Plasmonic Nanoparticles: artificial molecules with real applications

Naomi J. Halas
Stanley C. Moore Professor of Electrical and Computer Engineering, Professor of Chemistry, Professor in Bioengineering and Director, Laboratory for Nanophotonics, Rice University, Houston, TX, USA 77005

In recent years we have shown that certain metallic nanoparticles possess plasmon resonances that depend very sensitively on the shape of the nanostructure. This interesting observation has led to a fundamentally new understanding of plasmon resonances of metallic nanostructures- "Plasmon Hybridization"- where the collective electronic resonances in a metallic nanostructure are understood to be a classical analog of the single electron quantum states of simple atoms and molecules. The Plasmon hybridization picture explains the tunability of nanoshells, a dielectric core, metallic shell nanoparticle which is the simplest nanostructure with tunable plasmon resonances. More importantly, it provides a nanoscale "design rule" for understanding the plasmon resonances in an entirely new family of plasmonic nanostructures, and for the coupling of plasmonic nanostructures to meso- and macroscopic structures such as nanowires or thin metallic films. A variety of surface enhanced spectroscopies such as Surface Enhanced Raman Scattering, (SERS) Surface Enhanced Infrared Absorption (SEIRA), as well as fluorescence enhancement of nearby molecules and materials, can exploit these types of designed metallic nanostructures as tailored, high-performance substrates yielding large and highly reproducible enhancements. In addition, by tuning plasmon resonances into the near infrared region of the spectrum, the physiological "water window" can be accessed, where blood is essentially transparent and light penetrates maximally through human tissue. With bioengineers, we have developed a suite of applications for plasmonic nanoparticles in biomedicine, including light-triggered drug delivery and photothermal cancer therapy.

Topics:

1. **Fundamental Plasmon Hybridization**
2. **Chemical sensing: SERS, SEIRA and combining both on the same substrate**
3. **Biomedical applications of Plasmonics: past, present and future**
    a. **nanoscale pH meter based on SERS**
    b. **"turning up" ICG fluorescence**
    c. **Nanoshell-based cancer therapy: tumors and strategies for metastatic disease**
    d. **New vectors for gene therapy**