Crystallization of $SrAl_{12}O_{19}$ Nanocrystals from Amorphous Submicrometer Particles

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The use of advanced tools like transmission electron microscopy (TEM) and modern analysis techniques has greatly advanced our understanding of crystallization, particularly from solution, which is crucial for designing and creating specific crystals. However, there is still limited knowledge about the process of crystallization under high-temperature annealing (HTA) conditions, which is commonly used to obtain metal oxide crystals. While hydro-/solvothermal methods are widely used on a small scale in laboratories, HTA is the preferred method in many industries for large-scale production of metal oxide crystals. Unfortunately, the lack of precise control over the shape and size of these crystals under extreme HTA conditions restricts their applications.
In this study, we employed ex-situ TEM to investigate the transformation of a single amorphous spherical submicrometer precursor particle of $SrAl_{12}O_{19}$ (SA_6) into a nanosized hexagonal crystal, which is thermodynamically favored, at a temperature of 1150 °C. The sequential steps of this transformation are observed and explained in detail, illustrating the contributions of both kinetic and thermodynamic factors to the evolution of crystal shape and morphology. The findings reveal a nonclassical process of nucleation and growth, involving densification, formation of crystallite domains, oriented attachment, surface nucleation, two-dimensional (2D) growth, and surface diffusion of atoms, ultimately leading to the formation of a hexagonal platelet crystal. The TEM images also provide insights into a parent crystal that influences the crystal lattice and morphological orientation of a network of interconnected platelets.