Designing Piezoelectric Films for Micro Electromechanical Systems

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Abstract: Piezoelectric thin films are of increasing interest in low-voltage micro electromechanical systems for sensing, actuation, and energy harvesting. They also serve as model systems to study fundamental behavior in piezoelectrics. Next-generation technologies such as ultrasound pill cameras, flexible ultrasound arrays, and energy harvesting systems for unattended wireless sensors will all benefit from improvements in the piezoelectric properties of the films. This paper describes tailoring the composition, microstructure, orientation of thin films, and substrate choice to optimize the response. It is shown that increases in the grain size of lead-based perovskite films from 75 to 300 nm results in 40 and 20% increases in the permittivity and piezoelectric coefficients, respectively. This is accompanied by an increase in the nonlinearity in the response. Band excitation piezoresponse force microscopy was used to interrogate the nonlinearity locally. It was found that chemical solution-derived PbZr(0.52)Ti(0.48)O(3) thin films show clusters of larger nonlinear response embedded in a more weakly nonlinear matrix. The scale of the clusters significantly exceeds that of the grain size, suggesting that collective motion of many domain walls contributes to the observed Rayleigh behavior in these films. Finally, it is shown that it is possible to increase the energy-harvesting figure of merit through appropriate materials choice, strong imprint, and composite connectivity patterns.

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