MBE growth of SnTe films on GaAs substrates with ZnTe buffer layers

Masakazu Kobayashi[1,2]* and Su Nan[1]
*cosmos@waseda.jp
1 Department of Electrical Engineering and Bioscience, Waseda University, Tokyo, Japan
2 Kagami Memorial Research Institute for Materials Science and Technology,
Waseda University, Tokyo, Japan

Topological crystalline insulators (TCI) are expected to be used in spin-electronic devices because of their unique properties —— surface conductivity and bulk insulation. SnTe has received attention widely as a TCI. The substrate material choice is a very important parameter to achieve high quality thin films. There are several substrate materials that are relatively lattice matched to SnTe such as BaF_2 and CdTe [1,2]. These substrates would require special treatment procedures, and that will limit the device applications. Although GaAs substrates is lattice mismatched to SnTe, the substrate treatment procedure was well established. In the past study, SnTe films have been grown directly on GaAs (100) substrates by MBE. Since the various findings were found in those study, the SnTe layer growth with ZnTe buffer layers were performed. Relatively high quality ZnTe layers can be easily grown on GaAs substrates, and the existence of the buffer layer would improve the crystallographic quality of the SnTe layer.

ZnTe layers of about 40nm were grown on GaAs substrates at around 350 ºC. The SnTe layer growth was then followed. SnTe layers were grown using elemental sources by conventional MBE with the molecular beam intensity ratio (J_{Te}/J_{Sn}) between 0.7~2.9. The value was tuned by changing the beam intensity of Te while keeping the Sn beam intensity constant. The substrate temperature was calibrated using the oxide desorption of GaAs substrates from run to run. Most of samples were grown at 240 °C but lowered to 210 ºC for comparison. After the film growth, X-ray diffraction θ-2θ measurements were performed and diffraction peaks originated from SnTe were clearly confirmed. A peak originated from hexagonal Te was often observed when the molecular beam intensity ratio became Te rich. In the SEM measurements, relatively smooth surface was confirmed when the XRD of sample exhibited no Te peak. On the other hand, dotted materials were clearly observed on the surface when the hexagonal Te diffraction peak was observed by XRD. The distribution density of the dot was high when the Te diffraction peak signal intensity was strong. Those crystallographic properties were improved after introducing the ZnTe layer. The surface smoothness improvement was noticeable. The granular morphology was observed when the layer was directly grown on the GaAs substrate, but the smooth and large plateau patterns were observed from samples grown on the buffer layer. A standard Hall measurement was performed at room temperature. The sample exhibited relatively high resistivity, and it is probably associated with the existence of Te segregation. As a supplement, the X-ray fluorescence measurement was performed and a similar trend was observed.

The introduction of ZnTe buffer layer has clearly improved the surface morphology of SnTe films. This result was useful for achieving TCI properties and device quality SnTe films.

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