Samarium 4f states in doped IV-VI and II-VI semiconductors

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The PbTe is a IV-VI narrow-gap semiconductor (Eg = 0.32 eV at 300 K) crystallizing in a rock-salt structure. It is considered as a suitable material for infrared detectors and lasers as well as in thermoelectric devices. Formation of solid solutions of PbTe with other IV-VI compounds can lead to inverted band structure and the character of topological crystalline insulator (like Pb1-xSnxTe). Introducing Sm atoms into $Pb_{1-x}Ge_xTe$ lattice we make a system belonging to the family of diluted magnetic semiconductors developed in recent decades. In such a system doped with Sm the magnetic ions interact ferromagnetically via the RKKY mechanism.

In the reported study we doped a subsurface region of $Pb_{0.97}Ge_{0.03}Te$ by deposition of Sm atoms under UHV conditions and annealing of the sample in order to facilitate Sm diffusion into the crystal. The experiment was carried out in the HASYLAB synchrotron laboratory in Hamburg, Germany. The Fano resonance [1] photoemission study of the $Sm/Pb_{0.97}Ge_{0.03}Te$ after sequential Sm deposition steps was performed to determine the contribution of the Sm4f electrons to the valence band of the system and to monitor the process of introduction of Sm into the substrate crystal host lattice. After each deposition step and after subsequent thermal treatment the contribution of both Sm^{2+} and Sm^{3+} ions were assessed. The analysis of the acquired data and a comparison with the results of similar studies of Sm doped CdTe, ZnO and GaN [2] show that the thermal treatment at 250degC leads to conversion of Sm^{2+} to Sm^{3+}, which is observed in resonant photoemission spectra. In case of $Pb_{0.97}Ge_{0.03}Te$, annealing leads also to Sm^{4+} states, which corresponds to the valence of the cations in the substrate crystal host lattice.

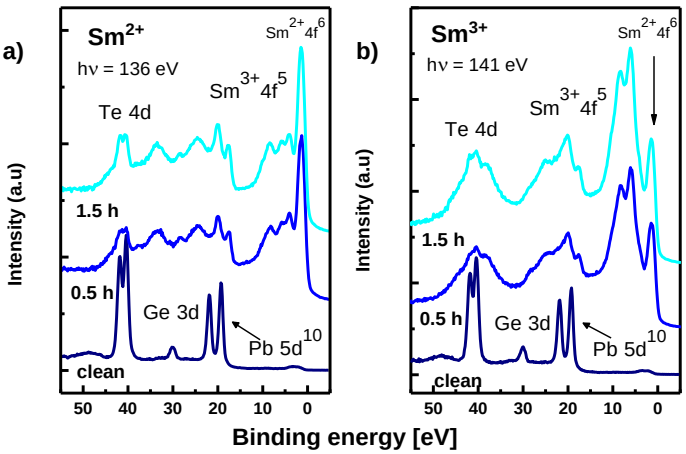

Fig.1. Resonant photoemission spectra after annealing of $Pb_{0.97}Ge_{0.03}Te$ sample with the Sm cap layer.

[1] Fano, U., Phys. Rev. 124, 1866-1887 (1961).
[2] Guziewicz, E., Orlowski, B.A., Kowalski, B.J. et al., Appl. Surf. Sci. 282, 326-334 (2013).
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