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Frontiers of plasmonics

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Surface plasmons are quanta of collective oscillations of free electrons at metal-insulator interface, usually excited by photons. Since it was first proposed in 1950s by Ritchie, new interests have been aroused due to recent advances in synthesis and fabrication of various nanostructures. Novel optical properties were frequently reported on these materials, with great potential applications in physics, chemistry, biology and cancer therapy, etc. Some of them have even exhibited enormous economic values. Due to the wide interest and uniqueness of surface plasmons, a new branch of nano-optics has come into being, that is, plasmonics. Different from the conventional optics restricted by the diffraction limit, plasmonics concerns manipulating light at the nanometer scale. The localized surface plasmons can cause huge enhancement of the electromagnetic field in the nanogaps of nanostructures, which is the physical reason of surface-enhanced Raman scattering (SERS). Apart from light intensity, the polarization of light can also be manipulated through plasmons coupled between nanoparticles, which actually acts as a nanoscale half-wave plate. Another important property of these plasmonic structures is waveguiding. As well known, the diffraction limitation is the fundamental obstacle to fabricate dielectric photonic components and devices small enough for large-scale integration. However surface plasmons can overcome this limitation. The significant progress in plasmonics has stimulated scientists to develop nanoscale plasmonic analogues of macro- and microscale optical components such as electrooptic devices, transistors and modulators, etc. By combining various nanoscale optical devices, it may be possible to build integrated nanophotonic circuits, offering substantial improvements in bandwidth and speed for next-generation information technologies.

The following articles are concerning the recent progress in plasmonics, including fabrications, experimental measurements and theoretical calculations of optical properties of nanostructures. Chen et al. [1] fabricated ordered arrays of metallic nanoparticles and investigated the far-field properties experimentally and theoretically. Bao et al. [2] extended the plasmon hybridization method to include realistic permittivities for metals and calculated the plasmon-induced electromagnetic field enhancements. Yang et al. [3] discussed the physical enhancement properties of SERS and tip-enhanced Raman spectroscopy (TERS) using finite-difference time-domain method. Ameen et al. [4] investigated the electromagnetic interaction of light with polar materials in the infrared region by boundary element method, where they found surface phonons can couple efficiently to infrared light in micron-sized antennas made of polar materials. Gu et al. [5] reviewed the Green's matrix method for solving the surface plasmon resonances and near field in arbitrarily shaped nanostructures and in binary metallic nanostructures. Ma et al. [6] reviewed the recent developments on hyperlens. Guan et al. [7] studied the dual-layer metallic grating structures as SERS substrates, and they demonstrated the advantages of high uniformity, reproducibility and sensitivity of the structures for SERS applications. Guo et al. [8] demonstrated a silver nanowire ring resonator, which offers opportunities for realizing compact plasmonic resonators with tight confinement for hybrid optical and plasmonic signal processing.

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3 Yang Z L, Li Q H, Ruan F X, et al. FDTD for plasmonics: Applications in enhanced Raman spectroscopy. Chinese Sci Bull, 2010, 55: 2635–2642
4 Ameen M, Garcia-Etxarri A, Schnell M, et al. Infrared phononic nanoantennas: Localized surface phonon polaritons in SiC disks. Chinese Sci Bull, 2010, 55: 2625–2628
5 Gu Y, Li J, Martin O J F, et al. Solving surface plasmon resonances and near field in metallic nanostructures: Green's matrix method and its applications. Chinese Sci Bull, 2010, 55: 2608–2617
6 Ma C B, Aguinaldo R, Liu Z W. Advances in the hyperlens. Chinese Sci Bull, 2010, 55: 2618–2624
7 Guan Z Q, Håkanson U, Anttu N, et al. Surface-enhanced Raman scattering on dual-layer metallic grating structures. Chinese Sci Bull, 2010, 55: 2643–2648
8 Guo X, Zhang X N, Tong L M. Silver nanowire ring resonator. Chinese Sci Bull, 2010, 55: 2649–2651

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