

Synthesis and Structure-Property Elucidation of Group IV Semiconductor Nanocrystals and Metal Nanoparticle Superstructures

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This presentation will include two projects, which we have been working over the past few years on the design and synthesis of nanocrystalline Group IV alloy semiconductors and the use of sol-gel chemistry for the assembly of metal nanoparticles into porous superstructures.

(a) Nanocrystalline Group IV Alloy Semiconductors¹

Group IV semiconductor nanocrystals have gained tremendous interest in optoelectronic applications owing to high natural abundance, low cost of elemental components, and lack of toxicity. A number of synthetic methodologies for colloidal Si and Ge nanocrystals have been developed to date and new methods continue to appear on a regular basis. However, these methods generally lack the wide tunability of particle size and emission energies resulting in minimal exploration of photophysical properties. To address this issue, we have recently studied the incorporation of elemental Sn into colloidal Ge, to produce $GexSn_{1-x}$ alloy nanocrystals displaying composition tunable direct and indirect bandgaps and consequently absorption and emission energies. This talk will present the physical characterization of $GexSn_{1-x}$ nanocrystals using X-ray diffraction, transmission and scanning electron microscopy, energy dispersive, absorption and emission spectroscopic techniques. The effect of synthetic parameters on the primary particle size, morphology, composition, fundamental band structure, and optoelectronic properties of alloy nanocrystals will be discussed.

(b) Sol-gel Assembly of Metal Nanoparticles into Porous Superstructures²

The ability to assemble nanoparticles into functional superstructures is an important challenge that needs to be addressed for the generation of nanoparticle-based devices. Sol-gel method represents a facile yet powerful strategy for the self-assembly of metal oxides, chalcogenides, and metal-semiconductor hybrid nanoparticle systems into three-dimensionally connected porous nanostructures. In contrast to traditional oxides, where gels are formed by hydrolysis and condensation of molecular precursors, gelation in non-oxidic systems (with the exception of carbon), is achieved by condensation of the pre-formed nanoparticles. Herein, the application of later strategy for the assembly of hollow metallic spheres (Au, Ag, and Pt) will be presented. Preliminary characterization of the resultant metal aerogels is done using powder X-ray diffraction, transmission electron microscopy, surface area and porosimetry, and UV-visible spectroscopy. The effect of synthetic parameters on the primary particle size, morphology, surface area, and optoelectronic properties of metallic gel frameworks will be discussed in the light of their application in electrocatalysis.

References

- (1) Esteves, Richard J.; Ho, Min Q.; Arachchige, Indika U. *Chem. Mater.* **2015**, *27*, 1559-1568.
- (2) Gao, Xiaonan; Esteves, Richard J.; Luong, Thi T. H.; Jaini, Rajendra; Arachchige, Indika U., *J. Am. Chem. Soc.* **2014**, *136*, 7993-8002.