Investigation of inorganic single $CsPbX_3$(X=I, Br) Perovskite nanocrystals by micro-photoluminescence

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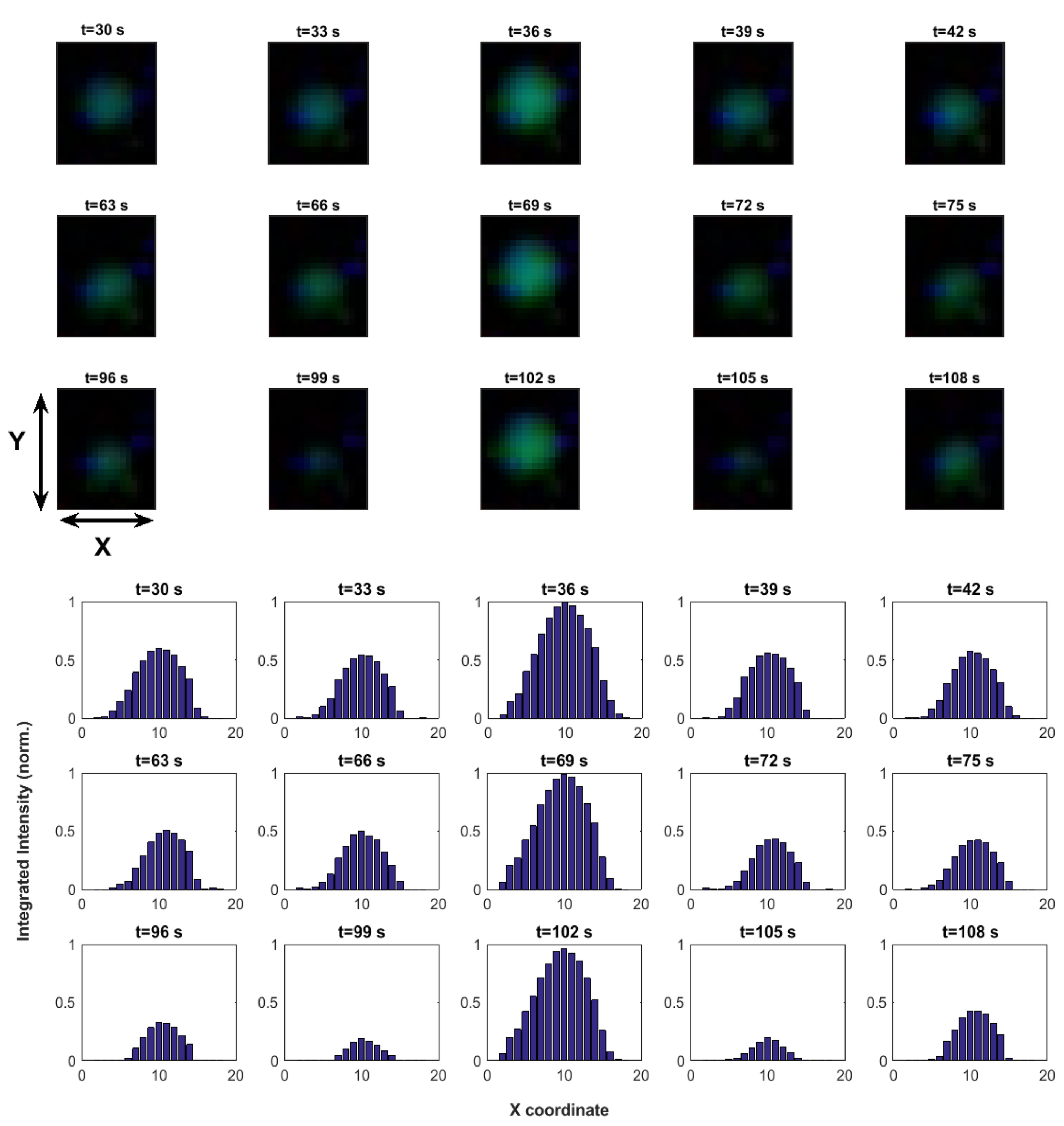
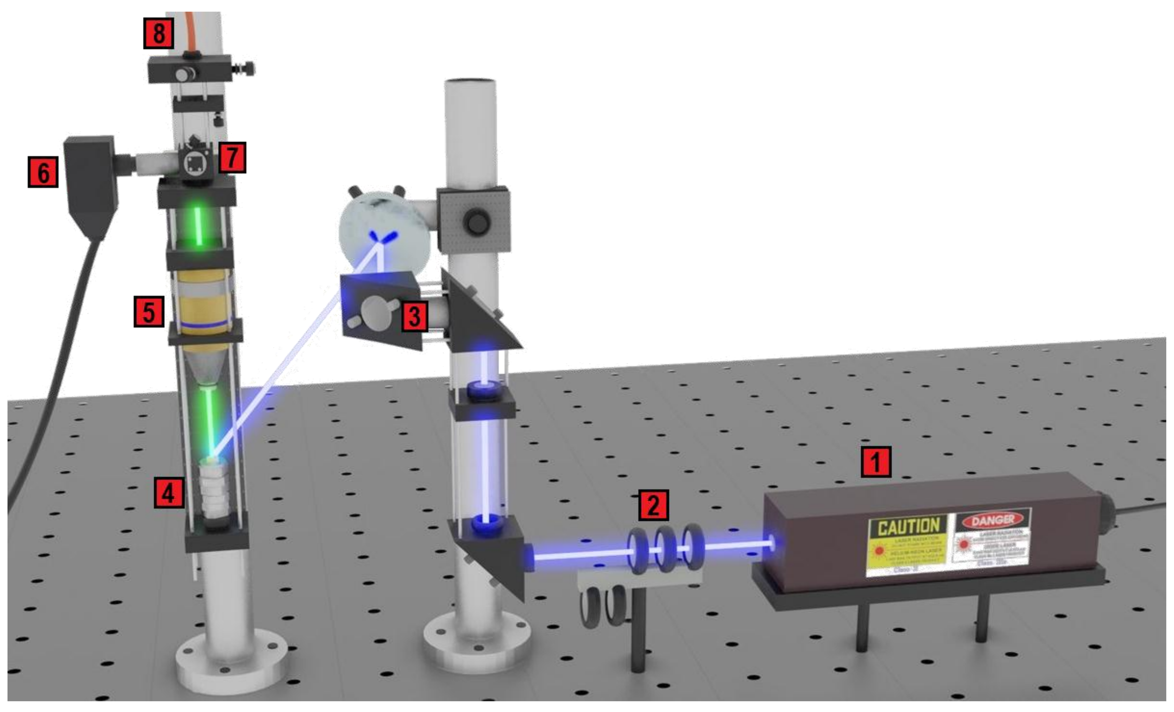
Abstract

The metal halides with perovskite crystalline structure are an example of semiconductors that have given rise to photovoltaic devices and emitters with high efficiency in a short space of time. This has been possible because thin layers can be formed by very simple deposition techniques, with optical and electro-optical properties as good as those of crystalline semiconductors such as silicon or GaAs. In this work we have studied the light emission properties of semiconductor nanocrystals of $CsPbBr_3$ and $CsPbI_3$ individually at low and room temperatures. These nanocrystals deposited by dip coating the substrate into the colloidal solution, so that they are spatially separated from each other, which allow using a simple photoluminescence micro-spectroscopy assembly, which we have developed in our laboratory. With the statistical study conducted on tens of nanocrystals we have deduced an average peak energy of 2.414 eV (1.83 eV) at room temperature, in freshly prepared samples of $CsPbBr_3$ ($CsPbI_3$), which is consistent with the value measured in dense layers of nanocrystals (2.422 eV) and the average peak energy of $CsPbBr_3$ fresh samples at low temperatures is around 2.31 eV.

I. The blinking effect of the PL intensity, which is observed in freshly prepared $CsPbBr_3$ nanocrystals.

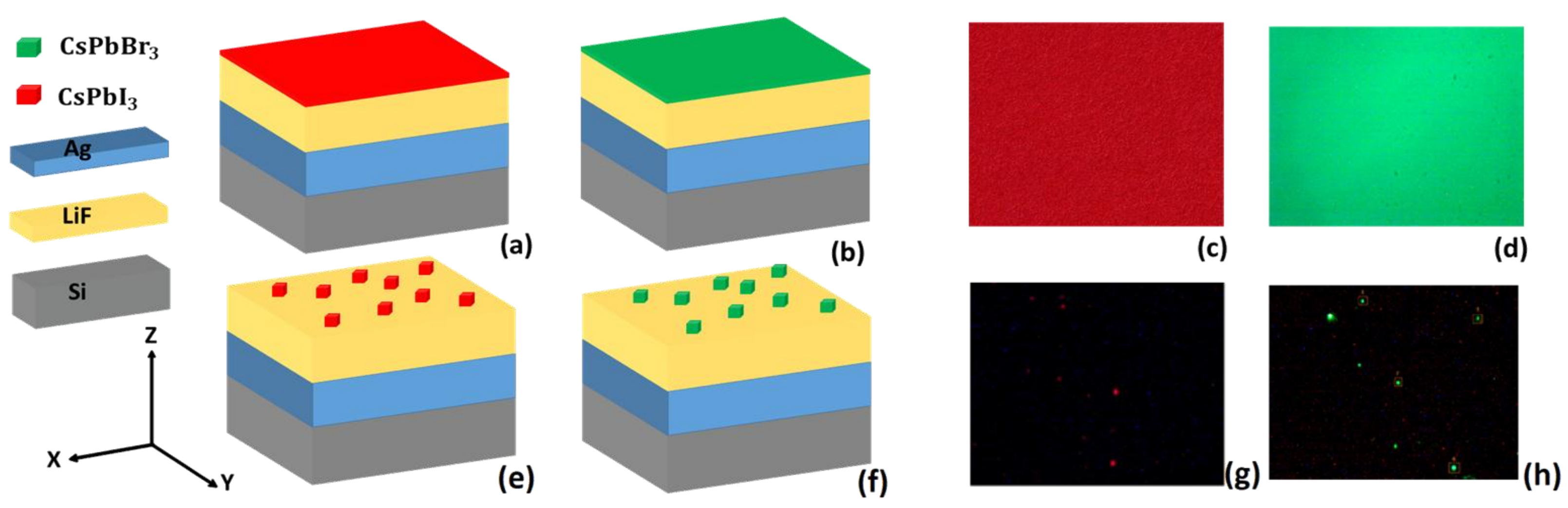


First cluster of the images represents evolution of a single $CsPbBr_3$ perovskite nano crystal as a function of time and the second cluster illustrates emitted light intensity corresponding to the first cluster.

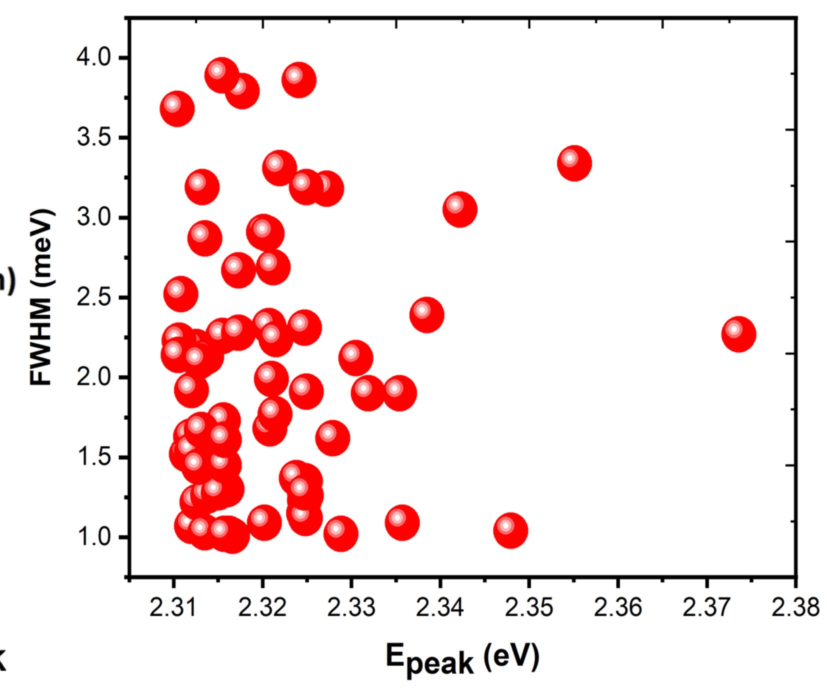


Assembly of micro-PL with which measurements were made in isolated perovskite nanocrystals. The mounting elements are: 1-Laser source, 2-Filter set, 3-Guiding laser pumping system, 4-XYZ scroll tower with piezoelectric drive, 5-Objective 50x long working distance, 6-Camera CCD, 7-Beam separator (1 mm quartz sheet), 8-Multimode fiber optic coupler 200 µm in diameter core.

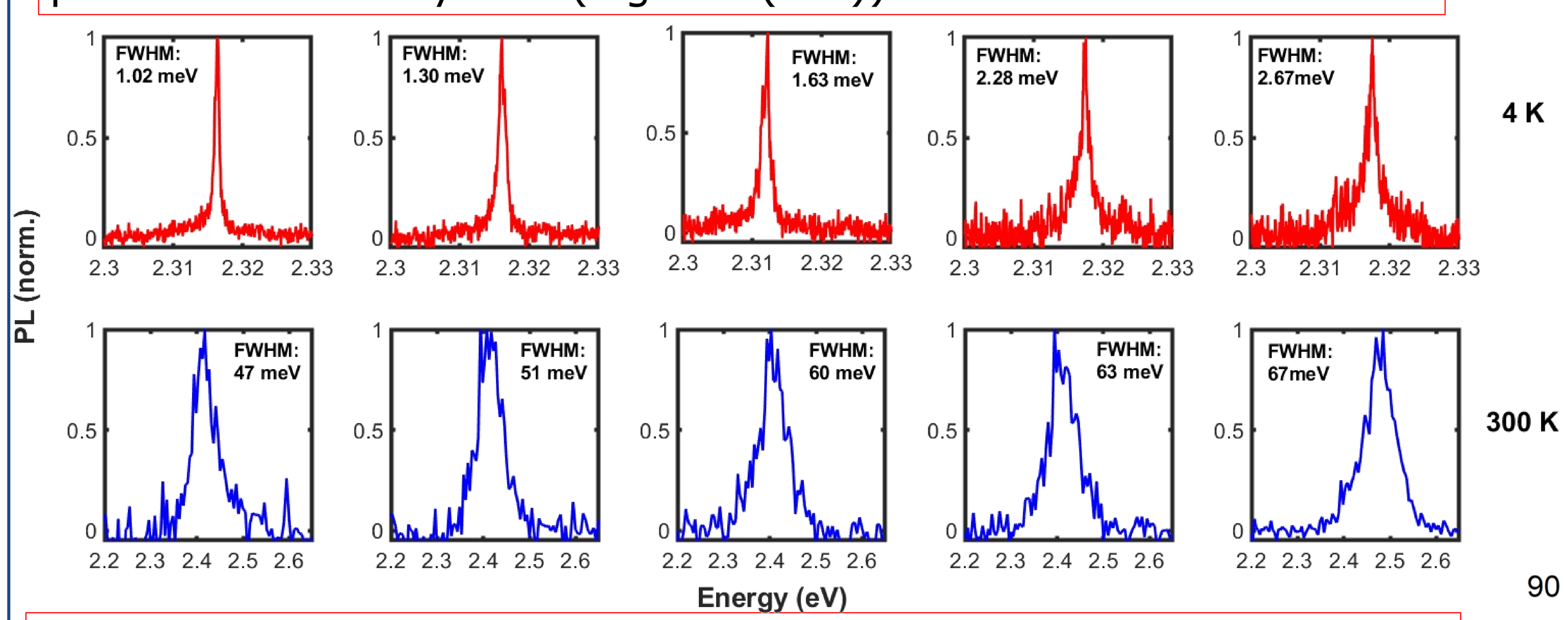
II. Micro-PL of Single Perovskite Nano-Crystals at room and low temperatures



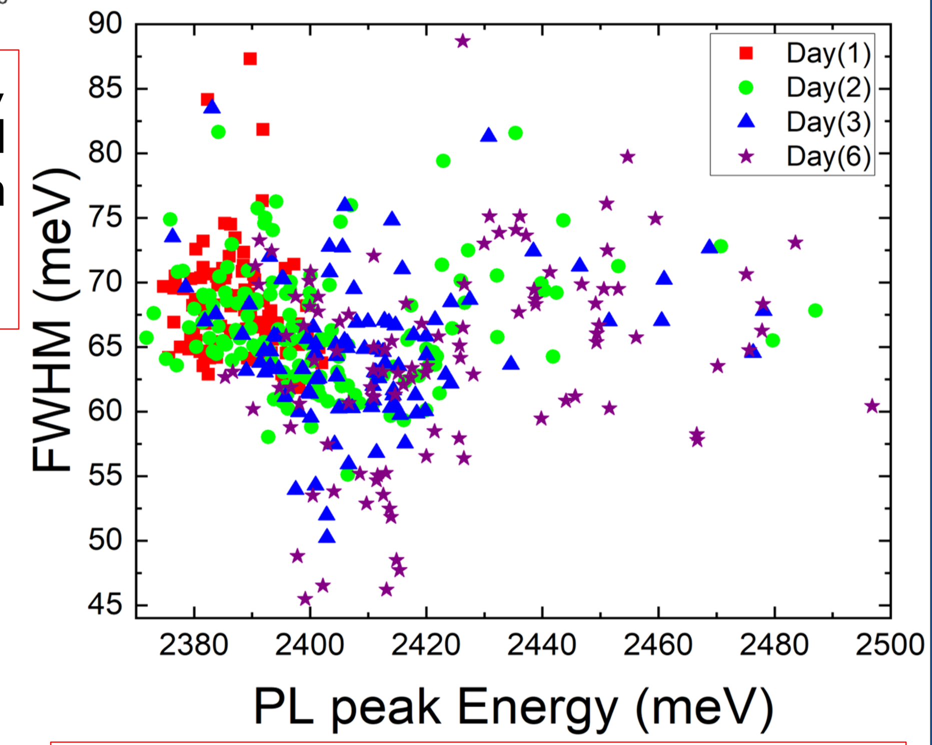
Schematic and micro-PL image of prepared samples to illustrate the difference between a compact layer of nanocrystals (Figures (a-d))and a dispersion of isolated perovskite nanocrystals (Figures (e-h))



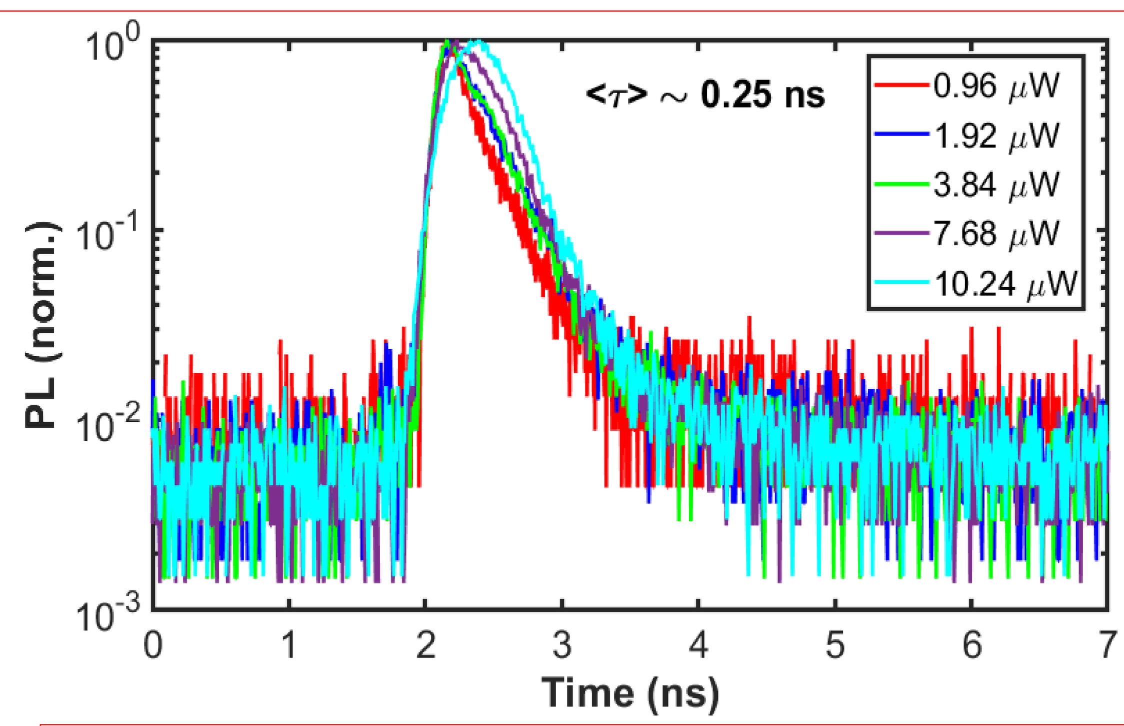
Statistics of Single perovskite nanocrystals ($CsPbBr_3$) at 4K, low power (fraction of a microwatt), the spread of PL Linewidth is consistent with spectral diffusion(electric field fluctuations charges).



The Lorentzian PL spectra of single nanocrystals($CsPbBr_3$) , whose line widths are some meV at 4 K (due to spectral diffusion) and greater than 50 meV at 300 K (due to phonon interaction).



Plot of FWHM of $CsPbBr_3$ as a function of its corresponding PL peak energy at 300 K in around 100 nanocrystals in a fresh sample (red squares) and at different days, up to 5 days later (violet stars).



The PL decay time is quite short in $CsPbBr_3$ at 4 k.

III. Conclusions

To summarize, we have prepared different samples of nanocrystals of $CsPbBr_3$ and $CsPbI_3$ dispersed on a substrate of Si / Ag / LiF / PMMA, having optimized the concentration of nanocrystals to be able to obtain samples in the that the nanocrystals are sufficiently separated in comparison to the spatial resolution of our microscope. The effect of blinking or intermittency of the photoluminescence intensity, which is observed in some of the nanocrystals of $CsPbBr_3$, has been illustrated. Besides, the energies of the excitonic optical transitions in the isolated nanocrystals have been analyzed, in the width of the measured photoluminescence lines and their intensities. And we have deduced an average energy for the excitonic optical transition of 2,414 and 1.83 eV for nanocrystals of $CsPbBr_3$ and $CsPbI_3$, respectively, in freshly prepared samples at room temperature and around 2.31 eV at low temperature.

IV. Acknowledgement

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