# Electronic and crystallographic structure of $(Eu_xBi_{1-x})_2Te_3$ thin films

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$Bi_2Te_3$ - one of the known topological insulators is considered as a promising material for multiple applications in next generation electronic or spintronic devices [1]. The crystal of $Bi_2Te_3$ is a semiconductor with the bulk energy bandgap of 0.15 eV. Its bandgap contains gapless, topologically protected surface states responsible for its exceptional magnetoelectric properties [2]. The time-reversal symmetry, responsible for linear dispersion of the surface states, can be broken to open a gap by different factors (e.g. Coulomb, magnetic and disorder perturbations).

Here we focused on the response of a $Bi_2Te_3$ surface to the disorder introduced by substitution of europium in place of bismuth. Europium was selected due to its magnetic properties, directly related to its valency state; $Eu^{3+}$ is non-magnetic (J = 0) while the $Eu^{2+}$ has a large pure spin moment (J = 7/2) [3]. The applicability of the same element which may exhibit in in two different valency states (of which one is magnetically ordered and second is not) was crucial indicator of europium selection.

The growth of the layers of the $Bi_2Te_3$ with europium was realized in the MBE chamber. The films were grown on mica substrate with 20nm thick and different composition ($Bi_2Te_3$, $BiEuTe_3$, $Bi_{0.5}Eu_{1.5}Te_3$, $Bi_{1.5}Eu_{0.5}Te_3$ $Eu_2Te_3$)

The structural characterization of grown layers was realized using the RHEED techniques. Crystalized in hexagonal phase 20nm thick $Bi_2Te_3$ doped with europium shows, depending on amount of europium, monocrystalline structure with weak contribution of polycrystalline patterns. The lattice parameter of the obtained films depends on quantity of added europium.

The electronic structure studies were conducted *in-situ* after deposition process using the X-ray Photoelectron Spectrometer (XPS). The chemical states of bismuth and tellurium were obtained from the detailed analysis of the Bi*4*f and Te*3*d multiplets. The chemical state and the valency state of europium were investigated by the analysis of Eu3*d* multiplets.

The analysis of the chemical shifts of the core levels as well as the relative changes in photoemission lines area ratio, allowed to conclude that in such enviroment europium occurs in divalent state, tellurium remains in chemical state characteristic for $Bi_2Te_3$, whereas for particular composition small amount of Bi is being removed from $Bi_2Te_3$ lattice forming metallic phase.

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Reference

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