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GUEST EDITORIAL

Special Section Guest Editorial: MOEMS and Nanophotonics in India

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Over the past decade, India has made significant strides in micro- and nano-systems research, driven by government initiatives that have encouraged innovation and provided generous funding for nanofabrication and characterization facilities. A key focus of this progress has been in photonics and optical microsystems. In this JOM special section, we throw the spotlight on some of this work.

In their paper, "Unravelling the role of plasmonics in gold nanoparticle-integrated tapered fibre platforms for sensing applications," Kumar et al., of the Department of Physics, IIT Bombay, investigate the use of tapered telecommunication fibers for refractive index sensing in the visible spectrum. The fabrication of these tapered fibers from single-mode fibers involves a two-step chemical etching process. Refractive index sensing is achieved by attaching gold nanoparticles to the tapered fibers. The authors demonstrate sensitivity to refractive index changes induced by varying concentrations of sucrose solution. Notably, the sensors' advantages include a straightforward fabrication process and label-free biomolecule detection.

George and Bhattacharya, in their paper titled "Overcoming challenges in fabrication of beam-shaping meta-optics using sensitive mr-EBL resist," address the crucial area of fabrication of dielectric metaoptics. Flat optics, as they are also known as, are set to revolutionize optical systems due to their compact size and ability to combine different optical functions. The key focus areas being studied by various groups include creating high-efficiency metasurfaces for beam steering, focusing, and holography, and developing flat lenses for compact optical systems. A significant challenge in fabricating these sub-wavelength structures using standard electron beam lithography lies in achieving repeatability and high precision over a range of lateral sizes. The authors present an innovative approach carried out at the Centre for NEMS and Nano-Photonics, IIT Madras, utilizing mr-EBL resist, and demonstrate how it reduces both patterning time and the number of process steps, facilitating more efficient fabrication.

The next two papers, from the research group led by Prof. Bijoy Krishna Das at IIT Madras, explore advancements in silicon photonics. Conducted at the Centre for Programmable Photonic Integrated Circuits and Systems (CPPICS), these studies leverage the benefits of CMOS-compatible fabrication, which allows seamless integration with electronic circuits. By focusing on design innovations, silicon photonics can scale in a fabless ecosystem similar to CMOS electronic circuits, promoting broader adoption and faster commercialization. This would allow companies and research groups to focus on design and intellectual property generation activities while outsourcing fabrication, fostering a more accessible and efficient development cycle for optical microsystems. The paper titled "Distributed Bragg reflector-based resonance filters for silicon photonics: design and demonstration" introduces novel distributed Bragg reflector (DBR)-based filters. The authors present two band-pass filter designs—higher-order DBR coupled cavity filters for the L-band and apodized DBR cavity filters for the C-band. These filters, designed for low insertion loss and high rejection ratio, have broad applications in wavelength division multiplexing, modulators, sensors, and broadband noise suppression. By demonstrating improved performance and miniaturization, this research contributes to the development of compact, high-performance optical microsystems, with potential applications extending from optical communication systems to quantum computing. The second paper, "Four-wave mixing in silicon nanophotonic waveguides and microring resonators: influence of nonlinear effects," examines the role of four-wave mixing (FWM), a phenomenon crucial in optical communication and signal processing. FWM is significant in silicon nanophotonic waveguides due to silicon's strong third-order nonlinearity, enabling efficient wavelength conversion and broadband signal processing. The paper studies in detail the impact of two-photon absorption, free carrier absorption, and dispersion, which degrade performance at higher pump power levels. The study extends to silicon photonic microring resonators, demonstrating their potential for quantum photonic circuits. Experimental results in silicon photonic wires and waveguides support the simulations, confirming the importance of controlling these nonlinear effects in high-power applications.

Although this special section presents only a fraction of the outstanding work being done in India, the papers include a diverse range of topics—from plasmonics in tapered fiber platforms and metasurface fabrication to distributed Bragg reflector filters and four-wave mixing in silicon photonics. While these contributions highlight the advancements in India, their relevance transcends geographical boundaries and will undoubtedly benefit researchers worldwide.

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