A novel, 1 m long multilayer-coated piezo deformable bimorph mirror for focussing high-energy X-rays

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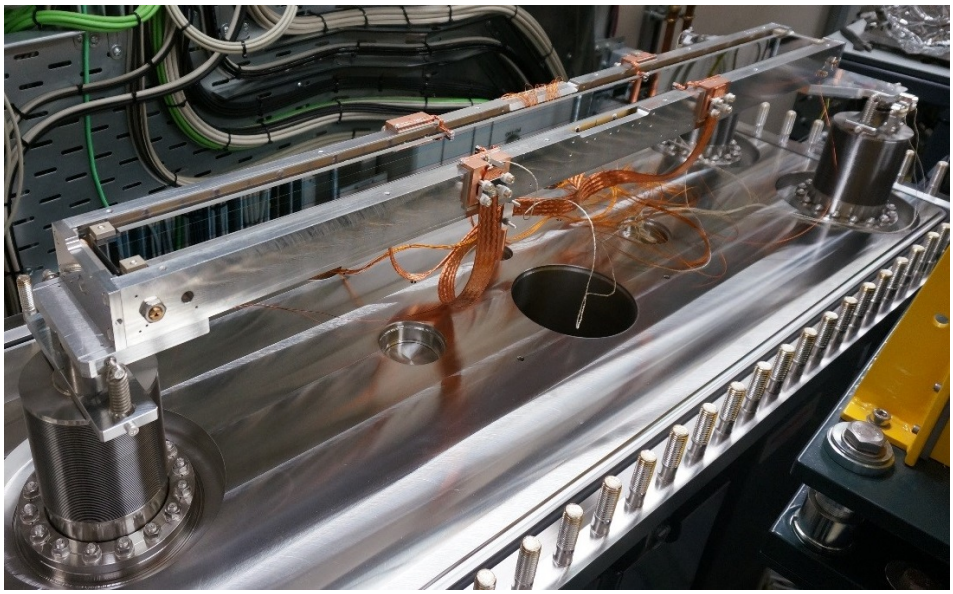
The X-ray pair distribution function beamline I15-1 at Diamond Light Source requires optical elements that focus a wiggler X-ray beam of high energy (40-80 keV) and large area (11.0 mm $\times$ 4.4 mm) into a small spot (FWHM $\sim$ 700 μm (h) $\times$ 20 μm (v)) at a variable distance between sample and detector. X-ray lenses do not reach the necessary effective apertures because of absorption and the limits of fabrication technology. The aperture of conventional silicon X-ray mirrors, even with metal coatings, is likewise limited by the shallow critical angle for high-energy X-rays. As a solution, CINEL manufactured the first multilayer-coated bimorph mirror for use at a synchrotron beamline. A silicon substrate was polished by Thales-SESO to have an elliptically curved surface. The mirror was then coated with three multilayer stripes (Ni/B_4C, W/B_4C, Pt/B_4C) of 1 m length by Rigaku Innovative Technologies. Each stripe's d-spacing was chosen so that the Bragg angle of its first-order reflection would occur at 4.2 mrad at the center of the mirror. Moreover, each stripe's d-spacing was graded along the mirror's length to ensure high reflectivity from the whole stripe. Piezoelectric actuators were then glued to the substrate by Thales-SESO to convert it to a bimorph deformable mirror. This enables the mirror to vary its focusing distance from 3.6 m to 4.8 m, and to compensate for residual long-wavelength slope errors. The mirror's capability to provide vertical focusing exceeding specifications was demonstrated by ex-situ metrology and in-situ X-ray measurements. Representative results will be presented.



The vertically focusing, multilayer-coated bimorph mirror mounted on its holder in the Diamond beamline I15-1.