# Field-responsive Nanostructured Optical Materials and Interfaces for Energy, Healthcare, and Neurophotonics

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This talk will focus on development of nanostructured stimuli-responsive multi-domain and functionally-graded nanostructures and hybrid organic:inorganic nanocomposites applicable for energy harvesting, healthcare diagnostics and therapy,and the emerging field of Neurophotonics for mapping and modulation of brain functions.[1-3] By utilizing multiscale (*quantum to continuum*) modeling of properties in support of experimental materials synthesis and characterization, we create an interactive, real-time feedback loop that generates and validates fundamental design principles for producing energy-coupled materials whose behavior can be adaptively changed via external stimuli including optical, electric, and magnetic fields. We use bottom-up nanochemistry to create hierarchical multi-component nanostructures and assemblies, tailoring their interfacial interactions and dynamics. Three classes of materials will be described: (1) *Multiphoton harvesting and photon transforming nanostructures* that provide radically new approaches to control and manipulate photons, including energy and phase, on-demand. Many emerging biomedical and photovoltaic technologies require light of a specific wavelength range that is not readily deliverable to the site where it is needed. Photon management by *in situ* and on-demand transformation of photons from one spectral region to anotherusing these optical nanotransformers can significantly benefit these applications. (2) *Photoswitchable interfaces* that allow on-demand light activated manipulation of theinterafface such as photo-switching of a nanocatalyst andoptical patterning of nanostructures capped with photoreactive ligands. We introduce the concept of remote photoinitiated reconfiguration of ligands adsorbed onto a nanocatalyst surface to enable reversible modulation of the catalytic activity.We also describe photopatterning, both by direct laser writing and by mask-based lithography using linear and nonlinear optical excitations, of noble metal nanoparticles, quantum dots, and transparent conducting oxides capped with photoreactive ligands. This approach can be used for direct laser writing of three-dimensional optoelectronic circuits (3) A New class of *nanomaterials for magnetic control of light that* will enable manipulation of optical fields by relatively weak static magnetic fields such as due to brain waves . We demonstrate an entirely new direction where large magneto-optic effects can be achieved in chiral polymer nanocomposites with magnetic and plasmonic inclusions.

Finally, this talk will highlight specific examples oftechnological applications ofour work, including multispectral solar energy conversion and combined diagnostics and therapy (theranostics). In the biomedical area, a major application area currently pursued in our lab is brain research in the emerging field of Neurophotonics, where we apply these field responsive materials for functional mapping of the brain using optical and photoacoustic imaging, as well as magneto-optics to sense regioselectively the magnetic field due to brain waves. We have also demonstrated remote and noninvasive actuation of optogeneticstimulation of brain activityusing near IR absorbing optical nanotransformers that can provide an effective intervention/augmentation strategy to enhance the cognitive state and lay a foundation for a futuristic vision of augmented "super human" capabilities.

The talk will conclude with a presentation of multidisciplinary opportunities in the area of field responsive dynamic materials.

1. P.N. Prasad "Nanophotonics", John Wiley & Sons, New York (2004).
2. G. Chen, C. Yang, and P.N. Prasad,*Acc. Chem. Res.*, **2013**, *46*(7), 1474–1486.
3. P.N. Prasad "Introduction to Nanomedicine and Nanobioengineering" Wiley (2012)