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Plasmonics and Hot Electrons: feature issue introduction

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Abstract: Light-matter interaction can be significantly enhanced in plasmonic nanoparticles and nanostructures, as the latter give rise to high-field localization and enhancement. This feature issue highlights six contributions on recent advances in plasmonics, hot-electron dynamics, quantum surface and tunneling effects, as well as their applications, with a focus on practical materials and nanostructures with enhanced hot-electron generation.

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1. Introduction

The current active research topics of plasmonics and nano-optics include propagating and localized surface plasmons, quantum surface effects, quantum tunneling injection, and ultrafast and steady-state non-equilibrium dynamics of excited electrons in metals. The unique properties of highly energetic hot carriers bring new and exciting opportunities for fundamental studies and practical applications. Hot electron nanoemitters and excited electron contributions to nonlinear effects play a particularly important role. Novel materials for energy and photovoltaic and photocatalytic devices have been the subject of extensive investigation. Comparative studies of near-field effects with thermal and non-thermal effects in plasmonic materials have recently been reported. This Feature Issue covers a broad range of topics related to plasmonic and hot electrons.

Bekshaev *et al.* [1] present a systematic theoretical study of the spatial distributions of energy, momentum, and angular momentum of a surface plasmon-polariton (SPP) field formed near a flat interface between metal and dielectric. An important novel result in the article is the use of the hydrodynamic model of an electron gas in a metal, which allows to identify and consistently describe specific details in the energy and momentum distributions localized in the immediate vicinity of the interface.

Bosomtwi *et al.* [2] propose utilizing the lattice effect in an array of nanoscatterers to enhance hot-electron generation in nanoelectrodes in an aqueous environment. Collective resonances are known to increase plasmonic near fields significantly and result in stronger light-matter interaction. This effect has been extensively researched in recent years and demonstrated for dipole and quadrupole resonances in nanoscatterers of various nature. Similarly, the periodic arrangement of nanotubes can result in the excitation of collective plasmonic resonances facilitated by the lattice. These resonances, in turn, result in stronger electric fields and more efficient hot electron generation.

Wu *et al.* [3] report on a deep neural network and analyze near- and far-field properties in plasmonic nanostructure with its help. Bowtie plasmonic nanoantennas are employed for training the deep neural network and inverse design of transmittance spectral response and electromagnetic field distribution. The deep neural network can potentially be applied in multifunctional photonic devices and sensors. The reported technique demonstrates a paramount approach to handle extensive electromagnetic data and utilize them in designing practical applications.

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Zhao *et al.* [4] propose the structure of double-groove as a broadband polarization multiplexer for surface plasmon polaritons (SPPs) and analyze the mode distributions with the photoemission electron microscopy (PEEM). In the design, when the double groove is excited with different circular polarizations, the SPPs fields shows the asymmetrical mode. The proposed multiplexer could be further applied in plasmonic integrated circuits.

Tang *et al.* [5] review their previous high resolution microscopic and spectroscopic studies of intense light scattering from single particles. In these studies, they measured the Point-Spread-Function (PSF) obtained from spherical and rod-shaped Au, Ag, and Si particles as a function of the illumination intensity. They showed that in all cases, the PSF and the overall scattered field intensity can be well explained by the heating of the particle, which, in turn, gives rise to a strong thermo-optic response whereby the permittivity changes significantly due to the rising temperature. Modelling based on a self-consistent solution of Maxwell and heat equations was shown to reproduce the measured data convincingly. This work described an important step beyond the well-established photothermal microscopy technique. Finally, Tang *et al.* demonstrated the applicability of their results to optical switching and super-resolution microscopy.

Finally, Gordon and Dobinson [6] summarize the progress of combing plasmonics and CMOS-like nanophotonics in their Opinion article. Plasmonic structures in general, including the slot and gap waveguide geometries, have an important role to play in telecommunication systems. Gap plasmonic structures have high application potential because of practical benefits, such as the inherent electrical contacts that are provided by the geometry. The authors overview the increased capability of plasmonics and possible strategies for exceeding Tb/s serialization in an integrated platform.

We hope that this feature issue would give a topical insight into the emerging directions in plasmonics and hot electrons and motivate future research directions. We express our gratitude to all reviewers and authors for their efforts in contributing and improving the manuscripts. We also thank Alexandra Boltasseva, Editor-in-Chief of Optical Materials Express, and Stavroula Foteinopoulou, Feature Editor, for supporting this feature issue and the Optica Journal staff for their help during the review process and production.

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