ESRF	**Experiment title:** Radiation damaging on Bi-2212 superconducting micro-crystals	**Experiment number**: MA-1510
Beamline: ID22-NI	**Date of experiment**: from: 23/05/2012 to: 28/05/2012	**Date of report**: 27/02/2013
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Report:

During experiment MA-1510 we succeeded in measuring two different crystals of $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) mounted on a sapphire substrate with silver metallic stripes as electrical contacts, as shown in Fig.1.

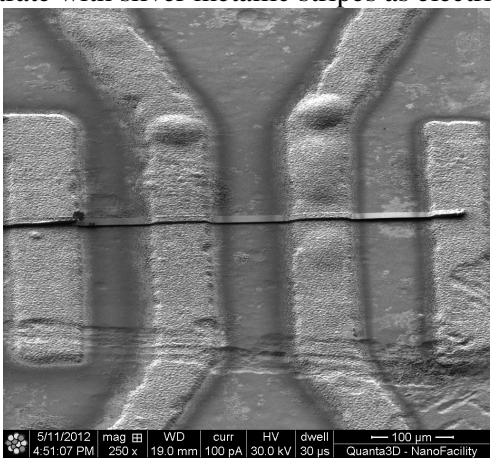

Fig. 1: Ion beam image of sample WBAP013 measured during experiment MA-1510

This study represents a continuation of a previous investigation (CH-3307) performed on ID22 [1].

In this experiment, each crystal has been damaged by taking three fluorescence maps in a region about 30 microns long placed between the two central silver contacts, which is the region sensed by the 4-probe electrical measurements. We worked at the fixed energy of and 17.054±0.004 keV, as resulting from the elastic peak of fluorescence spectra. First, fluorescence maps were collected in frontal geometry, then a grazing incidence geometry was used because of its greater efficiency in energy deposition in the crystals. Each fluorescence map lasted between 11 and 17 hours and was alternated with electrical measurements performed out of the beam.

The effects of the irradiation on in-plane electrical properties have been clearly detected, as shown in Figure 2 .

It is apparent that the room-temperature resistivity increases with increasing the dose (see upper inset of Fig.2). Correspondingly, the mid-point critical temperature increases from 79.3K for the as-grown sample up to 80.7 K for the highest dose (see lower inset of Fig.2). This electrical behavior seems to indicate a change from the overdoped to the nearly optimally doped regime for the material.

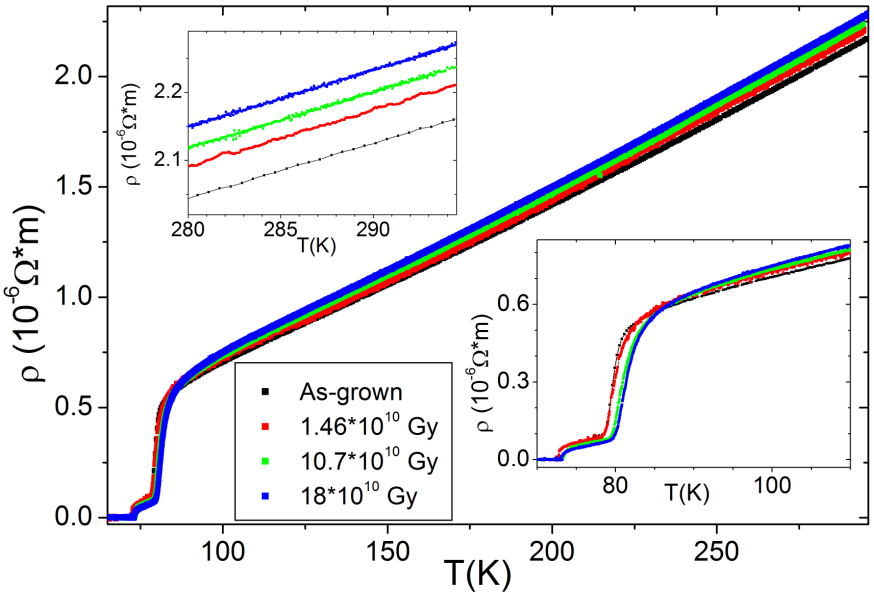

Fig. 2: Variation of electrical resistivity with X-ray irradiation for sample WBAP013.

If so, corresponding changes should be observed in the c-axis of the crystal. This issue was addressed by the second part of the experiment by acquiring nano-diffraction patterns in the grazing incidence geometry at several positions. We succeeded in aligning the samples by combined use of optical microscope and of fluorescence scans, and this was possible just because of the fact that beam sizes were much less than the typical crystal thickness (1.59 µm). However, even under these circumstances, many angles had to be tried in a time-consuming way at the different sample positions because of some crystal twisting. The results obtained from the analysis of series of Bragg reflections (Fig. 3left part) on the equatorial plane are summarized in Fig. 3 (right part).

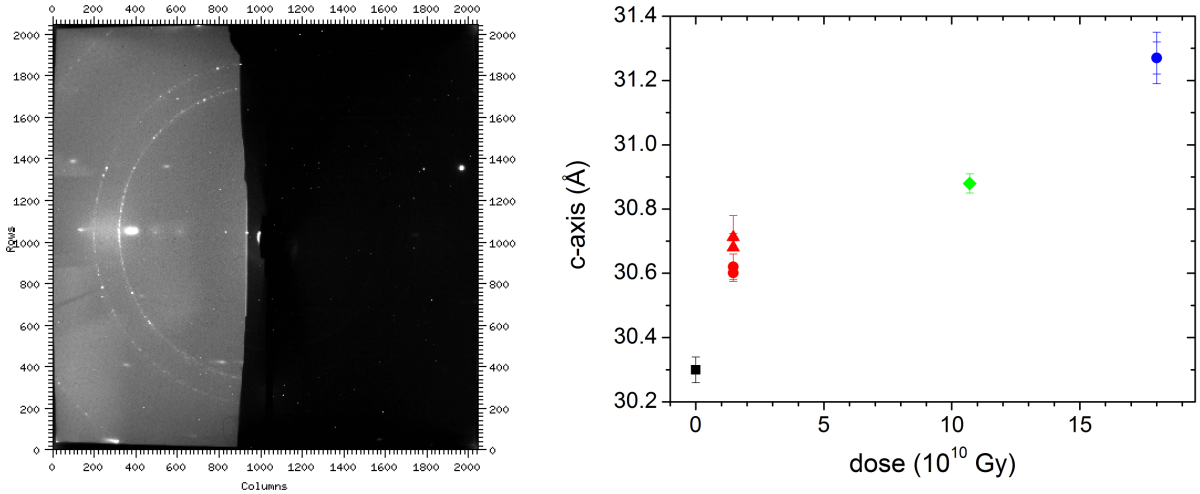

Fig. 3: Left: typical nano diffraction image . Right: c-axis versus X-ray dose for sample WBAP013.

It is clear that c-axis length increases with increasing the dose, confirming that O content is reduced in the sample (figure 3, right part). This is probably related to crystal heating induced by the high power density of the nano-beam, but this has to be confirmed by FEM analysis (under way).
Effects of X-ray damage on out-of-plane transport properties in nano-patterned devices could not be studied because of shortness of time.

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References.

[1] G. Aldica, S. Cagliero, A. Agostino, C. Lamberti, M. Truccato, "17 keV-photon induced damage of Bi-2212 whiskers by synchrotron µ-beam exposure", *Supercond. Sci. Technol.*, **24** (2011) 035009.