INTERNATIONAL WORKSHOP ON X-RAY MIRROR DESIGN, FABRICATION, AND METROLOGY

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Preface

The International Workshop on X-Ray Mirror Design, Fabrication, and Metrology (IWXM), Osaka, Japan, was held as a satellite meeting of the Conference on Synchrotron Radiation Instrumentation (SRI) 2009, Melbourne, Australia, in October, 2009. The workshop was organized by a collaboration of scientists from a number of leading synchrotron institutions and universities around the World, such as Osaka University, SPring-8, KEK (Japan), ALS, APS and NSLS (USA), ELETTRA (Italy), ESRF, Synchrotron SOLEIL (France), BESSY (Germany), Diamond (UK), SSRF (China), NSRRC (Taiwan) and PAL (Korea). The workshop followed a series of parallel workshops focused on metrology (1st, 2nd and 3rd International Workshop on Metrology for X-ray and Neutron Optics) and on active X-ray optics (1st and 2nd X-ray and XUV Active Optics Workshop, ACTOP06 and ACTOP08) and included the 3rd workshop on X-ray and EUV active optics (ACTOP09). The workshop brought together more than 100 participants: manufacturers, optical and mechanical engineers, designers, and users of X-ray optics; allowing for free exchange of ideas, highlighting of existing problems and challenges, and searching for ways to improve existing instrumentation for sub-microradian and sub-nanometer accuracy. A visit to the Osaka University mirror fabrication laboratory, SPring-8, and the X-ray free electron laser (XFEL) facility was included in the workshop.

The main topics covered by the workshop were: Finishing technology for X-ray mirrors, Metrology challenges for X-ray mirrors, New concepts for active/adaptive optics, Mirror design and realization, Beamline performance and scientific results obtained by using new X-ray mirrors, and Future specifications for optics at new SR and FEL sources.

The leitmotif of the workshop was a strong understanding that only immediate efforts to improve the quality of X-ray optics and their fabrication and metrology would allow reaching the expected performance of 4th generation X-ray sources (new synchrotron radiation and free electron laser facilities). Promising fabrication methods such as elastic emission machining (EEM), ion beam figuring, and profile deposition are providing unprecedented results in terms of surface finishing and figuring, with accuracy close to 1 nm P-V even on mirrors longer than 100 mm. Realization of the potential of the fabrication techniques is impossible without comprehensive efforts developing both ex situ, and at wavelength, in situ, metrology of X-ray optics. The Long Trace Profiler (LTP) pioneered the ex situ metrology method; and recently impressive highly accurate measurements have become possible with new slope measuring instruments using a precise autocollimator, and with sophisticated data acquisition methods for effective suppression of random noise, systematic errors and errors due to instrumental drifts. Besides the classical methods based on profilometers or interferometers, there are many interesting stitching techniques, in which both high precision and high spatial resolution are simultaneously achieved. In order to test and increase the reliability of metrology measurements, sophisticated calibration methods, such as a method of calibration of modulation transfer functions of surface profilometers based on binary pseudo-random gratings and arrays, are under development.

Use of in situ wavefront sensing techniques, such as Shack–Hartmann sensors and wave-optical phase retrieval methods, for precise characterization and final tuning of X-ray optics were discussed throughout. The in situ techniques have allowed for X-ray beam focusing with a focused spot size of below 50 nm. Some of the techniques combine an active system (with mechanical or piezoelectric actuators); but in only a few cases a direct modification of the optical surface takes place. In this respect, a method of wavefront correction with an additional optical element seems to be very promising.

The importance of increased investment in optical metrology is strongly recognized by the world-wide X-ray community and synchrotron management. New metrology laboratories with high performance, state-of-the-art metrology instrumentation and with excellent environmental conditions are under construction. There are impressive plans for upgrade and further development of the existing laboratories. All these developments are being accomplished in a strong collaboration of scientists and engineers from different institutions.

In conclusion, we hope that the high level of creative cooperation and collaboration of scientists around the world, which we saw during the workshop, will find further development in the course of the next workshop planned to be held at the Diamond Light Source in the spring of 2011.

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