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Strongly coupled plasmon excitations in nanostructures and device applications

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Since the 16th century, optical device size and performance has been limited by diffraction. However the diffraction limit can be circumvented via design of "plasmonic" device components with spatial confinement of light at dimensions less than 10% of the free-space wavelength. Achieving control of light-material interactions at nanoscale dimensions requires structures that guide electromagnetic energy with a lateral mode confinement below the diffraction limit. Electromagnetic energy can be guided below the diffraction limit along ultrathin metallic stripes and subwavelength scale chains of closely spaced metal nanostructures via non-radiating surface plasmons. Recent experiments confirmed that strongly coupled collective plasmonic modes in metal nanostructures enable electromagnetic energy transport over distances of about 0.5 μm in plasmon waveguides. The emission rate from active dipole emitters such as semiconductor nanocrystals can also be enhanced by coupling into metallic nanostructures. Thus there appears to be no fundamental scaling limit to the size and density of photonic devices, and ongoing work is aimed identifying important device performance criteria in the subwavelength size regime. Ultimately it may be possible to design an entire class of subwavelength-scale optoelectronic components that form building blocks of an optical device technology scaleable to molecular dimensions, with imaging and spectroscopy applications.

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