Commissioning, new developments and new equipment at the Engineering Materials Science Beamline HARWI II

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As has been reported last year [1] GKSS and GFZ are operating the beamline Harwi II in order to perform engineering materials science and geoscience experiments. With the intention of improving the conditions for performing engineering materials science experiments, i.e. texture and residual strain analysis and microtomography, some new equipment has been installed and tested in 2006, and shall be shortly introduced here.

Commissioning of the first monochromator, which was already installed last year, has been performed. It is a fixed–exit double–Laue–crystal monochromator, which scatters in the horizontal and provides a maximum beam of $10 \times 10 \text{ mm}^2$. Using annealed Si 111 crystals (FWHM: $\approx 6^\circ$, thickness: 5 mm) a spectrum was recorded at 17 mm gap, which is shown in fig. 1. With respect to the filters in the beamline (10 mm carbon and 1 mm copper) the intensity maximum was found to be $\approx 1.7 \cdot 10^{10}$ photons/sec/mm$^2$ in the centre of the beam at 75 keV.

A second fixed–exit monochromator has been built up and installed in the monochromator tank. It uses the vertical scattering geometry and consists of a fixed ”first–crystal tower” with crystal changers and a set of three ”second–crystal towers”. The latter are located on a translation stage parallel to the beam and can be independently moved into the beam. Three sets of monochromator crystals can thus alternatively be aligned and used without breaking the vacuum of the tank. The monochromator is optimized for imaging experiments and offers a beam up to 70 mm in width.

![Figure 1: Spectral flux through an aperture of $1 \times 1 \text{ mm}^2$ measured in the optics hutch of HARWI II behind the horizontal monochromator (Si 111 annealed, wiggler gap: 17 mm).](image-url)
The energy range currently available is 16 to 60 k\(\text{eV}\), but shall be extended to higher energies in future. Moreover, new crystal bender units are in construction.

Fig. 2 gives an overview of the new monochromator. More details are presented in [2]. The optics hutch equipment was completed by the installation of a beam diagnostics and beam manipulation table. As shown in fig. 3, various components can be aligned using four linear stages perpendicular to the beam, and the whole equipment can be moved 75 cm aside in order to protect it against radiation in cases of white beam experiments. In the shown configuration the table is equipped with

- a large slit system with a maximum aperture of 85 by 85 mm,
- an ionization chamber, which can be used in the vertical monochromator beam,
- a direct beam camera, which can be used in the horizontal monochromator beam,
- two fast shutters for horizontal and vertical monochromator beam, respectively,
- a diode, which is used to monitor high energy photons,
- a filter box, which is equipped with various iron absorbers, allowing selecting iron thicknesses between 0 and 45 mm in 3 mm steps (fig. 4) and
- an evacuated "white beam" tube.

![Figure 2: View through a maintenance hatch into the monochromator tank. The first tower of the vertical monochromator carries an additional copper block working as calorimeter. The middle tower of the secondary towers ensemble is moved into the beam. Actual energy setting is 36 keV here. In the foreground, the translation stage of the horizontal monochromator is visible.](image)

Figs. 5 and 6 show photographs of the table.
The shutters are newly constructed and differ from those used at other high–energy beamlines in the lab. Each consists of two separate Densimet blocks, which are independently moved into and out
Figure 3: Principle of the operation modes of the diagnostics table. a) Vertical monochromatic beam, b) horizontal monochromatic beam (the table plate is on the right side for both configurations) and c) small fraction of the white beam (the table plate on the left side). The beam–stop for the white beam is located between the monochromator tank and the diagnostics table and the second beamshutter is the last component within the optics hutch.

Figure 4: The interior of the filterbox equipped with 4 different iron absorbers. One slot is still empty. The beam is coming from the right.

of the beam by four pressure cylinders. This design not only allows very fast movements, but also guarantees a homogeneous exposure of the illuminated area. The working principle of the shutters is shown in fig. 7. Since there are two possibilities for the status "shutter closed", the position of each separate block has to be controlled, which at the moment is only done by software, but will in future be carried out using Beckhoff technology.
A detector portal was installed in the experimental hutch I. It consists of a large framework, which covers nearly the whole interior space of the hutch. Two detector carriers equipped with linear travels allow to move two 2D position-sensitive detectors independently to any possible position behind the sample. Numerically, possible locations for the detectors are approximately 0 – 10000 mm behind the sample, -350 – 1500 mm in height with respect to the vertical beam position and ±1140 mm with respect to the horizontal beam position. The positioning accuracy is about 100 μm but will be further enhanced in future by the use of encoders.

As an example, fig. 8 shows one of two available gas-multi-wire detectors (manufactured by DENEX), which will be used for residual stress analyses, mounted on one of the two carriers. In fig. 9 a texture experiment was assembled on one of the experiment tables and an image plate scanner (model MAR 345) was positioned behind the sample using the detector portal.

Figure 5: View of the beam diagnostics table from above. The table is aligned for the vertical monochromator beam, and the beam is coming from the right (marked by the arrow). The red bars symbolize the x-ray beam.

Figure 6: Side view of the beam diagnostics table. The beam is coming from the right.
Figure 7: The working principle of the new shutters (vertical cut). Note the two possibilities a) and b) to open the shutter window.

Figure 8: One of the 2D position-sensitive gas-multi-wire photon detectors mounted on one of the detector portal carriers.

In order to perform in-situ residual stress analysis experiments a stress rig was constructed and manufactured by INSTRON. Tab. 1 summarizes the technical parameters and fig. 10 shows the device. It works servo-hydraulically and is equipped with water-cooled clamps. The rig can be used either in-situ or ex-situ, i.e. for long-term experiments.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Height</td>
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<tr>
<td>Weight</td>
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<td>Mechanical load</td>
<td>±100 kN</td>
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<tr>
<td>Max. sample length</td>
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<td>Max. sample thickness</td>
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<tr>
<td>Free viewing angle</td>
<td>±80°</td>
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</table>

Table 1: Technical parameters of the stress rig.
Figure 9: A diffraction experiment on the experiment table 1 uses an image plate scanner mounted on the detector portal.

Figure 10: The new stress rig shortly after delivery.

References