Molecular beam epitaxy grown 2D transition metal dichalcogenides

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Layered transition metal dichalcogenides (TMD) are routinely obtained via exfoliation from bulk crystals. This method though efficient enough for research purposes lacks reproducibility and scalability indispensable for application related goals. The obvious solution to get around these problems is use of the epitaxial thin film growth methods. The most common one, already applied for the growth of two-dimensional (2D) TMD structures is chemical vapour deposition (CVD). This technique however has limited capabilities, it doesn't provide in-situ growth control tools, and is not suitable for the growth of multi-layer structures (heterostructures). Molecular beam epitaxy (MBE) is free from these disadvantages, and has already been used for the growth of TMD layers by a number of research groups [1-4]. Even though layered TMD materials grow in the Van der Waals (VdW) epitaxy mode, i.e. the films are only weakly bound to the substrate, the role of the latter (e.g. crystalline symmetry, lattice parameter), is essential to ensure distinct orientation, and lateral homogeneity of the MBE grown TMD layers. I will present results of our recent efforts aiming for the MBE growth of large area TMD films of selected TMD materials - $MoTe_2$ WTe_2, and $NiTe_2$ on 2-inch GaAs substrates. All three compounds are interested also in the context of topological properties - WTe_2 and $MoTe_2$ in one of its crystalline phases (orthorhombic Td structure) are classified as type II Weyl semimetal; $NiTe_2$ - as type II Dirac semimetal. Both topological semimetals, exhibit unique magnetotransport properties (due to the inherent spin-momentum locking of the topologically protected charge carriers), which are potentially useful for spintronic device applications. The MBE growth of TMD materials enables use of the standard *in-situ* growth control tools such as reflection high energy electron diffraction (RHEED). This technique provides precise/essential information concerning the thickness of deposited TMD layers, their crystalline perfection, orientation with respect to the substrate. Moreover it allows to evaluate composition of ternary TMD solid solutions such as $(Mo,W)Te_2$. In spite of the initial *in-situ* characterization of TMD layers I will also present results of electrical (magnetotransport) measurements and detailed structural characterization of TMD cross-sections with use of the advanced, state-of-the art transmission electron microscopy.

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