Design and Fabrication of Adjustable X-ray Optics Using Piezoelectric Thin Films

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Piezoelectric adjustable optics are being developed for high throughput, high resolution, low mass X-ray mirror assemblies. These optics require robust piezoelectric thin films and reproducible lithographic patterning on curved glass substrates. This work details the cleaning of Corning Eagle XG glass substrates for thin shell X-ray mirrors by a three stage acid and solvent cleaning procedure before a 0.02 mu m Ti adhesion layer and a 0.1 mu m Pt bottom electrode layer was deposited using DC magnetron sputtering. Piezoelectric $Pb(Zr_{0.52}Ti_{0.48})(0.99)Nb_{0.01}O_3$ thin films with a thickness of 1.5 mu m were then deposited by radio frequency magnetron sputtering in three 0.5 mu m layers with intermittent annealing steps in a rapid thermal annealing furnace at 650 degrees C for 60 seconds. Defects observed in the piezoelectric thin films were linked to residue remaining on the glass after cleaning. 112 piezoelectric cells and 100 mu m wide conductive Pt traces were patterned using bilayer photolithography. The photoresist layers were deposited using spin coating at 2000 and 4000 RPM to achieve uniform 1 mu m thick layers, resulting in reproducibly resolved features with limiting resolutions of approximately >25 mu m. The resulting mirror pieces achieved a 100% yield, with average relative permittivity of 1270, dielectric loss 0.047, coercive field 30 kV/cm and remanent polarization of 20 mu C/cm(2). While the defects observed in the films appeared to have not influence on the electrical properties, additional cleaning steps using DI water were proposed to further reduce their presence.