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Ceramics of potassium sodium niobate by field–assisted sintering techniques: Spark plasma sintering versus spark plasma texturing

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[1] Teresa Hungria, Jean Galy, Alicia Castro, Spark Plasma Sintering as a Useful Technique to the Nanostructuration of Piezo-Ferroelectric Materials, Advanced Engineering Materials, 11, 8, 615 – 631, 2009. [2] R. Wang, R. Xie, T. Sekiya, and Y. Shimojo, "Fabrication and characterization of potassium-sodium niobate piezoelectric ceramics by spark-plasma-sintering method," Mater. Res. Bull., vol. 39, no. 11, pp. 1709–1715, 2004. [3] M. Bah, F. Giovannelli, F. Schoenstein, G. Feuillard, E. Le Clezio, and I. Monot-Laffez, "High electromechanical performance with spark plasma sintering of undoped K0.5Na0.5NbO3 ceramics," Ceram. Int., vol. 40, no. 5, pp. 7473–7480, 2014. [4] R. López-Juárez, F. González-García, J. Zárate-Medina, R. Escalona-González, S. D. De La Torre, and M. E. Villafuerte-Castrejón, "Piezoelectric properties of Li-Ta co-doped potassium-sodium niobate ceramics prepared by spark plasma and conventional sintering," J. Alloys Compd., vol. 509, no. 9, pp. 3837–3842, 2011. [5] G. Noudem, D. Kenfaui, D. Chateigner, and M. Gomina, "Toward the enhancement of thermoelectric properties of lamellar Ca3Co4O9 by edge-free spark plasma texturing," Scripta. Materialia, vol. 66, no. 5, pp. 258–260, 2012.

CERAMICS OF POTASSIUM SODIUM NIOBATE BY FIELD-ASSISTED SINTERING TECHNIQUES: SPARK PLASMA SINTERING VERSUS SPARK PLASMA TEXTURING

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Key Words: KNN, Spark-Plasma-Sintering, Spark-Plasma-Texturing, electroceramics, peizeoelectrics

Potassium sodium niobate (KNN) is one of the most promising lead-free systems. However, undoped KNN has poor sinterability and by conventional sintering results in inadequate densification and, consequently, in inferior physical and electrical properties. The highly volatile alkaline sodium and potassium do not permit the increase of the sintering temperature somehow required to densify the niobium based ceramics. This conflict can be solved if the mass transport during the sintering step is enhanced, since the temperature and time needed for consolidation must be reduced in order to avoid volatilization. Among the methods reported for activation of the mass transport during the sintering process, the application of an electrical current through the sample during heating represents a promising technique for rapid densification of ceramics at relatively low temperatures [1]. The most novel and increasingly used among Field-Assisted Sintering Techniques (FAST) is Spark Plasma Sintering (SPS). SPS has been tried before to densify KNN ceramics. Dense SPS KNN ceramics with densities around 96 % presented enhanced dielectric properties (ε_r = 557) [2-3]. In what concerns the electromechanical performance of piezo and ferroelectrics, their dependence on the ferroelectric domain structure and crystallographic orientation is also well known. Because the microstructure of the ceramics determines average structural orientation and domain configuration, in this work an alternative FAST is used, i.e. Spark Plasma Texturing (SPT). SPS and SPT are quite similar, however in SPT, the sample is allowed to deform freely during the pressure stage [4]. Here we report the enhanced properties of KNN ceramics sintered by SPT. By using SPT, we were able to achieve denser ceramics (100 % densification) with a reduced average grain size ($\bar{G}$ = 1.24 µm). This ceramics present a moderate dielectric response (ε_r = 238), enhanced piezoelectric response (d_{33} = 125 pC/N) and unique ferroelectric response (P_r = 38 µC/cm^2 and E_c = 14 kV/cm) (Figure 1). The comparison between SPT and SPS is established and the mechanisms discussed.

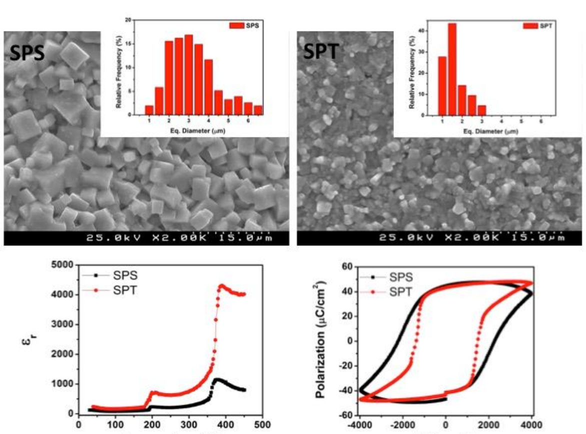

Figure 1 – Comparison between SPS and SPT samples in terms of microstructure, dielectric and ferroelectric response.

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