Phonon modes and resonance effects measured with helium atom scattering from the Bi(111) surface

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Since the semimetal Bismuth (Bi) has remarkable differences between its bulk and surface properties it is a promising candidate for nano-scale applications. Strong spin-orbit splitting gives rise to metallic characteristics on the bismuth surfaces. Whereas Bi bulk properties have been analyzed very well open questions about the lattice dynamics of the Bi surfaces remain.[1]

Being a surface sensitive technique, Helium Atom Scattering (HAS) makes it possible to investigate elastic as well as inelastic phenomena associated with shapes and changes of the electron corrugation slightly above the Bi(111) surface. [2]

Very recently we completed the inelastic measurements and are now able to present the surface phonon dispersion curves of Bi(111) along both high-symmetry directions. In addition to typical Rayleigh modes unexpected features appeared. Ab-initio calculations made it possible to identify modes originating in longitudinal resonance effects as well as nearly dispersionless modes originating in vibrations of the second bilayer. These subsurface modes can only be observed by HAS because of the electron phonon coupling. Movement of the atoms in subsurface layers causes oscillations of the electron charge density above the first layer.

Furthermore, temperature dependent changes were investigated by cooling the sample down to 103 K. Indications of more extraordinary features were revealed and are subject to further investigations.

[1] P. Hofmann, Prog, Surf. Sci. 81 (2006) 191.

[2] M. Mayrhofer-Reinhartshuber et al., J. Phys.: Condens. Matter 24 (2012) 104008