Tuning Plasmon Resonance of In_2O_3 Nanocrystals Throughout Mid-Infrared: Dopant, Phase, and Electronic Structure Dependence

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Synthesis, properties, and applications of gold and silver nanostructures with tunable localized surface plasmon resonances (LSPRs) have been a subject of intense investigation over the past decade. The focus on these noble metal plasmonic nanomaterials stems from their facile synthesis, stability to oxidation, and the visible-range LSPR transitions. However, among other drawbacks, these nanostructures are also costly for large-scale applications and exhibit high optical losses. Consequently, doped transparent metal oxide nanocrystals have emerged as a new class of unconventional plasmonic materials. In this talk I will present the results of our recent work on colloidal indium oxide-based plasmonic nanocrystals. Using size-structure correlation, indium tin oxide (ITO) nanocrystals were prepared in the stable bixbyite (*bcc*-ITO) and metastable corundum (*rh*-ITO) phase, revealing a dramatic difference in their optical and electrical properties. Unlike *rh*-ITO, *bcc*-ITO nanocrystals exhibit a strong LSPR absorption in the near-infrared region due to the presence of free electrons, enabled by the low activation energy donor states. I will also discuss colloidal synthesis and spectroscopic properties of two new plasmonic nanocrystal systems based on In_2O_3, antimony and titanium-doped In_2O_3, and comparative investigation of their electronic structure using combined Drude-Lorenz model and density functional theory. Fundamental understanding of the electronic structure and phase-dependent plasmonic properties allowed us to design and prepare plasmonic In_2O_3-based nanocrystals tunable throughout the entire mid-infrared region. Application of these colloidal mid-IR plasmonic nanocrystals will also be discussed.

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