Quantum Dots Still Shining Strong 30 Years On

About 30 years ago in the former Soviet Union, Aleksey Ekimov, experimenting with semiconductor-doped glasses,[1] was seeking the help of theoretician Alexander Efros[2] to explain apparent color changes of what appeared to be tiny particles of variable sizes. At the same time, Louis Brus in the United States[3,4] and Arnim Henglein in Germany[5] discovered striking color changes of II–VI semiconductor nanoparticles grown as aqueous colloidal suspensions, giving rise to the simple description of the band gap dependence on size that is now familiar to students the world over as the "Brus formula".[6] These publications are widely considered to be the inception of what is now the flourishing field of quantum dots (QDs). Most of those early researchers, joined by their figurative academic "children" and "grandchildren" gathered in Paris in May 2014 at a conference hosted by ESPCI, organized by Benoit Dubertret and Peter Reiss to celebrate 30 years of research on QDs.

> **The inherent interdisciplinarity behind the understanding of such effects, driven by chemists and fueled by physicists, is in fact one of the most remarkable features that has kept the field fresh and active for the past 30 years.**

One strikingly beautiful aspect of colloidal QDs is the way their emission colors change with particle size, making them perfect illustrations, not only to researchers but also to the general public, of the basics and the wonders of nanoscience. How many students—including myself some 25 years ago—have been attracted to the QD field by images of brightly shining flasks (Figure 1) displaying the most basic consequence of the quantum-confinement effect in

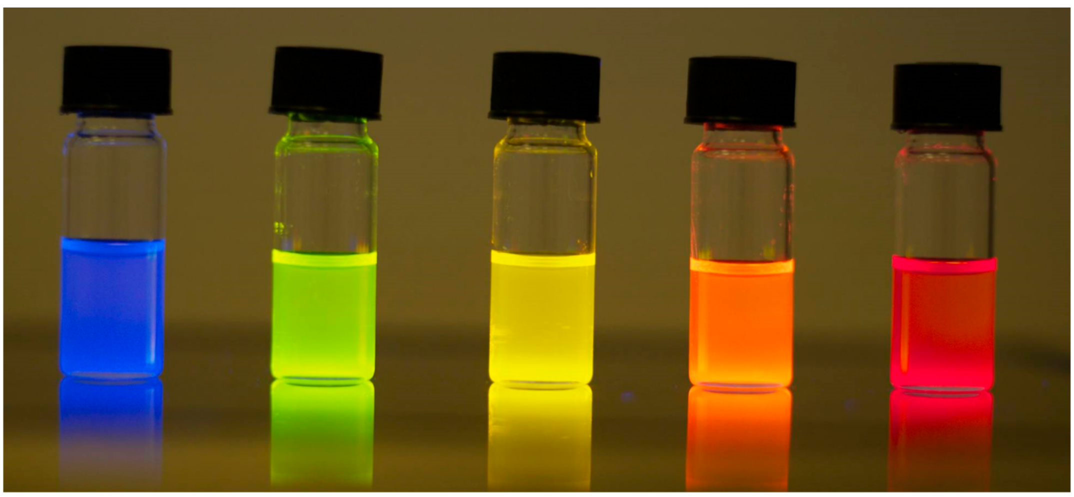

Figure 1. Parisian quantum dots (CdSe/ZnS, courtesy of Benoit Dubertret) shine in bright colors, a beautiful demonstration of the quantum confinement effect in contemporary nanoscience that continues to catch the attention of students and the public alike.

solid state physics *via* chemically synthesized colloidal nanocrystals? The inherent interdisciplinarity behind the understanding of such effects, driven by chemists and fueled by physicists, is one of the most remarkable features that has kept the field fresh and active for the past 30 years. There is no sign of the field losing any of its original and sustaining vibrancy; many new and exciting findings have been shared by the community coming together in Paris following two well-established conferences in the field, QD2014 in Italy and NaNaX6 in Austria.

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Prof. S. T. Lee of Soochow University joins *ACS Nano* this month as an associate editor.

Continuing synthetic developments, largely concentrating on emerging nontoxic materials, near-infrared emitting QDs, and novel surface ligands and flourishing photophysics-related studies, all belie the strong and determined push toward real commercial applications. Robust QDs providing unprecedented color purity have already entered the market, commercialized as components in HD TV displays. Photovoltaic applications of QDs are thriving, with new record certified conversion efficiencies reported regularly, and studies of water-splitting systems utilizing QDs as components of hybrid materials are on the rise. Meeting old friends while catching up with new topics, reflecting back on what has happened in the field over an exciting 30 years of research, and being surrounded by close colleagues from around the world were among the warm comments by participants of this memorable event.[7]

Announcements. This month, *ACS Nano* is pleased to welcome Dr. S. T. Lee as our newest associate editor. Prof. Lee is a frequent contributor across broad areas of science and engineering, including light-emitting materials, diamond-based materials, and both hard and soft matter.[8−10] He joins us from Soochow University in China, where he is the founding Director of the Functional Nano & Soft Materials Laboratory (FUNSOM) and the Director of the College of Chemistry, Chemical Engineering and Materials Science.

Disclosure: Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

Andrey Rogach
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REFERENCES AND NOTES

1. Ekimov, A. I.; Onushchenko, A. A. Quantum-Size Effects in Optical Spectra of Semiconductor Microcrystals. *Sov. Phys. Semicond.* **1982**, *16*, 775–778.
2. Efros, A. L.; Efros, A. L. Interband Absorption of Light in a Semiconductor Sphere. *Sov. Phys. Semicond.* **1982**, *16*, 772–775.
3. Rossetti, R.; Nakahara, S.; Brus, L. E. Quantum Size Effects in the Redox Potentials, Resonance Raman Spectra, and Electronic Spectra of Cadmium Sulfide Crystallites in Aqueous Solution. *J. Chem. Phys.* **1983**, *79*, 1086–1088.
4. Alivisatos, A. P. Birth of a Nanoscience Building Block. *ACS Nano* **2008**, *2*, 1514–1516.
5. Weller, H.; Koch, U.; Gutierrez, M.; Henglein, A. Photochemistry of Colloidal Metal Sulfides. 7. Absorption and Fluorescence of Extremely Small Zinc Sulfide Particles (The World of the Neglected Dimensions). *Ber. Bunsen-Ges. Phys. Chem.* **1984**, *88*, 649–656.
6. Brus, L. E. Electron−Electron and Electron−Hole Interactions in Small Semiconductor Crystallites—The Size Dependence of the Lowest Excited Electronic State. *J. Chem. Phys.* **1984**, *80*, 4403–4409.
7. http://www.30-years-qds.com/.
8. Tang, Y. B.; Lee, C.-S.; Xu, J.; Liu, Z.-T.; Chen, Z.-H.; He, Z.; Cao, Y.-L.; Yuan, G.; Song, H.; Chen, L.; *et al.* Incorporation of Graphenes in Nanostructured TiO_2 Films *via* Molecular Grafting for Dye-Sensitized Solar Cell Application. *ACS Nano* **2010**, *4*, 3482–3488.
9. Zhuo, S.; Shao, M.; Lee, S. T. Upconversion and Downconversion Fluorescent Graphene Quantum Dots: Ultrasonic Preparation and Photocatalysis. *ACS Nano* **2012**, *6*, 1059–1064.
10. Jin, L.; Yang, K.; Yao, K.; Zhang, S.; Tao, H.; Lee, S. T.; Liu, Z.; Peng, R. Functionalized Graphene Oxide in Enzyme Engineering: A Selective Modulator for Enzyme Activity and Thermostability. *ACS Nano* **2012**, *6*, 4864–4875.