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Brighter side of semiconductor nanocrystals: How to make defects useful

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Abstract:

One of the most exciting properties of undoped semiconductor nanoparticles is the photoluminescence that is spectacular both in terms of its colour tunability and emission efficiency, based on quantum size effects. However, self-absorption as well as susceptibility to surface degradation are known to drastically affect the quantum efficiency of such bandgap emissions, posing a serious challenge to any technological exploitation of these materials. Emissions from dopants, particulary Mn in doped II-VI semiconductors, however, are known to have negligible self-absorption and resistance to degradation via surface reactions. Unfortunately, these advantages were realised at a cost, with hardly any tunability of the Mn emission till we recently introduced a novel way to achieve this counter-intuitive tunability from an atom-like emission.[1, 2, 3]
In our search for such novel approaches to achieve tunable PL emissions from semiconductor nanoparticles without the disadvantage of any self-absorption, we have been intrigued by the question whether other forms of defects, besides point defects as represented by atomic dopants (e.g. Mn in II-VI semiconductors), can also be meaningfully used to serve the purpose. The presence of defects, primarily surface defects, in semiconductor nanocrystals has been recognized as one of the major deterrents to achieve improved photoluminescence properties. Though it provides a Stokes' shifted PL emission, it affects adversely our ability to control the emission wavelength and to improve the photoluminescence efficiency. In addition to point defects, I shall present our experimental realisations, supported by theoretical considerations, of using "protected", extended defects in semiconductor nanoparticles for interesting PL properties.[4]

1. Hazarika A, Layek A, De S, Nag A, Debnath S, Mahadevan P, Chowdhury A, and Sarma D D, Phys. Rev. Lett. 2013, 110, 267401.
2. Hazarika A, Pandey A, and Sarma D. D., J. Phys. Chem. Lett. 2014, 5, 2208.
3. Hazarika A et al., Unpublished results.
4. Das S et al., Unpublished results.