Synthesis and Luminescent Properties Of Core/Shell Quantum Dots

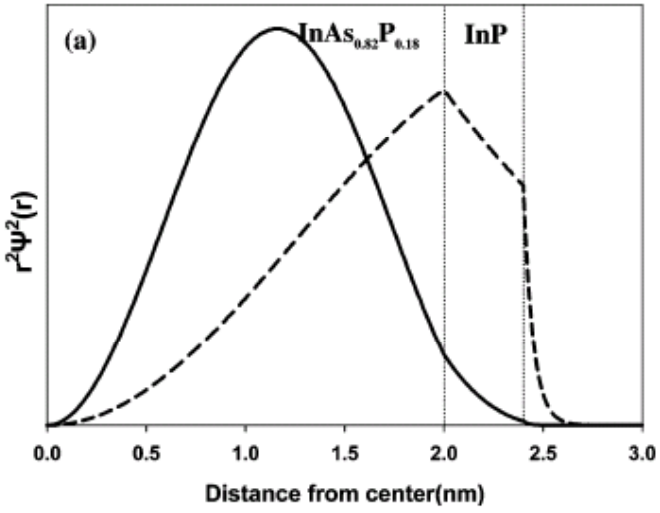
Nathan Pfaff

Materials 265

Fall 2008

Why Core/Shell Construction?

- Allows for complete surface passivation
- Localization of carriers in shell or core
- Core/Shell Heterostructures
  - Type 1 – Electron/Hole Confinement (InAsP/InP/ZnS)
  - Type 2 – Electron/Hole Separation (CdTe/CdSe)



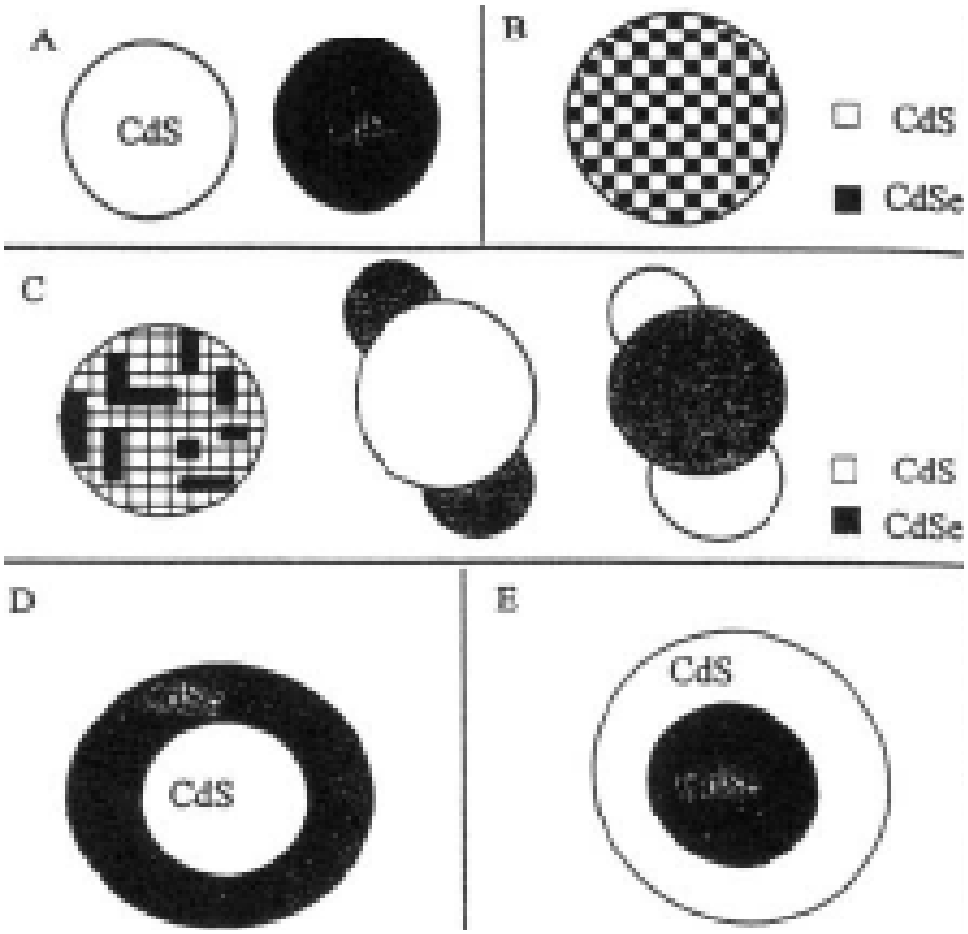
Sang-Wook Kim et. al.
J. Am. Chem. Soc. **127 (**2005) 10526-10532.

Materials Selection

- Core/Shell materials must not have high solubility to prevent alloying
- Lattice Constants
- Matching Surface Free Energies

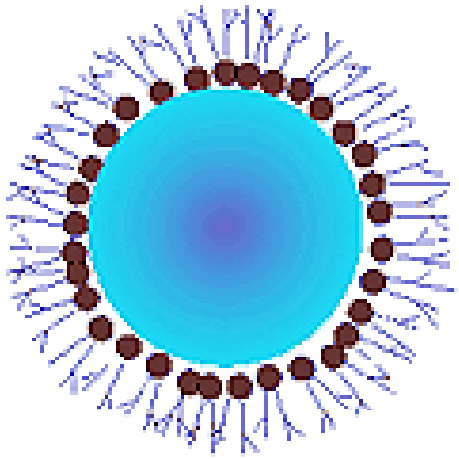
C.B. Murray, C.A. Kagan and M.G. Bawendi.
Annu. Rev. Mater. Sci. **30** (2000) 545-610.

Growth Concerns



D.Y. Godovsky
Advances in Polymer Science
153 (2000) 171.

Reverse Micelle Synthesis

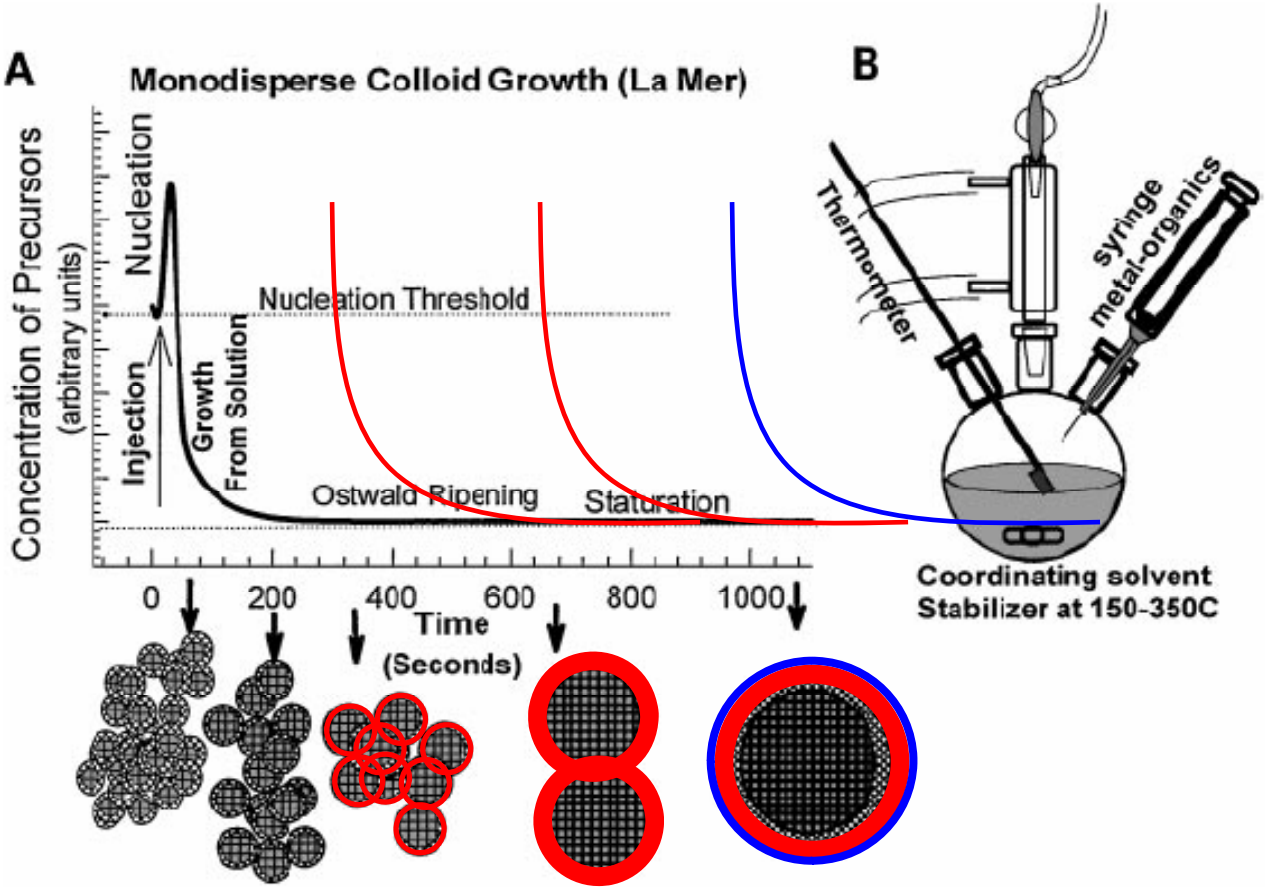


www.eie.gr

- Micelle solution
  - Heptane - AOT (0.12M) + Water
- Inject Precursor solution
  - Na_2S and $Zn(ClO_4)_2$
  - Phenyl(trimethylsilyl)Se in heptane and $Cd(ClO_4)_2$
- Inject capping agent
  - Thiophenol and pyridine
- Regrowth

A.R. Kortan et. al. J. Am. Chem. Soc. **112** (1990) 1327-1332.

Secondary Growth Synthesis



Indium Acetate + Olecic Acid in octadecene + $(TMS)_3P$+ $(TMS)_3As$

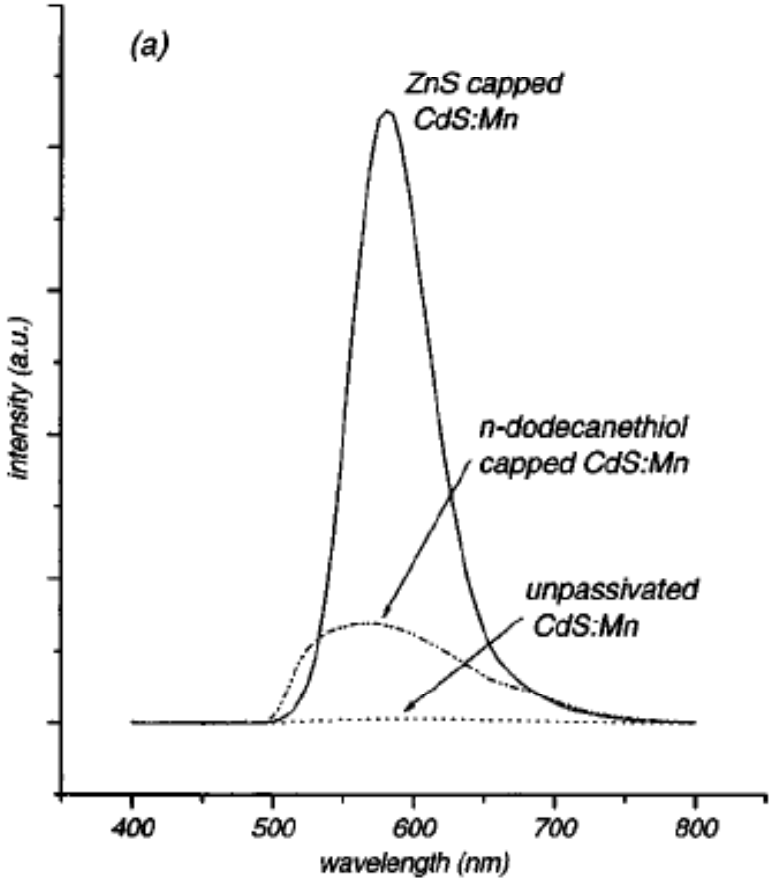
Indium Acetate +octadecene + $(TMS)_3P$

Et_2Zn + TOPSe

C.B. Murray, C.A. Kagan and M.G. Bawendi. Annu. Rev. Mater. Sci. **30** (2000) 545-610.

Sang-Wook Kim et. Al. J. Am. Chem. Soc. **127 (**2005) 10526-10532.

Resulting Properties – High QE



PL Emission spectra of unpassivated, n-dodecanethiol capped, and ZnS capped CdS:Mn nanocrystals

H. Yang and P. Holloway
Appl. Phys. Letters
82 No 12 (2003) p. 1966.

Resulting Properties – Narrowed PL

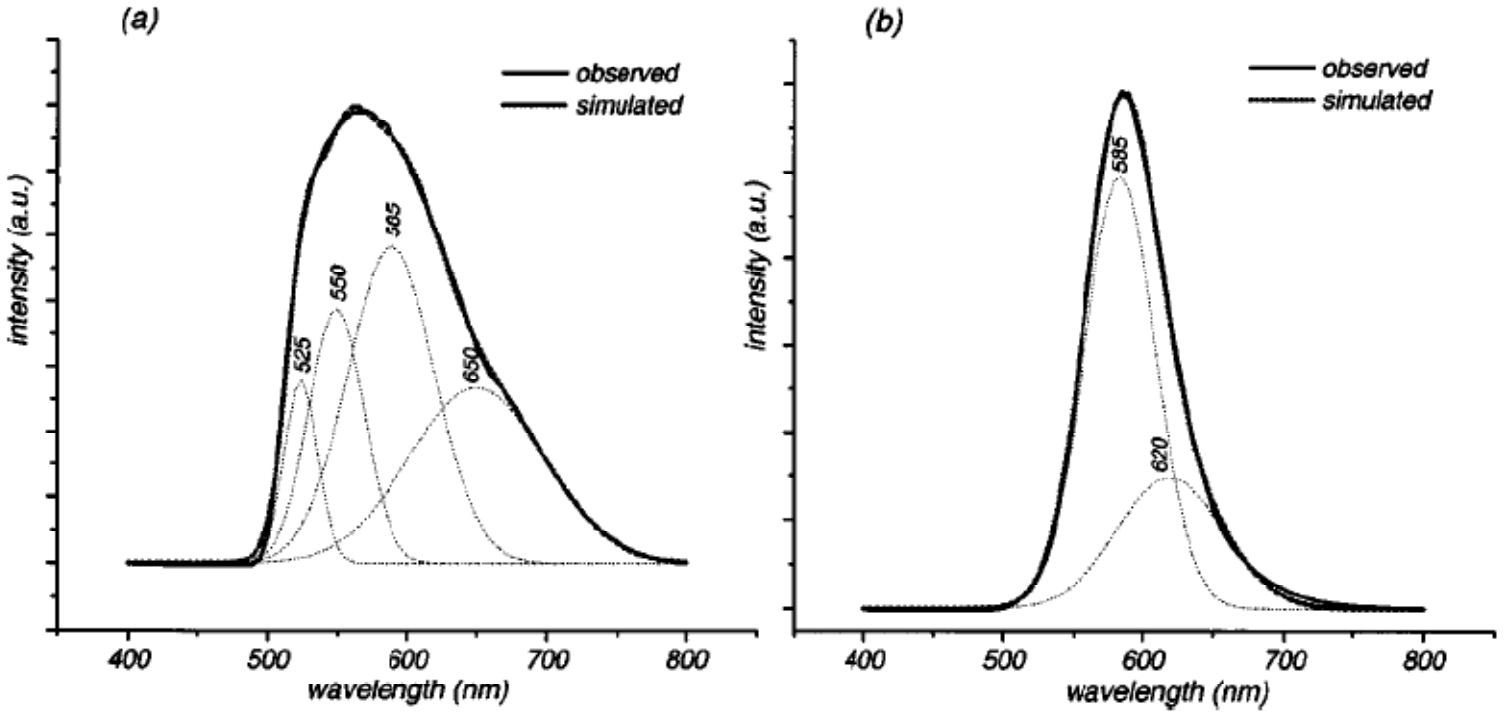


FIG. 4. Deconvolutions of PL emission spectra of *n*-dodecanethiol capped (a) and ZnS capped (b) CdS:Mn nanocrystals.

H. Yang and P. Holloway. Appl. Phys. Letters. **82** No 12 (2003) p.1967.

Results – Core/Shell/Shell

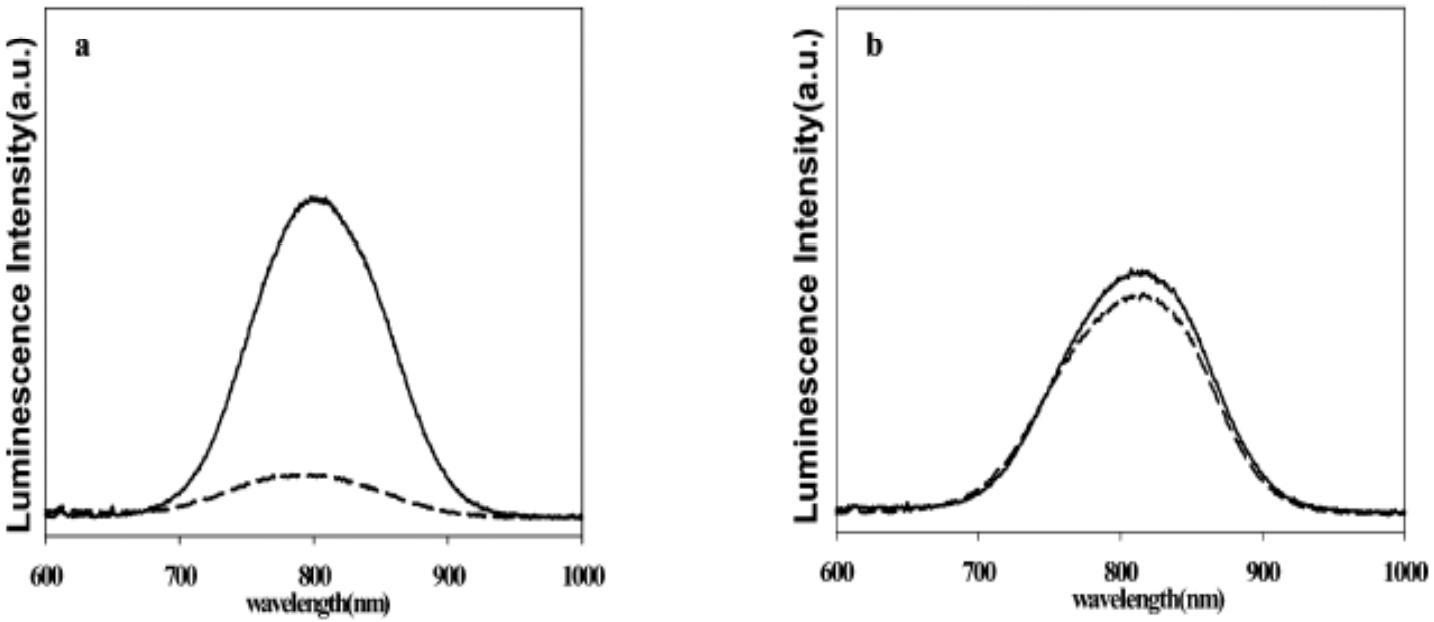


Figure 10. (a) Photoluminescence of $InAs_{0.82}P_{0.18}$/InP core/shell QDs in hexane (solid line) and PBS buffer (pH 7.0) (dashed line). (b) Photoluminescence of $InAs_{0.82}P_{0.18}$/InP/ZnSe core/shell QDs in hexane (solid line) and PBS buffer (pH 7.0) (dashed line).

Sang-Wook Kim et. al. J. Am. Chem. Soc. **127 (**2005) 10526-10532.

Results – Core/Shell/Shell

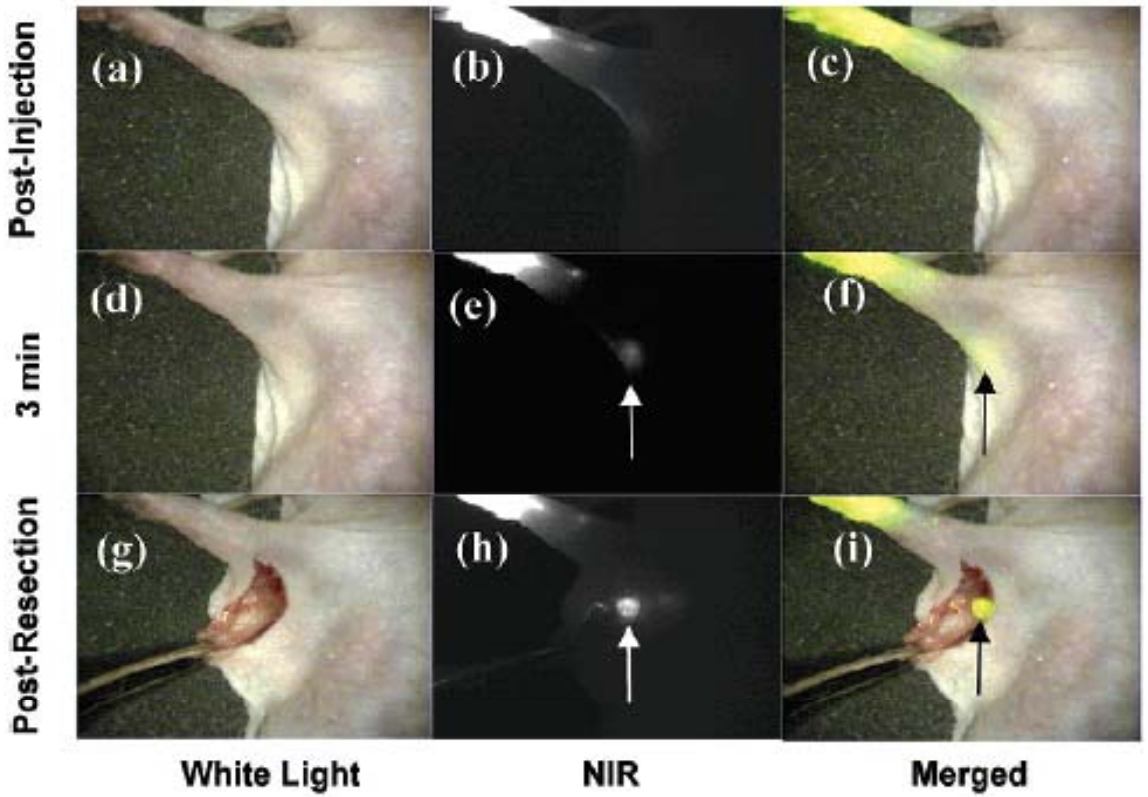


Figure 14. Postinjection (a, b, c), 3 min postinjection (d, e, f), and post-resection (g, h, i) images using white light, NIR fluorescence, and color/NIR merge, respectively.

Sang-Wook Kim et. al. J. Am. Chem. Soc. **127 (**2005) 10526-10532.