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Deposition of PZT thin films onto copper-coated polymer films by means of pulsed-DC and RF reactive sputtering

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In this work, we investigate reactive sputter-deposition of $Pb(Zr,Ti)O_3$ (PZT) thin films directly on copper-coated polymer films. Deposition of PZT on such temperature-sensitive substrates requires a low processing temperature in order to minimize interdiffusion and reaction between the film and the substrate. Another constraint of PZT deposition is lead and titanium resputtering by impinging energetic ions. This limits the maximum ion energy to values below 70 eV.
Large area PZT deposition onto Cu-coated Kapton™ substrates was performed by means of reactive magnetron sputtering from 200 mm diameter metallic targets. Pulsed-DC sputtering has been employed for the Zr-target, RF-sputtering for the Pb-target and high-power-pulse sputtering for the Ti-target. The pulsed-DC mode was optimized to avoid arc events. RF-sputtering has shown to give the best result in terms of preventing droplet formation at the Pb-target. Repetition frequency and duty cycle of the high power pulse at the Ti-target were selected to provide a high current discharge with ions impinging on the substrate at energies of some tens of eV. These ions will affect the film surface by breaking chemical bonds similar to a chemical reaction. They are not able to penetrate into the material and will therefore not cause residual damage. On the other hand, the ion flux carries energy increasing thus the surface temperature of not intentionally heated substrate. This provides the necessary energy for the crystallization of the ceramic film.
Film microstructure characterization was carried out by X-ray diffraction, AFM, and electron microscopy. Composition analysis included X-ray photoelectron spectroscopy and Rutherford back scattering. The dielectric properties and the ferroelectric polarization were examined by measuring C-V characteristics and P-E hysteresis loops. Piezoelectric coefficients were determined by piezoresponse force microscopy. Piezoelectric properties make the films promising for application in flexible piezoelectric sensors, actuators and power generators.

Keywords
Pulsed-DC reactive sputtering
RF reactive sputtering
complex oxide film deposition
temperature sensitive polymer substrate