The Fast Formation of Yttrium Iron Garnet: an In-Situ Study of Sol-Gel Synthesis

J. Thomas-Hunt [1], M. Christensen [1,2]

1 Department of Chemistry, Aarhus University, Denmark. 2 Department of Materials and Production, Aalborg University, Denmark

jth@chem.au.dk

The sol–gel synthesis route enables atomic-scale mixing of elemental species, enhancing diffusion into the crystal lattice and promoting bottom-up nanoparticle formation. Here, yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) derived from a sol–gel precursor is investigated under rapid sintering conditions using in-situ synchrotron powder X-ray diffraction (PXRD). The in-situ setup, with 0.1 s time resolution and heating rates up to 150 K s^{-1}, allows direct tracking of phase evolution under these extreme conditions [1]. Sequential Rietveld analysis shows that crystallization and growth occur within seconds, predominantly at the end of the heating ramp. The amorphous precursor transforms via transient $YFeO_3$ and Fe_3O_4 phases into YIG, yielding >85 wt% YIG; after initial formation, minimal changes occur during the dwell time at elevated temperatures. These results demonstrate sub-second phase transformations during ultrafast high-temperature sintering using in-situ PXRD and provide a framework for optimizing the rapid synthesis of complex oxides, that have relevance for applications such as spintronics.

[1] P. Shyam, et al., Appl. Mater. Today. (2023). 35, 101960.

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