ESRF	**Experiment title:** **Local structure of Co dopants in Bi_2Te_3 topological insulator**	**Experiment number**: MA-3682
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Report:

The purpose of the experiment was to determine the crystallographic sites, which are occupied by Co dopants in the single crystal of Bi_2Te_3 topological insulator. In principle, we aimed to verify, whether Co dopants are predominantly diluted into chalcogenide structure or they form the Co and Te rich precipitates. If the latter scenario is realized, we aimed to determine the structure and thus the stoichiometry of the precipitate phase.

Experiment was performed at ambient conditions using microbeam endstation of BM23 beamline. μXRF and μXAFS spectra have been collected from pristine and Co doped single crystals of Bi_2Te_3 as well as crystals irradiated and nanostructured using focused beam of Ga^+ ions. In addition, pristine and irradiated single crystals of Bi_2Se_3 have been probed. Elemental distribution maps of Co, Ga, Bi, Te and Se as well as X-ray absorption fine structure spectra at Co, Ga K-edge and Bi L_3-edge were measured.

μXRF measurements were performed in two stages. At first, large area (of 1÷10 mm^2) maps were probed. Afterwards the detailed maps were collected from selected small areas (of 0.0025÷0.1 mm^2) rich in Co and Ga. The measurements have confirmed the Co distribution observed using SEM-EDX method, namely that Co is predominantly distributed in the vicinity of linear defects (see example in figure 1). However, contrary to SEM-EDX, Co fluorescence intensity from the large areas of the undefected crystal is negligible. This results strongly supports the scenario of Co existing in precipitate phase only. However, the lateral width of the Co rich features observed is of the order of single pixel. As such, it is impossible to unambiguously state that Co is present in the precipitate phase only.

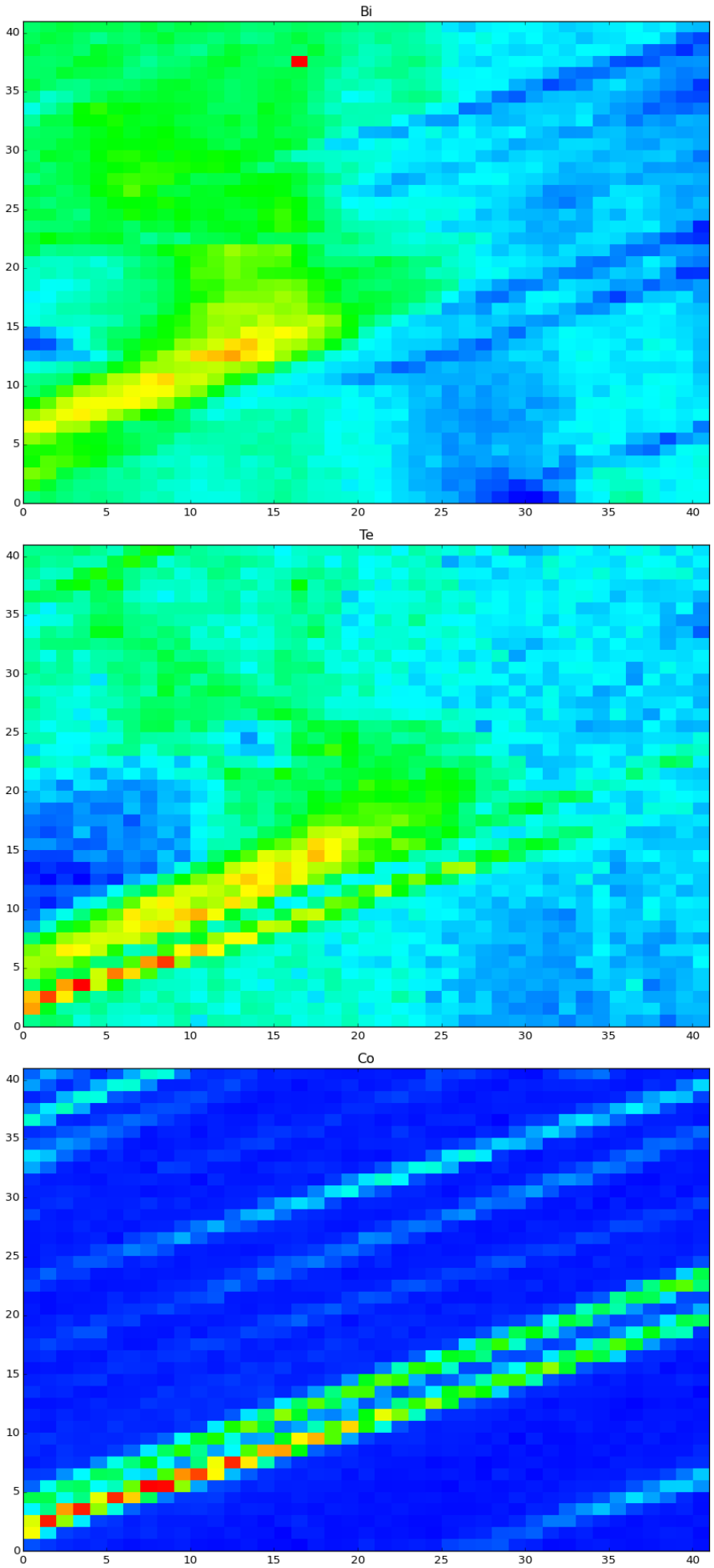

Figure 1. Elemental maps of the selected area of Co doped Bi_2Te_3. From top to bottom: Bi, Te and Co distribution maps.

Upon determination of the elemental distribution maps in the several areas of Co doped crystals, Bi L_3 and Co K-edge μXAFS spectra were probed from numerous Co-rich and deficient areas. Based on the expected beam motion during large energy scans of DCM [1] we estimate that the actual lateral width of the precipitates must be significantly smaller than 1 μm since the fluorescence intensity of many XAFS scans is strongly affected (see example in figure 2). However, the shape of XANES features is similar to that observed from large area spectra collected at SuperXAS.

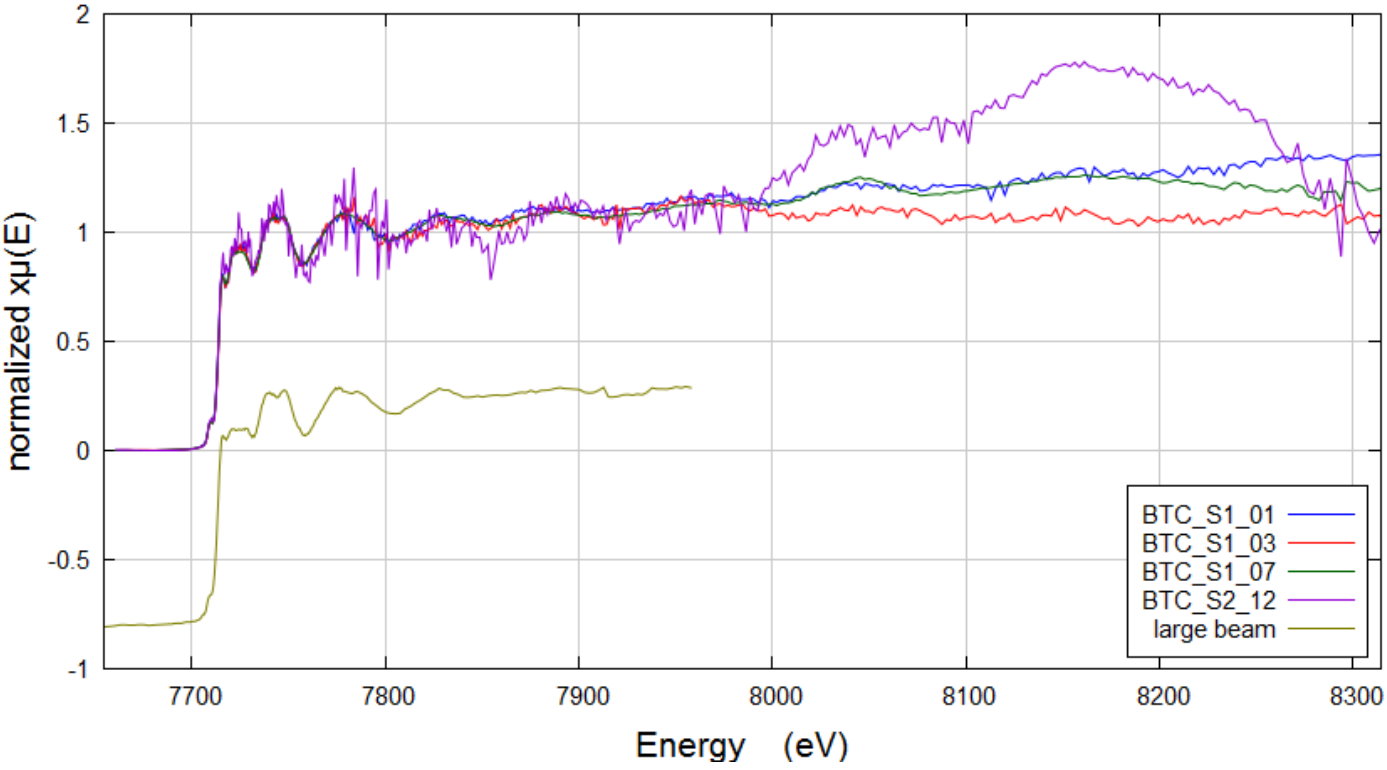

Figure 2. Comparison of individual Co K-edge μXAFS spectra of several Co-rich area (denoted as 'BTC_*') with an average XAFS spectrum probed over large area of the crystal (denoted as 'large beam'). All the spectra were background subtracted and normalized in the energy range 7740÷7815eV. Large beam spectrum was shifted for clarity.

At present, all the collected μXAFS spectra are verified and the systematic procedure for the determination of the spectral ranges unaffected by microbeam motion is being developed. We expect that the patchwork-like spectrum obtained as a result of such procedure would allow us for quantitative analysis (fitting by means of Artemis) of the local Co structure.

Reference

[1] O. Mathon, *et al.*, *Overview and future needs for ESRF double crystal monochromators dedicated to spectroscopy*, oral presentation during ESRF DCM Workshop 2014.