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Nanocrystals, mesocrystals, supercrystals – a toolbox for materials with collective optoelectronic effects?

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Abstract: Mesocrystals are three-dimensional, macroscopic arrays of iso-oriented nanocrystals (NC).[1] An open question is whether the structural order and orientation in such mesocrystals really matter in that they significantly change the optoelectronic properties of the array compared to a disordered ensemble of the same NCs? This presentation will detail how a combination of wide- and small angle X-ray scattering techniques in conjunction with X-ray cross-correlation analysis can answer this question.[2] It is established that in ordered arrays of PbS quantum dots anisotropic charge transport prevails, which is attributed to the dominant effect of shortest interparticle distance.[3] Similarly, it will be demonstrated that highly ordered micro-crystals of gold nanoclusters exhibit new optical transitions as well as a 100-fold increase in the charge carrier mobility in comparison to glassy, polycrystalline ensembles.[4] A combination of laser scanning confocal microscopy and X-ray nanodiffraction reveals the impact of structural defects in caesium lead halide perovskite NC mesocrystals onto their collective fluorescence properties.[5] These findings support the hypothesis that nanocrystals may be regarded as “artificial atoms”, and that under certain conditions, analogies between atomic crystals and NC supercrystals may be drawn. The presentation will discuss how far these analogies can go and which potential applications arise from the exploitation of collective effects in mesocrystals.

References

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[2] Mukharamova, N., Scheele, M. et al. *Small* **2019,** 15, 1904954.
[3] Maier, A., Scheele, M. et al. *Adv. Mater.* **2020**, 20, 2002254.
[4] Fetzer, F., Scheele, M. et al. *Nat. Commun.* **2020**, 11, 6188.
[5] Lapkin, D., Scheele, M., et al. *arXiv preprint (*arXiv:2109.05502*)* **2021**.