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Microstructural evaluation of CaMnO3 ceramics sintered by microwave irradiation for energy harvesting applications

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The use of thermoelectric materials could be a promising solution to a global energy crisis, due to its ability to convert thermal energy into electrical energy. Due to its intrinsic properties, perovskite CaMnO3 (CMO) is a propitious n-type semiconductor oxide for thermoelectric applications. Also, the adoption of microwave sintering in the ceramics processing favors shorter processing times, finer microstructures, and, in some cases, properties equal to or even superior to those of conventionally sintered ceramics. Hence, in this study, microstructural evaluation of CaMnO3 ceramics produced by chemical synthesis and conventionally (CS) or microwave irradiation (MI) sintered ceramics is reported. CaMnO3 powders were produced by the modified Pechini method, which was developed by the Functional Materials Development Group (GDMaF). The raw precursors were CaCO3 and MnO, which were solubilized in citric acid and nitric acid aqueous solutions, respectively. The final solution, obtained from the mixture of previous solutions, was dried at 343 K for 24 h. The non-crystalline powder obtained was calcined, for 3 h, at 1073 K, this temperature was based in differential thermal analysis (DTA). From this dried powder, samples in discs shape were uniaxially pressed under 175 MPa. After, the samples were sintered into a resistive conventional or by microwave irradiation furnaces, both at atmospheric air. After, dilatometric analysis was accomplished to determine the ideal sintering temperature in conventional sintering method. CMO ceramics were conventionally sintered at 1543 K, for 1, 12 and 24 h. By microwave irradiation, CMO ceramics were sintered without a hold time, for 15 min and 30 min at 1573 K. According to X-ray diffraction analysis, for CMO powders and conventionally sintered ceramics, it was confirmed that the CMO phase was predominant, however, a small amount of CaMn2O4 was produced. For microwave irradiation sintered ceramics, CMO was the unique phase present in samples. A scanning electron microscopy (SEM) was used for microstructural analyses. In conventionally sintering, the average grain sizes were 1.04±0.69 ?m, 2.64±1.39 ?m and 4.85±0.35 ?m, for the ceramics sintered for 1, 12 and 24 h, respectively. In microwave sintering, the average grain sizes were 0.46±0.16 ?m, 1.98±0.77 ?m and 3.03±0.27 ?m, for the ceramics sintered without a hold time, for 15 and 30 min, respectively. The CS-CMO ceramics presented equiaxial grains, however, MI-CMO ceramics showed plate-like grains, due to microwave effect and mass flow in preferred direction. For all ceramics, relative apparent densities reached values greater than 71 % of calculated theoretical densities, nevertheless, increasing sintering time culminated in density increases until a certain sintering time and, after, a slight decrease was observed because of grain growth phenomenon. In this way, the sintering technique and sintering time highly influence CMO ceramics microstructure.