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Luminescence, Doping, and Transport Properties of Silicon Nanocrystals produced via Nonthermal Plasma Synthesis

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Nonthermal plasma synthesis of nanocrystals is particularly suited for covalently bonded materials that require high temperatures to be produced with good crystallinity. Several years ago, we showed that plasma produced silicon nanocrystals are capable of high-efficiency photoluminescence, different from bulk silicon material. More recently, the capability of nonthermal plasmas to produce substitutionally doped nanocrystal materials has attracted attention, as substitutional doping had presented a significant challenge both for liquid and gas phase synthesis due to effects such as self-purification.
This presentation discusses the physics of plasma synthesis process. High photoluminescense quantum yields are achieved by careful surface functionalization through grafting alkene ligands to the nanocrystal surfaces. We also discuss the substitutional doping of silicon nanocrystals with boron and phosphorous using a nonthermal plasma technique. While the synthesis approach is identical in both cases, the activation behavior of these two dopants is found to be dramatically different. Finally, we present some experimental work on transport in films of highly phosphorous-doped nanocrystals, which indicates the approach to the metal-to-insulator transition.
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