ESRF	**Experiment title:** High-accuracy metrology of large mirrors with an angle-difference method	**Experiment number**: MI-695
Beamline: BM05	**Date of experiment**: from: 4th May 2004 to: 7th May 2004	**Date of report**: 9th February 2005 *Received at ESRF:*
Shifts: 9	**Local contact(s)**: O. Hignette, E. Ziegler	

Names and affiliations of applicants (* indicates experimentalists):

Jens Illemann*

Michael Schulz

both:

Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Section Imaging Optics

Bundesallee 100, 38116 Braunschweig, Germany

Report:

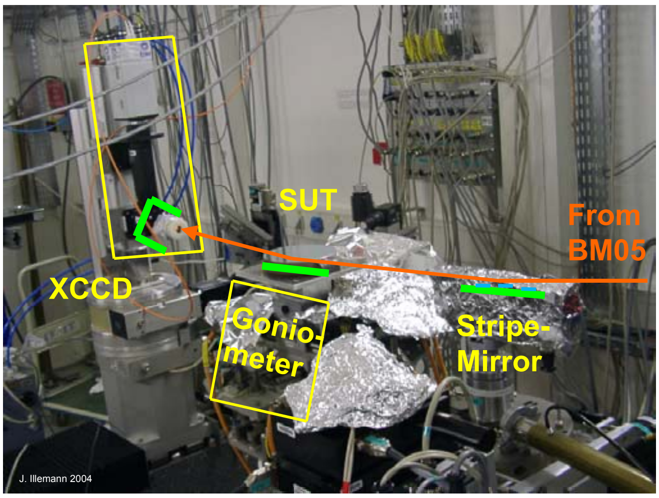

Figure 1: Actual setup during experiments.

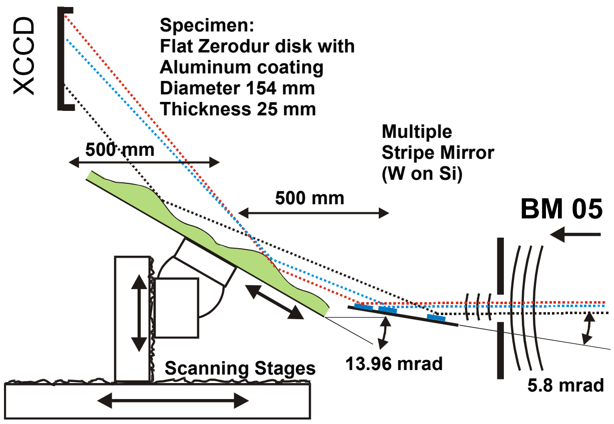

Figure 2: Schematic of the actual experimental setup.

The intention of the experiment was the development of an enhanced technique for determining the surface form of synchrotron mirrors. With the aid of a differential multiple beam deflection method (ESAD) the fluctuations of the synchrotron beam should be eliminated. For the first attempt a slightly different setup as compared to the one proposed was realized (fig. 1 & fig. 2). The multiple stripe mirror (MSM, fig. 3 & fig. 4) serves for the generation of a set of parallel beams. While the X-ray photon energy was adjusted to 11 keV and the incident angle to 5.8 mrad, the synchrotron beam is mainly reflected by the tungsten stripes and not by the silicon substrate. The tungsten stripes have a non-equidistant spacing and a width of 1 mm. This MSM is an ESRF in-house production: In the first step a layer of tungsten was sputtered on a superpolished silicon mirror. In the second step it was ion-beam etched, as the stripes were masked by metal wires.

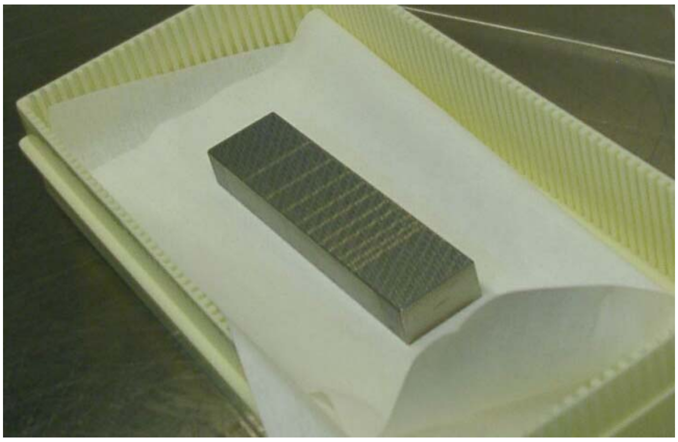

Figure 3: Multi Stripe Mirror (MSM)

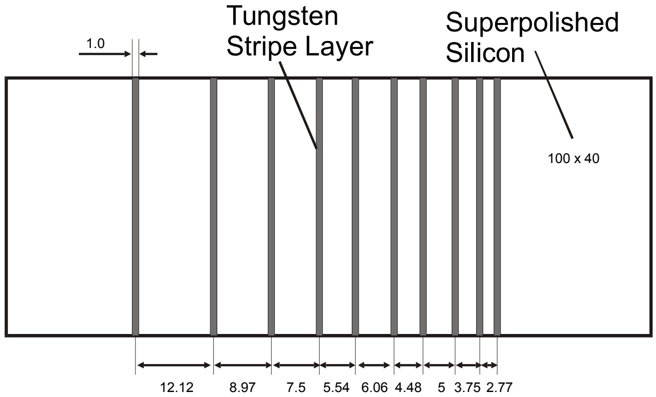

Figure 4: Dimensions of MSM in mm

The surface under test (SUT) is inclined by additional 2.4 mrad to the irradiating beam. So it has a sufficient high reflectivity. At least the radiation reflected two times reaches nearly orthogonal the screen of the XCCD. Here X-ray is converted to visible light and reflected and imaged to a water-cooled camera. This camera has 1280 times 1024 square shaped pixel with size of 2.23 µm. In figure 5-7 are shown exemplary a XCCD image, profile and the magnified detail of the stripe structure.

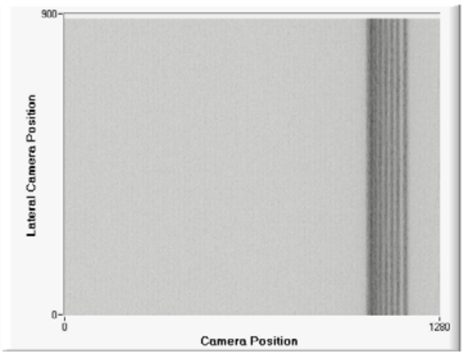

Figure 5: XCCD image

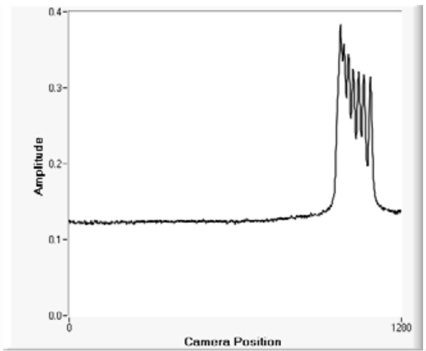

Figure 6: Profile

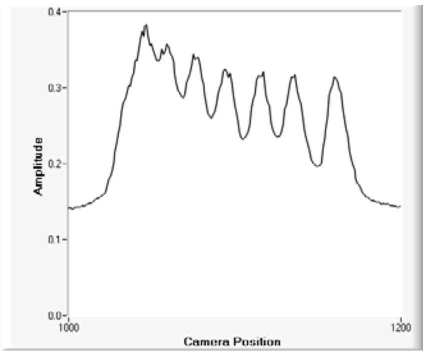

Figure 7: Detail

In this state of setup there are certain drawbacks: the scanning of the SUT has to be done parallel to its direction. This was done by a coordinate control of the horizontal and vertical stage (see fig. 2). This is not sufficiently accurate and not easy to handle. So the reflection point (distance to camera) is not fixed and the stripe structure moves over the field of view of the XCCD. For a new experiment a separate tilted stage has to be used and be aligned orthogonal to the scan direction of the stage by use of an autocollimator. For the given dimensions the angular error of the stage – reduced by a factor of 60 – contributes to the angular error of surface measurement. For that reason the use of a high-quality air-bearing stage is strictly recommended. Another drawback is the diffraction broadening of the detected peaks, that leads to crosstalk between the peak positions. At minimum an accuracy of 0.01 pixel in the determination of peak position differences has to be reached. The only use of changes of peak-position differences results in relaxed requirements: if the position of one peak could be hold constant by a servo loop, the differences would not depend on crosstalk and sub-pixel sensitivity effects for small variations of position. A way to eliminate the diffraction broadening limit is to focus with a third mirror on the XCCD or to bend the MSM.
Recapitulatory the experimental effort has to be increased considerably. Additional mechanical equipment to the present of BM 05 and a focussing mirror are necessary to implement the suggested deflectometric difference method. Further measurements are necessary before a publication should be done.

The authors want to thank the staff members of the ESRF, especially E. Ziegler and O. Hignette. The latter was intensively included in the conceptual planing. He and his team had done preliminary measurements and the production of the stripe mirror.