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Designer plasmonic structures and metamaterials for subwavelength photonics

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Plasmonic structures and metamaterials have opened up new opportunities for manipulating light at subwavelength scales thus opening up new frontiers in optical materials design and photonics in such areas as imaging, sensing and new optical sources. In this talk I will present recent research from our group in this area. Through innovative use of plasmonic structures we have demonstrated how one can design the far field and near field of state of the art semiconductor lasers and optical fibers. Examples are plasmonic laser antennas creating ultrahigh intense near field nanospots in the near infrared, mid-infrared semiconductor lasers with very low divergence and control of polarization (linear/circular) as well as multibeam lasers. Metamaterials have created unique opportunities for nanophotonics. Recently we have shown that by patterning the facet of Terahertz quantum cascade lasers with subwavelength periodic structures one can dramatically modify the surface plasmon dispersion curve which leads to a highly collimated THz beam with divergence reduced from 180 deg to 5 deg. I will also discuss work on new clusters of colloidal core-shell metallic nanoparticles using self-assembly techniques. Magnetic activity in trimers at near infrared wavelengths and strikingly pronounced Fano-like resonances in heptamers are among the exciting new findings from light scattering experiments. Such building blocks are an important stepping stone towards novel designer metamaterials synthesized bottom up. Finally experiments with gold plasmonic nanocavity gratings have shown that the latter can dramatically enhance surface nonlinear optical processes. The four-wave mixing signal was enhanced by a factor up to 2000, two orders of magnitude higher than previously reported.