Monitoring the growth of Bi_2Se_3 with Spectroscopic Ellipsometry

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ABSTRACT

Using in-situ spectroscopic ellipsometry (SE), we demonstrate a route towards monitoring film temperature, composition, and thickness in real time during deposition of the topological insulator Bi_2Se_3 by molecular beam epitaxy. In contrast to ex-situ SE, where the unknown dielectric functions and the thicknesses of each layer of a multilayer film have to be obtained by modeling a single set of SE data at room temperature, the step-by-step in-situ SE data allows us to obtain the dielectric functions for Bi_2Se_3, and related compounds such as In_2Se_3, and $(Bi_{1-x}In_x)_2Se_3$ during growth at growth temperature and at different film temperatures after growth, as well as after cap-layer deposition with greater accuracy and precision. The optical models can extract film thickness with an accuracy of less than one quintuple layer, and surface temperatures can be determined with a precision of 10 K. Our optical models even reflect the crystalline quality of the Bi_2Se_3 film, confirming that Bi_2Se_3 grown on an $In_2Se_3/(Bi_{1-x}In_x)_2Se_3$ buffer layer is superior to Bi_2Se_3 grown directly on Al_2O_3, a conclusion corroborated by transport data.