Plasmonics: Nanoparticle Chain Arrays Break Through the Diffraction Limit for Optical Devices

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Engineered Nanoparticle Electronic and Photonic Device Materials

Since development of the light microscope in the 16th century, optical device performance has been limited by diffraction. Optoelectronic devices of today are more than an order of magnitude bigger than state-of-the-art electronic devices for this reason. The NIRT investigators have shown that by circumventing the diffraction limit it is possible to design "plasmonic" optoelectronic device components with spatial confinement of light at dimensions less than 10% of the wavelength size. Thus there is no fundamental scaling limit to the size and density of optoelectronic devices, and ongoing work is aimed identifying important device performance criteria in the subwavelength size regime. Ultimately this research direction may yield a whole class of subwavelength-scale optoelectronic components (waveguides, sources, detectors, modulators) that could form the cornerstone of optical devices that are scaleable to molecular dimensions, with potential imaging, spectroscopy and interconnection applications in computing, communication and chemical/biological detection.

Such plasmonic devices exploit the dipole-dipole coupling at the plasmon frequency between nanoscale metal particles in particle chain arrays, and the dispersion relations for structure exhibit the tendency for electromagnetic excitations to "hop" between electric dipoles. Light can even propagate around sharp corners and through nanoscale networks -- all of which are impossible in conventional optical waveguides.

Further Reading:

"Plasmonics - A Route To Nanoscale Optical Devices"
Maier SA, Brongersma ML, Kik PG, Meltzer S, Requicha AAG, Atwater HA Advanced Materials 13 1501 (2001).

"Observation of coupled plasmon-polariton modes in Au nanoparticle chain waveguides of different lengths: Estimation of waveguide loss"
Stefan A. Maier, Pieter G. Kik, and Harry A. Atwater
Applied Physics Letters, 81 1714 (2002).

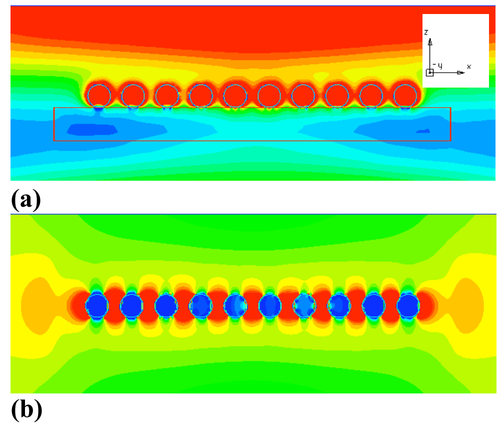

Fig. 1. Finite difference time domain (FDTD) calculations of illustrating spatial nanometer-scale spatial confinement of light at 590 nm wavelength in plasmon waveguides composed of 50 nm Au particles. In (a) cross-section view and in (b) plan view of longitudinal mode excited resonantly at the plasmon frequency.

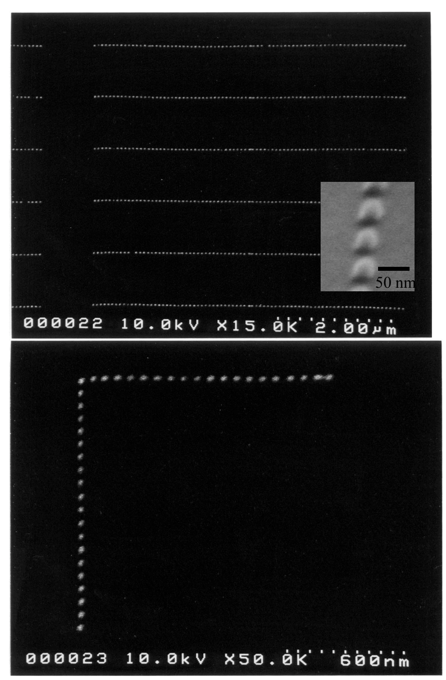

Fig. 2. Scanning electron microscope images of plasmon waveguides, and 90 degree bend waveguide fabricated using electron beam lithography. The gold dots are 50 nm in diameter and