Quantitative and High Spatial Resolution d_{33} Measurement of Piezoelectric Bulk and Thin Films

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A single beam laser interferometer based on a modified Mirau detection scheme with a vertical resolution of 5 pm was developed for localized d33 measurements on patterned piezoelectric films. The tool provides high spatial resolution (2 lm), essential for understanding scaling and processing effects in piezoelectric materials. This approach enables quantitative information on d33, currently difficult in local measurement techniques such as piezoresponse force microscopy.

The interferometer is built in a custom microscope and employs a phase lock-in technique in order to detect sub-Angstrom displacements. d33 measurements on single crystal 0.67PbMg0.33Nb0.67O3-0.33PbTiO3 and bulk PbZrTiO3-5A ceramics demonstrated agreement within <3% with measurements using a double beam laser interferometer. Substrate bending contributions to out-of-plane strain, observed in thin continuous PbZr0.52Ti0.48O3 films grown on Si substrates is reduced for electrode diameters smaller than 100 lm. Direct scanning across room temperature and 150 C poled 5 lm and 10 lm features etched in 0.5 lm thick PbZr0.52Ti0.48O3 films doped with 1% Nb confirmed minimal substrate contributions to the effective d33,f. Furthermore, enhanced d33,f values were observed along the feature edges due to partial declamping from the substrate, thus validating the application of single beam interferometry on finely patterned electrodes.