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Manufacture and optimisation of ZnO-based high-frequency transducers

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The aim of this work is to design and optimise ZnO-based BAW transducers operating at Gigahertz frequencies, with good vibration transmission and suitable electrical impedance (50 Ω). These volume wave transducers will be used for MEMS applications, in particular for nano-scale non-destructive testing (NDT), including the characterisation of interface defects and complex media.

High-quality ZnO films with a marked C-axis orientation are obtained using optimal sputter deposition conditions. The best crystallinity (ZnO (002) peak intensity and width at mid-height) was observed for deposition with an Ar:O_2 ratio of 80:20. Thickness homogeneity and deposition rate were rigorously controlled. Simulations based on the Auld model enabled us to define the transducer geometry so as to achieve a resonance of around 2.2 GHz.

The transducers are capable of generating volume waves in the 1.5–3 GHz range, with a central frequency of 2.2 GHz. They have insertion losses of around 4 dB and efficiencies of 17 dB. To improve their response, they were heat treated at 400°C. This treatment considerably optimised the crystallinity of the ZnO film, particularly in terms of the intensity of its peak (002) and FWHM (width at half maximum). The amplitude of the first purely acoustic echo showed an improvement of up to 38%. The annealing also resulted in a reduction in transducer insertion loss of around 3 dB and a gain in efficiency of around 3 dB. To further improve the response of the transducers after annealing, an electrical matching study will be carried out to reduce the imaginary component of the impedance.

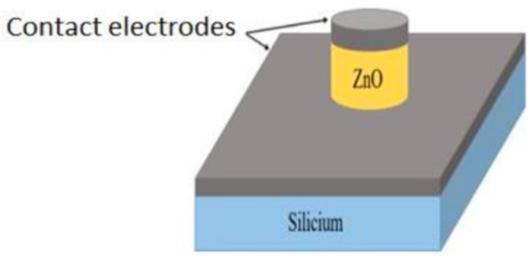

Figure 1: Ultrasonic transducer

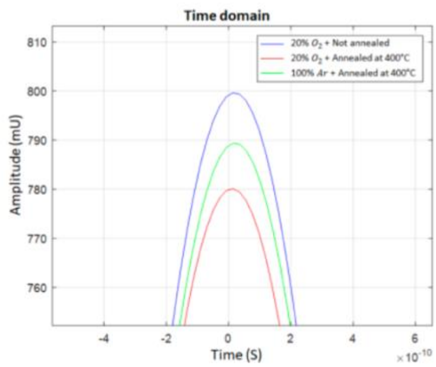

Figure 2: Acoustic response