# Transparent High Frequency Electrostrictive Ultrasound Transducers

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## Background, Motivation and Objective

Transparent ultrasound arrays could open up possibilities for through-illumination photoacoustic imaging and combined optical-photoacoustic imaging. Here we propose development of transparent/translucent ultrasound transducers based on hot-pressed lead magnesium niobite (PMN). These electrostrictive materials are manufactured without any PT-doping so the material is not piezoelectric without an applied bias voltage and has no residual polarization or polarization hysteresis. They possess a giant dielectric constant as high as 20,000, leading to extremely high electrostrictive coefficients. These materials are highly optically-transparent when polished on the both sides (Fig. 1. A) and an ITO layer can be used to form the electrodes. These kinds of transducers will facilitate light delivery for photoacoustic imaging and could enable optical imaging through the array.

## Statement of Contribution/Methods

We fabricated both bulk- and composite transducer. To form a single element transducer, a bulk piece of hot-pressed PMN is cut into ~1mm thick sample followed by double sided grinding into the desired thickness for a 20MHz transducer. Then the sample is polished to be optically-transparent, followed by ITO deposition (~200nm) on the both sides to form the electrodes. To form a composite single-element translucent transducer, bulk hot-pressed PMN was diced into pillars and filled with epoxy then lapped to the desired thickness. We used an impedance analyzer to characterize the resonance and anti-resonance frequencies and to estimate electromechanical efficiency as a function of bias voltage.

## Results/Discussion

The fabricated 20MHz single-element bulk transducer showed high transparency with >80% transparency in the visible-NIR range. The polished composite array was translucent but not transparent. Impedance analyzer results, shown in Fig. 1. B, indicate an electromechanical efficiency $k_t$ of 0.37 at a 40V bias level or 0.72 at 80V. This level of performance is comparable with single-crystal PMN-PT. This is the first demonstration of hot-pressed PMN as an electrostrictive transparent transducer. With additional work we aim to demonstrate arrays with transparent matching and backing layers and in particular demonstrate row-column arrays for next-generation 3D photoacoustic imaging.

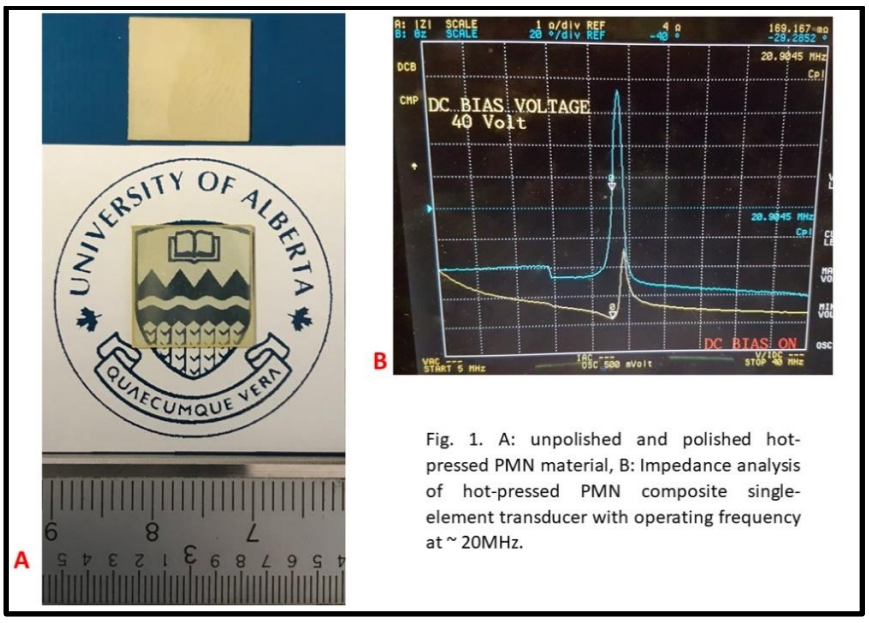


Fig. 1. A: unpolished and polished hot-pressed PMN material, B: Impedance analysis of hot-pressed PMN composite single-element transducer with operating frequency at ~ 20MHz.