2D transition metal ditellurides: Growth and Electronic properties

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Subject:

Original works of Geim and Novoselov in 2004 have highlighted the exceptional electronic properties of graphene and paved the way for the search of new two-dimensional materials (2D) [1]. A considerable research effort is now focused on materials with structural similarities such as boron nitride and transition metal dichalcogenides (TMDCs, e.g. MoS_2, WSe_2 ...) that exhibit an electronic band gap, prerequisite for optoelectronic applications. Among TMDCs, 2D tellurides are less widely studied despite their predicted non trivial topological states [2]. Also unlike selenides and sulphides, 2D tellurides are mostly semimetals and have a rather unusual tendency to exhibit an atomic arrangement, called polytype, characterized by a low symmetry.

The current PhD project aims at the control of the atomic structure and the electronic properties of 2D tellurides (WTe_2, $MoTe_2$) using *in situ* characterizations. More specifically, this PhD subject addresses:

(1) The challenging elaboration of large-scale (≈cm^2) 2D materials by molecular beam epitaxy (MBE) and the investigation of the relative stability of the different polytypes.

(2) The exploration of the corresponding electronic properties. This includes the determination of the spin-dependent band structure to unveil non trivial topological states.

2D materials will be obtained by *in situ* epitaxial growth (MBE) in a ultra-high vacuum chamber dedicated to tellurides already implemented at CINaM. The structural and morphological characterizations will be performed by low-energy microscopy (LEEM) and scanning tunneling microscopy (STM) available at CINaM. The electronic properties of the 2D tellurides will be determined by angle resolved photoemission spectroscopy (ARPES) in synchrotron facilities and in collaboration with Institut Jean Lamour (Nancy, France). This PhD project provides the opportunity to study the fundamental physics of 2D nanomaterials with advanced characterization techniques. Highly motivated candidates with a solid background in nanoscience, solid state physics and/or surface physics are required.

At CINaM, the PhD student will work in the Surface Structure and Dynamics team. Our group has initiated investigations on 2D materials [Fig. 1 (a-b)] with controllable electronic

properties and on GeTe epitaxial thin films [Fig. 1 (c-d)] characterized by an electrically-switchable spin texture of the band structure [3].

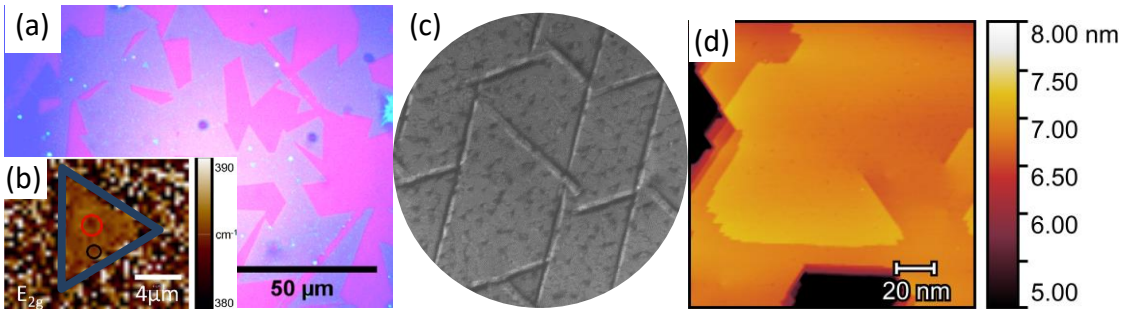

Fig.1: (a) Optical microscope image of a MoS_2 sample grown by CVD at CINaM. (b) Raman map showing that the MoS_2 island is mainly 1ML-thick (black ring) and that aditional monolayers start to grow from the island center (red ring). Laser excitation 532nm, 1.5mW. (c) LEEM image of a GeTe(111) thin film elaborated by MBE (electron energy: 26eV, field-of-fiew: 10µm). (d) STM image of a GeTe(111) thin film.

Bibliography:

[1] K. S. Novoselov *et al.* Science **306** (2004) 666
[2] A. Soluyanov *et al.* Nature **527** (2015) 495
[3] J. Krempasky *et al.* Phys. Rev. X **8**, 021067 (2018)