



# Electroceramics for End Users XII: PIEZO2023 with Ferroelectrics UK



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# Properties of PZT and KNN Electroceramics Sintered by SPS Without Post-Annealing

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Pb(Zr,Ti)O<sub>3</sub> and (K,Na)NbO<sub>3</sub> are perovskite ABO<sub>3</sub> piezoelectric oxides that share the propensity for volatility of the A-site cations which adversely affects the electrical performances. KNN is one of the lead free challenging piezoelectric material but PZT, despite its lead content, is still studied because of its unrivalled properties. Conventional production of piezoceramics include an energy consuming sintering step, typically above 1000°C for several hours. This step rises several issues related to the chemistry and the microstructure. Our goal is to reduce the PZT and KNN sintering temperature, with no post-thermal treatment while achieving properties comparable to those obtained with conventional high-temperature sintering. Spark Plasma Sintering (SPS) whose efficiency rely on the combination of pressure and pulsed current was already used to sinter PZT and KNN ceramics but with sintering temperatures usually higher than 900°C; also a post-annealing treatment under air (700 – 1000 °C) was mandatory to eliminate oxygen vacancies and recover insulating properties. In this work, the effect of sintering conditions, as well as the role of a protective layer between the mold and the powder, have been studied. Commercial powders are used, a micrometer sized PZT powder and a nanosized KNN powder. With the use of a protective layer, made of carbonate powder, and directly placed on the piezoelectric bed PZT powder, the best properties were obtained for the PZT ceramic at 875°C for 5 min. The relative density was 98% and the permittivity and electromechanical coupling factor  $k_{\text{eff}}$  were respectively 1500 and 40%. For KNN powder, thanks to the reactive nanopowder, with a temperature as low as 700°C and no protective layer, a relative density of 96% was achieved. Here the post-annealing was not compulsory and the KNN ceramics exhibit a permittivity of 660 with a low dissipation factor (0.02). Piezoelectric characterizations are under progress for KNN.

**Keywords:** KNN, PZT, protective layer, SPS, post-annealing, dielectric and piezoelectric properties