Amorphous to Crystal Conversion As a Mechanism Governing the Structure of Luminescent YV04:Eu Nanoparticles

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Abstract :
The development of functional materials by taking advantage of the physical properties of nanoparticles needs an optimal control over their size and crystal quality. In this context, the synthesis of crystalline oxide nanoparticles in water at room temperature is a versatile and industrially appealing process, but lacks control especially for "large" nanoparticles (> 30 nanometres), which commonly consist of agglomerates of smaller crystalline primary grains. Improvement of these syntheses is hampered by the lack of knowledge on possible intermediate, non-crystalline stages, although their critical importance has already been outlined in crystallisation processes.

Here, we combine time-resolved, in situ SAXS/WAXS and EXAFS to demonstrate that during the synthesis of luminescent Eu-doped YVO4 nanoparticles, a transient amorphous network forms with a two-level structuration. These two pre-structuration scales constrain topologically the nucleation of the nanometre-sized crystalline primary grains within the amorphous network, and their aggregation in nanoparticles, respectively. The amorphous network, which forms within 40 ms, therefore determines the nanocrystalline structure, which forms in the minute range. This template effect not only clarifies why the crystal size is found independent of the nucleation rate, in contradiction with the classical nucleation theory, but also supports the possibility to control the final nanostructure with the amorphous phase.

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