Textured Lead-free Piezoelectrics for High-frequency Ultrasound Imaging

Astri Bjørnetun Haugen[1*], Erling Ringgaard[2], and Franck Levassort[3]
[1]Department of Energy Conversion and Storage, Technical University of Denmark
Frederiksborgvej 399, 4000 Roskilde, Denmark
[2] MEGGITT Sensing Systems
Porthusvej 4, 3490 Kvistgaard, Denmark
[3] GREMAN UMR 7347 CNRS, François-Rabelais University, 26 Rue Pierre et Marie Curie,
37100 Tours, France
*Astri Bjørnetun Haugen: ahua@dtu.dk

High-frequency (>20 MHz) ultrasound transducers are 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 piezoelectrics such as $(Pb,Zr)TiO_3$, due to their high performance and versatility, optimized over several decades. However, lead-based materials have a high specific density and acoustic impedance (~35 MRayl), and are incompatible with future legislations.[3] Lead-free transducers, e.g. based on the biocompatible $K_{0.5}Na_{0.5}NbO_3$ (KNN), are therefore being explored.[4,5]

Recently, Huo and colleagues reported an ultrahigh electromechanical coupling factor (k_{33} ~95%) in a single crystal of Li, Ta and Mn-doped KNN.[6] Single crystals provide high properties, but are expensive and challenging to fabricate, therefore can textured ceramics be a good solution.[7] In this work, we are exploring textured lead-free piezoelectrics for high-frequency ultrasound transducers, based on the novel Li, Ta and Mn-doped KNN composition[6]. First results will be presented on the processing of such piezoelectric textured layers on substrate considered as a backing for high frequency transducer applications.

[1] Y. Chen, W.B. Qiu, K.H. Lam, B.Q. Liu, X.P. Jiang, H.R. Zheng, H.S. Luo, H.L.W. Chan, *et al.*, *Ultrasonics*, **56** 227–31 (2015).
[2] K.K. Shung, J.M. Cannata, and Q.F. Zhou, *J. Electroceramics*, **19** 139–145 (2007)
[3] European Parliament and The Council Of The European Union, *Off. J. Eur. Union*, **13** 1–24 (2003)
[4] N.M. Hagh, B. Jadidian, E. Ashbahian, and A. Safari, *IEEE Trans. Ultrason. Ferroelectr. Freq. Control*, **55** [1] 214–224 (2008)
[5] F. Levassort, K. Astafiev, R. Lou-Moeller, J.-M. Grégoire, L. Nielsen, W.W. Wolny, and M. Lethiecq, *Proc. Acoust. 2012*, 85–90 (2012)
[6] X. Huo, R. Zhang, L. Zheng, S. Zhang, R. Wang, J. Wang, S. Sang, B. Yang, *et al.*, "(K, Na, Li)(Nb, Ta)O3:Mn Lead-Free Single Crystal with High Piezoelectric Properties," *J. Am. Ceram. Soc.*, **98** [6] 1829–1835 (2015).
[7] A.B. Haugen, G.H. Olsen, F. Madaro, M.I. Morozov, G. Tutuncu, J.L. Jones, T. Grande, and M.-A. Einarsrud, *J. Am. Ceram. Soc.*, **97** [12] 3818–3825 (2014)