Phase controlled synthesis of $MoTe_2$ on graphene/SiC(0001) by MBE

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Ever since its discovery, graphene has been highly researched for its fascinating properties. However, the lack of bandgap in graphene has motivated a search for similar intrinsically semiconducting two dimensional materials. Transition metal dichalcogenides (TMDs) have been considered as an alternative owing to their unique electrical and optical properties. Bulk TMDs exhibit a wide variety of polymorphs, the important ones being *2H* and *1T'*. The *2H* phase is semiconducting while the *1T'* phase is metallic and the controlled transition from one phase to other has been investigated and the stabilization of one phase over the other is highly desirable. Among all the TMD tellurides, molybdenum telluride ($MoTe_2$) exhibits co-existence of both *2H* and *1T'* phases at room temperature due to the small energy difference between them [1]. While this co-existence is very promising for a large number of applications, it is also a challenge for the phase-specific synthesis of large area, highly crystalline films. Although there have been several studies on the Molecular Beam Epitaxy (MBE) synthesis of $MoTe_2$ on various substrates [2-4], growth mechanism, the influence of substrate temperatures on the structure and crystalline quality, the transition between the phases as well as the stabilisation of one phase over another are not fully reported yet. We present a systematic study of the growth of $MoTe_2$ on graphene/SiC(0001) by MBE at various substrate temperatures. The synthesized films were characterized by Reflection High Energy Electron Diffraction (RHEED), Low Energy Electron Diffraction (LEED), Auger Electron Spectroscopy (AES), X-ray Photoelectron spectroscopy (XPS) and Scanning Tunneling Microscopy (STM). For a given Te:Mo flux ratio, the crystalline quality of the films depends strongly on substrate temperature. At substrate temperatures between 150°C and 250°C, films containing co-existing phases are obtained. The *2H* phase can be stabilized by annealing the films with and without Te flux. Annealing without Te flux produces *2H* phase with higher number of defects and the domain edges are terminated by nanowires of Mo_6Te_6 (Figure 1). Annealing with Te flux improves the crystalline quality with uniform domains with smooth edges. STM analysis of the domains shows a network of inversion domain boundaries. Moiré patterns confirm the rotational alignment and symmetry seen in LEED.

References

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Figure

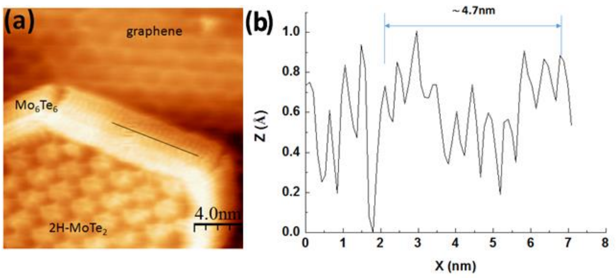

Figure 1: (a) STM image of a domain of *2H*-$MoTe_2$ on graphene (b) height profile of the Mo_6Te_6 nanowires formed at the domain edges showing the periodicity.