Study of MBE growth and thermal stability of Bi_2MnTe_4 thin films

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Magnetic topological insulators (TIs) promise to open new avenues in the fields of spintronics, electronics, quantum computing and metrology. Combining non-trivial band topology with magnetic order [1], these novel materials are expected to host Majorana fermions and exhibit unique phenomena such as the quantum anomalous Hall effect (QAHE). The QAHE has been observed by doping TIs with 3d transition-metals [2] and at the interface between TIs and magnetic insulators [3]. However, such observations were restricted to very low temperatures, arguably because of the disorder introduced in the material by doping and because of the intrinsic weakness of magnetic proximity effects. In this scenario, the realization of intrinsic magnetic TIs, stoichiometric well-ordered magnetic compounds, has emerged as a promising alternative for observing the QAHE at higher temperatures. One of the most intriguing materials is the antiferromagnetic layered van der Waals compound Bi_2MnTe_4. Although several recent works have confirmed its realization [4, 5, 6, 7, 8], many questions have yet to be addressed about its properties and those of its family $Bi_2MnTe_4/(Bi_2Te_3)_m$. These questions concern fundamental aspects, such as the interplay of the magnetic order and topology, and their growth and device-level integration. In this work, we study the growth of Bi_2MnTe_4 thin films by molecular beam epitaxy (MBE) technique. Using *in-situ* reflection high energy electron diffraction (RHEED) and *ex-situ* X-ray diffraction (XRD), and based on recent reports [9, 10, 11], we analyse the crystal structures, interlayer stacking and defects deriving from different growth conditions, particularly from different Mn:Bi flux ratios. For a relatively wide range of ratios, in which we obtain high-quality films in terms of RHEED patterns, our XRD characterization suggests the coexistence of different $Bi_xMn_yTe_z$ phases. In a film in which the Bi_2MnTe_4 phase is dominant, we demonstrate the absence of twin domains. Furthermore, XRD measurements as a function of temperature show that, above 150ºC, the Bi_2MnTe_4 irreversibly decomposes in a mixture of Bi_2Te_3 and metallic Te, in which the Mn seems to form an amorphous phase. This observation is partially in agreement with previous studies in bulk crystals [12] and suggests a severe constrain for the manipulation of the films during characterization and integration into electronic devices.

References

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