

# Chemical Information Call-in Candidate: Quantum Dots

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# OVERVIEW: Quantum Dots

- Why?
  - Expanding Applications and Production
  - Health and Environmental Concerns
- What Information Gaps?
  - Properties, Stability
  - Toxicity, and Environmental Fate
  - Analytical Methods
- Who?
  - Producers
  - Importers
  - Researchers



Quantum dots sorted by size emitting light of different colors  
(Roduner E. 2006. Size matters: why nanomaterials are different. Chem Soc Rev 35:583-592)

# Quantum Dot Applications

- **Light emitting diode (LED)**  
QD color emission tunable with size (quantum confinement)
- **Cell phone camera sensor**
- **Solar cells/photovoltaics**
- **Security inks**
- **Thermoelectrics**
- **Medical imaging**



Images: Evident Technologies, Inc.  
Softpedia. 2006. "Connect the Quantum Dots."  
<http://news.softpedia.com/news/Connect-the-Quantum-Dots-30244.shtml>  
Accessed July 19, 2010.

# Quantum Dot Production

## ***SOME POSSIBLE CA COMPANIES:***

Nanosys/QD Soleil, Bloo Solar, Life Technologies, Stion, Quantum Dot Corporation, Chemicon International, Zymera, InVisage Technologies, University of California schools, Intelligent Optical Systems, Kovio, NanoGram, Philips Lumileds Lighting Co., Toshiba America Electronics Components, Samsung Semiconductor, SEMI, UltraTech, Shrink Nanotechnologies, and others

## ***Production Methods:***

Colloidal synthesis

Chemical vapor deposition (CVD)

Cost = ~ \$1000 - 5000/gm

(highly dependent on composition and quality)

## ***Potential Market:***

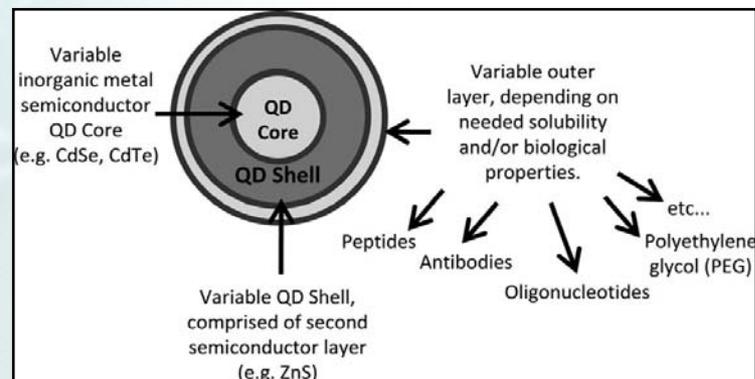
Market size 2007\* = \$11 million

Projected market size 2012\* = \$62 million

\* Bradley J, et al. 2008. Lux Research Inc.

Images: Heyman K. 2005. The Scientist 19(9): 35.

Pelley J, Daar A, Saner M. 2009. Toxicological Sciences 112 (2): 276-296



# Quantum Dot Properties and Potential Concerns

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- Cytotoxicity reported in QD containing heavy metal cores<sup>∞</sup> (eg.cadmium<sup>\*</sup>, lead, selenium, tellurium<sup>°</sup>)
- Degrades in low pH, air, and UV light
- Pulmonary vascular thrombosis reported in *in vivo* mice study<sup>˘</sup>
- QD unique from other nanomaterials—bulk material of components is well known to be toxic (unlike eg. CNT)
- Not all QDs are alike (size, shape, surface charge, surface functionalization)—each have different toxicity
- Ecotoxicity—Bioaccumulation of Cd in gills, digestive gland, and gonad tissues and metallothionein (MT) levels detected in freshwater mussel *Elliptio complanata*<sup>\*\*</sup>

<sup>∞</sup> Hardman R. 2006. *Environ Heal Persp* 114 (2): 165-172.

<sup>\*</sup> Derfus A. 2004. *Nano Lett* 4:11-18.

<sup>°</sup> Selenium and Tellurium are metalloids

<sup>˘</sup> Geys J. 2008. *Environ Health Perspect.* 116(12): 1607-13.

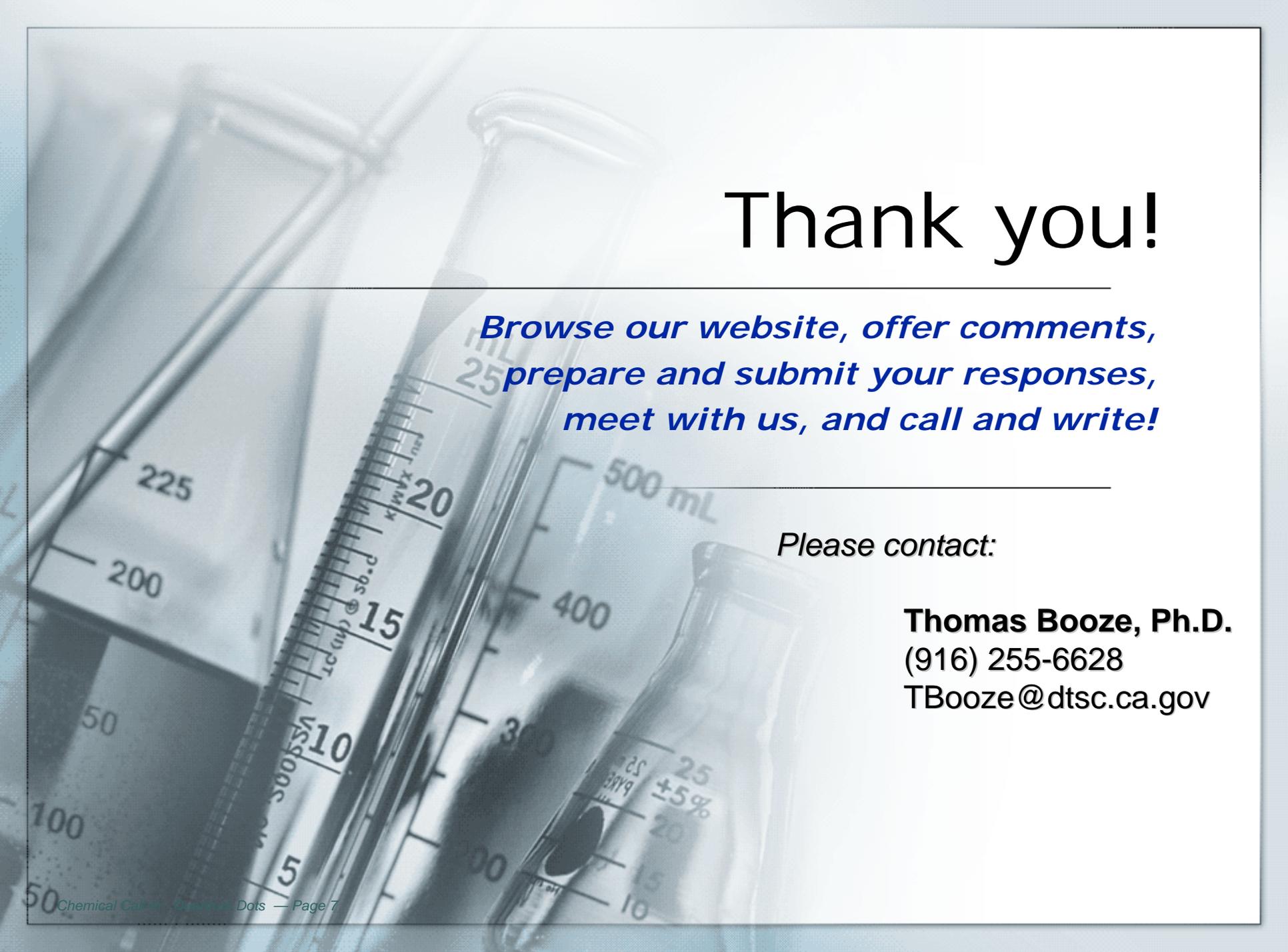
<sup>\*\*</sup> Peyrot C, Gagnon C, Gagne F et al. 2009. *Comp Biochem and Physio, Part C* 150: 246-51.

# Questions for Manufacturers, Importers, Researchers, and Others

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## Possible Call-in questions (incomplete list):

- What are the chemical compositions (purity, concentration, and chemical make-up) of your product's core and shell structures (including organic and inorganic attachments)? Specify its size, hydrodynamic diameter (HD), and surface area.
- What analytical detection methods do you use to determine its presence in the workplace and environment?
- What are the surface properties (surface reactivity, groups, charge) and solubility in water and other solvents?
- What is the stability of your product in different environments (variable pH, temp, pressure, O<sub>2</sub>, UV light, water, etc)? Does it aggregate in aquatic media?



# Thank you!

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*Browse our website, offer comments,  
prepare and submit your responses,  
meet with us, and call and write!*

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