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Lead-free, textured piezoelectric ceramics

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Piezoelectric ceramics are key materials in many applications, such as actuators for fuel injection, sensors for flow monitoring, and transducers for medical imaging. However, the vast majority of the materials are based on lead oxides such as $(\text{Pb,Zr})\text{TiO}_3$, and more sustainable, lead-free replacement materials are sought after. The biocompatible $\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3$ (KNN) is therefore being explored, for example for use in high-frequency ultrasound. Ultrasound above >20 MHz is rapidly becoming an established clinical tool for the high-resolution imaging of blood vessels and many other superficial structures requiring low penetration depth, such as skin tumors, exterior segments of the eye and small animals.^{1,2} The transducer is mainly composed of a piezoelectric material that generates ultrasound. At present, active layers are nearly always lead-based, they do however have a high specific gravity and acoustic impedance (~ 35 MRayl), and are incompatible with future legislations.³ Recently, Huo and colleagues reported an ultrahigh electromechanical coupling factor ($k_{33} \sim 95\%$) in a single crystal of KNN doped with Li, Ta and Mn.⁴ Single crystals provide high properties, but are expensive and challenging to fabricate. Textured ceramics (ceramics with crystallographically aligned grains) can therefore be a good solution.⁵ In this work, we are exploring textured lead-free piezoelectrics for high-frequency ultrasound transducers, based on the high- k_{33} composition of KNN doped with Li, Ta and Mn. The first results on synthesis of textured ceramics will be presented.

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