius strips. Such strips enclose polarization singularity points. The direction and number of Mobius strip twists serve as markers of the local field topology, playing for a 3D field a role similar to that of singularity topological types in cross-sections of paraxial light beams.

We study the statistical properties of optical Mobius strips constructed along random contours in random nonparaxial electromagnetic fields, determining how the main topological parameters of a polarization singularity influence the twist direction of such strips.

Problem statement

We consider a Gaussian random monochromatic electromagnetic field, i.e., a superposition of a large number of plane waves with uncorrelated random amplitudes, phases, and directions of wave and polarization vectors. Complex interference in such a field forms special regions, called CT-lines, in which polarization ellipses degenerate into circles [2]. Points on these lines, known as topological singularities, are characterized by the behavior of the polarization ellipses in their immediate vicinity.

Every polarization singularity can be fully described by a set of four scalar parameters $\gamma, \beta, \kappa, \varphi_z$ [3]. The first two parameters are widely used in the literature and define the topological type of the point. The other two allow one to distinguish finer details of the polarization ellipse distribution around it.

A Mobius strip traced near a singularity point along a small circular contour may be attributed to one of four distinct topologies, of which only two are generic and appear in the random case studied here. These two differ in the direction of the strip twist and depend both on the topology of the central polarization singularity and on the contour used to trace the strip.

Considering singularities with $\gamma, \beta, \kappa, \varphi_z$ distributed according to their probability densities in a Gaussian random field, we analytically show that if both the singular point and the contour direction are chosen randomly, the two twist directions of optical Mobius strips are equally abundant. However, for any given singularity, the two twist directions are not necessarily equally probable on a random contour. We complement the analytical results with numerical simulations to study the statistics of different types of optical Mobius strips depending on the topology of the central polarization singularity.

Discussion of the results

We find that for particular topological singularities, the percentage of one twist direction of an optical Mobius strip may reach 66%. We also show that a strong predominance of one twist direction over the other is most often observed for polarization singularities of the monstar topological type, especially near its boundary with the lemon type in the γ, β parameter space.

Although the parameters κ and φ_z do not affect the topological type of a polarization singularity, they still play an important role in determining the Mobius strip twist direction. For both small and large values of κ, the predominance of one twist direction over the other is weak for any combination of the other three parameters. However, near $\kappa \approx 0.14$, the contrast between the two twist directions increases dramatically. For small κ, the predominance of one twist direction is confined to a small region of the γ, β parameter space, whereas as κ increases, regions of significant imbalance expand over most γ, β combinations. The parameter φ_z has a weaker effect on the overall imbalance between twist directions, but it determines which direction prevails in a given region of the γ, β space.

References

[1] Mark R. Dennis, “Fermionic out-of-plane structure of polarization singularities,” Opt. Lett. 36, 3765-3767 (2011)
[2] J.F. Nye and J.V. Hajnal, “The wave structure of monochromatic electromagnetic radiation,” Proc. of the Royal Society of London. A. 409(1836):21–36, 1987
[3] K. S. Grigoriev and V. A. Makarov, “Indices of polarization Mobius strips surrounding lines of circular polarization in nonparaxial optical fields,” Opt. Lett. 48, 4420-4423 (2023)

Notes:

Advances in real 3D display by holography technology

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Abstract:

Three-dimensional (3D) display techniques deliver processed visual information to the human visual system, enabling stereoscopic perception through such as accommodation-based depth cues, vergence-based binocular disparity cues, and occlusion-related spatial position cues. Among these cues, parallax and spatial occlusion provide strong stereoscopic effects, while depth cues play a key role in ensuring physiological viewing comfort. Holographic display is widely regarded as an ideal 3D visualization solution, as it reconstructs 3D content by directly shaping the light wavefront. It not only offers natural physiological comfort to the human eye but also delivers a psychologically immersive stereoscopic viewing experience.

Holographic 3D display often faces inherent trade-offs between slow hologram generation, low display quality, and weak 3D perception. While deep learning-based methods have significantly improved generation efficiency and display quality, they still lack key factors enhancing 3D perception, such as parallax and occlusion culling. In our latest research, we propose new solutions for texture mapping, multi-view observation, and parallax effects, achieving noticeable improvements. Unlike approaches using RGB-D data, we utilize polygonal 3D models and propose a point-polygon hybrid method to map texture information [1]. We employ spectral envelope shifting to reflect light towards multiple viewpoints [2] and utilize a Lohmann lens to replace point-by-point computation [3], greatly increasing efficiency. Since polygonal model algorithms process propagation in the frequency domain, they naturally possess multi-angle diffraction characteristics; we demonstrate their advantages in 3D perception regarding parallax effects and occlusion properties. Furthermore, in the human-computer interaction experience of 3D displays, to enable real-time interaction, a lightweight post-processing method has been developed that allows for depth-preserving zooming of regions of interest (ROIs) on the display system [4].

References

[1]. Fan Wang, David Blinder, Tomoyoshi Ito, and Tomoyoshi Shimobaba. “Point-polygon hybrid method for generating holograms”. Optics Letters 48.12, pp. 3339–3342 (2023).
[2]. Fan Wang, David Blinder, Yogi Udjaja, Tomoyoshi Ito, and Tomoyoshi Shimobaba. “Dependent lighting on polygonal holograms using bump mapping”. Optics Letters 49.18 pp. 5180–5183 (2024).
[3]. Wang, Fan, et al. "A polygon-based hologram generated using the split-Lohmann lens method." Advances in Display Technologies XVI. Vol. 13915. SPIE, 2026.
[4]. Wang, Fan, et al. "Depth-preserving local zoom for holographic display." Sixteenth International Conference on Information Optics and Photonics (CIOP 2025). Vol. 13990. SPIE, 2025.

Notes:

3D OCT image processing for quantitative choroidal analysis

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Abstract:

Optical coherence tomography (OCT) has become an essential imaging modality in ophthalmology because it enables noninvasive three-dimensional (3D) observation of fundus structures with high spatial resolution. In particular, 3D OCT provides rich structural information that can support quantitative analysis of ocular tissues beyond conventional qualitative inspection. Among these structures, the choroid, a highly vascularized tissue located between the retina and the sclera, has attracted increasing attention because its structural characteristics are known to be closely associated with the development and progression of various retinal diseases. Quantitative assessment of the 3D structure of the choroid is important for understanding disease mechanisms, evaluating disease status, and monitoring treatment response.

Despite the clinical importance of choroidal analysis, accurate and reproducible quantification remains challenging. In OCT images, the choroid-sclera boundary is often poorly visible, making reliable extraction of the choroidal region difficult. As a result, choroidal assessment still depends heavily on manual measurements, which are labor-intensive, limited to sparse locations, and insufficient for comprehensive volumetric evaluation. In addition, many existing approaches are based on cross-sectional images and do not fully capture the 3D geometry of the choroid.

In this talk, I will present our recent work on 3D OCT image processing for quantitative choroidal analysis, with a particular focus on choroidal thickness assessment. The proposed framework integrates automated choroidal segmentation with morphology-aware thickness measurement, explicitly incorporating 3D structural information in both stages. I will discuss the methodological basis of this framework, its qualitative and quantitative validation, and its potential contribution to objective and reproducible choroidal assessment in ophthalmic imaging.

Notes:

From AR-head up display to MR-head up display

Hoang-Yan Lin

National Taiwan University, Taiwan

Abstract:

A head-up display (HUD) system was designed to combine the dashboard information for driver and scenes from windshield, so it is a augmented reality (AR) system. However, due to the development of smart cockpits, navigation system and advanced driver assistance systems (ADSA) are also expected to be integrated and helpful for driving safety. To real-time generate and display the navigation and ADSA signals, and to be mixed with the real scenes from windshield, a mixed-reality-HUD is developed. Holography and light-field displays together with projection technologies are used to positioning the signals to corresponding objects and scenes. Accelerated algorithms are developed for real-time generation of holographic or light-field signals.

Notes:

Multiobjective inverse design of nanophotonic devices using statistical learning global optimization

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Abstract:

Nanostructuring of materials has paved the way for manipulating and enhancing light-matter interactions, thereby opening the door for the full control of these interactions at the nanoscale. In particular, the interaction of light waves (or more general optical waves) with matter is a subject of rapidly increasing scientific importance and technological relevance. Indeed, nanophotonics aims at using nanoscale light-matter interactions to achieve an unprecedented level of control on light. In this talk, we will present our recent efforts and achievements toward the development of innovative numerical methodologies for the inverse design of nanoscale photonic devices. Numerical modeling plays a crucial role in this context, in particular for discovering non-intuitive nanostructures or material nanostructuring for harvesting and tailoring the interaction of light with matter at the nanoscale. In our works, we combine two main numerical ingredients: (1) high order Discontinuous Galerkin (DG) methods [1] for solving the system of time-domain [1] or frequency-domain [2] Maxwell equations in 3D, which are coupled to appropriate differential models of physical dispersion in photonic materials; (2) one of the most advanced optimization techniques that belongs to the class of Bayesian optimization and is known as Efficient Global Optimization (EGO) [3]. The capabilities of the resulting numerical methodology will be illustrated on several use cases of multiobjective and robust design of different nanophotonic devices.

References

[1] S. Lanteri, C. Scheid and J. Viquerat. Analysis of a generalized dispersive model coupled to a DGTD method with application to nanophotonics. SIAM Journal on Scientific Computing, Vol. 39, No. 3, pp. A831–A859 (2017)

[2] E. Agullo, L. Giraud, A. Gobé, M. Kuhn, S. Lanteri and L. Moya. High order HDG method and domain decomposition solvers for frequency-domain electromagnetics. Int. J. Numer. Model. Electr. Netw. Dev. Fields, Vol. 33, No. 2 (2019)

[3] D. Jones. Efficient global optimization of expensive black-box functions. Journal of Global Optimization, Vol. 13, No. 4, pp. 415-447 (1998)

Notes:

Perovskite quantum-dot-based memristor for neuromorphic photonic computing

Ya Ju Lee

National Cheng Kung University, Taiwan

Abstract:

Neuromorphic photonic computing has emerged as a promising paradigm to overcome the limitations of conventional von Neumann architectures, particularly in terms of data transfer bottlenecks, energy consumption, and latency. In this talk, we present our recent progress in perovskite quantum-dot-based memristive and photonic synaptic devices for next-generation intelligent vision systems. We first demonstrate an all- inorganic CsPbBr3 quantum-dot-based optoelectronic synapse that monolithically integrates optical sensing and synaptic functionalities within a unified material platform, enabling near-sensor computing and real-time image preprocessing. This architecture eliminates the need for heterogeneous integration and significantly improves system efficiency. We further introduce a Tamm plasmon-enhanced photodetector that achieves strong light-matter interaction and wavelength-selective absorption without requiring conventional color filters. The device simultaneously exhibits neuromorphic synaptic behaviors, enabling integrated perception, memory, and processing functions for tasks such as facial recognition. By combining memristive switching, optical resonance engineering, and quantum-dot materials, these devices provide a scalable platform for in-sensor computing and neuromorphic photonic systems. This work highlights a new direction toward highly integrated, energy-efficient artificial vision hardware.

Notes:

Multi-contrast Optical Coherence Tomography for oral cancer detection

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Abstract:

Introduction:
Early oral cancer is mainly diagnosed by clinician expertise and invasive biopsy, the latter being essential to distinguish benign from malignant lesions. However, overuse of biopsies can strain healthcare systems and reduce patient compliance. Consequently, optical sectioning techniques are gaining recognition as viable alternatives for future clinical practice. Among optical imaging modalities for oral evaluation, Optical Coherence Tomography (OCT) is a non-invasive method that utilizes light waves to produce high-resolution cross-sectional images of tissue. Polarization Sensitive OCT (PS-OCT) has emerged as a promising approach within the oral cavity, employing polarization-based measurements to assess tissue birefringence and visualize both structural and functional characteristics. This capability is particularly valuable in diagnosing intraoral conditions such as abnormal hyperplasia and early-stage cancers. Contrasts derived from PS-OCT image data may significantly enhance the detection of various oral diseases.

Methods:
A non-contact optical sectioning approach was developed utilising multi-contrast optical coherence tomography (OCT) for the early detection of suspicious lesions prior to pathological confirmation. The custom-built OCT system incorporates a 100 kHz swept-source laser with a center wavelength of 1310 nm. Interferometric signals are acquired and subsequently processed using software such as MATLAB to make necessary adjustments. This study presents a disposable handheld imaging device capable of integrating multiple image parameters—including differential intensity, phase retardation, fast optical axis, polarization uniformity, and angiography—thereby enabling comprehensive evaluation of tissue composition.

Findings and Conclusion:
This study combines computational techniques with a disposable probe for more hygienic, non-invasive oral imaging. The handheld probe offers ~10 μm lateral resolution in air, ~15 μm axial resolution, a 9 mm maximum FOV, and completes scans in 8 seconds. Multi-contrast OCT may help define tumor boundaries before surgery, potentially lowering recurrence rates. Future work should compare scanned data to pathological diagnoses to better assess the accuracy of each parameter.

Keywords: optical coherence tomography, oral cancer, optical biopsy
Acknowledgments:
This research was supported by the National Health Research Institutes, Taiwan (NHRI EX115-11326EI).

Notes:

Laser Micro/nanojoining of Carbon Nanotubes, Graphene, and Carbon-Copper Composites

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Abstract:

This talk presents advanced techniques for the precise joining and integration of carbon-based nanomaterials, including 1D single-walled carbon nanotubes (CNTs), 2D graphene, and 3D diamond-based composite materials, to address critical challenges in nanoelectronics and thermal management. A laser-assisted chemical vapor deposition (LCVD) method leverages optical near-field effects from CO_2 laser irradiation on pre-patterned substrates with sharp metallic tip electrodes, acting as optical antennas (Fig. 1). These antennas locally enhance the electric field, generating nanoscale heating to promote selective CNT growth between opposing electrode tips at a substrate temperature of ~500°C. The process ensures precise placement, reliable electrical contacts, and semiconducting properties, enabling scalable fabrication of CNT-based nanoelectronic devices. Additionally, a plasmonic-assisted LCVD approach uses silver nanoantenna arrays to couple laser energy into localized surface plasmon resonances, selectively activating catalyst nanoparticles in sub-100-nm gaps to grow CNT bridges in a single step. The resulting infrared bolometers exhibit high responsivity (~800 V/W) at room temperature due to enhanced optical field-CNT interactions. For 2D graphene, a laser-assisted nanowelding technique reduces graphene-metal contact resistance to 2.57 Ω·µm by creating localized defects at the contact interface, followed by thermal annealing to form strong covalent bonds, yielding a fourfold increase in photocurrent in photodetectors (Fig. 2). For 3D structures, a hybrid copper/carbon (Cu/C) metal matrix composite with carbide interphases (TiC or ZrC), enhances interfacial bonding and thermal conductivity for advanced thermal management in microelectronics. Microstructural and thermal characterizations confirm high-quality interfaces and superior performance, offering a versatile platform for next-generation electronic and optoelectronic devices.

Notes:

Chalcogenide glasses and infrared photonics

Johann Troles

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Keyword: Chalcogenide glasses, chalcogenide fibers, mid-infrared photonics

Abstract:

Chalcogenide glasses have emerged as a unique class of infrared-transparent materials, offering optical windows that extend well beyond the capabilities of conventional silicate glasses. Their high refractive index, wide transmission ranges from the visible to the mid-infrared (MIR), and excellent thermal stability make them particularly attractive for photonic devices operating between 2 and 12 µm. In this presentation, we will first outline the structural features and the resulting optical and thermal properties of chalcogenide glasses, highlighting the contrasts with glass systems. We will then describe key fabrication strategies, from bulk glass synthesis to fiber drawing, that enable precise control of composition and optical performance. Finally, we will illustrate a range of MIR photonic applications, including night-vision components, spectroscopic sensors, and the generation of novel mid-infrared light sources in both bulk and fiber architectures. These examples demonstrate how chalcogenide glass technology provides versatile platforms for next-generation infrared photonics and paves the way toward compact, high-performance devices for sensing, imaging, and nonlinear optics.

Notes:

Optical vortex induced forward transfer towards advanced printing technology

Takashige Omatsu

Chiba University, Japan

Abstract:

Laser induced forward transfer (LIFT) enables the cost-saving and resource-saving development of flexible electric/photonic/bioprinting devices as a nozzle-free printing approach.
We have proposed a new LIFT technology using the optical vortex with a ring-shaped spatial intensity profile and an orbital angular momentum instead of the conventional Gaussian beam, in which the optical vortex pulse twists an irradiated material (donor) to eject and propel a pico-litter-scale spinning donor microdroplet with a straight flight. This optical vortex induced forward transfer (OV-LIFT) offers an opportunity to develop further advanced printable devices and new generation bioprinting.

Notes:

Effect of laser wavelength in laser cavitation peening on fatigue strength improvement of Ti6Al4V

Hitoshi Soyama

Tohoku University, Japan

Abstract:

Laser peening, in which a pulsed laser is used for mechanical surface treatments, is a powerful tool to enhance fatigue properties of metals such as titanium alloy Ti6Al4V. There are two methods of laser peening, i.e., water film laser peening and submerged laser peening. At both laser peening, it has been believed that the expansion wave generated by laser ablation is confined by the inertial force of water, causing plastic deformation in the metal, i.e., peening effect. However, at submerged laser peening, following laser ablation, a cavitation-like bubble is generated, and collapse producing impact. The bubble is named as “laser cavitation”. Soyama found that impact at laser cavitation collapse is larger than that of laser ablation by optimizing peening condition. Then, submerged laser peening a kind of “cavitation peening”, in which cavitation bubble collapse impact is used for peening, and it is named as “laser cavitation peening”. At water film laser peening, the fundamental wave length of Nd:YAG laser, i.e., 1064 nm is used, as the half laser energy is lost during conversion from 1064 nm to 532 nm. On the other hand, 532 nm is used for submerged laser peening, to reduce absorption of laser energy by water. At laser cavitation peening, both 532 nm and 1064 nm can be used, as 1064 nm is useful to generate cavitation bubble. A fiber laser, whose wave length is 1080 nm, also create laser cavitation, and great advantage of the fiber laser is maximum repetition frequency, i.e., 50 kHz, whereas Nd:YAG lasers operate at frequencies of tens to around 100 Hz. In the case of Ti6Al4V, fatigue properties are strongly affected by heat treatment. Then, the keynote lecture will explain the effect of laser wavelength in laser cavitation peening on fatigue strength improvement of Ti6Al4V and introduce examples of its application.

Notes:

On the use of femtosecond lasers to tune functional properties of materials

Yves Bellouard

Ecole Polytechnique Fédérale de Lausanne, Switzerland

Abstract:

Notes:

Multi-pulse optical vortex laser ablation in liquid: Plasmon-assisted asymmetric microstructuring

Haruki Kawaguchi[a, b], Ryo Yasuhara[a, b], Reina Miyagawa[c, a], Koji Sugiokad, Yoshiaki Nishijimae, Hiroaki Furusef, Masato Ota[a,b], and Hiyori Uehara[a, b].

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Keywords: Optical vortex, Laser ablation, Laser ablation in liquid

Abstract:

The interaction between optical vortex with helical wavefront and materials has become an active research field. Recently, we proposed laser ablation in liquids by optical vortex and discovered that asymmetric bowtie-shaped microstructures can be fabricated against the symmetry of intensity profile.
In this presentation, we demonstrate that the formation of these unique asymmetric bowtie structures would be induced by the local plasmonic electric field enhancement caused by the optical vortex from the simulation and experiment.
This research provides us with the insight that the spatial structure of light is a key factor determining the nano-microstructuring process by laser ablation.

Notes:

Femtosecond laser nano machining for microfluidic and optical applications

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Abstract:

Introduction
Since its discovery at the end of the twentieth century[1,2], Femtosecond Laser Irradiation followed by Chemical Etching (FLICE) has found extensive applications in both academic and industrial settings, owing to its remarkable versatility in creating three-dimensional hollow structures with micrometric precision within transparent media[3,4]. In particular, fused silica represents one of the most suitable materials to be processed with this technique, as the fabricated devices inherit its excellent chemical, mechanical, and optical properties. Therefore, they can be employed in a wide range of optofluidic experiments, a research branch that combines optics and microfluidics, finding applications in the development of lab-on-a-chip devices[5]. Over the last few years, FLICE has been successfully used to realize chip-integrating features ranging from the micrometric to the centimetric scale, but up to now, the possibilities of making it effective at the nanoscale, in fused silica glass, have not been explored. The nanomachining of fused silica would be useful to boost the research in the fields of nanofluidics and nanoptics.

In this framework here we present a novel approach to obtain empty structures inside fused silica with nanometer scale, and will demonstrate its applicability in fields like optics and optofluidics.

Materials and Methods
For the irradiation we use the second harmonic of a Yb-doped fiber laser (Satsuma, Amplitude Systems S.A.), at a repetitions rates under 50 kHz. The beam is focused by a 150x glycerin immersion microscope objective, with a numerical aperture of 1.35 (Zeiss, Plan-Apochromat). The objective is accommodated on a pneumatic 1D translational stage (Aerotech, ANT130-035-L-ZS-PLUS), allowing the translation on the vertical axis, while the fused silica sample is mounted on a 2D stage (Aerotech, ANT95-50-XY-CMS-ULTRA) permitting the movement on the transversal plane. This system allows the relative movement between the beam focal volume and the sample, with an error which can be assessed to be $<$ 10 nm. The chosen fused silica substrate is Corning 7980, Standard Grade. After irradiation the samples are submerged in a 1 M NaOH aqueous solution at 65 °C.

Results Discussion and Conclusions
A deep study of the pulse energies allows us to work at different regimes, moreover when it is chosen slightly above the nonlinear absorption threshold the modified volume is minimized and sub-micrometer size whole are obtained. For relatively high pulse energy (80 nJ), the modification shows an irregular cross section, which is elongated in the direction of propagation of the beam. Decreasing the energy, the profile becomes initially ellipsoidal (60 nJ) and then almost circular for energies between 40 nJ to 30 nJ. For r energies lower than 30 nJ, there is no modification visible. This process enables precise multiscale structuring of fused silica, integrating milli-, micro-, and nanoscale features into a monolithic chip.

We will demonstrate the potential of this new regime fabricating integrated structures like sub-wavelength gratings or even permeable nano-membranes directly integrated into cell-growth microfluidic chips.

We envisage that this submicrometer resolution in fused silica material will further empower the FLICE technique allowing it to move into nanofluidic and nano-optics research.

References

[1] Kondo, Y., Qiu, J., Mitsuyu, T, Hirao, K., Yoko, T. Three-Dimensional Microdrilling of Glass by Multiphoton Process and Chemical Etching. Jpn. J. Appl. Phys. 38 L1146 (1999)

[2] Marcinkevičius, A. et al. Femtosecond laser-assisted three-dimensional microfabrication in silica. Opt. Lett. 26, 277-279 (2001).

[3] Osellame, R., Cerullo, G. & Ramponi, R. Femtosecond Laser Micromachining: Photonic and Microfluidic Devices in Transparent Material. Topics in Applied Physics 123 (2012).

[4] Gattass, R. R. & Mazur, E. Femtosecond laser micromachining in transparent materials. Nat Photonics 2, 219–225 (2008).

[5] Sugioka, K. & Cheng, Y. Femtosecond laser processing for optofluidic fabrication. Lab on a Chip vol. 12, 3576–3589 (2012).

Notes:

Holographic laser material processing using a spatial light modulator

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Abstract:

Femtosecond laser processing has emerged as a powerful technique for high-precision micro-processing due to its capability of inducing nonlinear absorption and minimal thermal damage. However, conventional single-beam scanning approaches often suffer from limited throughput and flexibility. To overcome these challenges, we have introduced a holographic femtosecond laser processing technique that utilizes spatial light modulator (SLM) to generate arbitrary light patterns in three dimensions via computer-generated holograms (CGHs).

By dynamically modulating the phase of the input beam with an SLM, we can produce multiple simultaneous foci with controlled spatial distributions and tailored beam profiles. This enables parallel processing, adaptive focus shaping, and even the generation of non-diffracting beams such as Bessel beams. To ensure high fidelity of the projected patterns, we incorporate feedback control and aberration compensation into the CGH design process, allowing precise beam shaping even under optical distortions.

We present applications of this technique in transparent material processing, such as laser marking, surface and volumetric micro-structuring, and through-glass via (TGV) drilling. This presentation highlights the potential of holographic beam shaping with femtosecond lasers as a next-generation solution for scalable, flexible, and intelligent laser microfabrication systems.

Keywords: Femtosecond laser processing, holographic beam shaping, spatial light modulator (SLM), computer-generated hologram (CGH)

Notes:

Direct nanofabrication on solids with intense femtosecond laser pulses

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Abstract:

Superimposed multiple shots of intense femtosecond (fs) laser pulses form a periodic nanostructure on solid surfaces through ablation. It is so-called laser-induced periodic surface structure (LIPSS). The structure size observed is 1/10–1/5 of the laser wavelength, indicating the possible formation of nanoscale structures beyond the diffraction limit of light. This phenomenon has attracted considerable interest since the first observations twenty five years ago because the self-organized surface nanostructure suggests not only a potential route to transcend the diffraction limit in the laser-matter interactions but also various kinds of surface functional applications such as wettability control, light absorption enhancement, light phase and polarization control, surface coloration, friction coefficient reduction, and cell spreading direction control. For fabricating a well-defined periodic nanostructure or nanograting, one of the most critical subjects has been to understand and control the interaction processes for nanostructuring at the surface. We have unveiled its physical mechanism and demonstrated that the self-organization process of nanostructuring can be regulated to fabricate homogeneous nanogratings on solids in the air. We have also demonstrated the first observation of SPPs excited on Si using pump–probe reflectivity measurements. After irradiation with a 400-nm, 300-fs pump pulse at a fluence of 200 mJ/cm^2, a pronounced reflectivity dip appeared at an incident angle of approximately 24°. The dip was deepest for delay times of 5–10 ps, coinciding with the highest reflectivity outside the dip and the strongest surface ablation. These results show resonant excitation of SPPs on transiently metallized Si and strong coherent coupling between fs pulses and SPPs, leading to enhanced ablation via intense plasmonic near-fields. I introduce our findings, which indicate that fs laser pulses are a powerful tool for exciting SPPs in nonmetallic materials via ultrafast laser–matter interactions.

Notes:

Advances in visible fluoride fiber lasers

Yasushi Fujimoto

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Abstract:

Visible-range laser sources are expected to have applications in various fields, including medicine (drug discovery, surgery, etc.), biology (flow cytometry), precision machining, marking, solar cell processing, and displays. In this presentation, we will describe the history and current status of visible-light fluoride fiber laser development, and introduce our research results and recent topics. Technology of fluoride glass and its fiber development is the key issue for the progress in visible fluoride fiber lasers. Since ZBLAN, which is a well-known fluoride glass, has weak for water exposure or humidity, researches on AlF3-based weather-resistant fluoride glass (WPFG) without NaF have been progressed from the perspective of weather resistance. WPFG shows excellent property of water resistance than ZBLAN glass; i.e. while ZBLAN experienced a weight loss of 5.23 wt% after 24 hours of immersion in water at 23°C, WPFG in a similar experiment showed a weight loss of only 0.01 wt%. Our group successfully drawn an optical fiber using WPFG.

On the other hand, advances in visible fluoride fiber lasers have been supported by advancements in blue semiconductor excitation technology and the successful fabrication of Pr-doped single-mode double-clad weather-resistant fluoride glass fibers (Pr:SM-DC-WPFGF). Achieving to fabrication of Pr:SM-DC-WPFGF, the fiber laser output power reached 2 W in 2019, and also using Dy:SM-DC-WPFGF, we achieved a maximum output of 445 mW and a slope efficiency of 51.2%. Furthermore, the beam quality of the yellow laser was evaluated as to be a single-mode.

Above developments, that is advances in blue LD-pumped visible optical fiber lasers, inspire to spread a variety of applications, for example, visible ultrashort pulse fiber lasers, Laguerre-Gaussian (LG) mode beam generation in visible, high-efficiency and compact CW-UV fiber laser. Especially, visible fluoride fiber lasers enable the generation of UV laser light with a single wavelength conversion, promising a highly efficient, compact, and maintenance-free compact high-efficiency UV coherent light source. We obtained UV output from a 640 nm Pr:WPFGF fundamental wave using a wavelength conversion crystal (BBO/Type-I: phase matching angle $\theta m = 37.65°$). The obtained maximum UV (320 nm) output after wavelength conversion was 413 mW, with a conversion efficiency of 30%, achieving sufficient output and efficient wavelength conversion characteristics.

With the realization of double-clad fibers in the visible region, and coupled with the recent increase in the power output of blue LDs, it is believed that we are now on the horizon of achieving even higher-power visible optical fiber lasers (~20W). In addition, several other topics are expected to see further development, including mode-locked ultrashort pulses, new beam mode generation, highly efficient compact ultraviolet light sources, and the development of yellow solid-state fiber lasers, which have been difficult to realize with semiconductor lasers until now.

Notes:

Second Harmonic Generation Enhancement of a Ferroelectric Crystal

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Keywords: niobium oxide dichloride (NbOCl2), ferroelectrics, second harmonic generation

Abstract:

Introduction
Layered niobium oxyhalides ($NbOX_2$, X = Cl, Br, I) have recently emerged as promising candidates for realization of efficient nonlinear light sources at nanoscale1-2, owing to their intrinsic ferroelectricity, strong in-plane anisotropy, and large second-order susceptibility coefficients. Even though their SHG conversion is very high, which still needs to be increased remarkably to meet the requirement for practical application of quantum light sources.

Methods
In this work, we engineered a silver plasmonic resonator which consists of circular ring structures to amplify the local electric field upon excitation. Meanwhile, it is able to boost effective nonlinear polarization while maintaining isotropic optical response across all polarization states. Coupled with the plasmonic resonator, the van der Waals crystal of $NbOCl_2$ emits enhanced intensity of SHG.

Results and Conclusions
We have demonstrated a polarization-insensitive plasmonic resonator which can significantly enhance the intrinsic SHG of $NbOCl_2$ and also validate its superior air-stability as a van der Waals ferroelectric with giant optical nonlinearity. The optical properties were measured by an ellipsometer. There is negligible difference between a fresh sample and the same sample ageing after one year. It validates the Environmental robustness of NbOCl2 flakes. In addition, we have observed a strong hotspot formation at the ring edges of polarization- insensitive ring resonator upon excitation at 780 nm excitation. Last but not least, a fivefold enhancement of SHG intensity was acquired by spatial mapping the plasmonic resonators. In summary, this study establishes a versatile approach for boosting nonlinear optical responses in atomically thin ferroelectrics and advances the development of high-performance, chip-scale nonlinear photonic systems.

Acknowledgements
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Notes:

Optical frequency comb engineered plasmonic spectroscopy for precision gas dynamics measurement

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Abstract:

While surface plasmon resonance (SPR) sensors are highly sensitive to molecular interactions, traditional intensity-based detection is frequently limited by environmental and instrumental noise. This work presents an ultra-precision sensing platform by integrating optical frequency combs with plasmonic nanostructures and chip scale acoustic optic modulation.

We first demonstrate that an optical frequency comb can be transformed into a plasmonic comb within nanostructures and subsequently reverted to its original state without degradation in stability of 10^{-19} or linewidth of 1 Hz. Building on this fundamental concept, we developed a frequency comb referenced plasmonic phase spectroscopy technique capable of resolving noble gas dynamics at a single molecular resolution of 10^{-11} RIU. By leveraging sharp plasmonic phase slopes and high heterodyne carriers, we achieved a resolution of 0.06 Ar atoms per nanohole at 5 Hz, while successfully resolving fast dynamics up to 200 Hz. The light matter interaction was further enhanced by a factor of over 3800 through the synergy of plasmonic resonance and thermophoresis assisted optical confinement.

To facilitate miniaturization, we implemented a multi frequency acoustic optic phase modulation platform using soft polydimethylsiloxane (PDMS). This chip scale integration supports a 0.5 MHz spectral resolution, a 200-fold improvement over traditional spectroscopic systems. Furthermore, we discuss the potential for nonlinear frequency conversion of optical frequency combs using various nanostructures. This integrated approach paves the way for cost-effective, multifunctional, and ultra-precision laboratory on a chip tool for quantum metrology and real time biomedical diagnostics.

Notes:

Novel Spin-Optoelectronics in 2D Magnet-Based van der Waals Heterostructures

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Abstract:

The ability to engineer spin-dependent phenomena at the atomic scale is central to next-generation electronic and optoelectronic systems. Two-dimensional (2D) magnet-based van der Waals (vdW) heterostructures provide a unique platform for this purpose by enabling direct control of spin through intrinsic magnetic order and engineered interfacial interactions. In this talk, I will present two representative spin-optoelectronic vdW heterostructures based on Fe_3GeTe_2 and CrI_3. Specifically, we demonstrate that an Fe_3GeTe_2/hexagonal boron nitride ferromagnetic tunneling contact enables efficient spin injection into monolayer WSe_2, where bias-driven spin-polarized hole injection induces a population imbalance between the ±K valleys and results in helicity dependent electroluminescence (Nature Nanotech. 17, 721–728 (2022)). This spin–valley conversion is supported by density functional theory calculations and helicity-resolved electroluminescence measurements. In addition, we demonstrate a spin-polarized light-emitting diode (spin-LED) that operates without an external spin injector (Nature Commun., in press). This is achieved using a graphene/h-BN/CrI_3/h-BN/graphene vertical heterostructure, in which monolayer CrI_3 serves as the active light-emitting layer. Although spin-unpolarized carriers are injected through graphene contacts, the electroluminescence becomes circularly polarized due to magnetic-order–governed recombination in CrI_3. Notably, the emission exhibits a polarization degree of ~20%, exceeding most conventional spin-LEDs, and can be reversibly switched with a small magnetic field (~0.17 T). Together, these results point to a unified platform in which 2D magnetic materials enable both spin generation and spin-dependent light emission, opening new opportunities for integrated spin-optoelectronic devices.

Notes:

Oxide semiconductor-based plasmonic metasurfaces for infrared applications

Hiroaki Matsui

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Abstract:

Solar radiation entering through windows contributes to the heating of buildings, and efforts to regulate this heat for occupant comfort often result in increased energy consumption. Effective regulation of energy exchange between a building's interior and exterior is essential for enhancing energy efficiency. Thus far, extensive research has been devoted to designing energy-efficient windows. In general, the three-dimensional nanoparticle (NP) assembled film show interesting optical properties that differ from naturally occurring materials, such as metals, oxides, and semiconductors. In this study, we focus on the optical response of thin films comprising Sn doped In2O3 NPs (ITO NP films) for solar-thermal shielding applications. The ITO NP films have the functionality of plasmonic metamaterials in the infrared range, which are largely different from optical properties of ITO bulk films. The plasmonic metamaterials of ITO NP films are correlated to the electric field strength at interparticle gaps, leading to high infrared reflectance under maintaining high visible and microwave transmissions. The selective IR reflectance based on strong Lorentz resonances as the ITO NP films were electrically polarizable but magnetically inactive. Thermal shielding efficiency was demonstrated via a comparison of the air temperature change in a simulated box used as a model house. Additionally, we demonstrate the significance of NP packing density on the enhancement of the IR reflectance. The role of interparticle spacing for high IR reflectance was revealed by comparing theoretical analysis. Our work confirmed that the optical control in plasmonic metamaterials must be considered in the structural design of transparent and reflective materials for solar-thermal shielding applications.

Notes:

Rotational motion measurement based on dual-comb spectroscopy

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Abstract:

Introduction

The refinement of optical and semiconductor components continues to advance year by year, necessitating precise processing and measurement of objects at the nanometer scale. Optical sensors capable of non-contact measurement with high resolution and a wide measurement range are widely used in precision measurement. In previous studies, a mode-locked laser angle sensor capable of measuring a wide range of angles with high sensitivity was developed. Among these optical sensors, a measurement method utilizing an optical frequency comb [1] as the light source is expected. An optical frequency comb is a laser that has a comb-like spectrum with evenly spaced frequencies in the frequency domain, and it was designated as the national standard of length in Japan in 2009 due to its high stability and frequency accuracy [2, 3]. In this study, we apply the principles of the mode-locked laser angle sensor and develop a dual-comb angle sensor using two optical frequency combs. Moreover, the optical frequencies of the optical frequency combs can be synchronized with GPS which anyone can obtain easily [4]. By the proposed method, it is possible that anyone can measure angular displacement with the identical 1 pulse-per-second signal via GPS.

Materials and Methods

An optical frequency comb is incident onto a diffraction grating, and the diffracted light is focused onto the end face of an optical fiber using a lens. This dispersion is used to detect the rotation angle of the diffraction grating. By applying dual-comb spectroscopy, the longitudinal modes are separated and observed. The optical setup is shown in Fig. 1.

Results, Discussion and Conclusions

We confirmed the possibility of acquiring beat spectra for angle response using dual-comb spectroscopy. The diffraction grating was fixed, and the difference in repetition rate between the two optical frequency combs is controlled to be 5 kHz, to acquire beat spectra from the diffracted light. Subsequently, FFT (Fast-Fourie-Transform) processing was applied to the acquired signals. It is confirmed that the angle dependent spectrum was like a Gaussian function as shown in Fig.2. Thus, the beat spectra for angle response were achieved according to the proposed principle.

References

[1] Coppin P. et al., "Novel optical frequency comb synthesis using optical feedback", Electronics Letters, 26, (1990), 28.

[2] Jone D. J. et al., "Carrier-Envelope Phase Control of Femtosecond Mode-Locked Lasers and Direct Optical Frequency Synthesis", Science, 288, (2000), 635-639.

[3] Udem T. et al., "Absolute Optical Frequency Measurement of the Cesium D1 Line with a Mode Locked Laser", Physical Review Letters, 82(18), (1999), 3568-3571.

[4] Kawasaki K. et al., "Laser frequency calibration system with optical frequency comb linked to national standard of frequency", Journal of the Japan Sodiety for Precison Engneerring 81(9), (2015), 881-884.

Notes:

Photo-thermoelectric conversion with carbon nanotubes and non-destructive testing application

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Keywords: carbon nanotube; photo-thermoelectric effect; longer-wavelength photo-sensing

Abstract:

Introduction

Photo-thermoelectric (PTE) effect synergizes two energy-harvesting phenomena between photo-absorption induced heating and thermoelectric response. PTE sensors play an advantageous role in photo-detection by uncooled broadband operation without external voltage bias at the lower-limit of thermal noise, facilitating non-contact material identification via wavelength-specific optical information. This work summarizes the fundamental strategy for employing carbon nanotubes (CNTs) as the PTE sensor material toward non-destructive industrial testing applications. The presenting CNT film PTE sensors effectively aggregates non-invasive permeable optical features in millimeter-wave (MMW)–infrared (IR) regions against non-metallic materials. Such advantages of the PTE sensor bring non-destructive detailed material identification at in-line of on-site configurations with lightweight, freely deformable, and thin-film (at a few micrometer thicknesses) structures of CNT films [1,2].

Methods

This work introduces device fabrication of the CNT film PTE sensor via spatially alignable robot-assisted desktop mechanical air-jet dispense printing of the source material inks in an air-exposed room temperature conditions under normal room illumination[3]. This scheme handles CNT film channels at line-width and alignment-pitch of 300 μm on arbitrary supporting substrate materials (e.g., cellulose acetate membrane filter, polyimide, polyurethane, silicon, and so on). The presenting device assigns heterogeneous material bonding structure as the photo-detection area, such as the pn-junction across CNT film channels or electrode interfaces by the PTE-unique management of their effective Seebeck coefficients of respective constituents being proportional to response signal intensity.

Results

The presenting CNT film PTE sensor performs ultrabroadband photo-detection (660 nm–60 mm wavelengths) over operation regions of conventional wide-band elements at comparable sensitivity (minimum noise equivalent power of a few $pWHz^{-1/2}$) with existing narrow-band devices. As this device allows mechanical deformations without a loss of the inherent advantageous photo-detection performances (within 20 % error ratio of noise equivalent power against hundreds of bending), this work demonstrates dynamic real-time non-destructive in-line pharmaceutical monitoring. This compact on-site demonstration specifically performs material identification of pharma pills (visibly indistinguishable by human eyesight) themselves and concealed hazardous impurities at analysis error ratio within 5 % against conventional bulky stational spectrometers. Such high-usable ultrabroadband monitoring with the CNT film PTE sensor further develops a pioneering research concept of non-destructive and non-invasive MMW–IR computer vision testing, which collectively satisfies material identification and 3D structural reconstruction for detailed testing applications.

Reference

[1] K. Li, et al. A chemically enriched, repeatedly deformable, and self-recoverable broadband wireless imager sheet, Commun. Mater. 6, 147, 2025.

[2] M. Kubota, et al. In-line multi-wavelength non-destructive pharma quality monitoring with ultrabroadband carbon nanotubes photo-thermoelectric imaging scanners, Light Sci. Appl. 14, 306, 2025.

[3] M. Yamamoto, et al. Mechanically alignable and all-dispenser-printable device design platform for carbon nanotube-based soft-deformable photo-thermoelectric broadband imager sheets, npj Flex. Electron. 9, 42, 2025.

Notes:

Formation of structural color on pencil lead and penciled letters by plasma etching

Hiroshi Moriwaki

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Abstract:

Structural coloration has attracted attention as a dyeing technology that enables coloration without the use of dyes or pigments, which could have negative impacts on the environment. However, the formation and control of structural colors on samples require special materials, equipment, and techniques in conventional methods for the formation of structural colors. In this study, a method by which structural colors can be formed simply by irradiating pencil lead or writing made by a pencil on paper with plasma was introduced. Structural colors can be produced using a pencil, which is one of the most familiar materials, and an inexpensive plasma generator typically used for the hydrophilization of the surface of materials. Furthermore, by varying the plasma irradiation time, it was possible to control the colors with high reproducibility. By removing graphite in a pencil lead through plasma etching, the clay in the pencil lead remains on the surface as fine protrusions, which act as a thin film to generate structural colors via thin-film interference. The structural colors produced change depending on the thickness of the clay layer, which is altered by the duration of plasma exposure. Using this method, coloring of the pencil lead can also be controlled by using a plastic plate for masking, allowing for selective coloring of certain areas. In addition, by extending this method, writing letters on pencil lead that can only be read with an infrared camera was successfully achieved. Through this research, I believe that using structural colors for coloring will become more familiar and serve as a step toward wider social adoption.

Notes:

Laser-Induced Plasma Processing Enabling Open-Air Nitriding of Metal Surfaces

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Abstract:

Introduction

Laser induced plasma (LIP) is a unique plasma that generated via a nanosecond pulsed laser beam irradiation with a high densified energy. The lifetime of LIP is less than several microseconds, and an ultrahigh-temperature field exceeding ~10^4 K appears within the ultra-short periods. The metal surface in contact with the LIP thus melts instantaneously. The surrounding gas is absorbed into the molten pool through convection currents known as Marangoni convection, and the pool is quenched momently. As a result, a new surface layer composed of the ambient gas components is formed. When LIP is generated in air, the dominant constituent of which is nitrogen, a nitride layer is expected to be produced even in open-air.

Materials and Methods

A nanosecond pulsed Nd:YAG laser system (LPS-1000, CNI) emitting at a wavelength of 1064 nm, with an energy of 300 mJ per pulse and a repetition frequency of 10 Hz, was used. The laser beam was focused onto the surface of an AISI 316 stainless steel surface using a plano-convex lens with a focal length of 200 mm. During irradiation, the AISI 316 stainless steel mounted on an XY stage was translated at a speed of 2 mm s^{-1} to process the entire surface. All experiments were conducted in air without any atmospheric control. The generated plasma was observed using a digital camera. The surface and cross-sectional structures of the samples after laser irradiation were evaluated by SEM/EDS.

Results, Discussion and Conclusions

Irradiating an austenitic stainless steel such as AISI 316 with a focused nanosecond pulsed laser beam in air leads to the formation of a nitrogen solid-solution layer, corresponding to an expanded austenitic structure known as the S phase. This processing is carried out in an open-air environment without atmospheric control; nevertheless, the primary surface layer formed is the S phase rather than an oxide layer (Fig. 2). The resulting layer thickness ranges from 3 to 10 μm, depending on the laser irradiation conditions. The surface hardness of AISI 316 stainless steel increases to nearly twice that of the untreated material, thereby improving wear resistance by suppressing plastic deformation and abrasive wear [1]. Consequently, LIP processing is expected to serve as an innovative technology for rapidly and easily improving metal tribological performance.

References

[1] N. Ohtsu, S. Takeda, R. Endo, K. Miura, T. Kiba, Comparison of open-atmosphere nitriding on various metal surfaces triggered by a focused pulsed laser irradiation, Surface and Coatings Technology 454 (2023) 129190

Notes:

Free-Space Quantum Communication over an Urban Atmospheric Link in Moscow: System Design and Field Experiments

Tretiakov V V[1,*], Klimov A N[1], Balygin K A[1], Vakhrusheva V[1] and Kulik S P[1]

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Abstract:

We report on the development and field testing of a free-space quantum key distribution (QKD) system based on phase–time encoding, adapted from a commercially available fiber-based platform (ViPNet QTS). In contrast to our previous laboratory-oriented studies, the present work focuses on long-term operation over an urban atmospheric optical link of 400 m length between two buildings of Lomonosov Moscow State University in Moscow. The system employs a multimode free-space delay interferometer for phase-state analysis, enabling robust interference measurements under conditions of atmospheric turbulence and multimode beam propagation.

Stable secret key generation at rates of several hundred bits per minute with a quantum bit error rate of approximately 4.2% has been demonstrated over extended periods ranging from several hours to multiple days. The system exhibits reliable autonomous operation and resilience to environmental fluctuations inherent to urban free-space channels. In addition, ongoing efforts are aimed at achieving stable daylight operation, which represents a critical requirement for practical and commercial deployment of free-space QKD systems. Preliminary results indicate that the chosen system architecture and encoding scheme provide a promising pathway toward continuous key distribution under realistic atmospheric and background illumination conditions.

Introduction

Quantum key distribution (QKD) provides provably secure communication based on the principles of quantum mechanics. While fiber-based QKD systems have reached technological maturity [1] and have been deployed in metropolitan networks, their applicability is fundamentally limited by optical fiber attenuation. Free-space optical (FSO) channels therefore represent an attractive alternative for urban building-to-building links and satellite-based quantum communication systems [2]. Atmospheric channels impose additional challenges, including turbulence-induced wavefront distortions and coupling losses, which strongly limit the efficiency of single-mode detection schemes commonly used in fiber-based QKD systems. Consequently, multimode reception becomes essential for practical free-space implementations.

In our earlier work, we demonstrated a practical method for adapting a commercially available fiber-based QKD platform (ViPNet QTS) to free-space operation using phase–time encoding and a free-space multimode delay interferometer [3,4]. This approach enables efficient phase-state analysis of multimode quantum signals while preserving the internal architecture of the original system.

Materials and Methods

The QKD system was deployed on a 400 m urban atmospheric optical link between two buildings of Lomonosov Moscow State University. Free-space optical terminals were installed at both ends of the link for transmission of the quantum and synchronization signals at a wavelength of 1550 and 850 nm respectively. The system is based on the commercial ViPNet QTS platform implementing the phase–time encoding protocol with decoy states [4]. A Wi-Fi bridge was used as a service communication channel for system control and classical post-processing. The transmitting module operated in its standard fiber-based configuration. On the receiving side, the single-mode fiber Mach–Zehnder interferometer was replaced with a free-space multimode Michelson interferometer employing polarization routing, enabling high-visibility interference of multimode atmospheric signals. The received signal was delivered to the cryptographic hardware via a multimode fiber, allowing the optical terminal to be separated from the trusted indoor zone.

Chromatic and modal dispersion effects were previously investigated under laboratory conditions [3]. Chromatic dispersion mismatch was shown to cause only a moderate visibility reduction at 1550 nm, while modal dispersion in the multimode fiber does not limit system performance for fiber lengths up to approximately 1 km.

Ongoing experiments focus on long-term system stability and on achieving continuous daylight quantum key distribution, which is critical for practical free-space deployment.

Results, Discussion and Conclusions

Field experiments were performed on a 400 m urban atmospheric link using the developed free-space QKD system based on phase–time encoding. Stable system operation was achieved under real atmospheric conditions. The use of a free-space multimode Michelson interferometer at the receiver enabled reliable phase-state analysis of multimode optical signals and ensured stable interference visibility, in agreement with earlier laboratory studies. During extended measurement sessions, the system demonstrated stable secret key generation at rates of several hundred bits per minute with a quantum bit error rate (QBER) of approximately 4.2%. The QBER remained within acceptable limits over continuous operation periods lasting several hours and, in repeated runs, over multiple days. These results confirm the robustness of the chosen system architecture against environmental fluctuations typical for urban free-space channels.

The impact of chromatic and modal dispersion on system performance was found to be negligible for the implemented link length. This observation is consistent with prior laboratory investigations, which showed that chromatic dispersion mismatch between the fiber-based transmitting interferometer and the free-space receiving interferometer leads only to a moderate reduction in interference visibility at 1550 nm, while modal dispersion in the multimode fiber does not limit system performance for multi-mode fiber lengths up to approximately 1 km [3]. Consequently, dispersion effects do not represent a dominant source of errors in the present field implementation.

In addition to nighttime operation, experiments aimed at achieving continuous quantum key distribution under daylight conditions are currently in progress. Daylight operation is a critical requirement for practical and commercial free-space QKD systems, and preliminary measurements indicate that the developed platform provides a promising basis for stable key distribution under increased background illumination.

In conclusion, the presented results demonstrate the feasibility of long-term, stable free-space quantum key distribution over an urban atmospheric link using a minimally modified commercial fiber-based platform. The demonstrated performance and operational stability highlight the potential of this approach for practical deployment in urban quantum communication networks. The work was carried out within the framework of joint research and with the support of InfoTeCS JSC.

References

[1] Teng Yun Chen, Jian Wang, Hao Liang, Wei Yue Liu, Yang Liu, Xiao Jiang, Yuan Wang, Xu Wan, Wen Qi Cai, Lei Ju, Luo Kan Chen, Liu Jun Wang, Yuan Gao, Kai Chen, Cheng Zhi Peng, Zeng Bing Chen & Jian Wei Pan. Metropolitan all pass and inter city quantum communication network. Optics Express 18(26), 27217–27225 (2010). https://doi.org/10.1364/OE.18.027217

[2] Sheng Kai Liao, Wen Qi Cai, Wei Yue Liu, Liang Zhang, Yang Li, Ji Gang Ren, Juan Yin, Qi Shen, Yuan Cao, Zheng Ping Li, Feng Zhi Li, Xia Wei Chen, Li Hua Sun, Jian Jun Jia, Jin Cai Wu, Xiao Jun Jiang, Jian Feng Wang, Yong Mei Huang, Qiang Wang, Yi Lin Zhou, Lei Deng, Tao Xi, Lu Ma, Tai Hu, Qiang Zhang, Yu Ao Chen, Nai Le Liu, Xiang Bin Wang, Zhen Cai Zhu, Chao Yang Lu, Rong Shu, Cheng Zhi Peng, Jian Yu Wang & Jian Wei Pan. Satellite to ground quantum key distribution. Nature 549(7670), 43–47 (2017). https://doi.org/10.1038/nature23655

[3] V. V. Tretiakov, A. N. Klimov, K. A. Balygin & S. P. Kulik. Laboratory demonstration of free space phase time encoding quantum key distribution system with multi mode delay interferometer. Laser Physics Letters 22(9), 095201 (2025). DOI:10.1088/1612-202X/adfdc2

[4] Infotecs. ViPNet Quantum Trusted System (ViPNet QTS). https://infotecs.ru/upload/iblock/399/215e88a8b0r0171252flouc2oiow0s0g/Quant_web.pdf (accessed 2026 01 14).

[5] Jeongwan Jin, Sascha Agne, Jean Philippe Bourgoin, Yanbao Zhang, Norbert Lütkenhaus & Thomas Jennewein. Demonstration of analyzers for multimode photonic time bin qubits. Physical Review A 97, 043847 (2018). https://doi.org/10.1103/PhysRevA.97.043847

Notes:

Performance Enhancement of Photo-thermal Sensors through Selective Noise Removal

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Keywords: Carbon nanotube (CNT), sensor, Photo-thermoelectric (PTE), multiwavelength photo, Thermal Noise, Selective noise reduction

Abstract:

Background
In recent years, repeated collapses of public infrastructure have increased the need for effective inspection methods. Engineers, therefore, require non-destructive testing technologies that achieve high-speed, low-noise imaging within practical inspection times. Carbon nanotube (CNT) thin films absorb photo across a broad wavelength range from ultraviolet to infrared, allowing inspectors to identify diverse target materials. [1] However, CNT thin-film sensors generate high noise, which forces operators to extend measurement times in practical use. This work removes noise sources in CNT thin films and overcomes the trade-off between measurement time and noise.

Methods
This work employed single-walled carbon nanotubes (SWCNTs) and deposited a CNT thin film onto polyurethane-coated glass slides. This work then applied pure water to the film surface and removed it to eliminate surfactants. This work adopted this procedure based on the assumption that surfactants contributed to thermal noise. This work allowed the film to dry at ambient temperature. It measured the electrical resistance before and after immersion, the thermal-noise magnitude as a function of frequency, the Seebeck coefficient, and the absorbance.

Results
This work reduced the electrical resistance to between one-third and one-half of the original value through immersion in pure water. This work also decreased thermal noise over the measured frequency range. This work increased the Seebeck coefficient by a factor of 1.5 through immersion treatment. Spectroscopic measurements conducted in this work confirmed that the CNT thin film-maintained photo absorption across the ultraviolet-to-infrared wavelength range after immersion. Imaging tests performed in this work demonstrated the ability to acquire more explicit images within shorter measurement times.

Conclusion
This work eliminated thermal noise by removing surfactants from the CNT film. This work further achieved selective noise reduction through immersion while preserving the PTE response. Building on these results, this work aims to develop low-noise CNT thin-film sensors from alternative perspectives.

References
[1] H. Hmamashima, et al. Structural stability-driven dynamic range analysis of carbon nanotube photo-thermoelectric sensors, Advanced Sensor Research, in-press, 202500133.

Notes:

Experimental Study of a Sub-Millimeter Conical Light Collector: Toward Far-Infrared Neutrino Decay Photon Detection

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5Department of Engineering, Chubu University, Kasugai, Japan

Abstract:

Introduction
The absolute mass of neutrinos remains one of the fundamental open questions in particle physics, despite significant progress made by neutrino oscillation experiments [1,2]. One possible approach to probe neutrino mass is the search for radiative decay of heavier neutrino states, which is expected to produce photons in the far-infrared region.

The COBAND (Cosmic Background Neutrino Decay) [3,4] experiment aims to detect such photons in the 40–80 μm wavelength band using a rocket-borne far-infrared telescope. At the focal plane of the optical system, the telescope forms a spot with a diameter of approximately 400 μm, while the superconducting detectors employed have an active area of only ~40–60 μm. This mismatch necessitates an efficient and compact light collector capable of operating over a broad wavelength range.

In this work, we investigate a sub-millimeter-sized conical light collector that was fabricated and experimentally evaluated as a prototype device. The optical performance of the collector is assessed using actual samples, with an emphasis on its feasibility as a compact and broadband light-coupling solution for far-infrared and terahertz applications.

Materials and Methods
A conical light collector was designed with a 400 μm entrance aperture and a 60 μm exit aperture. One prototype device was fabricated by ultrashort-pulse laser micromachining of a fused SiO_2 substrate. An aluminum layer was deposited on the inner surface to enhance reflectivity, with a nominal target thickness of 100 nm.

The optical performance of the SiO_2-based collector was characterized using laboratory light sources in the visible (460 nm), near-infrared (1.5 μm), mid-infrared (9.6 μm), and far-infrared (57 μm) wavelength regions. Collection efficiency was measured as a function of incident angle using precision translation and rotation stages.
In addition, a newly fabricated conical light collector based on a metal substrate was investigated. Its optical performance was evaluated at a wavelength of 57 μm, which is directly relevant to far-infrared applications.

Results, Discussion and Conclusions
Experimental evaluation of the SiO_2-based conical light collector showed a collection efficiency of approximately 20% at wavelengths below 9 μm, representing nearly an order-of-magnitude enhancement compared to direct coupling without a collector. The angular dependence of the collection efficiency measured at 9.6 μm was in good agreement with optical simulations assuming an effective aluminum film thickness of about 1 nm.

At a wavelength of 57 μm, no transmitted signal was observed for the SiO_2-based collector, which is attributed to insufficient reflectivity caused by the extremely thin aluminum layer formed by self-shadowing effects during deposition. Reflectance-based analyses consistently indicated an effective aluminum thickness in the range of 0.8–1.0 nm. Parametric studies suggest that increasing the reflective layer thickness to approximately 500 nm could improve collection efficiencies to the 40 50% range across visible to far-infrared wavelengths, potentially satisfying the requirements for far infrared neutrino decay photon searches.

In parallel, a newly fabricated metal-substrate conical light collector was evaluated experimentally at a wavelength of 57 μm. The results demonstrate the feasibility of extending the collector concept to metal-based implementations for far-infrared applications.

These results indicate that sub-millimeter-scale conical light collectors offer a viable and broadband compatible approach for coupling far-infrared and terahertz radiation into small-area detectors. With further optimization of reflective performance, the collector is expected to be applicable not only to neutrino decay searches such as COBAND, but also to a wide range of far-infrared and terahertz technologies.

References
[1] Y. Fukuda et al. (Super-Kamiokande Collaboration), Phys. Rev. Lett. 81, 1562 (1998).
[2] S. Navas et al. (Particle Data Group), Phys. Rev. D 110, 030001 (2024).
[3] S. H. Kim et al., J. Phys. Soc. Jpn. 81, 024101 (2012).
[4] S. H. Kim et al. (COBAND Collaboration), Proc. Int. Conf. on Technology and Instrumentation in Particle Physics (2017).
[5] R. Kashiwagi, " Development of a sub-millimeter-sized SiO2 collector for far-infrared wavelengths to search for cosmic background neutrino decay light," Journal of the Japan Society of Infrared Science and Technology, vol. 35, no. 2, 2025 (to be published).

Notes:

Optical Tweezers-Induced Droplet Formation of Poly (N, N dimethylacrylamide-co- N-tert-butylacrylamide) for Fluorescent Molecule Extraction and Detection

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Abstract:

Introduction

Aqueous solutions of poly (N-substituted acrylamides) exhibit reversible thermo-responsiveness near their lower critical solution temperature (LCST). A representative example, poly(N-isopropylacrylamide) (PNIPAM), has an LCST of approximately 32°C, which is close to biological temperature. In contrast, while polymers of N, N-dimethylacrylamide (DMAA) and N-tert butylacrylamide (nTBA) which possess structures like NIPAM, but do not clearly exhibit LCST on their polymerization, it has been reported that the LCST can be tuned by controlling the hydrophilic-hydrophobic composition ratio through copolymerization 1. The LCST of NIPAM–nTBA copolymers has been reported to show concentration dependence 2. In contrast, it is of interest to investigate whether DMAA–nTBA copolymers (Fig.1) also exhibit concentration-dependent LCST and other physicochemical properties. In this study, we focus the near infrared (NIR) laser into an aqueous copolymer solution to induce phase separation via a local temperature rise, thereby forming and trapping droplets. By extracting fluorescent dye molecules into these droplets, we aim to elucidate their unique characteristics and properties.

Materials and Methods

P(DMAA-co-nTBA) (DMAA mole fraction: 0.60) was synthesized via radical polymerization using AIBN as an initiator. An aqueous solution of the copolymer (0.1, 0.2, 0.5, 1.0 wt%) was prepared, A quartz cuvette with a 1 cm path length was used for the DLS measurements. An aqueous solution (0.2 wt%) was prepared by dissolving a trace amount of the fluorescent dye Coumarin 481 or Coumarin 151 (about 1.0×10-5 mol/L) was dissolved. Microspectroscopic measurements were performed using NIR laser (1064 nm) for optical trapping, a visible laser (532 nm) for Raman excitation, and an LED lamp (385 or 475 or 550 nm) for fluorescence excitation.

Results, Discussion and Conclusions

The relationship between temperature and particle size of P(DMAA-co-nTBA) aqueous solutions at different concentrations was measured using DLS. It was confirmed that phase separation occurred more rapidly as the polymer concentration in the aqueous solution increased. In addition, when NIR laser was focused on the aqueous solution, droplet formation was observed and the droplets could be optically trapped. Furthermore, the fluorescent dyes Coumarin 481 and Coumarin 151 were successfully extracted into the droplets, resulting in fluorescence enhancement. It was also confirmed that the fluorescence intensity increased significantly with increasing laser power. These results suggest that the droplets induced by optical pressure may be applicable as extraction sites and photochemical reaction fields.

References

1) H.Y. Liu, X.X. Zhu, Polymer ,1999, 40, 6985-6990

2) A.A.A. Smith, C. Maikawa, H.L. Hernandez, E. A. Appel, Polym.Chem., 2021,12, 1918-1923

Notes:

Modulating the Laser-Induced Phase Separation Characteristics of NIPAM-DEA Random Copolymers

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Abstract:

Introduction
Poly(N-isopropylacrylamide) (PNIPAM) and poly(N,N-diethylacrylamide) (PDEA) are thermoresponsive polymers that exhibit a lower critical solution temperature (LCST). When a near-infrared (NIR) laser beam is focused into their aqueous solutions, a local temperature increase induces phase separation, leading to the formation and trapping of a polymer droplet at the focal point1,2. Because the internal environment of these droplets is more hydrophobic than the surrounding medium, organic molecules can be extracted within them. This study investigates how the composition of random copolymers of N-isopropylacrylamide (NIPAM) and N, N diethylacrylamide (DEA) influences droplet formation and molecular extraction, demonstrating that copolymerization allows for control of these laser-induced liquid phases.

Materials and Methods
Seven types of random copolymers of NIPAM and DEA with varying molar fractions were synthesized via radical polymerization. Aqueous solutions of these copolymers (1.0 wt%) were prepared, and a fluorescent coumarin derivative (10 μmol/L) was added. Microspectroscopic analysis was performed using an experimental setup equipped with a NIR laser (λ= 1064 nm) for optical trapping and an LED lamp (λ= 385 nm) for fluorescence excitation.

Results, Discussion and Conclusions
The phase transition temperatures of the copolymer solutions decreased as the molar fraction of NIPAM and DEA approached a 1:1 ratio, indicating a non-linear relationship between composition and LCST. Upon NIR laser irradiation, a single droplet or polymer-rich domain was formed for all compositions. As a representative result, for the DEA-5 copolymer (5% DEA molar fraction), the extraction of fluorescent coumarin derivative into the droplet was observed through a significant increase in fluorescence intensity at the focal point. Crucially, we found that adjustments to the molar fraction of these structurally similar monomers allowed precise control over the droplet's properties. Specifically, the minimum laser intensity required for droplet formation, the internal polymer concentration, and the structural homogeneity of the phase separated domain were significantly altered by the copolymer ratio.

References
1. M. Ishikawa et al., Chem. Lett. 22, 481 (1993).
2. M. Matsumoto et al., Langmuir 37, 2874 (2021).

Notes:

Extraction of 3-Perylenecarboxaldehyde into an Ionic Liquid Microdroplet Formed by Optical Tweezers

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Abstract:

Introduction

Ionic liquids (ILs) are salts that exist in the liquid state under ambient conditions. Some IL/water mixtures exhibit phase separation upon heating. Such thermo-responsive IL solutions enable the extraction of organic molecules into an IL-rich phase. Optical tweezers provide a promising approach to locally control the phase separation and to generate a single microdroplet. Indeed, we have previously demonstrated such droplet formation by irradiating a near-infrared (NIR) laser beam into IL solutions [1, 2]. In this study, we investigate the extraction behavior of 3-Perylencarboxaldehyde (FPe) into the IL microdroplet and discuss how the initial dye concentration affects the extraction efficiency.

Materials and Methods

The IL used is tetrabutylphosphonium 2,4,6-trimethyl-benzensulfonate ($[P_{4444}]^{+}[2,4,6\text{-MeSO3}]^{-}$). An aqueous solution of the IL (10 wt%) was prepared, and a single IL microdroplet was produced by irradiating a focused continuous-wave NIR laser beam (λ = 1064 nm). The concentrations of the IL and FPe within the droplet was evaluated using Raman and fluorescence microspectroscopy.

Results, Discussion and Conclusions

A small microdroplet was observed at the focal point 30 sec from the beginning of irradiation. The droplet continuously increased in diameter under laser irradiation while remaining stably trapped. As the droplet grew, the IL concentration within the droplet increased. Accordingly, FPe was extracted into the droplet, resulting in enhancement of the fluorescence intensity. We investigated the extraction efficiency by varying the initial concentration of FPe. The fluorescence enhancement became high with the increase in the initial dye concentration. In addition, fluorescence spectral shape changes were observed, due to deprotonation. These results suggest that the extraction efficiency of FPe into IL droplets is modified by the protonation state, which is dependent on the initial concentration.

References

1. Tanaka, M.; Tsuboi, Y.; Yuyama, K., Chem. Commun. 2022, 58(84), 11787–11790.
2. Tanaka, M.; Kuramichi, I.; Tsuboi, Y.; Yuyama, K., Jpn. J. Appl. Phys. 2022, 61(10), 100901.

Notes:

Optimization of Black Silicon Nanostructures for Optical Tweezers: Achieving Stable Trapping of 70-nm Particles

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Abstract:

Introduction

Optical tweezers are a technology that uses optical forces from laser beams to manipulate micro-objects and are expected to contribute significantly to the fields of biophysics and analytical chemistry. However, as the target size scales below 100 nm, stable trapping becomes exceptionally difficult due to thermal fluctuations. Traditional optical tweezers often require a high-power laser, which may cause thermal or optical damage to objects.

To overcome these limitations, we focus on the localized electric field enhancement on nanostructured silicon surfaces, known as Black Silicon (Black-Si). Black-Si features sub-wavelength spike structures that can enhance local optical density. In this study, we examined the structural optimization of Black Si—specifically the density and height of the nanostructures—to improve the trapping performance for 70-nm polystyrene beads. This approach aims to realize high-performance optical tweezers for the selective manipulation and analysis of sub-100 nm objects.

Materials and Methods

For the substrates, we used silicon crystals without nanostructures (Flat-Si) and three types of Black -Si fabricated via plasma dry etching (PE) with varying treatment times (10, 20, and 40 minutes). The PE times modulate the height, morphology, and density of the nanostructures.

As the trapping targets, fluorescent polystyrene nanoparticles (PSs) with diameters ranging from 500 nm to 70 nm were used. These were dispersed in water. A near-infrared laser (λ = 1064 nm) served as the trapping light source, and the trapping performance was evaluated through micro-fluorescence imaging and spectroscopy.

Results, Discussion and Conclusions

We successfully trapped PSs with a diameter of 70 nm on Black-Si. The fluorescence intensity increased several-fold relative to the background, and the emission peak matched the characteristic wavelength of the PSs. Therefore, the particle trapping was evaluated using a quantitative method.

Also, it revealed that Black-Si with higher-density (shorter PE times) exhibited superior trapping performance, trapping a lot of PSs. This trend is consistent with numerical simulation of the electric field, which suggests that shorter inter-structure distances lead to a higher density of "hot spots".

These findings contribute to the advancement of manipulation for sub-100 nm substances and the development of selective analysis.

References

T. Shoji, Y. Tsuboi, et al., Sci. Rep., 2017, 7, 12298

Notes:

Realtime spectroscopy using THz parametric generation/detection

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Abstract:

We have studied an injection-seeded terahertz (THz) wave parametric generator (is-TPG) using nonlinear optical crystals (NLO) and is suitable for measurements through shielding [1-3]. The multi-wavelength is-TPG has been realized, and it is now possible to acquire fingerprint spectra of reagents in real time [4]. Further, we have developed practical THz tag reading system using combination of a multi-wavelength is-TPG and a machine learning [5].

THz wave parametric generation with an is-TPG uses a near-infrared (NIR) pump beam and seed beam input to the $MgO:LiNbO_3$ crystal. In contrast, the THz parametric detector uses a THz wave as the seed beam instead of a NIR beam. In the detection configuration, when the pump beam and THz wave are input into the crystal, the THz wave is upconverted to the NIR Stokes beam by parametric processes in the crystal that are measured using a NIR detector. This THz generation and detection scheme has allowed us to develop a high-dynamic range THz wave spectroscopic system that can be used for spectroscopic imaging of chemicals hidden in thick envelopes.

We have also developed THz tag reading system using combination of a multi-wavelength is-TPG and a machine learning by deep neural network. Reagent pellets with clear fingerprint spectra were used as the THz tag. Incident angle of THz-wave does not affect the fingerprint spectrum. The tags were swiped by hand at a speed of about 10 cm/sec. along a holder placed at the focal point of THz-wave. The detection Stokes beams, predicted reagent name, and predicted probability were displayed in each captured frame. We achieved accurate and fast tag identification even though the intensities of the detection Stokes beams were weak and the differences between the images were slight due to the shielding material.

This work was partially supported by Japan Science and Technology Agency (JST) ASPIRE Program (JPMJAP2340) and FOREST Program (JPMJFR212J), and Japan Society for the Promotion of Science KAKENHI (22J20963, 24K00943).

References

(1) K. Murate, S. Mine, K. Kawase. (2023) "Terahertz Parametric Generators and Detectors for Nondestructive Testing Through High-Attenuation Packaging Materials," IEEE Journal of Selected Topics in Quantum Electronics, Vol. 29, 8500813. DOI: 10.1109/jstqe.2023.3296989

(2) S. Mine, N. Yamamoto, K. Kawase, and K. Murate. (2024) "Collinear injection-seeded terahertz parametric generator," APL Photonics, Vol. 9, 036103. DOI: 10.1063/5.0182369

(3) S. Mine, S. Tanaka, K. Kawase, K. Murate. (2025) “Terahertz parametric detection using a lithium tantalate,” Optics Letters, Vol. 50, 527-529. DOI: 10.1364/OL.544632

(4) K. Murate, S. Mine, and K. Kawase. (2023) "Wide dynamic range and real-time reagent identification and imaging using multi-wavelength terahertz parametric generation and machine learning," Scientific Reports, Vol. 13, 12743. DOI: 10.1038/s41598-023-40013-y

(5) K. Murate, H. Kanai, K. Kawase. (2021) “Application of Machine Learning to Terahertz Spectroscopic Imaging of Reagents Hidden by Thick Shielding Materials,” IEEE Transactions on Terahertz Science and Technology, Vol,11, 620 – 625. DOI: 10.1109/TTHZ.2021.3094128

Notes:

Probing polaron dynamics in organic light-emitting diodes

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Abstract:

Organic light-emitting diodes (OLEDs) exhibit complex time-dependent behaviors originating from the interplay of carrier transport, trapping, interfacial accumulation, and exciton formation. Transient electroluminescence (Tr-EL), which measures emission dynamics during and after electrical pulsing, offers a unique time-resolved window into these processes.
However, prior studies have typically focused on a narrow region of the Tr-EL waveform, thereby limiting their utility in providing a comprehensive understanding of the EL characteristics.

This work presents a unified perspective for interpreting complete Tr-EL signals, from the onset response to the late-time decay, enabling the systematic identification of how charge carriers migrate, accumulate, and recombine under electrical excitation. Using OLEDs comprising six phosphorescent emitters in both single-host and exciplex-forming host environments, three characteristic Tr-EL behaviors are established:

(1) initial overshoot, driven primarily by the slow release of trapped carriers and subsequent transient recombination.

(2) terminal (delayed) overshoot, arising from interfacial charge redistribution after pulse termination.

(3) negligible overshoot, characteristic of architectures with efficient carrier extraction and balanced recombination.

Time-dependent drift–diffusion simulations reproduce these distinct signatures and reveal the mechanistic origin of each regime. In particular, the simulations highlight how trap density, mobility asymmetry, interfacial barriers, and carrier extraction rates jointly determine the appearance, intensity, and timing of overshoot features. Two-dimensional contour maps of overshoot amplitudes further reveal a sharp, non-monotonic dependence on zero-field mobility, providing predictive design rules for device architectures that minimize parasitic charge storage and enhance recombination efficiency.

This analysis demonstrates that Tr-EL is not merely a supplementary optical probe, but a holistic tool capable of quantifying carrier balance, identifying space-charge formation, and revealing hidden loss pathways that are invisible to steady-state measurements. The insights obtained here are broadly applicable to phosphorescent, TADF, and hyperfluorescent OLEDs, as well as to emerging emissive platforms in which recombination dynamics critically determine efficiency and stability.

This talk will discuss how these findings enable rational optimization of emissive-layer design, host–guest interactions, and charge-transport layer engineering, ultimately guiding the development of next-generation OLEDs with improved efficiency, reduced roll-off, and enhanced operational lifetime

Notes:

Laser-induced perturbation of single neuronal cells

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Abstract:

Neurons form highly complex networks and communicate through synaptic connections. To identify functional connectivity within neuronal networks, it is essential to understand the spatiotemporal dynamics of electrical activity propagation evoked by precise and non-invasive stimulation. Non-invasive and non-destructive techniques for manipulating cellular activity at the single-cell level are critical for understanding information processing of neurons in the central nervous system. Here, we demonstrate the laser-induced perturbation of single neurons within cultured neuronal networks. Femtosecond laser-induced stimulation of a target neuron was evaluated using simultaneous fluorescence calcium imaging and extracellular electrophysiological recordings.

A femtosecond laser (center wavelength: 800 nm, pulse width: ~100 fs, repetition rate: 82 MHz) was focused on a single rat hippocampal neuron. At a laser power of 30 mW and an irradiation duration of 8 ms, the significant increase in Ca^{2+} fluorescence was observed at the target neuron, indicating extracellular Ca^{2+} influx through transient membrane disruption via femtosecond laser induced ablation. When the target neuron was positioned near a microelectrode array, frequent electrical spike signals were detected following irradiation, suggesting that the propagation of neuronal activity was induced by laser irradiation. Furthermore, we applied a femtosecond optical vortex laser for neuronal stimulation. Fluorescence recovery analysis of the cell membrane revealed that the membrane disruption was transient, with the recovery occurring significantly faster under optical vortex irradiation than under conventional Gaussian beam irradiation. These results suggest that the accelerated membrane recovery is assisted by the orbital angular momentum of the optical vortex.

Notes:

Zeno-based universal protection of qubits from decoherence

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Abstract:

One of the main challenges of quantum technologies is mitigating decoherence, i.e., the unavoidable coupling of quantum systems (e.g., qubits) with the environment. Decoherence occurs in many realistic scenarios, unavoidably degrading the quantum information encoded in the qubit. One possible way to suppress decoherence is to exploit the Quantum Zeno Effect (QZE) [1,2]; however, QZE-based schemes require prior knowledge of the state to be protected is required [3-6].

Here we introduce a QZE-based scheme named Quantum State Universal Protection (QSUP), granting universal protection of arbitrary qubit states propagating through a decoherence-affected quantum channel [7]. We implement the QSUP protocol with polarization-encoded single-photon qubits passing through a free-space channel, testing it for different qubit sates and decoherence mechanisms (realized via birefringence). Specifically, in our realization a Mach-Zehnder-like interferometer (MZI) is placed within the quantum channel, separating the two polarization components of the qubit in the MZI arms. Birefringent crystals are responsible for inducing (controlled) decoherence in the polarization states travelling through the quantum channel. Since the polarization component propagating in each MZI arm is now known, QZE-based protection can be applied via frequent polarization projections.

Experimental results show that our protocol grants output qubit states showing close-to-1 Purity and Fidelity (w.r.t. the input ones) in all cases, dramatically increasing the robustness and reliability of the transmitted quantum information. Our strategy is universally applicable, since it does not depend on the form of decoherence occurring within the quantum channel nor on the specific quantum state undergoing QSUP, in contrast to state-dependent protection schemes or tailored quantum error correction codes. As such, it provides a broadly applicable solution for quantum communication, distributed quantum sensing, and quantum computation.

References

1. B. Misra and E. C. G. Sudarshan, The zeno's paradox in quantum theory. J. of Math. Phys. 18, 756 (1977).
2. W. M. Itano, D. J. Heinzen, J. J. Bollinger, and D. J. Wineland, Quantum zeno effect. Phys. Rev. A 41, 2295 (1990).
3. F. Piacentini et al., Determining the quantum expectation value by measuring a single photon. Nat. Phys. 13, 1191 (2017).
4. E. Rebufello et al., Protective Measurement - A New Quantum Measurement Paradigm: Detailed Description of the First Realization. Appl. Sci. 11, 4260 (2021).
5. S. Virzì et al., Quantum zeno and anti-zeno probes of noise correlations in photon polarization. Phys. Rev. Lett. 129, 030401 (2022).
6. S. Virzì et al., Sensing microscopic noise events by frequent quantum measurements. Phys. Rev. Appl. 21, 034014 (2024). 7. F. Atzori et al., Universal Protection of Quantum States from Decoherence. arXiv:2602.18327 (2026).

Notes:

Next-Generation Biomedical Imaging with Terahertz Point-Source Microscopy

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Abstract:

Introduction
Terahertz (THz) bioimaging is a promising non-invasive technique for evaluating biological samples, but strong water absorption and limited resolution still hinder practical applications.

Method
We developed a THz point-source microscope by tightly focusing a femtosecond laser onto a nonlinear crystal to generate a localized THz pulse, achieving high-resolution and high sensitivity imaging.

Results
The microscope enabled cellular-level imaging of unstained cancer tissue, lesion sites, and micro-organs such as the inner-ear cochlea, as well as single-cell observation. These results highlight its potential for next-generation THz biomedical imaging and diagnosis.

Keywords: Terahertz microscopy; Terahertz point-source; Bioimaging

Notes:

A Full-Duplex Transceiver System for 6G Non-Terrestrial Networks

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Abstract:

Introduction

The integration of Non-Terrestrial Networks (NTN) is a pivotal evolution in 6G communications, enabling seamless global coverage via Low Earth Orbit (LEO) satellites. To maximize spectral efficiency, full-duplex (FD) technology is highly desired. However, implementing FD in satellite transceivers presents critical physical-layer challenges, primarily the overwhelming self-interference (SI) between the high-power transmit (Tx) signals and the extremely weak receive (Rx) signals. Furthermore, satellite payloads are strictly constrained by Size, Weight, and Power (SWaP) limitations. Traditional approaches relying on bulky circulators or significant spatial separation between antennas are incompatible with the miniaturization requirements of modern LEO terminals. Therefore, establishing a high passive isolation barrier directly at the antenna frontend is crucial to prevent the saturation of the receiver's Low-Noise Amplifier (LNA) without relying on heavy filtering circuits.

Materials and Methods

To address the strict SWaP constraints and SI challenges, this study proposes a shared-aperture dual band dual-polarized array antenna operating in the Ku-band (uplink: 13.75-14.5 GHz, downlink: 10.9 12.7 GHz). Instead of physically separated antennas, a unified aperture is utilized to handle both Tx and Rx operations simultaneously, significantly reducing the physical footprint of the frontend system. The core methodology relies on establishing mode orthogonality to achieve high Tx/Rx isolation. This is realized through a meticulously engineered stacked-patch configuration combined with an aperture coupled feeding mechanism. By exciting orthogonal electromagnetic modes for the Tx and Rx ports, the direct coupling path is intrinsically suppressed at the physical layer. The design eliminates the need for additional filtering components, relying entirely on the structural topology to maintain isolation across the required bandwidths.

Results, Discussion and Conclusions

The proposed shared-aperture array antenna successfully demonstrates the viability of high passive isolation in a highly compact form factor. Through the strategic implementation of mode orthogonality, the antenna achieves an isolation level exceeding 35 dB between the Tx and Rx ports across both the uplink and downlink frequency bands. This ¿35 dB passive isolation effectively serves as the critical first line of defence, satisfying the threshold required to protect the receiver's LNA from saturation caused by Tx signal leakage.

By operating in a shared aperture, the design breaks the traditional trade-off between broadband performance and high isolation, offering a highly SWaP-efficient solution tailored for 6G NTN LEO satellite terminals. The elimination of supplementary filters not only reduces the overall weight and complexity of the RF frontend but also minimizes insertion losses. In conclusion, this frontend architecture provides a robust, scalable, and lightweight hardware foundation for full-duplex satellite communications.

References

1. B. Smida et al.," Full-Duplex Wireless for 6G: Progress Brings New Opportunities and Challenges," IEEE Journal on Selected Areas in Communications, vol. 41, no. 9, pp. 2729-2750, Sep. 2023.
2. L.-C. Chang et al.," A Duplexing Hybrid Slot Antenna Design with High Isolation for Short Range Radar Detection and Identification Applications at 24 GHz Band," IEEE Transactions on Antennas and Propagation, vol. 70, no. 4, pp. 2468-2479, Apr. 2022.
3. L. Zhang et al.," A Single-Antenna Full-Duplex Subsystem with High Isolation and High Gain," IEEE Open Journal of Antennas and Propagation, vol. 5, no. 3, pp. 589-600, Jun. 2024.
4. Y. Li et al.," A 1024-Element Dual-Circularly Polarized Phased-Array Transmitter for Ka-Band SATCOM," IEEE Transactions on Microwave Theory and Techniques, vol. 73, no. 2, pp. 1-15, Feb. 2025.

Notes:

Toward quantum simulations and computations with three-dimensional Rydberg atoms

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Abstract:

Recent experiments with hundreds to thousands of Rydberg atoms arranged in two-dimensional arrays have shown remarkable progress in analog quantum simulation and computation. Extending these atomic arrays to three dimensions is expected to enable richer qubit connectivity and the implementation of various Hamiltonians. In this talk, we present our work on the application of three-dimensional Rydberg atom arrays for quantum simulation and computation. As a relevant preliminary experiment, we have observed the quantum dynamics of bilayer Rydberg atom clusters with N=13. We also measured antiferromagnetic spin correlations between interlayer Rydberg atoms while varying the interlayer distance along the axial direction. Furthermore, we discuss potential applications of three-dimensional Rydberg atoms to adiabatic quantum computation using more complex geometrical arrangements. For quantum simulations, leveraging various Rydberg atom interaction types, such as van der Waals, resonant dipole-dipole interactions are considered.

Notes:

High-purity single-photon generation based on cavity quantum electrodynamics

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Abstract:

We propose a cavity quantum electrodynamics (QED) scheme for generating single photons with high purity [1]. Single-photon sources are a crucial resource for photonic quantum information processing, including quantum communication and distributed quantum computation. In conventional cavity-QED photon sources based on Λ-type three-level atomic systems, the purity of the emitted photons is severely degraded by reexcitation processes triggered by spontaneous atomic decay. Such reexcitation leads to unwanted multiphoton components and temporal-mode mixing, which reduces photon indistinguishability in practical implementations.

To overcome this limitation, we introduce a four-level atomic system coupled to a one-sided optical cavity. In addition to the standard excitation and cavity-coupled transitions, our scheme employs an auxiliary laser that drives the transition between two excited states. This additional coupling suppresses the population of the excited state responsible for reexcitation, thereby inhibiting the reexcitation process. Using the effective operator formalism for open quantum systems, we analytically derive expressions for the photon generation probability, the reexcitation probability, and the resulting single-photon purity and fidelity.

Our analysis shows that the reexcitation probability can be made arbitrarily close to zero by increasing the driving strength between the excited states, while the total photon generation probability remains unchanged and reaches the universal upper bound known for cavity-QED-based single-photon sources. These results demonstrate that high purity can be achieved without sacrificing efficiency, in stark contrast to conventional three-level schemes. We verify the analytical predictions through numerical simulations based on the full master equation.

We further discuss the trade-off between photon emission time and reexcitation suppression, as well as the influence of additional atomic decay channels, and show that their effects can be strongly mitigated in the proposed scheme. Finally, we outline feasible experimental implementations using current cavity-QED technologies, including neutral atoms such as ytterbium. Our scheme provides a practical and scalable route toward high-purity single-photon sources for high-fidelity quantum communication and distributed quantum computation.

References
[1] Seigo Kikura, Rui Asaoka, Masato Koashi, and Yuuki Tokunaga, Physical Review Research 7, 013251 (2025)

Notes:

Ultrathin Solar Cells as an Energy Harvester for Wearable Devices

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Abstract:

Extreme thinness can reduce the weight of electronics, significantly decreasing wearer discomfort when worn. Furthermore, it also enhances mechanical robustness against bending, as the applied strain is determined by the material's softness and device thickness. In a simplified model, film thickness is inversely proportional to strain, meaning that a thinner film experiences less strain for the same bending radius. Additionally, an important benefit when considering photovoltaic devices is that we can expect maximized power output per unit area, which is advantageous for applications where weight is a critical parameter. We focus on improving both the power conversion efficiency (PCE) and the environmental stability of ultra-thin em erging photovoltaics and their potential applications for wearable devices and soft robot systems.

Notes:

Investigation of Near-field Chirality in Plasmonic Nanostructures via Photoemission Electron Microscopy

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Abstract:

Introduction
Chiral systems, which are not superimposable on their mirror images attract considerable interest because biological homochirality is fundamental to life. Theoretical and experimental studies noted that the interaction between three- and two-dimensional chiral metal nanostructures and incident light could generate twisted near fields on the nanostructures. Irradiation on the nanostructures by light with angular momenta, such as CPL and optical vortices, also cause asymmetric near fields (NF).[1-3] In this study, we discuss the chirality of the NF intensity distribution for achiral gold nano rectangular structures (Au-NRs) and clusters of Au nanodots with chiral arrangements (Au-NWs) under CPL irradiation by multiphoton photoemission electron microscopy (MP-PEEM).[4-5]

Materials and Methods
The Au nanostructures were fabricated using electron beam lithography (EBL) and lift-off techniques on the indium thin oxide (ITO) and TiO_2 coated Au/SiO_2 (TiO_2/Au). A commercially available positive resist was spin-coated onto the substrate. After EBL exposure and development, a 2-nm-thick titanium and 30-nm-thick Au layers were deposited via sputtering. Lift-off was performed by successively immersing the sample in the resist remover. We used a Ti:sapphire femtosecond laser with a tunable central wavelength as an excitation source for MP-PEEM to obtain the NF intensity spectra, as well as for NF mapping at different wavelengths. CPL was generated using a quarter-wave plate for chiral PEEM measurements.

Results, Discussion and Conclusions
The NF intensity distribution images of Au-NRs on ITO substrates with different aspect ratios were observed MP-PEEM under left- and right-CPL (LCPL and RCPL) irradiations. In the case of a square Au-NR, similar NF intensity distribution images, which show four spots at the corners, were obtained under LCPL and RCPL irradiation. The near-field intensity of an anisotropic Au-NR under RCPL irradiation was significantly larger than that under LCPL irradiation in the upper-right and lower-left corners. We propose an interpretation that the chiral near-field intensity distribution on an achiral plasmonic nanostructure is extrinsically caused by the interference between two linearly polarized plasmonic modes.
To understand the NF properties of Au-NWs on TiO_2/Au, we measured differential NF spectra between LCPL and RCPL using the MP-PEEM. The differential NF spectra of Au-NWs with left- and right-handed chiral arrangement shows positive and negative signals, respectively. This indicates that the chiral arrangements formed collective mode in near field.

References
[1] S. Hashiyada, T. Narushima, H. Okamoto, J. Phys. Chem. C 2014, 118, 22229-22233.
[2] S. Zu, Q. Sun, E. Cao, T. Oshikiri, H. Misawa, Nano Lett. 2021, 21, 4780-4786.
[3] T. Arikawa, T. Hiraoka, S. Morimoto, F. Blanchard, S. Tani, T. Tanaka, K. Sakai, H. Kitajima, K. Sasaki, K. Tanaka, Sci. Adv. 2020, 6, eaay1977.
[4] T. Oshikiri, Q. Sun, H. Yamada, S. Zu, K. Sasaki, H. Misawa, ACS Nano 2021, 15, 16802-16810.
[5] T. Oshikiri, Y. Matsuo, H. Niinomi, M. Nakagawa, Photochem. Photobiol. Sci. 2025, 24, 13-21.

Notes:

Daily-use-light holography for multidimensional image sensing

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Abstract:

We present digital holography techniques with daily-use light in which multidimensional information such as three-dimensional (3D) space, time, phase, and wavelength is obtained as speckleless holograms. Particularly, we introduce three daily-use-light digital holography techniques and their systems: natural-light full-color motion-picture holography, Newton-ring holography, and self-reference common path in-line digital holography with the designed phase mask. Exploiting self-interference incoherent digital holography, single-shot phase-shifting interferometry, and a polarimetric image sensor, we have proposed fully-passive single-shot full-color digital holography, developed portable natural-light digital holography systems, and performed natural-light full-color digital motion-picture holographic imaging on a moving body. We found that incoherent digital holography is implemented only with a half mirror and a convex mirror, based on the Newton ring. Such the technique is termed Newton-ring holography and we have performed its video-rate incoherent digital holographic 3D imaging capability. We also developed speckleless holography in which self-reference holography, a commercially available light-emitting diode, and the designed phase mask with the coded phase aperture are utilized for quantitative phase imaging of transparent objects in 3D space. The technique is developed from the Zernike phase-contrast microscopy and enables the extension of the measured depth range and multiwavelength-multiplexed digital holographic imaging by the combination of the signal processing of digital holography. We show these digital holography techniques and the experimental results obtained with the holography techniques. Then, the possibility for simultaneous multidimensional imaging is discussed.

Notes:

Multidimensional Solitons

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Abstract:

It is commonly known that the interplay of linear and nonlinear effects gives rise to solitons, i.e., self-trapped localized structures, in a wide range of physical settings, including optics, Bose-Einstein condensates (BECs), hydrodynamics, plasmas, condensed-matter physics, etc. Nowadays, solitons are considered as an interdisciplinary class of modes, which feature diverse internal structures.
While most experimental realizations and theoretical models of solitons have been elaborated in one-dimensional (1D) settings, a challenging issue is prediction of stable solitons in 2D and 3D media. In particular, multidimensional solitons may carry an intrinsic topological structure in the form of vorticity. In addition to the "simple" vortex solitons, fascinating objects featuring complex structures, such as hopfions, i.e., vortex rings with internal twist, have been predicted too.
A fundamental problem is the propensity of multidimensional solitons to be unstable (naturally, solitons with a more sophisticated structure, such as vortex solitons, are more vulnerable to instabilities). Recently, novel perspectives for the creation of stable 2D and 3D solitons were brought to the attention of researchers in optics and BEC. The present talk aims to provide an overview of the main results and ongoing developments in this vast field. An essential conclusion is the benefit offered by the exchange of concepts between different areas, such as optics, BEC, and hydrodynamics.

References

[1] Y. Kartashov, G. Astrakharchik, B. Malomed, and L. Torner, Frontiers in multidimensional self-trapping of nonlinear fields and matter, Nature Reviews Physics 1, 185-197 (2019) https://doi.org/10.1038/s42254-019-0025-7.

[2] B. A. Malomed, (INVITED) Vortex solitons: Old results and new perspectives, Physica D 399, 108-137 (2019) https://doi.org/10.1016/j.physd.2019.04.009; free access: https://authors.elsevier.com/a/1ZXATc2Eea3QG

[3] Z. Luo, W. Pang, B. Liu, Y. Li, and B. A. Malomed, A new form of liquid matter: quantum droplets, Front. Phys. 16, 32501 (2021) https://link.springer.com/article/10.1007/s11467-020-1020-2.

[4] B. A. Malomed, Multidimensional dissipative solitons and solitary vortices, Chaos, Solitons & Fractals 163, 112526 (2022) https://doi.org/10.1016/j.chaos.2022.112526.

[5] B. A. Malomed, Multidimensional Soliton Systems, Advances in Physics X 9:1, 2301592 (2024); an Update, Advances in Physics, https://doi.org/10.1080/00018732.2025.2586343 (2025).

[6] G. Li, Z. Zhao, B. Liu, Y. Li, Y. V. Kartashov, and B. A. Malomed, Can vortex quantum droplets be realized experimentally? Frontiers of Phys. 20, 013401 (2025).

[7] B. A. Malomed, Prediction and observation of topological modes in fractal nonlinear optics, Light: Science & Applications 14, 29 (2025).

[8] B. A. Malomed, Multidimensional solitons (a book), AIP (American Institute of Physics) Publishing, Melville, NY, 2022.

Notes:

Cascaded metasurfaces for holography and electromagnetic field enhacement

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Abstract:

In this talk, I will introduce novel advanced light-manipulation strategies based on multi-layered and hybrid metasurface platforms, focusing on two distinct yet synergistic functional regimes: directional holographic modulation and resonant near-field enhancement. First, we propose a generalized framework for achieving bidirectional asymmetric meta-holograms using a cascaded dielectric metasurface platform. By strategically separating multiple metasurfaces and employing a stochastic gradient descent (SGD) optimization algorithm, we overcome the reciprocity-induced constraints between forward and backward Jones matrices. This approach enables polarization-independent, polarization-dependent, and fully generalized vectorial asymmetric modulations, offering unprecedented degrees of freedom for polarization-direction multiplexing in integrated optical systems. Second, I transition from far-field wavefront control to near-field energy localization by introducing a hybrid metal–dielectric bilayer nanograting that facilitates strong-coupling-induced Bound States in the Continuum (BIC). In this cascaded architecture, the upper metallic nanograting acts as an incident wave concentrator, while the lower dielectric nanograting serves as a low-loss resonator. Our theoretical and experimental analysis reveals a large Rabi splitting energy of approximately 436 meV, leading to an 8-fold enhancement in electromagnetic energy storage compared to conventional single-layer resonators. By addressing the trade-off between field intensity and storage lifetime through temporal and spatial coupled-mode theories, we unveil a novel formation principle of BICs at the Gamma-point. Together, these works demonstrate that cascaded and hybrid meta-optics platforms significantly expand the capabilities of modern nanophotonics, providing robust solutions for multifunctional wearable devices, high-speed optical communications, and highly resonant nanophotonic applications.

Notes:

Hybrid integrated photonic quantum computing and quantum simulation

Jun Gao

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Abstract:

Photonic quantum technologies offer a compelling route toward scalable quantum information processing by combining low noise, long coherence, and ultrafast signal manipulation in an integrated platform. In this talk, I will present an overview of my group's recent progress in hybrid integrated quantum photonics, focusing on the development of chip-scale architectures that combine nanowire-based quantum emitters, low-loss photonic circuits, and single-photon detection. This hybrid integration strategy provides a promising pathway toward compact and scalable quantum systems in which the essential building blocks—quantum light sources, programmable circuits, and detectors—can be co-integrated on a single chip.

I will further discuss our work on programmable photonic quantum processors based on silicon photonics, which enable reconfigurable quantum state control and open new opportunities for quantum simulation. In particular, I will highlight two recent works. First, we realized programmable emulation of coherent absorption of quantum light using ancilla-assisted nonunitary transformations, revealing phase-controlled switching between transmission and absorption, as well as distinctly nonclassical multiphoton effects relevant to quantum state engineering. Second, I will introduce our recent experimental simulation of a non-equilibrium quantum piston on a programmable photonic quantum computer, where two-photon interference is used to access quantum work statistics, irreversibility, and fluctuation relations in driven many-boson dynamics.

Together, these results illustrate how programmable integrated photonic hardware can move beyond conventional linear-optical quantum information processing and serve as a versatile platform for exploring open-system dynamics, quantum thermodynamics, and next-generation quantum functionalities.

Notes:

Liquid crystals for nonlinear photonics

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Abstract:

Ferroelectric nematic liquid crystals (FNLCs) combine fluidic processability with high second-order nonlinear susceptibility, providing a versatile platform for "Soft Mattonics". We present nonlinear light field manipulation via photopatterned FNLC microstructures. By discovering a novel NX mesophase featuring periodically-modulated unipolar and bipolar orders, we achieve designable, defect-free in-plane domain engineering. This allows the direct generation of second-harmonic perfect vector beams from a single-layer, micrometer-thin device. Additionally, we demonstrate reconfigurable nonlinear Pancharatnam-Berry (PB) optics using ion-doped FNLCs. Spatial modulation of the nonlinear PB phase enables programmable beam steering and dynamic control of second-harmonic signals under ultra-low electric fields (0.06 V/μm). These advancements establish a foundation for miniaturized and reconfigurable nonlinear photonic applications.

References

[1] Zhang, G.-Y. et al. Periodically-modulated unipolar and bipolar orders in nematic fluids towards miniaturized nonlinear vectorial optics. Nat. Commun. 16, 9419 (2025).
[2] J.-T. Pan et al., Nonlinear geometric phase coded ferroelectric nematic fluids for nonlinear soft-matter photonics, Nat. Commun. 15, 8732 (2024).
[3] Chen, H.-F. et al. Reconfigurable nonlinear Pancharatnam-Berry diffractive optics with photopatterned ferroelectric nematics. Light: Science & Applications 14, 314 (2025).
[4] Z.-Y. Wang et al., Vectorial liquid-crystal holography, eLight 4, 5 (2024).
[5] L.-L. Ma et al., Programmable self-propelling actuators enabled by a dynamic helical medium, Sci. Adv. 7, eabh3505 (2021).
[6] Yu, X. et al. Programming chaotic centers for shaping light branching in topological nematic vortices. Sci. Adv. 12, eaec5012 (2026).
[7] L. L. Ma et al., Self-assembled liquid crystal architectures for soft matter photonics, Light: Science & Applications 11, 270 (2022).
[8] Ma, L.-L., Wei, Y., Wang, N., Chen, W. & Lu, Y.-Q. Soft Matter Photonics: Interplay of Soft Matter and Light. ACS Nano 19, 11501 (2025).

Notes:

Modeling light scattering of dense and polydisperse colloidal suspensions

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Abstract:

Introduction
Colloidal suspensions are essential in various nano- and micro-scale engineering and scientific fields, such as slurries in chemical engineering, colloidal photocatalysts in environmental remediation, and milk in food science [1]. High-concentration suspensions are in strong demand across many industries because they improve product quality and reduce transportation costs by lowering the overall weight of the suspensions. Consequently, there is a growing need for non-destructive methods to evaluate particle properties—such as particle size distribution and degree of aggregation—in high-concentration colloidal suspensions.

Light-scattering techniques have been extensively developed as promising tools for evaluating particle properties. However, most existing techniques require sample dilution, typically to volume fractions below 5%. As a result, reliable evaluation methods for high-concentration systems remain under development. To address this challenge, simultaneous and appropriate modeling of particle properties and light scattering, together with a fast solution method, is essential. In this study, we aim to develop a fast calculation method based on the local monodisperse approximation (LMA) within the framework of dependent scattering theory (DST).

Materials and Methods
Previously, we proposed a rapid method for polydisperse systems without particle agglomeration based on the LMA and DST [2]. The LMA was originally developed in chemical physics as an approximation for particle configurations [3]. The DST describes far-field interference among scattered electric fields in dense colloidal systems [4]. In the present study, we extend this LMA–DST-based approach to polydisperse systems with particle agglomeration (simply denoted as LMA). Particle agglomeration is incorporated using the sticky hard-sphere model with stickiness parameters [5].

Results, Discussion and Conclusions
We calculated the reduced scattering coefficients at a volume fraction of 10% over a wavelength range of 600–1000 nm (near-infrared) using three models (LMA, polydisperse DST, and monodisperse DST) for two particle size distributions (binary and Gaussian) under a strong stickiness condition. The reduced scattering coefficient represents the inverse mean free path of photons in the diffusive regime. Here, the polydisperse DST is considered as an accurate model because it reproduces the experimental data well [2].

The maximum relative error of the LMA was less than 1%, whereas that of the monodisperse DST (the conventional model) reached 55%, indicating that the LMA achieves nearly the same accuracy as the polydisperse DST. At the same time, the LMA achieved a computational speedup of more than 800 times compared with the polydisperse DST. These results indicate that the LMA is a promising candidate as an accurate and efficient forward model for the non-destructive evaluation of particle properties using scattered light in nanotechnology applications.

References

[1] F. Bonacci, X. Chateau, E.M. Furst, J. Fusier, J. Goyon, A. Lemaître, Contact and macroscopic ageing in colloidal suspensions, Nat. Mater. 19 (2020) 775–780.
[2] H. Fujii, H. Na, J. Yi, K. Kobayashi, M. Watanabe, Particle size distribution effects on the light scattering properties in non-diluted colloidal suspensions: A numerical study, Colloids Surf. A: Physicochem. Eng. 703 (135208) (2024) 1–9.

I[3] J.S. Pedersen, Determination of size distributions from small-angle scattering data for systems with effective hard-sphere interactions, J. Appl. Crystallogr. 27 (1994) 595–608.
[4] H. Fujii, L. Tsang, J. Zhu, K. Nomura, K. Kobayashi, M. Watanabe, Photon transport model for dense polydisperse colloidal suspensions using the radiative transfer equation combined with the dependent scattering theory, Opt. Express 28 (15) (2020) 22962–22977.
[5] H. Fujii, K. Nishikawa, H. Na, K. Kobayashi, M. Watanabe, Polydisperse stickiness and particle size on light scattering in dense colloidal suspensions: A numerical study using the binary sticky hard-sphere model, Results Phys. 73 (2025) 108247.

Notes:

Spin-optoelectronic devices based on dilute nitride semiconductors operating at room temperature

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Keywords: spin-optoelectronics, circular polarization, dilute nitride semiconductor

Abstract:

Introduction

Spin-optoelectronics is a new research area aiming to utilize the coupling between photon and spin angular momentum based on semiconductor. However, the electron spin polarization, reflecting circular polarization, is lost in conventional semiconductors at room temperature.

Approach

We have integrated the defect-enabled spin amplification of dilute nitride GaNAs with III-V semiconductor technologies.

Results/ Findings

We have demonstrated the room-temperature operation of spin-polarized light-emitting diodes, spin photodiodes, and electric-field-effect spin-optoelectronic devices. Our results indicate that dilute nitride semiconductor is a key material for practical spin-optoelectronic applications.

Notes:

Development of high-power conduction-cooled active-mirror laser system SENJU 100J, 100Hz

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Abstract:

We report on the development of the high-power conduction-cooled active-mirror laser system SENJU toward 100 J, 100 Hz operation. This program is aimed at realizing next-generation high-energy and high-repetition-rate solid-state lasers for scientific and industrial applications. The core technology is a cryogenically cooled Yb:YAG ceramic active-mirror amplifier, which enables efficient heat removal, reduced thermal distortion, and scalable aperture enlargement.
To achieve high average power operation, we have developed a conduction-cooled active-mirror architecture using low-temperature Yb:YAG ceramics and a heat-sink design optimized for thermal expansion matching. This approach significantly suppresses wavefront distortion under cryogenic operation and provides a practical route to compact and efficient multi-pass amplification. In the SENJU-Lite stage, a 5-cm-class active-mirror amplifier system demonstrated 10 J output at 100 Hz with an optical-to-optical efficiency of 31.3%, showing stable and high-quality operation.
Based on these results, we designed the SENJU system as a 100 J, 100 Hz active-mirror laser module using larger-aperture gain media and an increased number of amplifier heads. A large-aperture laser head for SENJU was successfully fabricated, and only small deformation of the near-field and far field beam profiles under cryogenic cooling was confirmed. Amplification experiments with a four head configuration were also carried out, demonstrating performance consistent with the design expectation. Numerical simulations and gain measurements further indicate that the present architecture is scalable to the 100 J class with an extended multi-head configuration. In this presentation, we report the design concept, cryogenic laser-head development, and recent amplification results of SENJU, and discuss its scalability toward 100 J, 100 Hz operation.

Notes:

Mid-infrared Signal Detection Based on a Spectrum Transducer

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Abstract:

The Mid-infrared (MIR) spectral region contains the absorption and emission spectrum of numerous molecules and structures and is often referred to as the chemical fingerprint spectral region for the analysis of the composition of substances. In addition, this band is closely related to the thermal radiation of objects and also contains atmospheric communication windows. As a result, MIR spectroscopy has fruitful applications in areas such as biomedicine, environmental monitoring, communications, and remote sensing, stimulating extensive research in recent years. However, the development of detectors in this band is still unsatisfactory, limiting many practical applications. Compared to their visible or near-infrared (NIR) counterparts, MIR detectors such as mercury cadmium telluride and indium antimonide suffer from low detection sensitivity and high noise levels at room temperature, therefore they have to work in low temperature to reduce dark noise, which places additional burden on the applications.

A method based on spectrum transducing technique based on nonlinear processes offer an effective alternative, by which the signal light in Mid-infrared band is converted to visible or near-infrared light and then detected using high-performance detectors like silicon-based APD. This technique has the advantages of room-temperature operation and real-time processes. In this talk, I will firstly introduce the basic principle of spectrum transducing detection, then I will show some important results achieved in this field, especially focusing on the progresses obtained in my group recently. Finally, I will give some prospects for potential applications.

References
[1] Z.-Q.-Z. Han, Xiao-Hua Wang, Jin-Peng Li, et.al., High resolution up-conversion imaging in the 10 μm band under incoherent illumination, arxiv:2505.24367
[2] Wu-Zhen Li, Chun Zhou, Yang Wang, et. al., Mid-infrared and telecom band two-color entanglement source for quantum communication, accepted by laser & Photonics Reviews (2025).
[3] Z.-Q.-Z. Han, Z. Ge, W.-T. Luo, et al., "In-lab high-resolution midinfrared up-conversion stellar interferometer based on a synthetic long baseline", Physical Review D, 110, 063019 (2024)
[4] Z. Ge, Z.-Q.-Z. Han, F. Yang, et al., "Quantum entanglement and interference at 3 μm," Science Advances 10, eadm7565 (2024)
[5] Huili Wang, Ren-Hui Chen, Pengju Zhang, et.al, Detection efficiency measurement of an up-conversion single-photon detector at 3.39μm based on SPDC, Opt. Express.32,24317(2024)
[6] Li Chen, Dong Zhao, Kun Huang, et.al., Characterizing Mid-Infrared micro-ring resonator with frequency conversion, Opt. Express 32, 21795-21805 (2024)
[7] Z. Ge, Z.-Q.-Z. Han, Y.-Y. Liu, et al., "Midinfrared up-conversion imaging under different illumination condition," Physical Review Applied 20, 054060 (2023)
[8] Zhao-Qi-Zhi Han, Zhi-Yuan Zhou, and Bao-Sen Shi, Quantum Frequency Transducer and Its Applications, Adv Devices Instrum., 2023;4:0030 (2023)
[9] Zheng Ge, Zhi-Yuan Zhou, Jing-Xin Ceng, et.al., Thermal camera based on frequency upconversion and its noise-equivalent temperature difference characterization, Adv. Photon. Nexus, 2(4) 046002 (2023)
[10] Z. Ge, C. Yang, Y.-H. Li, et al., "Up-conversion detection of mid-infrared light carrying orbital angular momentum," Chinese Physics B, 31(10), 104210 (2022)

Notes:

Increased Precision by Ultrashort Pulsed Laser Processing in Water

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Abstract:

Introduction
Laser ablation by ultrashort pulses is a widely used technology due to the cold ablation processes and the versatility for being applied with almost any solid material. The reduction in thermal stresses, particularly important in the processing of ceramics and semiconductors, serves to mitigate the risk of defects and extends the operational lifespan of components. Moreover, ultrafast laser ablation facilitates previously unattainable levels of precision in applications like surface micro-structuring and drilling of thin substrates [1]. Typically conducted within a gaseous environment, ultrashort laser processes offer a flexible and cost-effective strategy for various applications. However, debris and thermal influence and damage, although on a very small scale, still limit the range of applications. This contribution describes our investigations into femtosecond laser ablation in a liquid medium for various applications, including surface ablation and micro drilling.

Materials and Methods
The advantages of laser ablation within liquid media have been systematically investigated. In the latter part of the 20th century, reactive laser ablation in the liquid phase (RLAL) emerged as a viable technique for nanoparticle generation [2]. This process involves ultrafast energy absorption, followed by lattice thermalization, resulting in prolonged extensive pressures and steep temperature gradients. These conditions render the liquid phase an excellent incubator for the ejected material [3]. A special flow chamber has been designed and simulated in which the experiments will be carried out. Also pump-probe experiments are powerful methods to visualize the plasma effects and to identify the appropriate process parameters.

Results, Discussion and Conclusions
It has been demonstrated that utilizing a liquid as the surrounding medium helps to minimize induced stresses in adjacent regions. The experiments have demonstrated that the processing of materials which are generally challenging to structure, such as brittle ceramics or semiconductors, along with highly thermally conductive metal substrates, exhibit superior surface finishes and dimensional accuracy compared to conventional laser processing. While these advantages are noteworthy, it is imperative to address impediments such as plasma shielding, as well as the formation of gas and cavity bubbles, with precision and understanding. A comparison between ablation in liquid and air impressively demonstrates the advantages.

References
[1] A. Gillner et al., Journal of Laser Micro / Nanoengineering, vol. 14, pp. 129-137, (2019)
[2] J. Neddersen et al. Applied Spectroscopy, vol. 47, pp. 1959-1964, (1993)
[3] A. Kanitz et al. Plasma Sources Science and Technology, vol. 28, 103001, (2019)

Notes:

Critical-point-enhanced sensing

Keyu Xia

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Abstract:

A non-Hermitian system can exhibit an exceptional point (EP), a critical point (CP) associated with the parity-time-symmetric phase transition. At the EP, the system response shows a sublinear dependence on a perturbation and the responsivity is exponentially enhanced in comparison with the Hermitian counterpart. This response enhancement has been intensively studied for a transformative sensor with unprecedented sensitivity. EP-enhanced responsivity has been demonstrated in gain-loss non-Hermitian sensors, but the expected sensitivity enhancement is compensated by the Petermann-factor-amplified noise. In this presentation, we will report two works demonstrating CP-enhanced sensing. The first work makes a loss-loss non-Hermitian sensor and demonstrates sensitivity enhancement. The second work reveals an EP-like response near the CP without phase transition in an equally lossy non-Hermitian sensor. In contrast to EP sensors, quantum Fisher information at the CP is significantly increased, implying an enhanced sensitivity even at the quantum level.

Notes:

Terahertz plasmonics for Bio-Medical Application

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Abstract:

Introduction

The terahertz (THz) band is a crucial electromagnetic region for intermolecular binding sensor applications. Its energy aligns with intermolecular vibrational energies, enabling direct observation of specific bonding states in biomolecular systems without fluorescent-labeling. This study focuses on exciting surface plasmon resonance (SPR) in the THz range to observe the synergistic effects of two resonance phenomena, namely, intermolecular vibrational resonance and SPR, aiming the label-free detection of intermolecular binding. Despite previous research highlighting the potential of SPR using topological insulators (TIs) in the THz region, mainly through calculations, an experimental demonstration of label-free detection has not yet been achieved.

Materials and Methods

Based on these unique characteristics, Dirac-type materials are expected for using THz surface plasmon. Although the Dirac plasmon has attracted attention, studies have thus far focused on grating-coupled surface plasmon resonance (GC-SPR) in Bi2Se3. In this study, we have experimentally demonstrated topological-insulator terahertz prism-coupled surface plasmon resonance (PC-SPR) and GC-SPR. We observe GC-SPR in Bi2Se3 and Bi2Se2Te and PC-SPR in Bi2Se3. Based on physical properties obtained by Angular Resolved Photoemission Spectroscopy (ARPES), it is found that a surface state alone is not sufficient to enhance SPR; the Dirac point must lie between the conduction-band minimum and the valence-band maximum.

Results, Discussion and Conclusions

The terahertz (THz) band is a crucial electromagnetic region for intermolecular binding sensor applications. Its energy aligns with intermolecular vibrational energies, enabling direct observation of specific bonding states in biomolecular systems without fluorescent labeling. The latter part focuses on exciting surface plasmon resonance (SPR) in the THz range to observe the synergistic effects of two resonance phenomena, namely intermolecular vibrational resonance and SPR, with the aim of label-free detection of intermolecular binding. Despite previous research highlighting the potential of SPR with topological insulators (TIs) in the THz region, particularly in calculations, a label-free detection experiment has not yet been demonstrated. This study successfully demonstrated the direct detection of several important intermolecular interactions in biomolecules, which is not possible with conventional visible-light SPR, using a THz-SPR device with a Bi2Se3 grating structure. In addition, this study not only explores the mechanisms underlying the phenomenon but also discusses the limitations of current THz-SPR devices.

References

[1] H.Sugimoto et al., "Experimental verification of terahertz surface plasmon resonance using the Dirac electron system Bi2SexTe(3-x)", Optical Materials Express, Vol. 15, No. 4 (2025) 788-797.

[2] H.Sugimoto, M.Takahashi, K.Nishimura and H.Tabata,"Direct Measurement of Intermolecular Bonding of Bio-Related Molecules by Terahertz Surface Plasmon Resonance", IEEE Sensors Journal, Vol. 24, No. 24 (2024) 40634-40640.

Notes:

Molecular-Scale Exploration of Electrochemical Interfaces: Near-Field and Far-Field Approaches

Yasuyuki Yokota

Surface and Interface Science Laboratory, RIKEN, Japan

Abstract:

Since the electrolysis of water was first reported more than 200 years ago, basic and applied researches have been conducted on electrochemical reactions occurring at the interface between solution and electrode. In particular, the development of electrochemical devices such as storage batteries has become an urgent issue in recent years, and it is desirable to develop a method that can evaluate the details of the electric double layer, which determines device performance, at the atomic and molecular scale. In the field of surface electrochemistry, electrochemical scanning tunneling microscopy (EC-STM) has been widely used since the late 1980s to analyze the structure of electrodes and adsorbed species, and is now considered the most powerful in situ measurement technique. However, it is difficult to identify reaction products and evaluate their electronic states at the interface in an electrochemical environment because the presence of an electrolyte solution imposes various limitations on measurements. Therefore, we are developing a near field measurement system based on EC-STM (electrochemical tip-enhanced Raman spectroscopy, EC TERS) [1-3], and a far-filed measurement system based on ordinary optical spectroscopy [4-5]. In this presentation, we will introduce the current status of EC-TERS developments and then discuss the possibilities of electrochemical interface exploration using conventional optical microscopes.

References
[1] Y. Yokota, N. Hayazawa et al., J. Phys. Chem. C, 123, 23 (2019).
[2] Y. Yokota, M. Hong et al., Surf. Sci. Rep., 77, 100576 (2022).
[3] Y. Kobayashi, Y. Yokota et al., J. Phys. Chem. C, 127, 13929 (2023).
[4] Y. Yokota, R. A. Wong et al., J. Am. Chem. Soc., 143, 15205 (2021).
[5] Y. Kobayashi, Y. Yokota et al., J. Phys. Chem. C, 128, 15082 (2024).

Notes:

Zinc Oxide Nanostructured Random Lasers: Next-Generation Light Sources for Advanced Bioimaging and Biosensing

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Abstract:

Introduction

Random lasers (RLs) represent a novel class of light sources that operate without conventional optical cavities, achieving optical feedback through multiple scattering in a disordered gain medium. Unlike conventional lasers, which produce high spatial coherence leading to image-degrading speckle patterns, RLs provide low-coherence, speckle-free emission [1]. This unique feedback mechanism enables the development of compact, cost-effective laser systems and opens exciting possibilities in the biosensing and bioimaging realms [2]. RLs are particularly well-suited for detecting biomolecular interactions due to their high sensitivity to changes in refractive index and scattering conditions, making them excellent candidates for label-free, real-time sensing platforms.

Materials and Methods

Our work focuses on the development of ZnO nanorod-based random lasers as biosensing elements. ZnO is a wide-bandgap semiconductor (3.37 eV) with strong excitonic emissions at room temperature in the UV range and excellent biocompatibility. Well-aligned ZnO nanorod arrays were synthesized using chemical bath deposition (CBD). Precursor concentrations were adjusted from 0.01 M to 0.25 M to tailor morphological, optical, and electrical properties. Characterization was performed using Field-Effect Scanning Electron Microscopy (FESEM) and EDX to analyze morphology changes from randomly oriented ZnO nanostructures to nanorods, nanowalls, and nanoflakes. Crystallinity and lattice constants were evaluated via XRD.

Results, Discussion and Conclusions

Physical variations in the scattering medium directly affected RL emission characteristics. FESEM imaging confirmed that increasing CBD concentrations evolved the morphology from nanorods to high-density nanoflakes, which increased scattering centers [3-4]. Higher precursor molarity led to larger crystallite sizes and reduced the random lasing emission threshold. Specifically, the nanoflakes achieved at the highest concentration (0.25 M) exhibited the lowest random lasing threshold power density of 14.29 kW/cm2. Recent advances in multiphoton excitation (MPE) further demonstrate that NIR light can trigger UV upconversion lasing in these ZnO nanostructures, allowing for deeper tissue penetration and reduced photodamage in clinical bioimaging [5]. This study demonstrates that ZnO nanostructures, combined with the distinct advantages of random lasers, pave the way for innovative biosensing and healthcare diagnostics.

References

[1] M. N. Nordin et al., "Influence of annealing time on random lasing from ZnO nanorods," Results Phys., vol. 16, no. 102955, 2020.

[2] A. N. Azmi et al., “Review of Open Cavity Random Lasers as Laser-Based Sensors,” ACS sensors, 7(4) 914, 2022.

[3] N. Rosli et al., "Physical and optical effect of ZnO nanowalls to nanoflakes on random lasing emission," Results Phys., no. 104528, 2021.

[4] N. Rosli et al., " Random lasing emission of ZnO nanorods from different seeding thickness," Journal of Physics: Conference Series 2411, 1, 012018, 2022.

[5] A. A. McAsule & M. M. Halim, "Zinc oxide nanostructured random lasers: A review of their potential as light sources for bioimaging and biosensing applications," J. Appl. Phys. 138, 120702, 2025.

Notes:

Cross-correlated Homodyne measurement and its application for building quantum lidar

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Abstract:

Quantum illumination is experimentally implemented through joint measurement between idler and probe fields which are entangled. However, implementing QI without joint measurement has potential to eliminate quantum storage requirement and adds ranging functionality. Such designs will take QI closer towards quantum laser imaging, detection and ranging (lidar) technology. We propose homodyne cross-correlation technique along with QI to build an optical ranging technology without quantum storage.

The homodyne cross-correlation technique involves making measurements in different homodynes and then cross-correlating them. A homodyne measurement is phase sensitive. Hence, phase noise is detrimental if appropriate techniques to suppress it are not applied. Phase of the lidar probe field is measured by mixing it with a known reference laser field in a homodyne. The best reference field in the homodyne setup is the one with same modes and exhibits some correlation in phase fluctuation with the interfering laser. For this reason, we propose using two-mode squeezed coherent (TMSC) states instead of two mode squeezed vacuum for building quantum lidar. A TMSC state is generated by squeezing the input coherent state. Using a part of the initial coherent state as a reference field in the homodyne setup alleviates the phase noise and mode-matching problems.

We further demonstrate the efficiency of homodyne cross-correlation technique by extraction of coherent lidar probe immersed in environmental noise which is 3000 to 10000 times stronger than the lidar probe. The experiment is conducted to range a low-reflectivity target placed at three different distances.

Notes:

Chronicles of Light: Ultrashort Laser Pulses and the Transformation of Materials

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Abstract:

Ultrashort pulsed lasers are now regularly used in the ablation/surface processing/nanofabrication of various materials such as (i) metals (e.g., Ag, Au, Cu, Ag-Au, Au-Cu, Ag-Au-Cu) (ii) semiconductors (e.g., Si, Ge, GaAs, SiC, InP), 2-D materials (e.g., TMDCs, MXenes, few-layer graphene), etc. We have utilized the technique of ultrafast laser ablation for producing diverse nanoparticles/nanostructures of the above-mentioned materials along with functionalized/hybrid nanomaterials (e.g., Ag-Au/Si, Ag-Au/Ge, Ag-WS_2, etc.) [1-24]. We could achieve surface nanostructures and achieve wide-ranging nanocolloids using these short pulses by varying the focusing conditions (Gaussian, Bessel, Vortex, etc.), surrounding liquid, input pulse duration, input pulse energies, and the number of incident pulses on the surface. We will discuss the fabrication of novel 2D materials and composites along with the physics of these processes and their potential applications of these versatile nanomaterials in photonics, optoelectronics, etc.

References

[1] M. Chowdhury, S. Pradhan, N. Pradhan, V.R. Soma, R. Rawat, ACS Appl.Nano Mater., 9, 3100-3114 (2026).

[2] A. Kumar, S. Pradhan, N. Pradhan, Venugopal Rao Soma, J. Phys. Chem. C, 130(6), 2234-2243 (2026).

[3] S. Pradhan, N. Pradhan, Venugopal Rao Soma, Applied Surface Science, 719, 164980, (2025).

[4] J. Rathod, S. Pradhan, Venugopal Rao Soma, Surface and Interfaces, 76, 107905, (2025).

[5] Amrit Kumar, Supriyo Pradhan, R.K. Gupta, Venugopal Rao Soma, Next Materials, 9, 101297 (2025).

[6] K.R. Kumar, J. Rathod, M.S.S. Bharati, R.S.P. Goud, V.R. Soma, S.V.S.N. Rao, Opt. Expr., 32(21), 37394 (2024).

[7] S.S.B. Moram, C. Byram, V.R. Soma, Beilstein Journal of Nanotechnology, 15, 1054-1069 (2024).

[8] D. Banerjee, M. Akkanboina, K.R. Kumar, B. Ghose, V.R. Soma, J. Phys. Chem. C., 128, 4655-4665 (2024).

[9] S.K. Nayak, Md Soif Ahmed, M. Velpandian, P. Meduri, J. Rathod, V.R. Soma, S.S.K. Raavi, Optical Materials, 147, 114630 (2024).

[10] K.R. Kumar, D. Banerjee, M. Akkanaboina, R.S.P. Goud, A. Anjum, A.P. Gnana Prakash, A.P. Pathak, V.R. Soma, and S.V.S. Nageswara Rao, J. Phys. C: Cond. Matter, 36, 235702 (2024).

[11] B.K. Singh, D. Banerjee, A. Mangababu, Yagnesh Shadangi, N. K. Mukhopadhyay, Rajesh Rawat, A. P. Pathak, S. Venugopal Rao, A. Tiwari, A. Tripathi, J. Alloys and Compounds, 968, 172238 (2023).

[12] G. Ravi Kiran, G. Srikanth, C. Byram, Md Abu Taher, S.G. Acharyya, V.R. Soma, Tarak Nath De, IEEE Transactions on Nanotechnology, 22, 252-259 (2023).

[13] A. Mangababu, D. Banerjee, K.R. Kumar, R.S.P. Goud, V.R. Soma, S.V.S.N. Rao, Opt. Lett., 48(21), 5539-5542 (2023).

[14] D. Banerjee, A. Mangababu, R.K. Kanaka, V.R. Soma, Appl. Surf. Sci., 616, 156561 (2023).

[15] A. Mangababu, D. Banerjee, R.K. Kanaka, R.S.P. Goud, V.R. Soma, S.V.S.N. Rao, Surfaces & Interfaces, 36, 102563 (2023).

[16] V.S. Vendamani, Reshma Beeram, V. R. Soma, Journal of Alloys and Compounds, 959, 170573, 2023.

[17] R. Rawat, B.K. Singh, A. Tiwari, N. Arun, A. P. Pathak, Y. Shadangi, N. K. Mukhopadhyay, S.R. Nelamarri, S. Venugopal Rao, A. Tripathi, J. Alloys & Compounds, 927, 166905 (2022).

[18] T.K. Naqvi, A. Bajpai, S.S.B. Moram, M.M. Kulkarni, A.M. Siddiqui, S. Venugopal Rao, P.K. Dwivedi, J. Hazard. Mater., 407, 124353 (2021).

[19] G. Ravi Kiran, B. Chandu, Swati Ghosh Acharyya, S. Venugopal Rao, V.V.S.S Srikanth, Philosophical Magazine Letters, 97(6), 229-234 (2017).

[20] A. Mangababu, R.S.P. Goud, C. Byram, J. Rathod, D. Banerjee, V.R. Soma, S.V.S.N. Rao, Appl. Surf. Sci., 589, 152802 (2022).

Notes:

Shedding Light on Decay: Photophysical Evolution of Lead-Free MBB Perovskite Saturable Absorbers

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Abstract:

The pursuit of ecologically conscious photonics has positioned lead-free bismuth (Bi)-based perovskites as frontrunners for high-performance saturable absorbers (SAs). While their initial performance metrics are promising, a significant knowledge gap persists regarding their long-term operational reliability under realistic ambient stressors—most notably, indoor lighting. This study presents a 16-week longitudinal investigation into the material health and nonlinear dynamics of methylammonium bismuth bromide (MBB) SAs integrated into erbium-doped fiber lasers (EDFLs).

To isolate the specific impact of illumination, we compared two distinct configurations: a packaged SA maintained in total darkness (SA-WP) and an unpackaged SA (SA-WOP) subjected to continuous ambient indoor lighting (~260 lux). Our findings reveal a divergent evolutionary path for the two systems. While the dark-stored SA followed a regular degradation trajectory, the illuminated sample exhibited a complex photophysical response. Specifically, exposure to ambient light triggered a photo-induced bandgap decrease that led to a paradoxical enhancement in nonlinear response, where the modulation depth increased significantly over the evaluation period.

However, this gain in nonlinearity was coupled with accelerated material deterioration. The unpackaged sample suffered markedly higher linear transmission losses compared to its packaged counterpart, directly resulting in a substantial surge in the power required to initiate and sustain stable mode-locked operation. Throughout the 16-week trial, both systems maintained stable soliton operation, but their evolving pulse dynamics—characterized by systematic shifts in pulse duration and central wavelength—provided a real-time indicator of underlying material decline. These results provide critical insights into the photostability of lead-free perovskites and highlight the necessity of advanced light-blocking encapsulation strategies to ensure the operational longevity of next-generation, sustainable photonic components.

Notes:

Engineering High-Performance Laser Power Converters based on SiC Polytypes

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University of Santiago de Compostela, Spain

Abstract:

High power laser transmission (HPLT) is emerging as one of the most promising wireless power transfer technologies due to its ability to deliver energy efficiently over long distances. HPLT relies on monochromatic laser light directed toward a laser power converter (LPC), which transforms the incoming light into electrical power. Today, the most efficient LPCs are based on Gallium Arsenide (GaAs), reaching conversion efficiencies of around 69% at illumination intensities near 11 W/cm². However, as intensity increases, GaAs devices suffer a substantial drop in performance, primarily due to series resistance losses associated with their relatively low bandgap energy.

The RePowerSiC project seeks to overcome these limitations by developing a new generation of high efficiency laser power converters optimized for power densities close to 1 kW/cm²—representing a major step forward in HPLT capabilities. Its strategy combines the use of advanced wide bandgap materials with innovative device architectures. Central to this effort are silicon carbide (SiC) polytypes, which feature bandgap energies above 2.3 eV—over 50% higher than GaAs—and enable devices with targeted series resistances around 10^{-4} Ω·cm², more than an order of magnitude lower than current GaAs based LPCs.
The project aims to surpass 80% conversion efficiency and increase power transfer density by more than tenfold compared to existing technologies, while also promoting sustainable and cost effective fabrication methods. Such advancements could deliver compact, scalable LPCs capable of handling kilowatt level power flows, reducing or even eliminating the need for onboard energy storage.

If successful, RePowerSiC could revolutionize power delivery for remote and space based systems, including satellites, planetary rovers, landers, and in orbit energy distribution networks. Beyond its direct technological impact, the project could open new pathways for SiC device innovation and reshape future approaches to wireless energy transmission.

Notes:

Composite Coatings Synthesized by Laser Methods for Bone Repair and Preventing Infection

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Abstract:

Introduction
In the continuing search to improve implant integration and longevity, surface engineering via multifunctional coatings represents a highly promising strategy. Coatings wich can induce regenerative and osseintegrative properties can be applied for the functionalization of metallic implants. These layers provide a local modulation of the bone-to-implant interface. Bioactive glasses (BG) have demonstrated positive action for the modulation of bone cells' development, and further regeneration of the bone tissue. They can adhere to hard tissues and aid in the regeneration of those tissues by the formation of a calcium–phosphate layer on metallic implant-like surfaces. The formation of this apatite layer results in a linkage between the hard tissue and the bioglass, which further leads to bone healing.
Any type of implant is prone to infections caused by bacteria which can affect the healing time. Infections occur as an effect of bacterial attachment and subsequent biofilm formation at the implantation site. This bacterial community can develop resistance to antibiotics. Infections could prove difficult to be treated and some of them require implants revision surgery. Bioactive glass coatings can also function as depots for the adsorption and local release of antibiotics.
This study explores the fabrication and performance of innovative thin film coatings composed of bioactive glasses, antimicrobial substances, and additional biofunctional agents, designed to enhance both osteointegration and antimicrobial protection.
Materials and Methods
We employed matrix-assisted pulsed laser evaporation (MAPLE), a gentle and versatile laser-based technique, to deposit these composite materials onto various implant-like substrates, including titanium and stainless steel. To prepare a MAPLE target, the materials of interest were dissolved in an appropriate solvent. The predominant liquid phase of the target (matrix or solvent) was selected so that: i) it is not toxic in liquid or vapor phase, ii) it can form a dilute solution (homogeneous suspension), iii) the incident laser energy to be absorbed only by the solvent molecules and not by those of the material of interest. The solutions thus obtained were poured into a copper plate and then immersed in a liquid nitrogen bath to solidify. The frozen targets were introduced into the vacuum chamber on a cryogenically cooled rotating target holder, was continuously cooled down to avoid melting during the laser irradiation. At the same time, the targets were kept at liquid nitrogen temperature with the help of a cooler, connected to a liquid nitrogen tank, throughout the experiments. During the experiments, the targets were rotated to avoid perforation and to ensure a uniform deposition.
The resulting coatings were systematically evaluated for their antibacterial efficacy against clinically relevant bacterial strains—Staphylococcus aureus, Enterococcus faecalis, Escherichia coli, and Pseudomonas aeruginosa. Furthermore, biocompatibility assessments were carried out using osteoblast-like cells to examine cell adhesion, proliferation, and morphology.
Results, Discussion and Conclusions
The purpose of this study was to obtain thin films based on BG to increase the performance of metallic implants at the biointerface. BGs are an excellent alternative for enhancing the bioactivity and biocompatibility of implants because they are extremely biocompatible and more likely to integrate with human tissue than the sole metallic implants. The advantages of BG include encouraging tissue regeneration, degrading at a similar rate as tissue regeneration, and replacing broken bone and tissue that will integrate well with the body's environment. Due to its reaction process in host biological environment, which results in the development of a layer of hydroxycabonate apatite (HCA) with a mineral composition comparable to bone on the glass surface, BG creates linkages with the host bone, promoting its formation. Moreover, they have the

ability to control or prevent the corrosion of implant metals in biological conditions. Our results demonstrated that the MAPLE-deposited films maintained the integrity and functionality of all components. The coatings effectively inhibited bacterial colonization and biofilm formation without compromising cellular compatibility, highlighting a dual functionality that is critical for next generation hard tissue implants. These findings suggest that laser-fabricated bioactive-antimicrobial coatings may serve as a robust platform for biomedical applications, particularly in orthopedics and dental implants where infection control and bone regeneration are crucial.
Surface modification of metallic implants with bioactive glass coatings, obtained by laser processing, represents a suitable choice to easily integrate metallic implants and improve their overall biofunctionality. Our coatings hold promising perspectives for targeted applications in the field of biomaterials, tissue engineering, and regenerative medicine [1-5].

Acknowledgment
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References

[1] I. Negut, L. Floroian, C. Ristoscu, C.N. Mihailescu, J. C. Mirza Rosca, T. Tozar, M. Badea, V. Grumezescu, C. Hapenciuc, I.N. Mihailescu; Nanomaterials, 2020, 10, 385
[2] I. Negut, C. Ristoscu, T. Tozar, M. Dinu, A.C. Parau, V. Grumezescu, C. Hapenciuc, M. Popa, M.S. Stan, L. Marutescu, I.N. Mihailescu; Pharmaceutics, 2022, 14, 1175
[3] Irina Negut, Carmen Ristoscu; Applied Sciences, 2023, 13, 6151
[4] I. Negut, G. Gradisteanu-Pircalabioru, M. Dinu, B. Bita, A.C. Parau, V. Grumezescu, C. Ristoscu, M.C. Chifiriuc; Biomedicines, 2023, 11(10), 2772
[5] G. Grădișteanu-Pircălăbioru, I. Neguț, M. Dinu, A.C. Pârâu, B. Bița, L. Duță, C. Ristoscu, B. Sava; Biomedical Materials, 2025, 20(1), 015019

Notes:

Embedded metasurfaces machined inside standard fused silica by intense laser beams

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Abstract:

Usual nanofabrication processes require tedious etching, thermal and chemical steps. Here, we present a straightforward alternative approach: direct laser machining.

Using ultrashort intense shaped beams, a functional metaprism device, made of assembly of hollow nanochannels, is engraved directly inside glass, within a single-step, maskless and digital approach.

This sustainable fabrication method provides two main advantages: i) internal processing of devices inside bulk materials, and ii) possibility to use any dielectric materials, even standard glass which is usually not appropriated because of its low refractive index.

This opens a new paradigm in laser-based nanofabrication.

Keywords: ultrashort pulses, laser processing, metasurfaces

Notes:

Seamless integration of 3D hollow micro and nanostructures inside crystals for functional components

Airan Rodenas

Universidad de La Laguna, Spain

Abstract:

The area of laser micro and nanostructuring materials with laser pulses has witnessed a huge increase in the last decades. The most recent advances include structuring with high fidelity the volume of the materials, well beyond the surface where laser writing is most straightforward. In this presentation I will show our seminal discoveries on giant etching selectivity, and our most recent results, on the development of components like wavelength-thick microlenses, and micro-resonators, seamlessly fabricated within single-crystals, for general photonic applications.

Notes:

Measurement of Low-Repetition-Rate Thermal Effects in Liquids Using Femtosecond Z-Scan and Cavitation Monitoring

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Abstract:

Introduction

Understanding thermal effects induced by ultrashort laser pulses in transparent liquids is crucial for a wide range of applications requiring precise energy deposition. At low repetition rates, cumulative thermal effects are often considered negligible; however, thermal lensing phenomena may still occur and influence nonlinear optical measurements and laser–matter interaction thresholds. In particular, the interplay between thermal lensing and cavitation bubble formation remains poorly documented in the low-kilohertz regime. This work focuses on the fine measurement of thermal effects in liquids excited by femtosecond laser pulses at repetition rates up to 25 kHz. By combining a Z-scan–like configuration with monitoring of cavitation events, we aim to establish a quantitative link between thermal lens formation and cavitation threshold. Such an approach provides new insights into energy accumulation mechanisms in liquids under femtosecond infrared irradiation.

Materials and Methods

Experiments were performed using an infrared femtosecond laser delivering pulses of 300 fs full width at half maximum. The repetition rate was adjustable from single-shot conditions up to 25 kHz, allowing controlled investigation of low-cadence thermal accumulation. A Z-scan–type setup was implemented to probe laser-induced refractive index changes in the liquid samples [1, 2, 3], providing sensitivity to weak thermal lens effects. Simultaneously, cavitation bubble formation was detected using optical imaging [4], enabling precise determination of cavitation thresholds as a function of repetition rate.

Results, Discussion and Conclusions

The measurements reveal that even at relatively low repetition rates, thermal lensing effects can be detected and quantified in liquids exposed to femtosecond laser pulses. An increase in repetition rate leads to a progressive enhancement of the thermal lens, which correlates with a reduction of the cavitation threshold. These results indicate that weak cumulative heating, though often neglected in this regime, plays a measurable role in bubble nucleation processes. The combined Z-scan and cavitation monitoring approach proves to be a sensitive tool for disentangling nonlinear optical and thermal contributions. This study demonstrates that thermal effects must be carefully considered when controlling femtosecond laser interactions in transparent media. The findings are particularly relevant for applications requiring fine control of ultrashort laser pulses, such as ophthalmic surgery, microfluidic lab-on-chip fabrication, and laser processing of transparent materials.

References

[1] Zinoune, Julien-Bilal, Christophe Cassagne, Martinus HV Werts, et al. 2023 Wavelength-Dependence of the Photothermal Efficiency of Gold Nanoparticles in Solution by Z-Scan Photothermal Lens Spectroscopy. Chemical Physics Letters 823. Elsevier: 140501.

[2] Boudebs, G., Zinoune, J. B., Cassagne, C., & Chis, M. (2023). Thermal lens Z scan measurements for the determination of fluorescence quantum yields: theoret ical and experimental uncertainties for low and high quantum yields. Applied op tics, 62(29), 7669-7677.

[3] Zinoune, J. B., Cassagne, C., Chis, M., & Boudebs, G. (2024). Analytical devel opment of thermal lensing in an afocal setup with a Gaussian profile: relative beam size variation. Journal of the Optical Society of America B, 41(9), 2211 2219.

[4] Aguilar, Alberto, Aurélien Bernard, Amélie De Saint-Jean, et al. 2021 Astigma tism and Spherical Aberrations as Main Causes for Degradation of Ultrafast Laser-Induced Cavitation in Water. OSA Continuum 4(11). Optica Publishing Group: 2905–2917.

Notes:

Narrow-Linewidth 1550 nm Semiconductor Lasers with a Broad Operating Current Range

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Abstract:

Narrow-linewidth 1550 nm semiconductor lasers with a broad operating current range are essential light sources for coherent photonic systems, offering low phase noise, high spectral purity, and robust operation. This invited talk presents recent advances from the University of Glasgow's Photonic Integrated Circuit (PIC) research group in laser cavity engineering and topological photonics, enabling substantial linewidth reduction while maintaining stable single-mode operation over an extended operating current range.

First, a distributed feedback (DFB) laser incorporating a distributed phase-shift (DPS) region at the cavity centre is demonstrated. By modelling the intracavity field distribution and output spectrum, both the DPS length and phase shift are optimised. Compared with conventional π phase-shift DFB lasers, devices employing larger phase shifts (up to 15π) exhibit stable single longitudinal-mode operation over a significantly broader current range, alongside reduced threshold current, enhanced slope efficiency, improved side-mode suppression ratio (SMSR), and a linewidth reduction from 1.3 MHz to 220 kHz.

Second, a narrow-linewidth laser based on extended topological interface states (TIS) in a one-dimensional photonic crystal is presented. A zero-index, linearly dispersive photonic crystal is integrated with a four-phase-shift sampled grating, enabling phase-uniform photon propagation. The resulting extended TIS produces a more uniform intracavity photon distribution and suppresses spatial hole burning, yielding a minimum Lorentzian linewidth of 126 kHz—nearly an order of magnitude narrower than that of conventional DFB lasers.

Finally, a monolithic optical injection-locked topological interface state extended (MOIL-TISE) laser is demonstrated by integrating a TISE laser with a micro-ring resonator on an AlGaInAs multiple-quantum-well platform. The device exhibits stable single-mode operation from 65 to 300 mA with SMSR exceeding 50 dB. The Voigt linewidth is reduced from 2 MHz to 4.2 kHz, with an intrinsic linewidth of 983 Hz extracted from power spectral density measurements, highlighting the potential of this approach for ultra-coherent integrated light sources.

Notes:

Direct-laser-writing in optical fibers: engineering ultra-long waveguides and scattering nanoparticles

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Abstract:

Direct-laser-writing (DLW) in glass is a powerful microfabrication technique that enables three-dimensional structuring and modification of transparent materials with sub-micrometer precision. It relies on tightly focused, ultrashort laser pulses to induce localized changes in the glass without affecting the surrounding material. Because glass is transparent at the laser wavelength, nonlinear absorption processes occur only at the focal volume, leading to highly confined energy deposition. Depending on the laser parameters (pulse duration, energy, repetition rate, and scanning speed), DLW can produce various types of material modifications, including refractive index changes, nanogratings or microexplosions. These controlled modifications allow for the fabrication of a wide range of functional structures embedded in glass (such as optical waveguides or microfluidic channels), thus advancing the development of integrated and multifunctional photonic devices. Although the majority of research has concentrated on bulk glass, DLW can also be employed to inscribe small scale photonic components in optical fibers, the most frequently produced elements being fiber Bragg gratings. In this presentation, we will present two novel ultrashort laser-assisted fabrication processes of complex structures in optical fibers. First, the implementation of an innovative reel-to-reel DLW setup allowing the inscription, directly through the coating, of arbitrary long and low-loss waveguides in coreless silica fibers will be discussed [1]. Then, we will concentrate on a newly engineered class of optical fibers whose cores embed dielectric nanoparticles [2] thereby enhancing scattering characteristics that can be leveraged in laser and sensing applications. To achieve an unprecedented control over the scattering properties, we will show a novel approach using an ultrashort laser to locally heat the core of the fiber and thus modulate on purpose the characteristics of the nanoparticles.

References
[1] L. Colliard, J. Lapointe, N. Grégoire, S. Morency, R. Vallée, M. Bellec, M. Bernier, Opt. Exp. 32, 19735 (2024)
[2] W. Blanc, Z. Lu, T. Robine, F. Pigeonneau, C. Molardi, D. Tosi, Opt. Mater. Express 12, 2635 (2022)

Notes:

Tailoring the ultra-fast infrared optical response of Al:ZnO through nanostructuration

Tersilla Virgili[1], Luca Bursi[3,4], Riccardo Magrin Maffei[3,4], Michele Guizzardi[1], Andrea Villa[2], Alessandro di Bona[4], Sergio D'Addato,[3,4], Andrea Mescola[4], Gian Carlo Gazzadi[4], Arrigo Calzolari[4], Stefania Benedett[4]

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Keywords: transparent conducting oxide, nanostructuration, transient absorption spectroscopy

Abstract:

Introduction
Aluminum-doped zinc oxide (AZO) is one of the most promising transparent conductive oxides.

Methods
We designed, fabricated and characterized via ultra-fast MID-IR pump probe technique periodic arrays of nanostructures of AZO.

Results
In the film and larger nanostructures, we discovered that after pump excitation a non-thermalized carriers population decay rapidly in a thermalized one and then to the ground state, while for nanorods only one population is evident. Our results establish that it is possible to modify the ultra-fast response of AZO metasurfaces through nanostructuration making them promising building blocks for infrared plasmonics and nanophotonic applications.

Notes:

Photo-Induced Synaptic Functionality in 2D Tin Dichalcogenides

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Keywords: 2D materials, SnS2, SnSe2, SnSSe, field-effect transistor, photoconductivity, neuromorphic synaptic plasticity, optoelectronics

Abstract:

Two-dimensional (2D) tin dichalcogenides, including SnS2, SnSe2, and their ternary alloys (SnSSe), are emerging as highly promising platforms for neuromorphic and optoelectronic applications due to their tunable electronic and photoresponsive properties. In this work, we investigate the photo-induced synaptic behavior of back-gated field-effect transistors (FETs) based on ultrathin flakes of these materials under varying temperature, gate bias, and illumination conditions. Our results demonstrate that persistent photoconductivity (PPC), arising from trap states and surface adsorbates, plays a central role in mimicking synaptic plasticity. In SnS2 devices, we achieve responsivities up to ~100 A/W, with controlled current retention from short-term (~0.1%) to long-term (~30%) states, tunable via gate voltage and temperature. SnSe2 FETs exhibit gate-dependent optoelectronic plasticity, where negative gate bias prolongs PPC, enabling long-term potentiation, while positive bias accelerates recombination to produce short-term memory. Repetitive optical stimulation leads to cumulative learning and highly reproducible memory retention, highlighting the robustness of these 2D semiconductors for neuromorphic circuits.

Expanding the material design space, SnSSe ternary alloys combine the advantages of both parent compounds, showing broadband photoresponse with coexistence of positive and negative photoconductivity across 460–1000 nm. The interplay of material composition, substrate interaction, and trap-assisted photogating allows fine-tuning of synaptic weights and memory states. Furthermore, temperature-dependent transport studies reveal that carrier dynamics and Schottky-barrier modulation at the contacts enhance memory performance, suggesting multi-functional device operation.

These findings underscore the versatility of 2D tin dichalcogenides in implementing energy-efficient, optically controlled synapses and multifunctional memory devices. By leveraging intrinsic trap states, photogating, and compositional tuning, our work provides a foundation for scalable, reconfigurable neuromorphic architectures and broadband optoelectronic platforms based on 2D materials.

References:
[1] A. Sessa et al. Advanced Electronic Materials, 12, e00734 (2026)
[2] A. Sessa et al. Advanced Electronic Materials 11, e00327 (2025)
[3] S. De Stefano et al. ACS Applied Materials & Interfaces 17, 50901-50915 (2025)
[4] A. Sessa et al. 2025 IEEE 20th Nanotechnology Materials and Devices Conference (NMDC), 79-84 (2025)

Notes:

Robust and Precision Displacement Measurement through Speckle Pattern Imaging Technique

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Keywords: Robust, Precision, Displacement Measurement, Non-contact based and Speckle Pattern Imaging

Abstract:

Accurate and reliable displacement measurement is crucial for numerous engineering and scientific applications, including metrology. There are various kinds of displacement measurement techniques have been developed in the past decade, most of them are interferometry based. In interferometry displacement is measured by analyzing interference patterns created by the interaction of light waves. Common types displacement interferometry includes Michelson interferometry, Fabry Perot interferometry and Holographic Interferometry [1]. Interferometric techniques are highly precise and can be used for nanometer-scale displacement measurements. Michelson interferometry, Fabry- Perot interferometry measures displacement by measuring change in the intensity. They are often used in scientific research and metrology. While interferometry techniques are commonly employed for precision displacement measurement, they often entail complex experimental setups and lack automation capabilities. To address these challenges, this study proposes a robust method for displacement measurement utilizing speckle pattern imaging. As we know that speckle patterns are formed by the interference of coherent light on surfaces. Since speckle patterns offer a unique and versatile approach to capturing subtle deformations with high sensitivity. Therefore, in this study we introduced a non-contact based robust displacement measurement technique based on speckle pattern imaging.

Methods
In order to perform robust and precision small displacement measurements, in the current technique we have used a rotatable cantilever beam object in which one end of the cantilever beam is fixed for rotation, while the other end remains free for application of displacement. Displacement applied at the any position cantilever beam through the precision linear motorized stage induced a tilt in the cantilever beam object. This tilt is get measured by through mentioned algorithm in literature [3]. Then measured tilit is used to find bending displacement at free end of rotatable cantilever beam object. The schematic of experiment setup and flow diagram of algorithm is shown in fig. 1 and 2. The shifted speckle images are recorded at 20 μm intervals from the range 20 μm to 200 μm.

Results and discussion
Through the mentioned algorithm a speckle correlation code has been developed to detect tilt and bending displacement in a rotatable cantilever beam. The tilt is introduced by applying controlled bending displacement using a linear motorized stepper motor. Fig. 3 shows the reference speckle pattern captured when no tilt is applied. Fig. 4 displays the speckle pattern after applying a 20μm displacement, indicating induced tilt. The resulting change in speckle patterns is analyzed using the developed algorithm to obtain the slope, which quantifies the tilt. Fig 5 shown obtained tilt slope. Through the evaluated tilts bending displacements at free end are determined which is verified by the dial gauge indicator. The method enables accurate and robust bending displacement measurement through speckle correlation analysis. Overall, the approach demonstrates high sensitivity and reliability, making it a promising tool for non-contact displacement and force measurements in precision engineering applications such spring constant determination [3].

References
[1] Badami, V., & de Groot, P. (2013). Displacement measuring interferometry. Handbook of optical dimensional metrology, 4.
[2] Vikas, Kumar, K., Jewariya, M., Kumar, R., Titus, S. S. K., & Gautam, S. K. (2025). Robust and precision small-angle measurement through the speckle pattern imaging technique. Applied Optics, 64(9), 2195-2202.
[3] V., et al. "Simulation and Modelling of a Precision Method for Static Low Force Measurement." Experimental Techniques (2024): 1-10.

Notes:

Entanglement-inspired rangefinding for daylight noise suppression

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Abstract:

Quantum illumination has garnered significant interest since Lloyd's seminal paper in Nature, which highlighted its potential for enhanced sensitivity in sensing scenarios plagued by high loss and strong background noise. Notably, its advantage persists even when entanglement is degraded -- an inevitability in practical remote sensing -- thanks to the underlying energy-time correlations present in quantum light. Building on this foundation, several quantum rangefinding experiments have demonstrated that the primary benefit in such systems stems not solely from entanglement, but mainly from the ability to exploit energy-time correlations to suppress uncorrelated background noise. Photon sources used in these systems also exhibit super-Poissonian statistics, making them difficult to distinguish from the background and enabling covert operation. However, the practical deployment of quantum rangefinding remains limited by the intrinsically low brightness of quantum light sources, which restricts performance over longer distances.

Inspired by quantum illumination principles, we modify a classical optical source to preserve the noise-suppression benefits of energy-time correlation while significantly increasing brightness by over six orders of magnitude compared to quantum sources. Our approach employs a broadband pulse stretched in time via fibre dispersion, combined with pulse carving using time-delayed electro-optic signals to define three distinct energy channels. We have successfully integrated this frequency-agile, three-channel source into a rangefinding platform and carried out field demonstrations with targets on the external walls of buildings at distances of 155m and 413m, under challenging high-noise conditions such as bright sunlight and variable weather. These results highlight the potential of our modified classical approach for long-range, low-power, and covert remote sensing, offering a practical route to quantum-inspired performance in field-deployable systems.

Notes:

High performance femtosecond solid-state laser technology for secondary radiation generation

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Abstract:

The third generation of femtosecond laser sources, characterized by high average power and high repetition rates, have shown significant advantages in various fields such as the generation of high-order harmonics and attosecond pulses, the construction of XUV optical frequency combs, efficient femtosecond laser precision processing, and femtosecond laser surgery. This report provides a brief introduction to the current mainstream high-power femtosecond laser technology and proposes a high repetition rate, high average power all-solid-state femtosecond laser solution from the perspectives of system technical difficulty, comprehensive laser performance indicators, and system cost. It also explores technical challenges and solutions for Kerr lens mode-locked laser output; achieving an average power of 11W, a repetition rate of 2 GHz, and a pulse width of 200 fs in high repetition rate femtosecond oscillators. To date, an all-solid-state femtosecond oscillator has achieved a locking laser output with an average power of 31W and a pulse width of 156 fs. In the research on all-solid-state femtosecond laser regenerative amplification, thanks to excellent crystal thermal management, dispersion control, regenerative cavity design, and pulse compression technologies, experimental results have been achieved with the highest average power of 68 W, a maximum single pulse energy of 6.5 mJ, the shortest pulse width of 132 fs, and an adjustable repetition rate from 1 kHz to 1 MHz. The report provides an outlook on the amplification of 100-200 W power and subsequent nonlinear frequency conversion.

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