Langmuir-Blodgett films of lead chalcogenide quantum dots

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The Langmuir-Blodgett (LB) technique provides a straightforward method for the fabrication of thin films of a diverse range of nanocrystals, including lead chalcogenide quantum dots (Qdots).[1] The development of densely packed and homogeneous monolayers of infrared emitting Qdots is important, not only for the study of the optical properties of the Qdots under thin film conditions, but also for the development of photonic devices like LEDs, lasers and solar cells.

In this poster, we compare the optical properties of LB films consisting of PbS, PbSe and PbSe/CdSe core-shell Qdots. As can be seen in Figure 1, we find that PbSe Qdots show an oriented attachment, most probably due to the rapid oxidation of these Qdots in air or in contact with water. However, we can resolve this issue by growing a CdSe shell around the PbSe core Qdots. The improved stability of the Qdots leads to a highly ordered hexagonal close-packed structure. Air-stable PbS Qdots show the same high-quality morphology. [2]

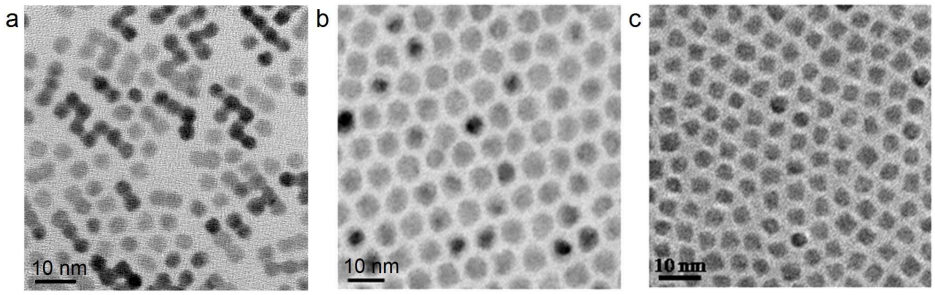

Figure 1: TEM images of LB depositions of (a) PbSe QDs, (b) PbSe/CdSe QDs, (c) PbS QDs.

However, despite the improved film quality for PbSe/CdSe and PbS Qdots, only the PbS Qdot LB films retain a high photoluminescence as it is shown in Figure 2. The PbS LB luminescence yield is similar to the yield of the PbS Qdots in suspension. For both PbSe and PbSe/CdSe, the LB film luminescence is almost completely quenched.[2]

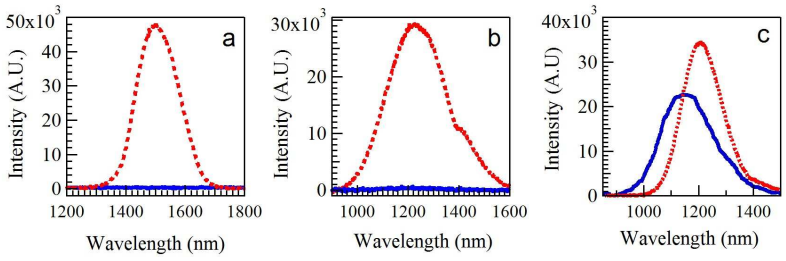

Figure 2: Photoluminescence of the colloidal solution (dotted line) and monolayer (full line), relative to the absorbance at 400 nm: (a) PbSe QDs, (b) PbSe/CdSe QDs, (c) PbS QDs.

Although PbS QD films are luminescent, they undergo oxidation under ambient conditions, causing a blue shift of the photoluminescence peak. Although this oxidation leads to a final decrease in effective size of about 1 nm after 1 month, the films maintain their photoluminescence (Figure 3). These results indicate that PbS QDs are the preferred material for near-infrared light-emitting applications based on lead chalcogenide LB films.

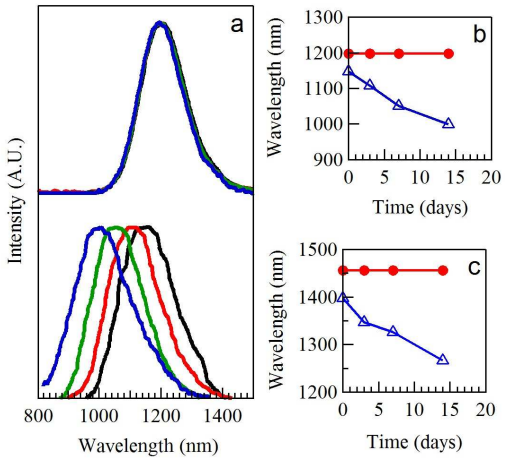

Figure 3: Effect of oxygen in PbS QDs. (a) Luminescence of a 3.7 nm colloidal solution (top) and monolayer (bottom) at different times. Evolution of the peak position versus time in colloidal QDs (dots) and monolayer (open triangles) in 3.7 nm QDs (b) and 5.2 nm QDs (c).

References

[1] Lambert K, Moreels I, Van Thourhout D, Hens Z, Langmuir **24** (2008) 5961.

[2] Justo Y, Moreels I, Lambert K, Nanotechnology **21** (2010) DOI: 10.1088/0957-4484/21/29/295606