HAPG mosaic crystals and their application in high resolution X-ray spectroscopy

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Highly Oriented Pyrolytic Graphite (HOPG) is a high-quality synthetic type of carbon that has successfully been employed for the fabrication of X-ray optics for more than two decades. As a mosaic crystal it provides the highest integral reflectivity of all known crystals in the photon energy range from 2 keV up to 100 keV. However, its high integral reflectivity is achieved at the expense of spectral resolution.

Recent improvement of the annealing process resulted in the fabrication of a novel type of pyrolytic graphite. Highly Annealed Pyrolytic Graphite (HAPG) combines a high integral reflectivity with a very low mosaicity which can be as low as 0.05°. A resolving power E/ΔE of 2000 in first order and 4000 in second order has been observed, making HAPG well suitable for application in high resolution X-ray spectroscopy.

In a joint research project of Physikalisch-Technische Bundesanstalt, Technical University Berlin and the manufacturer Optigraph, detailed characterization, modeling and simulation methods have been developed to understand the complex structure of HAPG. Experiments with synchrotron radiation for the investigation of its diffraction properties were carried out at a 7 T wavelength shifter beamline at the electron storage ring BESSY in Berlin. Furthermore, a ray-tracing simulation software has been developed which includes the description of multiple diffraction processes in flat and bent HAPG mosaic crystals with high accuracy.

The applicability of curved HAPG crystals for synchrotron radiation based high resolution X-ray Emission Spectroscopy (XES) was demonstrated at the µ-spot beamline at BESSY [1]. As a result a new type of high resolution spectrometer based on HAPG crystals in Von Hamos geometry has been constructed by TU Berlin at the Berlin Laboratory for innovative X-ray technologies (BLiX), where HAPG optics have successfully been employed for laboratory based XANES and XES spectroscopy. Another calibratable spectrometer for applications using synchrotron radiation is going to be developed by PTB, and shall substantially contribute to the speciation of advanced energy materials.