Fabrication of Adjustable Cylindrical Mirror Segments for the SMART-X Telescope

Author(s): R.H.T. Wilke, R.L. Johnson-Wilke, V. Cotroneo, S. McMuldroch, P.B. Reid, D.A. Schwartz, and S.Trolier-McKinstry

Source: IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control, Volume: 61, Issue: 8, Pages: 1386-1692, DOI: 10.1109/TUFFC.2014.3047, Published: AUG 2014

Abstract: The adaptive optics system for the SMART-X telescope consists of piezoelectric $PbZr_{0.52}Ti_{0.48}O_3$ (PZT) thin films deposited on the backside of the mirror. To achieve sufficient strain response from the piezoelectric films, the substrates chosen are thin, flexible glass pieces that can be slumped into the desired curvature. Preliminary testing has been performed using flat pieces and parts that were slumped into a cylindrical geometry. Commercially available boro-aluminosilicate glass segments (100 x 100 mm) were slumped along one axis to a radius of curvature of 220 mm. 2-mu m-thick PZT films were deposited via RF magnetron sputtering on flat glass substrates to demonstrate the viability of the processing approach. The deposited PZT showed high yield (>95%) on 1-cm(2) electrodes. The films exhibited relative permittivity values near 1500 and loss tangents below 0.05. In addition, the remanent polarization was 20 mu C/cm(2) with coercive fields near 30 kV/cm. 1-mu m-thick films with comparable electrical parameters were then deposited onto the slumped substrates. To understand the piezoelectric response of the films and characterize the device performance, influence function measurements were performed. The typical cell response using a 4 V (1.3V(c)) drive voltage corresponded to a 0.5 mu m out-of-plane displacement, which relates to an in-plane strain value larger than 150 ppm. Both of these parameters meet benchmark requirements for reaching the targeted 0.5 arcsecond resolution goal of the SMART-X telescope. These results demonstrate a viable route to fabricate highly functional mirror segments for the SMART-X telescope.