Colloidal quantum dots and metal nanoparticles at surfaces: a route towards new patterns

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The self-assembly of colloidal quantum dots, like that of any other rigid colloidal particles, is strongly dependent on the characteristics of the particle surface and its interactions with the environment. [1,2] However, the fundamental molecular interactions governing the self-assembly process and the resulting spatial arrangement at different length scales are often not fully understood. On the other hand, also in need of clarification is the role played by the coating organic ligands on the "fate of the charge carriers generated by light absorption", as pioneer of colloidal quantum dot science Arnim Henglein put it, [3] that is, on the the size-dependent optical properties that are a hallmark of these nanocrystals. [4-6]

The self-assembly of colloidal quantum dots at surfaces, therefore, by uniquely combining the versatility of colloidal quantum dot synthesis, the size-dependent optical properties of these nano-objects, and the physics of interfaces, constitutes a promising route towards the use of colloidal quantum dots as building blocks of complex hierarchical functional structures. Of particular interest is the introduction of plasmonic constituents in the system as new properties may arise due to exciton-plasmon coupling. [7,8]

In this work, thin drop-cast films of CdSe/ZnS colloidal quantum dots, gold nanoparticles, and their mixtures were investigated by laser scanning confocal microscopy and fluorescence lifetime imaging spectroscopy. A new deposition pattern has been observed in films of CdSe/ZnS colloidal quantum dots that is strongly dependent on the nature of the coating organic ligands and casting solvent. Casting solvent/organic ligand interactions and the directionality of the ligand/ ligand interactions dictated by ligand molecular architecture and alkyl chain flexibility are discussed as the origin of the deposition pattern. Introduction of gold nanoparticles, on the other hand, leads to the formation of regular superlatices.

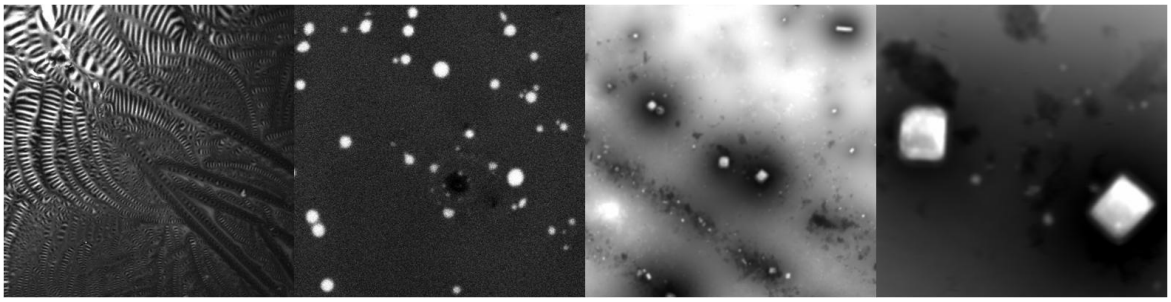

Fig. 1 Laser scanning confocal microscopy images of CdSe/ZnS and Au thin films drop-cast on glass. From to left to right: CdSe/ZnS (425μm x 425μm), luminescence image; Au (101μm x 101μm), luminescence image; CdSe/ZnS + Au (154μm x 154μm), transmitted light image; CdSe/ZnS + Au (29μm x 29μm), transmitted light image.

1) W. J. Baumgardner *et al.*, *Nano Lett.*, **2013**, *13*, 3225.
2) L. Bahrig *et al.*, *CrystEngComm*, **2014**, *16*, 9408.
3) A. Henglein *et al.*, *Chem. Rev.*, **1989**, *89*, 1861.
4) S. F. Wuister *et al.*, Angew. Chem., **2004**, *116*, 3091.
5) A. Sukhanova *et al.*, *Angew. Chem. Int. Ed.*, **2006**, *45*, 2048.
6) E. N. Bodunov *et al.*, *Ann.Phys.(Berlin)*, **2016**, *528*, 272.
7) C. Strelow *et al.*, *Nano Lett.*, **2016**, *16*, 4811.
8) J. Borges *et al.*, *Phys. Status Solidi RRL*, **2016**, *10*, 530.