Development of a DuMond-type crystal spectrometer for high energy X-ray emission studies.

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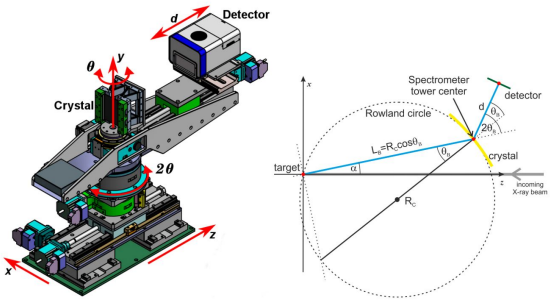
SuperXAS beamline at the Swiss Light Source [1] is specialised in X-ray absorption and X-ray emission spectroscopy to probe the chemical and electronical structure of functional materials. The beamline is equipped with two X-ray emission spectrometers for XES studies in the 4-15keV range. The goal of this project is to construct a high-energy-resolution crystal spectrometer that works for high X-ray energies (between 15-35 keV). These energies are required to probe K-edges of 4d elements, for example ruthenium (Ru). For higher X-ray energies Laue type spectrometers are more efficient then reflection based spectrometers. This approach leads us to the concept of a transmission type spectrometer in DuMond geometry, where we used a cylindrically bend crystal, which increases the solid angle but can also decrease the resolution through geometrical aberrations and imperfections in the crystal curvature.

We encountered two main challenges: to bend a silicon crystal in homogeneous and reproducible way and, to get a translation system with the possibility to align the crystal and the detector in relation to the source with sufficient accuracy. DESY [2] supported us with the design of a flexor bender which allowed working with different curvatures of the crystal. Huber [3] delivered linear and rotation stages, accurate enough to make possible alignment. As a detector we used a Pilatus 100K-S 2D detector [4] with a 1mm thick SI sensor.

After the first commissioning, we identified the main factors influencing the spectrometer energy resolution: i.e. the source size, the bending radius of the crystal and the quality of the crystal mosaicism. After optimisation we could reach a calculated energy resolution of ΔE_{ins}=4.82eV for Ru Kα1 line at 19.279 keV.



Left: Actual desing of the DuMond spectrometer with the Pilatus 100K-S 2D detector and the dedicated crystal bender on top. Right: Geometry of the DuMond type Spectrometer

References

[1] Paul Scherrer Institut (PSI), Psi.ch. (n.d.). https://www.psi.ch/sls/superxas/superxas (accessed March 2, 2018).

[2] Deutsches Elektronen Synchrotron (DESY), desy.de (n.d.) https://photon-science.desy.de/facilities/petraiii/beamlines/p11bioimaginganddiffraction/indexeng.html (accessed March 2, 2018).

[3] Huber, xhuber.de (n.d.) http://www.xhuber.de/produkte/1-positioniersysteme/ (accessed March 2, 2018).

[4] Pilatus 100K-S, dectris.ch. (n.d.) https://www.dectris.com/products/pilatus3/overview (accessed March 2, 2018).