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Crystal growth of Bi_2Te_3 and noble cleaved (0001) surface properties

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ABSTRACT

A high quality Bi_2Te_3 crystal has been grown by Bridgman method with the use of rotating heat field. The phase purity and bulk structural quality of the crystal have been verified by XRD analysis and rocking curve observation. The atomically smooth Bi_2Te_3(0001) surface with an excellent crystallographic quality is formed by cleavage in the air. The chemical and microstructural properties of the surface have been evaluated with RHEED, AFM, STM, SE and XPS. The Bi_2Te_3(0001) cleaved surface is formed by atomically smooth terraces with the height of the elemental step of $\sim 1.04 \pm 0.1$ nm, as estimated by AFM. There is no surface oxidation process detected over a month keeping in the air at normal conditions, as shown by comparative core level photoelectron spectroscopy.

1. Introduction

Bismuth telluride, Bi_2Te_3, is a representative member of the Bi_2Se_3 crystal family well-known for its pronounced layered crystal structure and good thermoelectric properties [1–5]. Recently, Bi_2Te_3 has become of wide research interest as a three-dimensional topological insulator (TI) where the novel state of quantum matter is realized [6–13]. Such electronic system possesses strong spin-orbit coupling that provides a combination of an insulating bulk and massless Dirac fermion surface states. The experimental realization of TI states was carried out by several methods including thin film and nanoplate preparation [9,10,12,14–16]. Besides this, it is well known that Bi_2Se_3 family crystals possess good cleavage properties and high-quality (0001) surface of macroscopic area can be prepared using the bulk crystal and cleavage procedure [5,7,17–24]. This method of the pristine surface preparation was used in many experiments on TI effect observation and top surface engineering of Bi_2Se_3–family crystals. Regrettably, as a rule, only a very short description of the crystal growth conditions and surface preparation conditions can be found in literature [7,17,18,21–30]. The formation and stability of the TI state at the crystal–vacuum (or air) boundary and device

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