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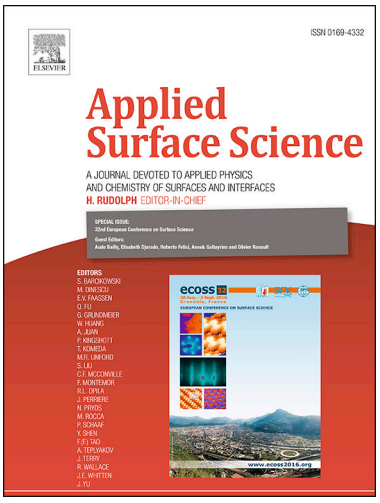

Full Length Article

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Dispersion properties of carrier concentration of $Bi_{0.38}Se_{0.62}$ films with topologically protected surface states revealed by spectroscopic ellipsometry

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Abstract: Optical properties evolution of $Bi_{1-x}Se_x$ films with different compositions were investigated by spectroscopy ellipsometry (SE). A significant dispersion of penetration depth of $Bi_{0.38}Se_{0.62}$ films was observed, which would lead to a varying carrier concentration with the different wavelength because of the topologically protected surface state. To describe the special properties of topological insulators, dispersive plasma energy was introduced into traditional dielectric function model. Optical properties of $Bi_{0.38}Se_{0.62}$ film were acquired by this modified model and the topologically protected surface state could be represented from the dispersion properties of free carrier concentration with the smaller plasma energy versus the deeper penetration depth. We demonstrated that SE is a useful tool for characterizing the properties of the topological insulators.

1. Introduction

Topological insulators, an electronic materials that have a bulk band gap like ordinary insulator but have topological protected states on their edge or surface.[1-4] Several materials have been reported as topological insulators via angle-resolved photoemission spectroscopy and scanning tunneling microscopy method, such as Bi_2Se_3, Bi_2Te_3, and Sb_2Te_3.[5-8] Among them, Bi_2Se_3 has a topologically protected band structure with the largest band-gap of ~ 0.3 eV and its Fermi level lies directly at the Dirac point. It offers the potential for topologically protected behavior in ordinary crystals at room temperature and greatly increases the potential for applications. So Bi_2Se_3 has attracted great attentions in both experiment and theory. However, the knowledge about the electronic and optical properties is still limited. Unlike usual materials, in topological insulators, the free carriers can only move along the surface. Since the optical constants reflect the interaction between the electrons and the optical field, the optical properties investigation on topological insulators can be used to study their electronic properties.

Ellipsometry is one of the popular tools for characterizing optical constants with nano-scaled films.[9-11] It has high precision in determining optical constants of various materials and thickness of thin film with a correct analysis optical model. Several works have been done with spectroscopic ellipsometry to research the optical properties of topological insulators,[12-15] but there still have a lot of properties to clarify. This work focuses on the specific optical properties of the topological insulators, and carrys out research on the bismuth selenide films of different composition by use of spectroscopic ellipsometry.