MNE 20 (2023) 100194

Contents lists available at ScienceDirect

Micro and Nano Engineering

journal homepage: www.sciencedirect.com/journal/micro-and-nano-engineering

Preface

Guest editorial: Plasmonics and nanophotonics: Trends, techniques and applications

Plasmonics and nanophotonics both deal with the interaction of light with structures of typically sub-wavelength size in one of more dimensions. Over the past decade or two, interest in these topics has grown significantly. This includes basic research towards detailed understanding of light-matter interaction and the manipulation of light on the nanometer scale as well as the search for applications ranging from quantum information processing, data storage, solar cells, spectroscopy and microscopy to (bio-)sensors and biomedical devices. Key enablers for this development are advanced materials and the variety of techniques to structure them with nanometer precision on the one hand, and progress in the theoretical description and numerical implementations, on the other. Besides the traditional metals Au, Ag, Al, and Cu also compounds such as refractory metal nitrides with much higher durability as well as semiconductors, dielectrics and hybrid structures have become of interest. Structuring techniques are not only aiming at the fabrication of individual elements with highest precision for detailed interaction analysis, but also at methods for large scale, low-cost nanofabrication mostly for sensor applications. In the former case, mostly electron beam lithography and focused ion beam milling are employed, while for high throughput various forms of nanoimprint and self-assembly based techniques are favored. Thin film deposition and pattern transfer techniques are mostly derived from those developed for nano-electronics, however more recently methods such as electroless plating, atomic layer deposition or etching and 3-D additive techniques are appearing. Thus, highly specialized expertise has been acquired in the different disciplines, and successful research and technology transfer will draw from this pool of knowledge.

The aim of this Special Issue is to showcase selected contributions representing the state of the art in plasmonics and nanophotonics and to provide a glimpse into future developments. The collected papers give an outlook on nanophotonics with novel materials (sapphire nanophotonics, CdSe/CdS nano-platelets, copper nanoparticles), geometric tuning of the optical properties (metal-insulator-metal configurations, asymmetric bowtie antennas), or expanding functionality by the local integration of nanoemitters (hybrid donor-acceptor nano-systems).

In a perspective article on the fabrication challenges and optical properties of sapphire nanophotonics, C.-H. Chang et al. highlight the beneficial optical features of sapphire, while pointing out the difficulty of nanopatterning this chemically inert, highly etch-resistive material. Using a multi-layer approach for tailoring the etch selectivity, the authors prepare high aspect-ratio antireflection layers consisting of moth-eye nanostructures. Broad-band reduced reflectivity is demonstrated over a wide range of angles.

A device based on colloidal CdSe/CdS nano-platelets is explored by J. R. Krenn et al. in view of designing high-gain lasing waveguides. Such nano-platelets are few-atoms thin semiconducting slabs with nanometer-scale lateral dimensions. This geometry leads to relaxed exciton localization that results in reduced non-radiative Auger recombination rates. The authors assemble such nano-blocks into lithographically tailored stripe waveguides. The high gain was shown to allow for lasing that relied only on the inherent reflection of the waveguide.

Broadband absorption constitutes an indispensable property for solar thermal collectors. In their work, N. Perdana et al. realize plasmonic multilayer nanocomposite thin-films based on copper nanoparticles in an alumina matrix. The system is investigated by numerical multi-scale T-matrix modelling as well as experimental tuning of the filling factor and other parameters of the system. Theoretically, up to 90% absorption over a broad spectral range could be demonstrated. The use of copper as the plasmonic material makes this approach more cost effective and less dependent on scarce materials than previous realizations.

In E. Bortchagovsky et al., the authors combine optical dark-field spectroscopy with high-resolution micro-ellipsometry for the study of plasmonic nano-arrays. The interaction with surface plasmons becomes apparent when the array is positioned in a metal-insulator-metal configuration of nano-disks separated from a metal film by an insulating layer. The observed resonances exhibit an asymmetric shape distinct from those of arrays on a dielectric substrate. With a theoretical dipole approach, the scattering and ellipsometric features can be assigned to corresponding resonances. The study highlights the added information that can be gained from correlative studies at the few-nanoparticles level.

In H. Hu et al., the well-known concept of plasmonic bowtie antennas is extended to asymmetric bowtie antennas with systematically varying base lengths. Through symmetry breaking, the mode degeneracy is lifted and a second base mode appears in the spectra, which is tunable relative to the constant base mode and the dipolar bonding mode. A reduced width of the plasmonic modes is observed, which the authors state could make these structures more advantageous for sensing applications.

Finally, an example of a hybrid nano-plasmonic system is outlined by A. Broussier et al., who investigate the down-conversion of surface plasmon polaritons on silver nanowires. A previously established technique to localize nano-emitters on nanowires by two-photon polymerization is expanded such that quantum dots with two different emission wavelengths are selectively attached. Green quantum dots are excited and launch a surface plasmon polariton in the silver wire, which in turn remotely excites red quantum dots. These then excite lower-energy surface plasmon polaritons, completing the down-conversion. The study presents a step in the direction of integrated plasmonic circuits.

The collected works thus give an impression of the state-of-the-art and current advances into future directions in plasmonics and

https://doi.org/10.1016/j.mne.2023.100194

Available online 3 May 2023

nanophotonics. The ongoing innovations require further developments in the fields of the employed nano-materials, nanofabrication techniques, and hybrid device integration.

We would like to thank all authors for their valuable contributions and the reviewers for their helpful comments.

Dieter P. Kern[a], Monika Fleischer[a], Marc Brecht[a,b], Helmut Schift[c]
[a] *Eberhard Karls University of Tübingen, Germany*
[b] *Reutlingen University, Germany*
[c] *Paul Scherrer Institute, Switzerland*
E-mail addresses: dieter.kern@uni-tuebingen.de (D.P. Kern), monika.fleischer@uni-tuebingen.de (M. Fleischer), marc.brecht@uni-tuebingen.de (M. Brecht), helmut.schift@psi.ch (H. Schift).