5.2 Scattering and Imaging

Single-crystal diffraction – the SCD beamline

G. Buth, S. Doyle, A. Rack, T. Weitkamp, S. Trabelsi-Bauer
Forschungszentrum Karlsruhe GmbH, Institute for Synchrotron Radiation (ISS), D-76344 Eggenstein-Leopoldshafen, Germany

^{1}st monochromator crystal cooling scheme

As stated in a previous report [1], performance of the beamline could be significantly improved by switching to an indirect cooling of the 1st monochromator crystal. However intensity oscillations of a few % in amplitude remained observable with the same period as the hunting of the water chiller. For this reason a water reservoir has been introduced in the crystal cooling cycle, significantly reducing the intensity oscillations. It is planned to replace the existing water chiller by a more reliable device with less temperature tolerance to further reduce intensity oscillations.

Switching from CCD to image plate operation

To save time and effort when switching from image plate to CCD operation and vice versa, and also to create space to accommodate the 6-circle diffractometer from the University of Karlsruhe (see separate report [2]), CCD and image plate station have been put on a common M³ table, with the image plate image plate operation within minutes instead of hours by removing shutter and collimator of the CCD station and pivoting the detector out of the beam path.

Improvement of the infrastructure

In conjunction with the relocation of the 6-circle diffractometer from the University of Karlsruhe to the ANKA SCD beamline [2] a number of infrastructure measures have been taken, such as enhancing the capacity of the mains power supplies, replacing the air conditioning by a device with more cooling capacity and continuous control and mounting the controllers of the D8 diffractometer and the CCD camera into a smaller rack.

References

[1] G. Buth, S. Doyle, K. Eichhorn, D. Lübbert & L. Helfen, ANKA Annual Report 2005, p. 156
[2] K. Eichhorn and G. Buth, ANKA Annual Report 2006

Imaging – the beamlines TOPO-TOMO and IMAGE beamline

With the successful separation of the former Fluorescence and Topography (FLUO-TOPO) beamline into two independent beamlines, the monochromator as well as the filter system originally located at FLUO-TOPO were transferred to the new fluorescence beamline FLUO, leaving only slits and a shutter at the TOPO-TOMO beamline. A new multilayer monochromator for TOPO-TOMO is currently under design.

In the meantime, equipment for tomography and topography with white light has been set up. Care has been taken to ensure that the components can be used at the future insertion-device beamline IMAGE as well.

A sample manipulator for high-resolution microtomography is now available. It consists of two high-precision motorized stages for sample rotation and transverse linear movement during tomographic scans (Micos GmbH, Eschbach, Germany), and a cradle and elevation stage for sample alignment (Huber Diffraktionstechnik, Rimsting, Germany).

An imaging detector system for microtomography with a field of view of up to 15 mm width and spatial resolution down to 5 µm is operational as well. The optics of this detector consists of large-aperture objective lenses for special use with X-ray detectors (Rodenstock TV Heliflex, XR Heliflex), and a conventional tele objective (Nikon Nikkor 180). This “macroscope” detector optic will be complemented later in 2006 by a microscope optic with variable magnification for resolutions down to 1 µm and below. Different scintillator screens are available for the macroscope. They are made of cadmium tungstenate (CWO) and bismuth germanate (BGO), materials which excel by their large stopping power and thus ensure high efficiency at a spatial resolution matched to that of the macroscope optics. An 11-Megapixel charge-coupled device (CCD) camera (PCO 4000) with 4008 × 2672 pixels of 9 µm size allows integral radiographic and tomographic imaging of large samples at high resolution. The dynamic range (5000 : 1) and readout speed of the PCO camera (5 frames per second max. speed) are adapted to the requirements of high-throughput tomography and time-resolved radiography at intermediate speed.

High-resolution X-ray diffraction and scattering from surfaces and interfaces – the NANO beamline

The NANO beamline will be a facility for high resolution X-ray diffraction and surface / interface scattering with the focus on in-situ and ex-situ structural characterisation of thin films, multilayers and nano-structured materials. Several experimental methods are planned, including high resolution symmetric/asymmetric X-ray diffraction, grazing incidence diffraction, grazing incidence small angle scattering and diffraction anomalous fine structure. The beamline will have a superconducting undulator source. The optical design of the beamline has been optimised to achieve high flux at the sample with defined beam characteristics suitable for nanostructure materials studies in the fields of condensed and soft matter. Moreover, a modular and flexible concept was followed in order to provide a compromise yielding reasonable resolution both in reciprocal and in real space.

Table 1: Summary of beam characteristics resulting from the simulation with XTrace[1]

Beam characteristics @ sample	
Beam size FWHM (HxV)	0.7×0.7 mm^2
Beam divergence FWHM (HxV)	0.03×0.004 mrad^2
Energy resolution $\Delta E/E$	10^{-4}
Flux [Ph/s] @ 7.6 keV	$4.6 * 10^{12}$

– The optical components of the beamline are displayed in figure1. A horizontally focusing mirror will be used to create a virtual source. A vertically collimating mirror will be placed before the double crystal monochromator (DCM) to achieve good energy resolution $\Delta E/E = 10^{-4}$ and a well collimated beam with low remaining divergence, as is required for high resolution diffraction investigation. A horizontally collimating mirror will be included so that it is possible to switch from a collimated to a focused beam. Two pairs of horizontal and vertical slits allow pre-selecting the beam size on the sample. The features of the beam at the sample are determined through a simulation using an X-ray optics program named XTrace that was specifically developed for the purpose [1].

– Two stations are planned for ex-situ and in-situ experiments: (i) NANO 1 for sample environmental chambers of moderate weight up to 50 kg and (ii) NANO 2 for heavy sample environment set-up up to 250 kg.

Collaboration

The Xtrace computer program was developed in collaboration with Dr. Martin Bauer.

References

[1] S.Trabelsi. Bauer, M. Bauer, R. Steininger, T. Baumbach, Ray tracing program XTrace, from the source up to the sample, to be published in Computers in Physics 2006.

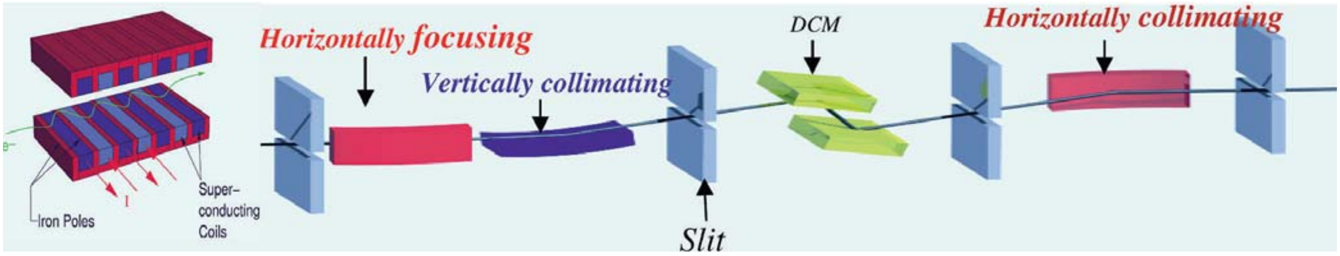

Fig. 1: Design of the beamline NANO.