ESRF	**Experiment title:** Resonantly enhanced x-ray optical switching by LiTaO3 in a high purity diamond crystal x-ray polarimeter	**Experiment number**: MA-3719
beamline: ID 18	**Date of experiment**: from: 24 January 2018 to: 30 January 2018	**Date of report**: 29.02.2020
Shifts: 18	**Local contact(s)**: Dimitrios Bessas	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Hendrik Bernhardt*, Ingo Uschmann*, Kai Sven Schulze*, Robert Loetzsch*, Annika Schmitt*, Berit Marx-Glowna*, Benjamin Grabiger*

Friedrich Schiller University Jena and Helmholtz Institute Jena, Jena, Germany

Ralf Röhlsberger*, Hans-Christian Wille*

DESY, Hamburg, Germany

Report:

In this experiment, we explored three main facts: first, we demonstrated that diamonds can be used for high-precision x-ray polarimetry, second, the polarization purity of current x-ray polarimeters is determined by the divergence of the source and, third, an electrically excited media inside the polarimeter can change the intensity by several orders of magnitude.

The polarimeter was realized by four diamond crystals for each polarizer, hence, eight diamonds in total. Each diamond was precisely aligned parallel to the other crystals using motorized mirror mounts, which are usually used in laser physics. Together with a compact and stiff holder, we realized a reliable operation during the beamtime. This setup enabled an extreme intensity ratio between the vertical and horizontal polarization components, called polarization purity, in the order of 10^{-10}. Figure 1 shows the strong intensity drop close to the crossed position of polarizer and analyzer.

By decreasing the horizontal divergence with a slit and a channel-cut with two different asymmetric reflections (V-channel-cut), we could improve the polarization purity further by a factor of three. This is in accordance with previous predictions that the polarization purity is currently limited by the divergence of the source. This is an important result for the further development of x-ray polarimeters. This is especially important for polarimetry at the new ESRF-EBS, which should enable polarization purities in the order of 10^{-12}.

As a sample to study optical switching of x-rays via polarization switching, we placed a 50µm thick LiTaO3 crystal between both polarizers. LiTaO3 is known as an optical switch in the visible range. With the analyzer crossed with regard to the polarizer, only photons that change polarization were detected by the avalanche photodiode. Such polarization changes are largest in the pre-edge region. Hence, we investigated the L3 edge of Tantalum. Figure 2 shows spectra behind the analyzer, in other words only $\sigma \rightarrow \pi$ scattered photons, for

different orientations of the sample and 1kV voltage compared with the no-voltage case. The changes in intensity could be attributed to induced strain. This strain leads to a shift of the Bragg reflections, which are known to change the polarization in its close vicinity. Especially the green line shows that this method allows switching of intensity by at least two orders of magnitude.

Because of the manifold findings during the experiment, the beamtime was a great step for the further improvement of polarimeters, for the application of this kind of polarimeter together with spectroscopy, and for the development of optical switches in the x-ray range.

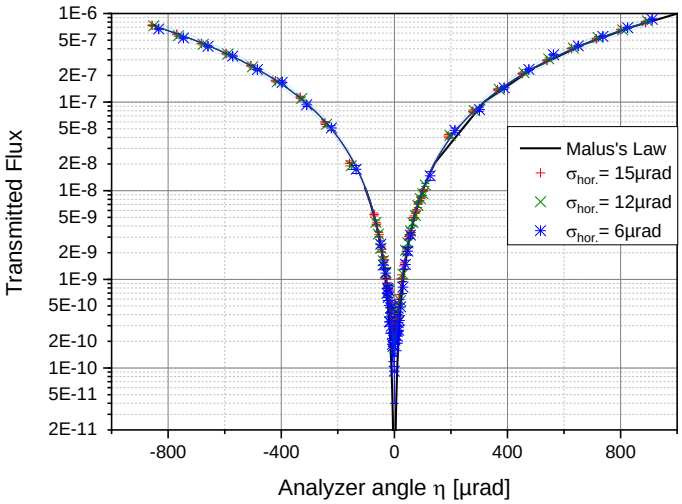

Fig. 1: Suppresion of the incoming photons by two diamond polarizers. Here, we created a polarization purity in the order of 10^{-10}.

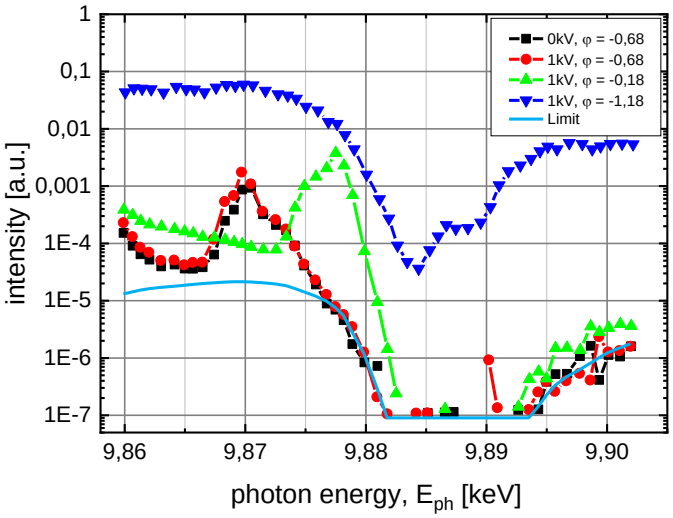

Fig. 2: Intensity behin the analyzer with a 50µm thick LiTaO3 sample inside the polarimeter. The intensity changes are caused by Bragg reflections and strain induced by the high voltage.