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PZT thin films on Kapton substrates – a comparison of sputter deposition technologies

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Recently, we demonstrated deposition of $Pb(Zr,Ti)O_3$ (PZT) thin films directly on copper-coated polymer films without intentional substrate heating. Here, the low pressure plasma carries energy to the substrate to be deposited, which leads to an increase of the substrate surface temperature without sufficient heating the substrate itself.
In this work, PZT thin films on Cu-coated Kapton films were fabricated (i) by means of a pulse-modulated RF plasma jet system generating a high density hollow cathode discharge for sputtering inside a PZT hollow cylinder which works simultaneously as a gas nozzle and (ii) by reactive sputtering using RF-, pulsed DC- and high-power pulse modes for the Pb, Zr and Ti targets respectively. RF-sputtering provided the best result in terms of preventing droplet formation at the Pb-target. The pulsed-DC mode was optimized to avoid arc events.
During plasma jet deposition, bipolar pulsed bias was applied on the substrate in order to provide ion and electron bombardment of the grown film and to support the crystallization process. In the case of reactive sputtering, ion and electron bombardments were adjusted by optimizing repetition frequency and duty cycle of the high power current pulse and by RF-biasing the substrate.
Structural analysis of the deposited films was performed by XRD. Depending on deposition conditions, a mixture of oxides (which can be transformed to PZT by RTA) or nanocrystalline PZT was obtained. Composition profiling was carried out by XPS and RBS. Film composition was analysed in a ternary TiO_2-ZrO_2-PbO diagram. The as-deposited films had a lead-enriched layer at the surface. Lead enrichment was obtained also at the PZT/Cu interface, but not at a PZT/Pt one. The bulk film composition was in rhombohedral range near the morphotropic phase boundary of the PZT phase diagram. The impact of deposition parameters on bulk film composition is discussed.

Keywords
sputter deposition
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polymer substrate