Engineered assembly of perovskite nanocrystals into ordered 3D architectures: the effect of Mn doping

M. Striccoli[1]*, C.N. Dibenedetto[1], R. Grisorio[2], D. Conelli[2], A. Panniello[1], D. Altamura[3], F. Scattarella[3], G. Suranna[2], C. Giannini[3], E. Fanizza[4,1], M.L. Curri[4,1,]

1 CNR-IPCF, Via Orabona 4 - Bari (Italy) Email: marinella.striccoli@cnr.it

2 Dept of Civil, Environmental, Land, Construction and Chemistry, Polytechnic of Bari -Via Orabona 4 Bari (Italy)

3Chemistry Department, University of Bari “Aldo Moro”, Via Orabona 4- Bari (Italy)

4 CNR-IC, Via Amendola 122/O - Bari (Italy)

Recent advances in colloidal chemistry have significantly expanded the synthesis of metallic, semiconductor, and magnetic nanoparticles, opening new avenues for technological innovation. Among these systems, quantum dots and halide perovskite nanocrystals have garnered substantial attention due to their tuneable electronic structures and distinctive emission characteristics, positioning them as promising materials for optoelectronic devices and quantum information technologies [1].The controlled assembly of nanocrystals into microscale architectures offers a powerful strategy for engineering materials with enhanced or emergent functionalities, while preserving the intrinsic properties of the individual nanoscale building blocks [2]. Within this framework, supercrystals—large-scale, self-assembled arrays of nanocrystals arranged into highly ordered three-dimensional lattices—represent a particularly compelling class of materials. Their final structure is dictated by interparticle ligand–ligand interactions as well as by the size and shape of the constituent nanocrystals, potentially giving rise to collective electronic and optical phenomena [4–7]. In this work, we investigate a slow destabilization approach based on capillary-driven self-assembly in an antisolvent vapor atmosphere to achieve the direct growth of superstructures on solid substrates. Undoped and manganese-doped $CsPbCl_xBr_{3-x}$ perovskite nanocrystals are employed as model building blocks [8]. The resulting superstructures are examined optically, morphologically, and structurally through confocal microscopy, SEM, XRD, and time-resolved spectroscopic techniques, revealing pronounced differences in assembly behaviour, morphology, and optical response induced by Mn doping. These findings provide key insights into how nanoparticle structure and emissive properties influence self-assembly pathways and the resulting collective optical behaviour in supercrystals. Overall, this work establishes a foundation for the rational design of functional nanomaterial-based architectures with tailored properties for next-generation optoelectronic technologies.

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