ZERNIKE INSTITUTE COLLOQUIUM

Thursday, November 3rd, 2016

16:00h, Lecture Hall: 5111.0080

Coffee and cakes from 15:30h

Electronic structure and electron dynamics in novel two-dimensional materials

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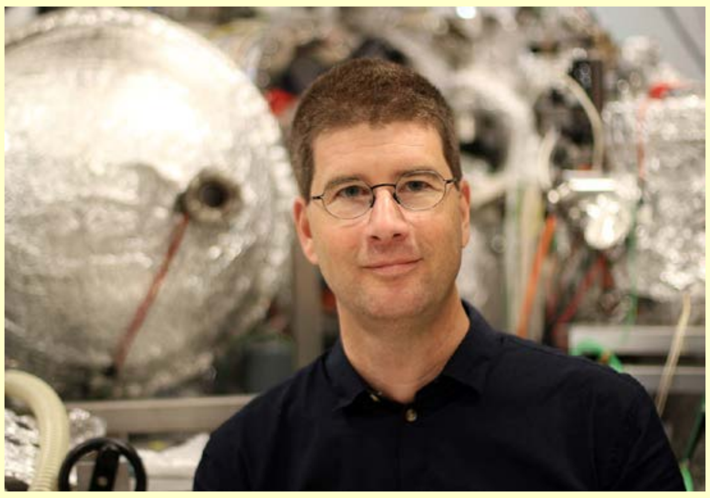

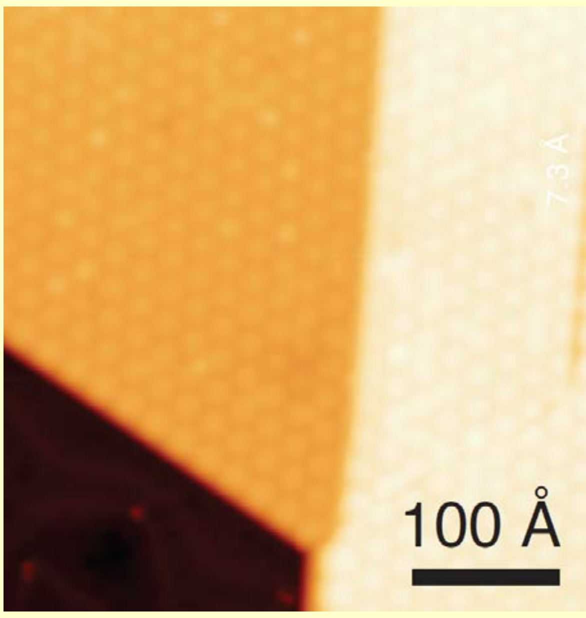

Fig. 1: STM image of a single layer of TaS_2 on Au(111). The hexagonal structure is not the atomic structure but a moire pattern arising from the lattice mismatch of Au and TaS_2 (PRB **94**, 081404(R), (2016)).

Artificial two-dimensional (2D) materials, such as graphene or single-layer transition metal dichalcogenides, often have electronic properties that are drastically different from their parent compounds. Moreover, these properties do not only depend on the 2D material as such but also to its environment, for example the substrate it is placed on. For instance, merely changing the dielectric properties of the substrate can strongly modify the band gap size of a 2D semiconductor.

Here we explore novel 2D materials such as single layers of MoS_2, WS_2 and TaS_2 by scanning tunnelling microscopy and angle-resolved photoemission spectroscopy (ARPES). The layers are grown epitaxially on Au(111), Ag(111) and graphene (see Fig. 1). For the semiconducting materials (MoS_2, WS_2), strong band gap renormalizations are observed due to the interaction with the substrate. For the metallic layers (TaS_2), we can study the effect of low dimensionality on electronic instabilities such as charge density waves and superconductivity.

While the static electronic properties of novel two-dimensional materials can be studied by standard ARPES, investigations of the ultrafast carrier dynamics require both time- and angular resolution and thus time-resolved (TR)-ARPES.

There is, moreover, the technical requirement of high photon energies since the interesting part of the aforementioned materials' electronic structure (i.e. the (gapped) Dirac cone) is placed at the two-dimensional Brillouin zone boundary. Recently, it has become possible to probe states at such high *k* by TR-ARPES, thanks to the arrival of ultrafast high harmonic laser sources. We can use this process to directly access the size and character of the band gap in a 2D material (see Fig. 2).

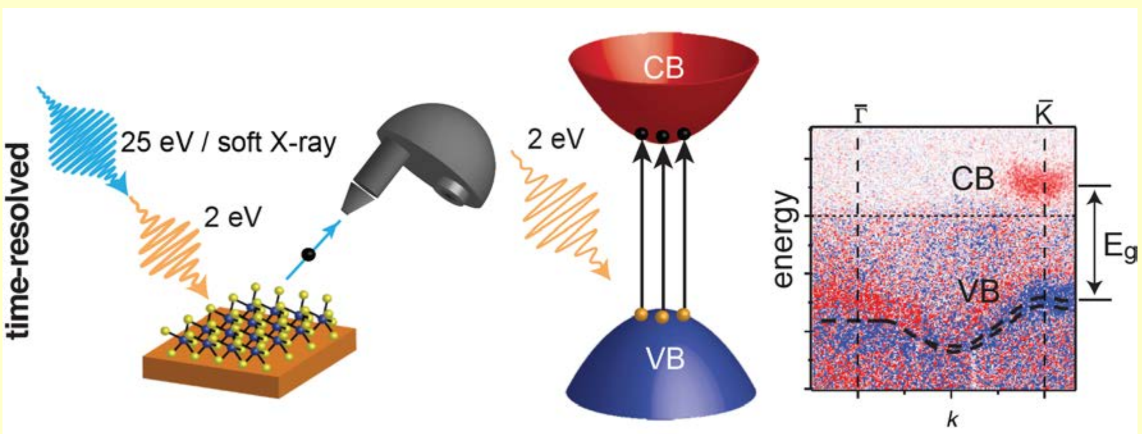

Fig. 2: Direct determination of the band gap size in a 2D semiconductor by resonantly pumping electrons into the conduction band and then detecting them in a photoemission experiment (Nano Letters **15**, 5883 (2015)).

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