Challenges in Double-beam Laser Interferometry Measurements of Fully Released Piezoelectric Films

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When utilizing double-beam laser interferometry to assess the piezoelectric coefficient of a film on a substrate, probing both top and bottom sample surfaces is expected to correct the erroneous bending contribution by canceling the additional path length from the sample height change. However, when the bending deformation becomes extensive and uncontrolled, as in the case of membranes or fully released piezoelectric films, the double-beam setup can no longer account for the artifacts, thus resulting in inflated film displacement data and implausibly large piezoelectric coefficient values. This work serves to identify these challenges by demonstrating d33,f measurements of fully released PZT films using a commercial double-beam laser interferometer. For a 1 μm thick randomly oriented PZT film on a 10 μm thick polyimide substrate, a large apparent d33,f of 9500 pm/V was measured. The source of error was presumably a distorted interference pattern due to the erroneous phase shift of the measurement laser beam caused by extensive deformation of the released sample structure. This effect has unfortunately been mistaken as enhanced piezoelectric responses by some reports in the literature. Finite element models demonstrate that bending, laser beam alignment, and the offset between the support structure and the electrode under test have a strong influence on the apparent film d33,f.