Low-Cost, Damage-Free Patterning of Lead Zirconate Titanate Films

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Abstract: The ability to pattern piezoelectric thin films without damage is crucial for the development of microelectromechanical systems. Direct patterning of complex oxides through microcontact printing was explored as an alternative to subtractive patterning. This process utilized an elastomeric stamp to transfer a chemical solution precursor of a piezoelectric material onto a substrate in a desired pattern. Polyurethane-based stamps improved wetting of polar solutions on the stamp. This allowed for high-fidelity patterning over multiple stamping cycles. Microcontact printing deposited patterned PbZr0.52Ti0.48O3 layers from 0.1 to 1m in thickness. The lateral feature sizes attained varied from 5 to 500m. Upon crystallization at 700 degrees C, the features formed phase-pure perovskite PZT. The printed features had comparable electrical and electromechanical properties to those of continuous PZT films of similar thicknesses. For example, 1m thick PZT features had a permittivity of 1050 and a loss tangent of 0.02 at 10kHz. The remanent polarization was 30C/cm2, and the coercive field was 45kV/cm. The piezoelectric coefficient e31,f was -7C/m2. These values indicated that the microcontact printing process did not adversely affect the PZT crystallization or properties for the thicknesses explored in this work.