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Introduction

The conference Adaptive X-ray Optics III met 17 August in San Diego, California, as part of the SPIE Optics + Photonics 2014 International Symposium Optical Engineering + Applications. As with the previous two biannual conferences in this series, its objectives were to provide an effective forum for discussion of recent progress in adaptive or active x-ray optics and to nurture interactions amongst engineers and scientists developing and utilizing active x-ray optics for diverse applications. The 17 papers presented within the 4 sessions of this conference addressed LIGHT-SOURCE APPLICATIONS, ASTRONOMICAL APPLICATIONS, DEVICE DEVELOPMENT, and MODELS AND ALGORITHMS.

LIGHT-SOURCE APPLICATIONS (Session 1) reported on development and application of active or deformable mirrors for use at synchrotron or x-ray free-electron-laser (XFEL) light-source facilities. Session 1's first presentation, by the Osaka University group, described a two-stage focusing system—using two piezoelectric-activated deformable mirrors (DM)—to fine focus an x-ray beam into a 90-nm spot in one dimension. The second presentation proposed a plan to focus an x-ray beam to a 1–2- μm spot at various focal distances at the European XFEL, using a 1-m-long deformable mirror with < 50 nrad RMS slope error. The session's last presentation described a Kirkpatrick–Baez (KB) mirror system with curvature, roll, and pitch adjustment, for the FERMI@Elettra FEL. This presentation showed that measurements of the focal spot (with plastic ablation imprints) agree with theoretical predictions.

ASTRONOMICAL APPLICATIONS (Session 2) reported on the development of active grazing-incidence optics for x-ray astronomy. Session 2's first presentation summarized the requirements for a large-aperture-area (≈ 3 m^2) high-resolution (< 1") x-ray telescope, the technical and programmatic challenges, and several approaches—both static and active—toward achieving this goal. The second presentation described technical requirements for the Square-Meter Arcsecond-Resolution Telescope for X-rays (SMART-X), a mission concept using adjustable x-ray mirrors, which the Smithsonian Astrophysics Observatory (SAO) is leading. Next, a related presentation reported on the current status of technology development of adjustable x-ray optics using thin-film piezoelectric deposition with patterned electrodes on the back of thin slumped-glass mirrors for bimorph (surface tangential) actuation. The session's last presentation discussed an alternate approach, which employs thin-film magnetically smart materials (MSM) in combination with a magnetically hard substrate to provide bimorph-like actuation through the magnetostrictive effect.

DEVICE DEVELOPMENT (Session 3) addressed technology development, fabrication, and characterization of surface-tangential actuators for bimorph adjustment of x-ray mirrors. Session 3's first presentation described the research at

Pennsylvania State University (PSU) to develop thin-film piezoelectric arrays on the backs of slumped-glass mirrors, in support of the SAO-led SMART-X mission concept. Recent progress includes improved device yield and incorporation of zinc-oxide thin-film transistors (TFT) onto pixilated electrodes over the thin-film lead zirconate titanate (PZT) piezoelectric layer, thus providing row-column addressing of individual pixels. The second presentation reported on initial efforts at Brera and at Palermo to correct the figure of thin grazing-incidence optics, using commercially available PZT pads attached to the backs of thin-walled slumped-glass or plastic-foil mirrors for bimorph actuation, in conjunction with feed-back based upon intra-focal x-ray images. The third presentation reported on fabrication and functional characterization at AOA–Xinetics of two x-ray deformable mirrors (XDM)—for use in a Kirkpatrick–Baez (KB) configuration—each with a 4x27 array of lead magnesium niobate (PMN) electrostrictive pads bonded to the back of a 100x300-mm^2 2.5-mm-thick silicon substrate. The next presentation described x-ray (18-keV) characterization of this XDM at an Argonne synchrotron beam line, using Talbot interferometry to monitor the mirror figure at various actuator settings. The fifth presentation reported on optimization, fabrication, and functional testing at AOA–Xinetics of a high-precision XDM, with a 1x45 array of PMN electrostrictive pads bonded to the back of a 450-mm-long thick silicon substrate. The last presentation of the session described calibration of this XDM's actuators and internal sensors (strain gauges and resistance thermometers), using high-precision phasing interferometry at Lawrence Livermore. This presentation concluded with a description of initial experiments in closed-loop operation of the XDM using only information from the internal sensors.

MODELS AND ALGORITHMS (Session 4) reported on analytic and numeric methods applied to problems in active x-ray optics. Session 4's first presentation investigated structures in the defocused x-ray image, showed a relationship with mid-frequency figure errors, and simulated mitigation of these errors using active figure control. The second presentation studied the influence of the mounting configuration on active figure correction and consequent performance of nested thin x-ray mirrors. The third presentation described development of an error-minimization scheme to address the inverse problem in active figure correction of x-ray mirrors. The final presentation of this session and Conference discussed focusing an XUV beam for a pump-probe experiment, which requires de-magnifying a high-harmonic-generation gas target to a 10-µm spot. This investigation simulated the spatial and temporal structure of the spot—focused using 3 toroidal grazing-incidence mirrors—and utilized a genetic algorithm to optimize the focus through active alignment of the 2nd and 3rd toroidal mirrors.

Overall, the presentations in this Conference demonstrate a gradual growth in the utilization of active x-ray optics for light-source applications and progress in developing active-optics technologies for x-ray telescopes. While specific requirements and constraints differ between (ground-based) light-source facilities and (in-space) x-ray telescopes, there are nonetheless many similar hardware, software, and theoretical issues.

We thank the Conference Program Committee for helping to organize the technical program and for fostering broad participation, and the session chairs and presenters for a successful and stimulating conference. We also appreciate the efforts of the SPIE staff in organizing and implementing the Conference and in publishing these Proceedings

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