# Van der Waals $SnSe_2$ epitaxial films on $Bi_2Se_3$(0001) and Si(111) surfaces

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Since the discovery of graphene, materials consisting of several-atom-thick layers attract enhanced attention. The absence of dangling bonds on molecular layers' surfaces and subnanometer thickness make prospects for creating next-generation electronic and optoelectronic devices [1,2]. The study of $SnSe_2$ van der Waals growth on the Si(111) and $Bi_2Se_3$(0001) surfaces with the control of defect concentration and electronic properties is a current issue preventing applications in modern electronics [3].

In this work we have realized the growth of a 30-nm-thick $SnSe_2$ film on $Bi_2Se_3$ surface using *in situ* reflection electron microscopy (REM) [4]. The atomic force microscopy (AFM) images show uniformly oriented 10–20-nm-high hexagonal mounds, the height of atomic steps on the film's surface is about 0.6 nm, which corresponds to the height of a $SnSe_2$ molecular layer. Half of the mounds have a shape of a hexagonal pyramid formed by exits of screw dislocations to the surface. However, a significant part of the surface is occupied by previously unobserved hexagonal $SnSe_2$ mounds with 1 μm-wide uppermost terraces. Such mounds do not have screw dislocations, and domain boundaries are not visualized between them, which indicates a low concentration of defects in the film's crystal structure. The combination of such features is typical for the growth of epitaxial films.

We have studied van der Waals epitaxial growth of a $SnSe_2$ film on a Si(111) surface by *in situ* REM. Prior to growth, the Si(111) surface was passivated with selenium at a temperature of ~100°C, to saturate dangling bonds that prevent the nucleation and growth of the van der Waals layer. The patterns of reflection high-energy electron diffraction observed during the growth corresponded to the layer-by-layer growth of $SnSe_2$ film. AFM images show that the height of atomic steps on the film surface is about 0.6 nm, which corresponds to the height of the $SnSe_2$ molecular layer. No misorientation of 3D islands was observed, which allows us to conclude that the film grew epitaxially. Raman scattering of films on both substrates reveals a set of vibrational modes corresponding to the layered 1T-$SnSe_2$ phase [5].

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