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Controlled assembly of luminescent colloidal nanocrystals into highly ordered 3D superstructures

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Recent progress in colloidal synthesis has profoundly advanced the synthesis of metallic, semiconductor, and magnetic nanoparticles, opening new perspectives for technological innovation. Among them, quantum dots and halide perovskite nanocrystals have attracted considerable interest due to their tuneable electronic structures and distinctive emission properties, making them promising candidates for optoelectronic applications and quantum information technologies[1]. The controlled organization of nanocrystals into microscale architectures represents a powerful approach for the design of novel materials with enhanced and emergent functionalities, while preserving the intrinsic properties of the individual nanoscale building blocks[2]. Within this context, supercrystals consist of large-scale, self-assembled arrays of nanocrystals forming highly ordered three-dimensional crystalline lattices[3]. Their final architecture is governed by interparticle ligand–ligand interactions and by the shape and size of the constituent nanocrystals, potentially giving rise to collective electronic and optical phenomena[4]. In this work, a slow destabilization strategy based on capillary-driven self-assembly in an antisolvent vapor atmosphere is investigated for the direct growth of superstructures on solid substrates. Undoped and manganese-doped CsPbClxBr3-x perovskite nanocrystals, CdSe quantum dots and gold nanoparticles, are employed as model building blocks[5]. The resulting superstructures, optically, morphologically and structurally investigated reveal remarkable differences in terms of assembly behaviour, morphology, and optical properties. These findings provide crucial insights into how the nanoparticle structures and their optical properties influences the assembly processes and the collective optical behaviour in supercrystals, allowing to design functional nanomaterial-based architectures with tailored properties for next-generation optoelectronic applications.

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