# Process Development for Adjustable X-ray Mirrors

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Thin adjustable X-ray mirrors can correct deformations generated from fabrication, gravity release, mounting stresses, drifting stresses in the reflecting layer(s) and thermal variations while maintaining high angular resolution (< 0.5 arcsecond) and large effective area (< 2 m2) required for future X-ray missions. This work presents fabrication process developments for adjustable mirror segments with actuators for the Lynx X-ray observatory mission concept. Piezoelectric actuator arrays were fabricated on the convex side of precision slumped glass or curved silicon mirror segments using a 1.5 μm thick lead zirconate titanate (PZT) film. A two-layer metal routing scheme with a polymeric insulator was used to independently address 288 actuators on the mirror. The two-layer metal allows narrow kerfs between actuators and increased actuator density. Anisotropic conductive film was used to bond thin flexible copper cables to flat edges of the mirror to interface with external control electronics. This prototype mirror has eight cables with a total of 290 connections to access the array. To reduce the cabling complexity for future mirrors, thin film transistors have been fabricated on the curved mirror to function as access switches. To facilitate this, a mask aligner that allows precision alignment on curved mirror segments was developed and arrays of thin film transistors (TFT) on curved substrates have been tested. TFT and actuator integration on future mirrors will reduce external connections to just two cables with a total of 30 connections. Keywords: Lynx, adjustable optics, X-ray optics, thin film piezoelectric, curved substrate aligner.

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