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LINE PLM5A: "X-RAY DIFFRACTION TOPOGRAPHY AND HIGH RESOLUTION DIFFRACTION OF MONOCRYSTALINE MATERIALS"

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The beamline will be used for investigation with synchrotron X-ray diffraction topography and high resolution X-ray diffraction.

The proposed beamline will contain two experimental stations. The first one, located 30-35 m from the source of radiation will serve for high resolution diffraction of monocrystalline materials. The second station will be dedicated mainly to diffraction topographic experiments employing both white and monochromatic beams. This station will be located at further distance from the synchrotron. The reason for that is to provide enhanced resolution in topographic experiments at the level of 0.5 μm. The distance from the source will be dependent on the focusing of the electron beam – the distance of 65 m corresponds to the maximal dimensions of apparent source on the level 0.2×0.4 mm^2. It is also expected that the topographic station will enable to obtain some images with phase contrast and eventually X-ray tomographic studies.

The important assumption of the present concept is the location of the beamline at a permanent magnet wiggler, as the which can provide enhanced intensity, important both for diffractometric and the topographic station located at the further distance from the source. The second reason is the shift of the wavelength spectrum towards shorter wavelength.

The proposed solution should provide a beamline competitive with most others in Europe and US [1,2]. The possibilities of topographic station will be significantly lower in case of building the normal short line on bending magnet. The lower intensity of the beam will also reduce a number of application in case of High Resolution Diffractometry

Technical data

1 Source: permanent magnet wiggler
2 Energy of wavelength: Between 3 - 60 keV
3 Energy resolution ΔE/E: between $10^{-4} – 10^{-5}$
4 Flux at first optical element: -Diffractometric station: 2×10^{11} ph/(sec·0.1% bandwidth) (1mm×1mm) (with monochromator), -Topographic station Flux at the sample 10^{10}-10^{11} ph/(sec·0.1% bandwidth) (5mm×10mm) (without monochromator)
5. Beamline optics and apparatus

- Optics: flat, diffractive at both stations,
- Apparatus: precise heavy load multi circle goniometers at both stations, with the possibility of using channel-cut analysers at diffractometric station.
- Piezo-electically controlled double crystal monochromator enabling easy wavelength tuning at diffractometric station.
- Piezo-electically controlled double crystal monochromator with the possibility of passing directly the white beam at the topographic station.
- Fast shutter, choppers for decreasing the beam intensity and laser systems for adjustment at topographic station.

6. Sample environment: For some experiments heating furnaces or cryogenic devices, should be available.It can be also possible to use epitaxial MBE reactors provided by users.
7. Beam size at sample: - diffractometric station: typically 1mm × 1 mm or lower; - topographic station: typically 1 cm × 0.5 cm in special cases up to 10 cm × 5 cm

8 Detectors

- Diffractometric station: high resolution PSD, scintillation and proportional counter
- Topographic station: photographic films, high resolution image plate, CCD camera with scintillation screen, scintillation or proportional counters for controlling of the setting of monochromatic beam topographs

9 Polarization: linear

10 Length:

- Diffractometric station: distance from the source to the sample 25 m and from the sample to the detector 20- 60 cm (with the possibility of using the channel cut analyzers in front of the detector).

- Topographic station: distance from the source to the sample 65- 90 m (essential for obtaining the sufficient resolution and coherence of the beam) and from the sample to the detector (photographic plate) – 10-60 cm

Application possibilities:

The diffractometric station:

1. The diffractometric station will provide the possibilities of precise recording of rocking curves and investigation of the reciprocal space maps of crystalline materials such as single crystal and layered (epitaxial, implanted etc.) structures as well as low dimensional structures.
2. High brilliance of the synchrotron beam 2-8 orders higher than in the case of conventional arrangements will enable the detection of a very low intensities of the diffuse scattered radiation and interference maxima, which are lower and located far from the diffraction maximum.
3. The synchrotron beam can be spatially restricted to several tenth of micrometers eliminating the influence of sample bandings and enabling studying the local differences of diffraction properties.
4. The diffractometric station will provide very highly collimated beam and analyzers with high resolution. In some cases fast measurements exploring high resolution PSD can be realized.
5. The station will enable relatively easy tuning of the wavelength and the change of the penetration depth, providing the possibility of the scanning of the strains along the depth of the low dimensional system together with controlling the chemical composition and the structure
6. The concentration and dimension of point defects and their clusters can be determined.
7. Non coplanar glide geometry can be realized enabling the evaluation of lattice parameter parallel to the surface, and providing the possibilities of studying of ultra thin layers.
8. The correlation effects connected with low dimensional systems and defect structure can be evaluated.
9. Easy tuning of the energy will also enable the optimization of radiation wavelength for different materials and problems.
10. The additional equipment such as cryostats, high temperature chambers and MBE reactors can be mounted for *in situ* investigations.

The topographic station:

1. X ray topographic investigation with high spatial resolution – better than 1 μm and with wider possibilities of choosing the reflection and wavelength.
2. High brilliance of the synchrotron source enables shortening the exposure times as well as very efficient realization of methods requiring strong restriction of wave front (section and pin-hole topography)
3. The methods requiring high angular collimation of the beam can be easily realized.
4. The interference effects occurring in the synchrotron topographs can be studied in aspect of diffraction physics and used for more precise evaluation of lattice strain and identification of crystallographic defects.
5. High coherence of the synchrotron beam enables an improvement of the resolution and obtaining of the phase contrast and related effects at high film to crystal distances [3-5].
6. The synchrotron topographic methods should provide visualization of lattice deformation and strain in single crystals, semiconductor wafers, layered and low dimensional structures. Analysis of extended crystal defects, particularly number, distribution and origin of dislocations, precipitates can be possible.
7. Some X-ray tomographic experiments can be possible.

References

[1] A.N. Danilewsky, R. Simon, A. Fauler, M. Fiederle, K.W. Benz: "White beam X-ray topography at the synchrotron light source ANKA, Research Centre Karlsruhe": *Nucl. Instrum. Meth. Phys. Res. B* **199** (2003) 71-74.

[2] B.M. Murphy, S.P. Collins, M. Golshan, M. Moore, J. Reid, G. Kowalski: „SRS station 16.3: high-resolution applications" *Nucl. Instrum. Meth. Phys. Res A* 467-468 (2001) 1014-1018.

[3] G. Kowalski, M. Moore, S. Nailer: "Application of x-ray phase-contrast imaging to polycrystalline CVD diamond" J. Phys. D: Appl. Phys. **32** (1999) A166-A171. [4] A.W. Stevenson, T.E. Gureyev, D. Paganin, S.W. Wilkins, T. Weitkamp, A. Snigirev, C. Rau, I. Snigireva, H.S. Youn, I.P. Dolbnya, W. Yun, B. Lai, R.F. Garrett, D.J. Cookson, K. Hyodo, M. Ando: "Phase-contrast X-Ray imaging with synchrotron radiation for materials science applications" *Nucl. Instrum. Meth. Phys. Res. B* **199** (2003) 427-435.

[5] Diamond Beamline Proposal 048 "A Coherent X-ray Diffraction and XPCS Beamline for the Diamond Light Source".