Can a SnTe/CdTe(001) heterostructure be a promising material to open an energy gap in its topological surface states?

Adrian Sulich[1]
Elżbieta Łusakowska[1], Wojciech Wołkanowicz[1], Piotr Dziawa[1], Janusz Sadowski[1,2], Badri Taliashvili[1], Tomasz Wojtowicz[3], Tomasz Story[1,3], and Jaroslaw Z. Domagala[1]
[1]*Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL 02 668 Warsaw, Poland*
[2]*Department of Physics and Electrical Engineering, Linnaeus University, 391 82 Kalmar, Sweden*
[3]*International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL 02 668 Warsaw, Poland*
sulich@ifpan.edu.pl

Topological crystalline insulators (TCI) with a possibility of distortion-induced opening of an energy gap in their metallic surface states are attractive materials in the context of spintronics and infrared optoelectronics development. The potential candidates for such materials can be, for example, SnTe or SnSe-based crystals. For our studies [1] we selected a SnTe/CdTe(001) heterostructure on 2° off-cut GaAs(001), because the technology of TCI is based nowadays mostly on bulk crystals and it needs a development of layered materials grown on commercially available substrates (see also: [2]).
SnTe layers with the rock-salt structure and with different thicknesses ranging from 20 to 1000 nm were deposited by means of molecular beam epitaxy on CdTe buffer with zinc-blende structure and with a standard thickness of 4 μm. To study an impact of the growth conditions on the structural properties of the topological crystalline insulator layer, SnTe beam equivalent pressure (used as a parameter to control the layer growth rate) was changed from 4.4 to 4.8 × 10^{-7} mbar and Te/SnTe molecular beam flux ratio was changed from 0 to 0.0156.
Crystallographic and morphological analysis of the samples was performed, using high-resolution X-ray diffraction and atomic force microscopy, since breaking crystal symmetry is known to affect the material's topological properties [3]. The results showed almost complete relaxation of the CdTe lattice and partial relaxation of SnTe, increasing from 86.2% to 98.3% (together with the layer thickness). Anisotropy of the spatial distribution of defects was found, leading to the SnTe unit cell monoclinic distortion, detected in some samples. A new, curious SnTe surface morphology with reduced symmetry was observed, analysed and compared with a recent study, devoted to morphological and electrical properties of a related material (SnTe films deposited directly on GaAs (100) substrates) [4]. Due to the magnitude of the SnTe lattice strain (~10^{-3}) measured in our samples, it can be predicted that it would be sufficient to affect the topological properties of this material.

References

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