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Plasmonics Systems and Applications

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The field of plasmonics has seen rapid growth in both research and application over the last two decades. One of the driving forces of this growth has been the maturation of several key nanotechnology processes which have made subwavelength features and structures, and thus the realization of theoretically predicted phenomena, possible. Electromagnetic waves in the optical regime are manipulated through light-matter interactions using conductive nanostructures, nanoparticles, thin films, or periodic arrays that are designed for propagation (via surface plasmon polaritons) or local field enhancement (with localized surface plasmons). Plasmonics combines many attractive features in nanoelectronics and optics, opening the door to highly integrated dense subwavelength components and circuits which will help alleviate the speed/bandwidth-bottleneck in important technologies such as information processing and on-board computing. Plasmonic devices could provide improved performance with respect to cost, size, weight, and power consumption as compared to conventional systems. This technology also feeds into a new class of devices that can provide unique functionality such as super lensing, etc.

Recently several important practical plasmonic devices and systems have been demonstrated in applications. Particularly significant are developments enabling applications otherwise unachievable in either electronics or photonics alone, thus providing the bridge between these two

technologies. The collection of nine papers in this special section showcases some of the state-of-the-art research in the field with an overview of key technologies in plasmonic systems and application development.

The special section showcases a mix of fundamental concepts in plasmonics, as well as applications of plasmonics devices and structures, and covers a broad variety of papers ranging from theoretical studies to practical demonstrations of devices and structures and their characterization. Two papers explore the properties of nonmetallic and complex nanoparticles for application in plasmonics.

The paper by [Rahaman and Kemp](#) presents the analytical solution of multiple core-shell nanoparticles using the multiple scattering theory which is verified using finite element method models. This approach is a computationally efficient method to describe the optical properties of a solid single or multiple metal nanoparticles. Such particles and their ensembles are used in multifunctional surfaces, and a quick method to analyze their properties is very useful to optimize and tailor their individual and cumulative responses.

Similarly, [de Souza et al.](#) show the potential of CdS quantum dots in phosphate glass matrix applications by presenting their nonlinear refraction and absorption properties.

The paper by [Jandaghian et al.](#) examines the important parameters in performance of long-range surface plasmons in an insulator-metal-insulator (IMI) structure to illustrate power savings that will be important when applied to optical switches.

There are two papers based on metal-insulator-metal (MIM) structures and their application to devices. The first paper by [Arianfard et al.](#) numerically investigates two plasmonic structures for band-pass and band-stop filters, and the results reveal that within the transmission spectrum, the selected central wavelength and the bandwidth of the filter can be tuned by the input signal intensity using a MIM waveguide coupled to a nonlinear rectangular nanocavity. The second paper by [Kumar et al.](#) also works on the Kerr effect. Here, the structure of a nonlinear Mach-Zehnder interferometer (MZI) using a plasmonic MIM waveguide has been numerically analyzed and a one-bit magnitude comparator is also designed.

There are also two papers that focus on the application of resonant plasmonic structures to chem-biosensing. The first paper by [Yi and Wu](#) demonstrates numerically an ultrasmall and highly sensitive plasmonic hydrogen sensor which shows potential for realization of a highly compact sensor with integration capability for applications in hydrogen fuel economy. The second paper by [Kostyukevych et al.](#) examines development of a multielement immunosensor device based on surface plasmon resonance for determination of the levels of three molecular markers of the system of hemostasis (fibrinogen, soluble fibrin, D-dimer). This sensor will enable diagnostics of prethrombotic states and the monitoring of the therapy of diseases of the blood circulation system.

The next paper by [Datta and Xu](#) shows how heat-assisted magnetic recording, considered to be the next-generation technology for high-density data storage devices, can be achieved using a tiny plasmonic antenna acting as a near-field transducer for subwavelength focusing.

Last but not least, the final paper by [Fannin et al.](#), which is featured on the cover of this issue, treats the fundamental resonance effects in hybridized metal-dielectric elements that can be applied in absorption, sensing, and displays. The paper presents numerical simulations as well as experimental results of a hybrid guided-mode resonance and surface plasmon resonance operating independently or in unison thus enabling a dual pixel that can be tuned with the input polarization state.

In summary, this special section illustrates the benefits of plasmonic devices and structures in a variety of applications. We hope that this special section provides readers with a broad overview of the many possible technologies that

form the enabling foundation for practical plasmonic devices, the applications of plasmonics to different systems, and the current research thrusts in the field. We would also like to take this opportunity to thank the contributing authors and the staff of *Optical Engineering* in helping to compile this special section on plasmonic systems and applications.

Monica Allen is a senior research electronics engineer at the Munitions Directorate, Air Force Research Laboratory, Eglin Air Force Base, Florida. Her research focuses on resonant sensing platforms for EO/IR technologies and components that can find applications in detection and sensing. Her primary areas of interest include nonlinear optical, photonic, and plasmonic physics through exploitation of light-matter interactions. Her other interests include modeling, simulation, and fabrication of micro- and nanostructures for gain and selectivity enhancement.

Jeffery Allen is a senior research electronics engineer at the Munitions Directorate, Air Force Research Laboratory, Eglin Air Force Base, Florida. His primary area of interest is electromagnetic wave matter interaction, metamaterials, optimized RF apertures, conformal/structurally integrated apertures, semiconductor physics, IR plasmonics, nonlinear optics, quantum sensing, and research in novel sensing paradigms. His current research involves development of analytical models, computational electromagnetics, and fabrication techniques for engineered electromagnetic structures for a wide range of applications.

Daniel Wasserman is an associate professor of electrical and computer engineering at the University of Texas Austin, where he is affiliated with the Microelectronics Research Center. He received a ScB from Brown University in physics/engineering and his PhD from Princeton University in electrical engineering. His research is focused on the midinfrared wavelength range, with an emphasis on optoelectronics, plasmonics, metamaterials, and optical materials. He is an associated editor of *Optica*.

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Stefan Maier currently holds the Lee Lucas Chair in Experimental Physics at Imperial College London. He is a graduate in applied physics from Caltech, USA, and his main research interests are in nanoplasmonics, nanophotonics, and solid-state physics. He is associate editor of *ACS Photonics*.