Signal oscillations in helium scattering by bismuth atoms in Bi$_2$Se$_3$ in low energy range

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Abstract

Analysis of bismuth selenide (Bi$_2$Se$_3$), a strong 3D topological insulator, revealed oscillations of the detected signal in dependence on primary ion beam energy. In this contribution, Low Energy Ion Scattering spectroscopy (LEIS) measurements on bismuth selenide were done for primary helium projectiles within the wide energy range from 0.5 to 6.0 keV. Dedicated LEIS-HS instrument Qtag 100 spectrometer (ION-TOF, GmbH, Germany) with scattering angle of 145° and perpendicular incidence was used. Structure of Bi$_2$Se$_3$ crystals is layered with a basic quintuple layer (QL) ordered as Se-Bi-Se-Bi-Se. These QL are separated by van der Waals gap, therefore a fresh and clean surface can be prepared by cleaving in vacuum [1].

Bismuth is a part of the group of elements where oscillatory behaviour was already noticed, such as gallium, indium or lead. Unlike in case of indium, oscillations of bismuth signal were described as more irregular [2]. At the same time, some regular pattern in oscillatory waves behaviour can be seen [3]. Moreover, clear differences exist between data for target atoms in elemental form and for atoms in compound form, as it was described in case of indium and indium arsenide crystals [2]. Recently, effect of impurities was described to cause ion yield oscillations in analysis of lanthanum surfaces [4].

Changes in oscillations of bismuth yields were observed after the measurement of thin bismuth film. Both shift in oscillatory peaks and shift in signal intensity were observed. On Figure 1, comparison of the oscillation curves of bismuth is displayed together with selenium. Correct understanding of presented topic helps to provide more precise LEIS quantification.

Figure 1: Comparison of the Bi$_2$Se$_3$ (Bi black line, Se red line) and Bi film (blue line) scattering yields for 4He$^+$ primary ions within energy range from 0.5 to 6.0 keV

References


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