

**MS16-1-4 Controlled reactive assembly of colloidal nanocrystal superlattices: mechanism and kinetics**  
**#MS16-1-4**

**D.M. Balazs<sup>1</sup>, J. Cimada Da Silva<sup>2</sup>, T. Dunbar<sup>2</sup>, T. Hanrath<sup>2</sup>**

**<sup>1</sup>Institute of Science and Technology Austria (ISTA) - Klosterneuburg (Austria), <sup>2</sup>Cornell University (United States)**

**Abstract**

Crystallization through attachment on nanoscale building blocks represents a novel way of creating 'designer materials'. The opportunity to tune the structure, and hence the quality and degree of interaction between the building blocks creates a wide parameter space for tailoring the ensemble-level properties, eventually reaching truly purpose-built materials. Traditionally, bottom-up synthesis meant using nanocrystals as a feedstock for conventional materials processing. The approach of controlled assembly through intermolecular forces, however, seems more promising for the ability to restrict particular degrees of freedom and to shift the energy- and timescales into the soft matter regime.[1] Moreover, working at interfaces of liquids (solvent-solvent or solvent-air), confines the assembly into a plane, enabling the formation of 2D-confined structures.[2]

Assembly and oriented attachment of colloidal quantum dots into a superlattice with long range order both at the atomic and multi-nanometre scale carries the promise of creating novel properties, particularly for semiconductor devices and related applications.[3,4] Additionally, the established reaction mechanism, control approaches and general behaviour can be translated into many other systems. The general approach to create ordered lattices has been established, but a knowledge gap persists in our ability to control the assembly and attachment process.[5,6] Filling these knowledge gaps is essential to establish the energetic-kinetic framework of a representative system that can be later generalized.

In this work, we report the results of our efforts to understand and control the formation of superlattices of PbSe colloidal nanocrystals. Using a combination of structural characterization techniques, such as electron microscopy and synchrotron-based X-ray scattering, we describe the process from the introduction of a droplet of a colloidal dispersion through an assembly of nanoparticles at a liquid surface into a correlated superlattice to an epitaxially connected hierarchical system. We describe the physics and chemistry of spreading, drying and reactive assembly, and establish the guidelines for applying the method to other systems.

**References**

- [1] G. M. Whitesides, B. Grzybowski, *Science* 2002, 295, 2418.
- [2] R. Dong, T. Zhang, X. Feng, *Chem. Rev.* 2018, 118, 6189.
- [3] K. Whitham, J. Yang, B. H. Savitzky, L. F. Kourkoutis, F. Wise, T. Hanrath, *Nature Materials* 2016, 15, 557.
- [4] D. M. Balazs, M. A. Loi, *Advanced Materials* 2018, 30, 1800082.
- [5] A. Abelson, C. Qian, T. Salk, Z. Luan, K. Fu, J.-G. Zheng, J. L. Wardini, M. Law, *Nat. Mater.* 2019, 1. doi:10.1038/s41563-019-0485-2
- [6] T. Hanrath, *Nat. Mater.* 2019, 1. doi:10.1038/s41563-019-0515-0