# Curved Piezoelectric Thick Films for High Resolution Medical Imaging

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## ABSTRACT

Piezoelectric thick films which have typical thickness between 20 and 60 micrometers and high thickness coupling factor (comparable to those of bulk ceramic with similar compositions, i.e. over 40%) have been under development for high frequency transducer applications for several years. The corresponding resonant frequency range is 20-60 MHz. These piezoelectric thick films with high efficiency are fabricated by different processes such as tape-casting or screen-printing. These techniques can be applied to deliver flat samples but require the addition of an acoustical lens to focus the beam.

This paper presents the performance of a high frequency single element transducer using a new integrated multilayer structure where a thick film is directly deposited on a spherical curved substrate. The chosen substrate is a commercial porous PZT (Ferroperm Piezoceramics Pz37) which is directly used as the transducer backing. For this, an unpoled cylindrical PZT sample with a thickness of 8 mm and a diameter of a few millimeters is used. The top face is machined to obtain a spherical surface with a radius of curvature which defines the focal distance of the transducer (typically between 6 and 10 mm). Then a gold bottom electrode is painted on and the PZT thick film is deposited by the pad-printing technique. Finally, a top electrode is painted on and the thick film is poled. The final thickness of the film is around 20 micrometers and the measured thickness coupling factor is over 40%. In this structure, the volume fraction of porosity in the substrate (24%) is higher than in the piezoelectric thick film which delivers a resonant frequency at 50 MHz. Based on these structures, the fabrication of single element transducers is relatively easy since there are less fabrication steps. Transducers have been characterized in terms of pulse-echo responses at the focal point (sensitivity, axial resolution) and radiation pattern (lateral resolution and depth of field). Results show that the sensitivity and axial resolution for the transducer integrating the pad-printed thick film are high. To compare the performance of this transducer with classical designs integrating $LiNbO_3$ or PVDF piezoelectric materials, simulations based on an extended KLM scheme and a propagation model have been performed where similar characteristics have been kept constant, such as center resonance frequency and focal distance. The results show clearly the interest of this pad-printing technology. Finally, transducers have been successively integrated in a high frequency medical imaging system to obtain in vivo human skin images and in a scanning acoustic microscope to produce images of reference objects.

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