ESRF	**Experiment title:** Heating at the nanoscale as a possible mechanism for radiation damage and X-ray nanopatterning	**Experiment number**: MA-5779
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Names and affiliations of applicants (* indicates experimentalists):

A. Alessio[1*], A. Agostino[2*], C. Prestipino[3*], S. Singh[1*], M. Truccato[1*]

[1] Department of Physics and NIS Centre, University of Turin, Turin, Italy
[2] Department of Chemistry and NIS Centre, University of Turin, Turin, Italy
[3] CNRS UMR 6226 - Universite Rennes 1 Chimie du Solide & Matériaux Sciences Chimiques de Rennes 1

Report:

Material modification induced by X-ray irradiation is often considered an undesirable side effect in applications involving high brilliance sources such as 4th generation synchrotrons, but it has been shown to be useful for functionalization of superconducting oxides such as Bi-2212 [1,2,3] and semiconducting oxides such as TiO_2[4,5].
The exact microscopic mechanism leading to material modifications upon X-ray irradiation is still missing, and it is crucial to precisely tune the electrical properties of materials.
One possible mechanism leading to material damage upon high brilliance X-ray irradiation is thermal fatigue due to rapid thermal expansion and contraction related to each synchrotron pulse.
To test this hypothesis, we performed this experiment collecting XRD measurements on thin film of different materials.
Because of the pulsed nature of synchrotron radiation, heating and XRD data collection are simultaneous, and the position of diffraction peak should give a direct measure of the thermal expansion due to the incoming X-ray beam.
We employed a nanobeam with size 700×300 nm^2 (H×V) and a maximum flux of 9.9×10^{10} photons/s, and performed the measurements with different incident photon fluxes, obtained by inserting a variable number of Al foils before the sample.
In this way the temperature increase induced by the incoming beam should result in a shift of the diffraction peak under investigation towards smaller 2θ angles upon irradiation with high flux compared to low flux measurements.
We could also test the reversibility or irreversibility of thermal effects by performing measurements at low flux alternated to high flux irradiation.
We focused on thin films with thicknesses in the order of 100 nm of different materials, namely PbTe, $KNbO_3$ and YBCO superconductor. Thin films were selected in order to have a uniform heating across the whole material and to remain in kinematic diffraction conditions.

Measurements at different temperatures have also been performed to check the effect of temperature on radiation damage and reversibility of thermal effects. A liquid He flow cryostat has been employed to perform measurements at 10K, 60K, 100K and 295K.

An in depth data analysis is still to be performed, but as it is shown in figure 1, some clear differences can be seen in the position and relative intensity of XRD peaks taken on a 100 nm thick PbTe sample at room temperature, clearly indicating a damage of the material induced by the increasing cumulative dose delivered during measurements.

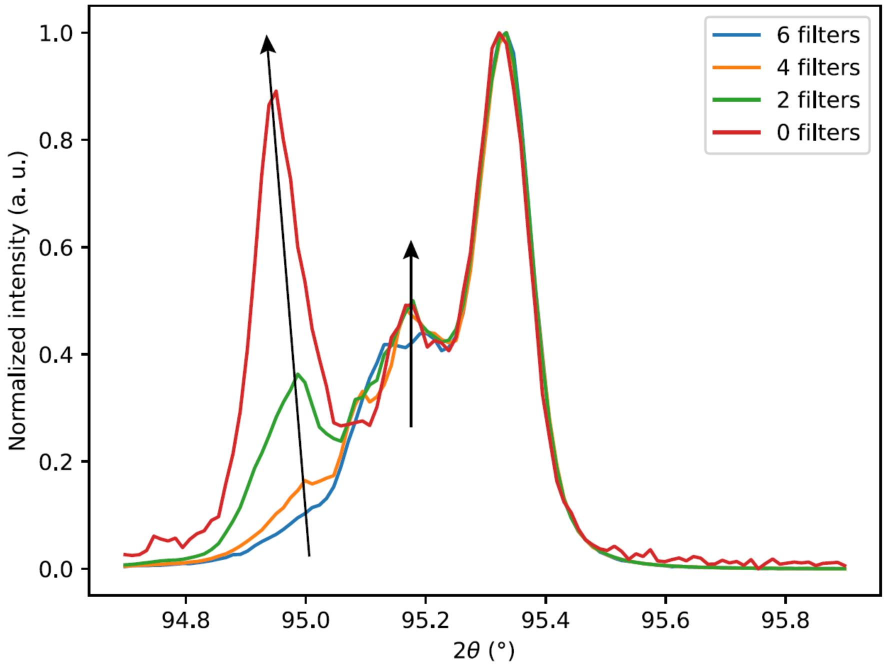

Figure 1 Diffraction peak for PtTe collected at different photon fluxes.

References

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