JARA|FIT Fundamentals of Future Information Technology

2nd Institute of Physics A

RWTH AACHEN UNIVERSITY

Open Master-Thesis Project

Construction of an UHV thermal desorption spectroscopy setup

Each individual member within the large family of 2-dimensional (2D) materials is interesting on its own. Some have unique physical properties due to their pronounced spin-orbit coupling, others are ferromagnetic or superconducting, and yet others show quantum phenomena even at room temperature. But the technological potential of each individual 2D material may be nothing compared to the one which unfolds as soon as different 2D materials are combined in so-called heterostructures. Preliminary experiments with such heterostructures already demonstrated interesting physical phenomena and created the dream of a completely new class of artificial solids with tailored physical properties [1].

Nevertheless, there is one fundamental challenge which must be overcome for this dream to become true: The avoidance of contamination at the interfaces of the stacked 2D materials. Due to their fabrication process or even their mere exposure to ambient conditions, the 2D materials are covered with contaminations. Such contaminations on atomically thin materials will significantly contribute to the overall heterostructure and degrade its properties [2]. But if even the "dirty" heterostructures nowadays show intriguing physics, what will be revealed as soon as clean interface are accomplished?

Therefore, we aim to improve the fabrication process of the heterostructures. For this, we are building an ultra-high vacuum (UHV) chamber, in which the 2D materials will be cleaned by vacuum annealing. Thereafter the heterostructure is assembled under an inert gas environment.

Together with a Postdoc the student will build the vacuum chamber and thereby acquire knowledge about vacuum physics and technology. With the completed chamber the student will then conduct experiments to answer the following question:

1) What kind of contaminations are on top of 2D materials after they were fabricated and exposed to ambient conditions?
2) What temperatures are needed to remove these contaminations under vacuum conditions?
3) Does the annealing step change the physical properties of the 2D material?

To answer the first two questions, the chamber will be equipped with a mass spectrometer. By gradually increasing the temperature of the 2D material, the contaminations will eventually have enough thermal energy to desorb, which will be detected by the mass spectrometer (thermal desorption spectroscopy [3]). To address the last question, the student will learn how to characterize the properties of 2D materials by different, non-invasive methods. These include Raman spectroscopy, photoluminescence, and atomic force microscopy.

Final note: The construction of any kind of UHV equipment requires disciplined and clean working.

[1] A. K. Geim & I. V. Grigorieva, Nature 499, 419 (2013) (freely accessible within the RWTH net)
[2] A. V. Kretinin et al., Nano Lett. 14, 3270 (2014) (freely accessible within the RWTH net)
[3] Wikipedia: Thermal desorption spectroscopy

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