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Designer magnetoplasmonics for adaptive nano-optics

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Abstract

Materials that provide real-time control of the fundamental properties of light at visible and near-infrared frequencies enable the essential components for future optical devices. Metal nanostructures that couple electromagnetic (EM) radiation on a sub-wavelength length scale to free electrons, forming propagating or localized surface plasmons, provide many exciting functionalities due to their ability to manipulate light via the local EM field shaping and enhancement. Magnetoplasmonics is an emerging field within nano-optics that operates with the combination of propagating or localized surface plasmons and magnetism. Active and adaptive magnetoplasmonic components capable of controlling light on the nanoscale with externally applied magnetic fields are envisioned to push the development of integrated photonic circuits, high-density data storage, or the advanced schemes for bio- and chemo-sensing. In these components plasmon-enhanced and controlled magneto-optical activity creates a new way of control for plasmonic devices, which is explored in this thesis.

Another focus of this thesis are chiral plasmonic materials that exhibit an enhanced chiroptical response due to the nanoconfinement of light and strong near-field coupling. These have benefits in applications like chiral sensing. Fundamentally, they offer an additional degree of freedom to control the phase and polarization of light on the sub-wavelength scale via interaction with its helicity, i.e., angular momentum. Adaptive chiral materials provide a new pathway for real-time control of chiral light's scattering and absorption by weak magnetic fields. Engineering of chiral materials that can manipulate the helicity of light is decisive for angular momentum-controlled nanophotonics.

A general topic of this thesis is the design and fabrication of advanced optical nanoantennas, used to dynamically manipulate light. Among applications are nanorulers, adaptive magneto-chiral and highly transparent magneto-dielectric surfaces.

Keywords: Photonics, magnetoplasmonics, magneto-optics, magneto-optical Kerr effect (MOKE), plasmon ruler, nickel, cobalt, gold, silicon, localized surface plasmon resonance, dimer, trimer, chiroptics, chiral transmission, 2D nanoantennas, dynamic tuning, metal-dielectric, 3D nanoantennas, metasurface, magnetic modulation, perpendicular magnetic anisotropy.