FLASH SINTERING AS A ROUTE TO PRODUCE LEAD-FREE PIEZOELECTRIC KNN

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Potassium Sodium Niobate, $K_{0.5}Na_{0.5}NbO_3$ (KNN), is one of the most promising lead-free piezoelectric materials. Flash sintering allows the reduction of both sintering temperature and time which, in the case of KNN, additionally opens up the possibility of overpass the limitations found in conventional sintering, i.e., secondary phase formation and limited final density (< 95% of relative density) due to alkalis volatilization at high sintering temperature (> 1100 ºC) and time (> 2h).

In this work, the Flash sintering of KNN was investigated and the role of variables such as the powder particle size and purity, applied electric field, sintering atmosphere and thermal schedule were accessed using dilatometric experiments with an applied electric field. Simulations studies with Finite Element Modeling, FEM, was used as a tool to model the microstructure of particle contacts and calculate the current density and Joule heating. The simulation data were compared to experimental results of the characterization of Flash sintered samples with XRD, Raman Spectroscopy, SEM and TEM analysis.

The Flash temperature (T_f) of KNN was found to vary between ~300ºC and ~900ºC, depending on some powder and processing variables, such as the density of contacts and surface conductivity of green compacts, sintering atmosphere and applied electric field. Liquid-phase assisted sintering is shown to be the prevalent FLASH sintering mechanism of KNN and by the selection of the appropriate powder and processing variables, high dense (95% of relative density) single phase ceramics could be achieved by Flash. Besides, despite some leakage currents, FLASH sintered KNN can be polarized and its ferroelectric characteristic determined. It is shown that FLASH sintered KNN behaves very closely to conventionally sintered one, in terms of permittivity as a function of temperature, with a Curie temperature of approximately 420 ºC.