Editorial

Proceedings of the 9th International Conference on Surface Plasmon Photonics (SPP9)

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The research field of plasmonics is concerned with the interaction of light with free electrons in conducting media, thus, having a natural emphasis on metal nanostructures while now also being explored in several other novel material systems ranging from macromolecules and two-dimensional materials (such as graphene) to doped semiconductors. The field of plasmonics is bridging fundamental research and diverse applications, embracing traditional topics such as sensing as well as emerging ones such as localized heating and hot-electron generation. The synergy of light with nanotechnology is opening a range of application areas important to society. After two decades of explosive growth, plasmonics is still going strong: according to "*2019 Research Fronts*", the topic "*Plasmonic properties of metal nanostructures*" belongs to the top 10 research fronts in physics [1].

The *International Conference on Surface Plasmon Photonics* (SPP) is a biennial independent and non-profit conference series widely regarded as the premier series in the field of plasmonics. The most recent conference, SPP9, was held in Copenhagen (May 26–31, 2019), exploring the breadth of fascinating topics and new directions that are emerging from plasmonics, including metasurfaces, graphene and other 2D materials, strong-coupling phenomena, topological plasmonics, quantum plasmonics, and hot-electron phenomena (Figure 1). Enabling deeply subwavelength electromagnetic field confinement, plasmonics epitomizes one of the key research areas within nanophotonics represented extensively at SPP9. This special issue includes a selection of invited papers from this conference.

SPP9 opened with a plenary talk by Thomas W. Ebbesen on polaritons in material science, including perspectives on strong-coupling phenomena in plasmonics as a new state of matter. In this special issue, this topic is elaborated in the paper by Thomas et al., considering ground state chemistry under vibrational strong coupling [2]. Xiong et al. investigate ultrastrong coupling in gold nanocubes coated with quantum emitters, positioned on a gold film [3]. Heilmann et al. experimentally explore strong coupling of dye molecules to dielectric lattice resonances [4]. Calvo et al. theoretically consider ultra-strong coupling phenomena in molecular cavity quantum-electron dynamics [5]. Baranov et al. experimentally explore cavity plasmon-polaritons in the context of circular dichroism [6]. Neuman et al. theoretically explore surface-enhanced resonant Raman scattering of molecules in plasmon-exciton systems in the strong-coupling regime [7].

In the area of 2D materials, Galiffi et al. [8] theoretically explore the nonlocal plasmon response in graphene with the aid of singular metasurfaces. Device aspects of hybrid graphene-plasmon systems are considered by Ding et al. combining graphene with plasmonic waveguides to enable large-bandwidth photodetectors [9]. Zhao et al. combine GeSe nanosheets with gold metal surfaces to enable surface-plasmon resonance sensors with enhanced sensitivity [10]. Ramazani et al. explore exciton-plasmon coupling and hot-carrier generation in boron nitride 2D layers [11]. Spreyer et al. experimentally study second harmonic generation in hybrid plasmonic metasurfaces and monolayers of WS_2 [12].

Within the context of plasmonic metasurfaces, Engelberg et al. exploit a Huygens nanoantenna-based metalens for outdoor photographic/surveillance applications in the near infrared [13]. Ding et al. exploit gap-plasmon metasurfaces for vortex-beam generation in the near infrared [14]. Going beyond the common temporal harmonic response of matter, Pacheco-Peña and Engheta theoretically propose a temporally effective medium concept in metamaterials with the potential to create a medium with a desired effective permittivity [15].

Concerning the advancement of nanofabrication processes for plasmonic structures, Hahn et al. explore helium-focused ion beam milling as a resist-free, maskless, direct-write method [16]. Gittinger et al. exploit a sketch-and-peel technique to define plasmonic dimer resonators [17].

On the topic of optical emission from plasmonic nanostructures, Buret et al. explore the effects of quantization in atomic-sized point contacts [18], while Krasavin et al. explore the tunneling regime of nano-gap dimers [19]. Kang et al. review work on quantum plasmonic effects in Angstrom-scale gap structures driven by terahertz radiation [20].

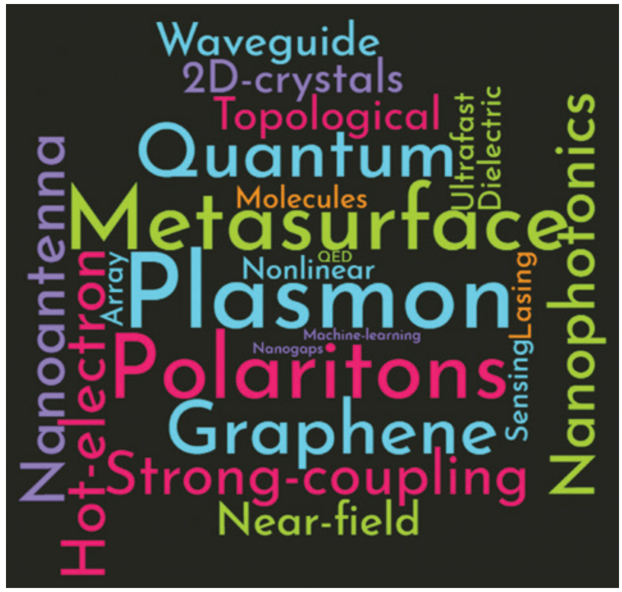

Figure 1: The breadth of research topics and directions within plasmonics illustrated by a word cloud compiled from the book of abstract from the *9th International Conference on Surface Plasmon Photonics (SPP9)* held recently in Copenhagen (SPP9.dk).

Khurgin reports fundamental limits to hot carrier injection from metals across metal-semiconductor interfaces in plasmonic nanostructures [21].

Within the context of plasmonic antennas, Sanders and Manjavacas explore theoretically parity-time symmetric plasmonic antennas for enhanced light-matter interaction with subwavelength emitters [22]. Pedrueza-Villalmanzo et al. offer a perspective on plasmonic nanoantennas for nanoscale chiral chemistry and advancing molecular magnetism [23].

On the subwavelength probing of plasmons, Esmann et al. demonstrate a near-field based spectroscopy method to quantitatively map the projected local optical density of states of a nanostructured sample with 10-nm spatial resolution [24]. Kaltenecker et al. use scanning near-field microscopy to investigate interference patterns caused by surface plasmon polaritons on mono-crystalline gold platelets with ultra-smooth surfaces [25].

Finally, as applications of plasmonic resonances, Bauer and Giessen tailor Fano resonances in metallic nanostructures for optical sensing [26], while Jia et al. explore gap plasmon resonances to produce plasmonic colors that can be viewed under dark-field illumination [27].

This special issue provides a perspective on recent research efforts and developments within the dynamic field of plasmonics, illustrating its breadth, and we hope, serving also to inspire new work and attracting new researchers to the field. One of the important SPP9 conference outcomes was awarding Carlsberg Foundation Scholarships to 12 excellent young researchers, including the first authors of Refs. [3, 8, 13]. The next issue in the conference series, the 10th International Conference on Surface Plasmon Photonics (SPP10), will be held in Houston (May 23–28, 2021). For more information, see SPP10.rice.edu.

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