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Systematic microstructural development with thermal diffusivity behaviour from nanometric to micronic grains of strontium titanate

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Abstract
Strontium titanate is a promising candidate for applications in thermoelectric, thermal management applications, and modern electronic devices because of its desirable thermal stability, chemical stability, and semiconducting behaviour. However, the absence of its important systematic development, having grain size from several nanometric up to micronic size with evolving thermal diffusivity behaviour, triggers the need for filling up the vacuum. Two different heat treatments have been carried out onto the samples which were with presintering and without presintering. Nanometer-sized compacted powder samples were sintered from 500 to 1400 °C using 100 °C increments. The parallel characterizations of structural, microstructural and thermal diffusivity properties were systematically carried out. Interestingly, three significant value-differentiated groups: weak, moderate, and strong thermal diffusivity were observed, resulting from the influence of different phonon-scattering mechanisms through a systematic development of microstructural properties for both heat treatments.

Keywords Thermal diffusivity · Thermal conductivity · Microstructure · Strontium titanate

Introduction

Strontium titanate ($SrTiO_3$) is a promising model material for electroceramic oxides, owing to its pronounced chemical and thermal stability as well as its wide versatility properties [1–3]. An extensive effort for understanding its multifunctional properties has been carried out since a few decades by the researchers working on transition metal oxides and has been greatly garnered interest both for experimentalists and theorists since 1950 [4].

The shape, size, distribution, and orientation of the grains play a key role in many of the macroscopic properties including thermophysical properties particularly thermal diffusivity. Therefore, in the case of polycrystalline materials, microstructural properties play a significant influence on the thermal transport properties, since extrinsic phonon scattered at defects, grain boundaries, and other crystal imperfections, thus affecting the thermal transport properties. Hence, phonon propagations in a material would determine the effectiveness of thermal energy transport in dielectric materials. Grain boundaries and additional phases were thought to be undesirable, and the goal was to eliminate them and obtain a structure as close as to single crystals as possible [5]. Wang et al. [6] have shown the lowest thermal conductivity at 300 and 1000 K, obtained in a 55-nm-grained strontium titanate,

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