WAVE FRONT ENGINEERING USING METAMATERIALS

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Sub-wavelength photonics is emerging as one the most exciting and potentially useful areas of physical optics. I will highlight recent research in my group aimed at inventing and investigating laser sources and optical fibers with unique near field and far-field properties[1]. Using surface plasmons interacting with metallic nanostructures and metamaterials built on the facets of semiconductor lasers with focused ion beam (FIB) processing, we have demonstrated new infrared light sources in the range from 0.8 to 10 microns that can create extremely intense (> 100 MW/cm^2) nanoscale size light-spots of dimensions much smaller than the wavelength.[2-4] These sources have revolutionary applications in areas such high density DVD's (1 Tb disks) and high resolution chem/bio imaging, for example to peer into the interior of cells.

Monolithically integrated metallic nanostructures have also been used to achieve beam shaping of quantum cascade lasers and in particular to dramatically reduce (by a ~ factor of 30) their divergence down to a few degrees in orthogonal directions, opening up exciting new applications in laser ranging, chemical sensing and optical wireless.[5-7] Lasers with built-in polarization control have also been demonstrated.[8]

To take full advantage of the potential of nanophotonics for beam engineering new soft-lithography techniques (*nanoskiving*[9] *and decal transfer*[10]) have been developed by us and the group of George Whitesides at Harvard, which allow fabrication of arrays of sub-wavelength features on non conventional templates such as the facets of optical fibers and curved surfaces such as those of micro resonators. These arrays include frequency selective surfaces for filtering, Surface Enhanced Raman Scattering (SERS) surfaces, new optoisolators, hyperlenses for below diffraction focusing in the far-field, etc.. Fiber based SERS sensors have been demonstrated.[11]
The talks will conclude with a discussion of exciting new directions.

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