$MoTe_2$ thin films and nanostructures grown by molecular beam epitaxy

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$MoTe_2$ belongs to layered transition metal dichalcogenides (TMD) with interesting optoelectronic properties, e.g. direct energy gap of 1 monolayer thick films, and very high exciton binding energies. As many other TMDs, $MoTe_2$ occurs in several polytypes - semiconducting hexagonal 2H phase, metallic monoclinic 1T' and orthorhombic T_d ones. The latter existing at low temperature (below 240 K) exhibits topological Weyl semimetal properties with very peculiar magnetotransport characteristics due to topological protection of Weyl quasiparticles involved in the charge transport [1].

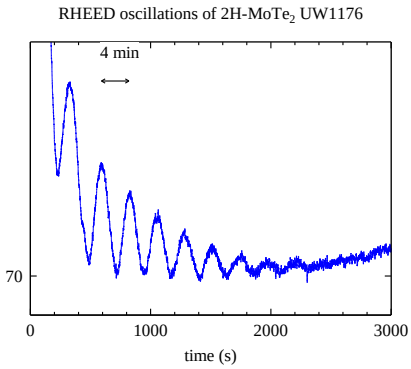

Fig. 1 RHEED intensity oscillations of 2H $MoTe_2$ grown on sapphire

So far 2D films of $MoTe_2$, similar to other TMDs have been obtained mainly by exfoliation from bulk crystals yielding flakes with micrometer size lateral dimensions and uncontrolled shapes.

Here we report on the successful molecular beam epitaxy (MBE) growth of $MoTe_2$ on large substrates (2-3 inch in diameter) of commercially available wafers of sapphire, GaAs or Si. The MBE growth is well controlled by reflection high energy electron diffraction (RHEED). Both the crystalline perfection and thickness of the deposited layers can be accurately controlled with this method. During the MBE growth of $MoTe_2$ films on different substrates distinct RHEED intensity oscillation are recorded (see Fig.1) enabling the control of the thickness up to 1 ML precision. Even though $MoTe_2$ on above mentioned (and other) substrates grows in the Van der Waals mode with weak interaction at the layer-substrate interface, the choice of a suitable substrate is of essential importance to obtain films with the best crystalline perfection and lateral uniformity. At some peculiar growth conditions the transition from 2-dimensional layer-by layer to 3-dimensional growth mode and formation of MoTe-based nanowires has been observed.

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REFERENCES

[1] A. N. Berger, et. al., B. A. Bernewig and A. N. Pasupathy; *npj Quantum Materials* **3** (2018) pp. 2-1 – 2-8.