PULSED LASER DEPOSITED $Pb(Zr,Ti)O_3$ THIN FILMS WITH EXCELLENT PIEZOELECTRIC AND MECHANICAL PROPERTIES

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We present for the first time the combined measured piezoelectric and mechanical properties of epitaxial, (110) oriented $Pb(Zr_xTi_{1-x})$ (PZT) thin films grown on microfabricated silicon cantilevers using pulsed laser deposition (PLD, x=0.4, 0.52, 0.6 and 0.8). The grown PZT thin films develop a strong (110) preferred orientation, which results in an effective piezoelectric coefficient ($d_{33,f}$) of 123 pm/V at the morphotropic phase boundary (Zr/Ti = 52/48). This value is 70% higher compared to sol-gel deposited films with an equal Young's modulus [1]. The Young's modulus of the PZT thin films was determined by measuring the shift in resonance frequency of microfabricated cantilevers (shown in Fig. 1) both before and after deposition of the films by means of a scanning laser-Doppler vibrometer. To this end, we developed a model to calculate the Young's modulus from the resonance frequency shift which includes an essential correction for the undesired undercut that is unavoidably introduced during the release of cantilevers [2]. The obtained Young's modulus is independent on cantilever length, as expected. For a 100 nm thick PZT film with a Zr/Ti ratio of 60/40, the mean value of the measured Young's modulus was found to be 122 GPa with a standard error of ± 1.3 GPa. Fig.2 shows an increase of the Young's modulus of the PZT thin films with increasing Zr/(Zr+Ti) ratio. The PLD-PZT thin film presented in this work combines excellent piezoelectric properties with a high Young's modulus, and is therefore a promising and exciting candidate for the active device layer in actuators and highly sensitive MEMS sensors.

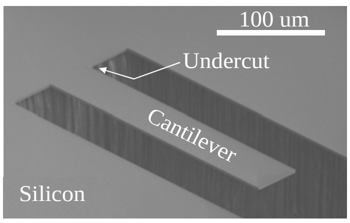

Fig. 1. Micromachined silicon cantilever

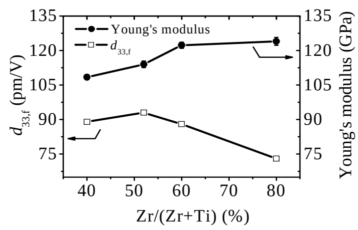

Fig. 2. $d_{33,f}$ and Young's modulus vs Zr/Ti ratio.

[1] S.H. Kim *et al.*, *Jpn. J. Appl. Phys.*, **42**, 5952 (2003).
[2] H. Nazeer *et al.*, accepted for publication in *Microelectron. Eng.*, (2011).