Fabrication and characterisation of high-frequency ultrasonic transducers based on piezoelectric thick films and porous backing

Danjela Kuscer\textsuperscript{1}, Tina Bakarič\textsuperscript{1}, Silvo Drnovšek\textsuperscript{1}, Barbara Malič\textsuperscript{1}, Julien Bustillo\textsuperscript{2} and Franck Levassort\textsuperscript{2}

\textsuperscript{1}Jozef Stefan Institute, Slovenia
\textsuperscript{2}François Rabelais University, France

The properties of the high-frequency transducer (>20 MHz), in particular its operating frequency, sensitivity and resolution, are defined by the geometry, microstructure and characteristics of piezoelectric material and backing. For the backing, acoustical impedance and attenuation coefficient are predominant properties to be determined. In this work, we proposed a novel method for the in-situ measuring of these backing’s properties at the operating frequency of the transducer.

We report on the processing and characterization of lead-zirconate-titanate based (PZT) piezoelectric thick films on a porous backing with tailored amount, size and shape of the pores. As a porous backing we used ~5mm-thick ceramic with nominal composition Pb(Zr\textsubscript{0.53}Ti\textsubscript{0.47})O\textsubscript{3} (PZT). The ceramic was prepared by hetero-coagulation process of PZT and polymethylmetacrylate in water at pH 8 followed by sintering the powder compacts at 1080 °C. Ceramic exhibited homogeneous microstructure with 15 % porosity and spherical, ~1 and ~10 µm-sized pores, respectively. The PZT thick films, screen-printed onto the electroded backing and sintered at 900 °C, had a thickness of ~25 µm, porosity of 20 % and thickness coupling coefficient of 45 %.

This integrated piezoelectric structure allows direct acoustic measurements of transducer components. The PZT thick film is electrically excited to measure the electroacoustic response in water and also the back-wall echoes coming from the backing if its thickness is sufficiently thin. The thickness of the backing was successively reduced and the measurements were repeated.

In the frequency range 15-25 MHz, the attenuation coefficients of backings with 1- and 10-µm-sized pores were 0.7 dB/mm/MHz and 4 dB/mm/MHz, respectively, the group velocities were ~3400 m/s which results in the acoustic impedance of ~22 MRa. The high attenuation in backing with 10 µm-sized pores and moderate acoustical impedance enable substantial miniaturisation of high-resolution ultrasonic imaging transducers.

Recent Publications

Biography

Asst. Prof. Danjela Kuscer, PhD in material science at the University of Ljubljana, Slovenia (1999). Current position: senior researcher at Jožef Stefan Institute and Assistant Professor at Jožef Stefan International Postgraduated School, Ljubljana, Slovenia.

Research: synthesis and characterisation of complex-composition ceramic applicable in electronics, including synthesis of (nano) powders by mechanically-assisted and solid state synthesis, synthesis of ceramic with tailored microstructure, patterning of thick film structures using water- and organic-based suspensions by electrophoretic deposition, screen- and inkjet printing, and their structural, microstructural and functional characterisation.

Publications: 120 publications and 150 technical reports. She holds one Slovenian, two USA patents and three PCT patent applications. She participated in 31 projects, of which she leads 7 EU and 5 national applied projects. Between 2014 and 2017 she won six national awards for the innovation in the field of ceramics, the most important being Puh recognition for 2015, the highest Slovenian science award for important applied work.

danjela.kuscer@ijs.si