Making doped 2D TMDs by atomic layer deposition for future transistors

Short description: You will explore doping of 2D materials by atomic layer deposition, building upon initial results from our group.

Background: If you look at roadmaps of Intel and TSMC, it is clear that the next-generation semiconductor in transistors that will replace silicon are so-called 2D transition metal dichalcogenides (2D TMDs). These two tech companies both state that there are two key challenges for this transition to happen in the next decade:

1. Doping of the 2D material (n- and p-type)
2. Controlled growth of the gate oxide onto the 2D material.

In this project, you will look at the 1st aspect using atomic layer deposition (ALD), a technique that enables layer-by-layer deposition of thin films with atomic-level control of the film thickness.

Project: In this project you will investigate doping approaches for 2D TMDs by ALD. While ALD processes to deposit 2D TMDs without doping (e.g. MoS_2 and WS_2) are well-established, you will build upon initial results of our group to make doped 2D TMDs by ALD (for example Al-doped MoS_2). In addition to this, also an approach called "remote doping" can be studied. In this latter form of doping ,you induce *n*- or *p*-type conductivity in the 2D material through interaction with the adjacent material. This project will have a strong component of understanding how the ALD growth process (studied with in-situ techniques) relates to the properties of the produced doped 2D TMD (optical, electrical, structural, ...)

In this project you will work with ALD and gain experience on working in a cleanroom facility. You will learn about important characterization techniques such as spectroscopic ellipsometry, Raman, X-ray photoelectron spectroscopy and Hall effect.

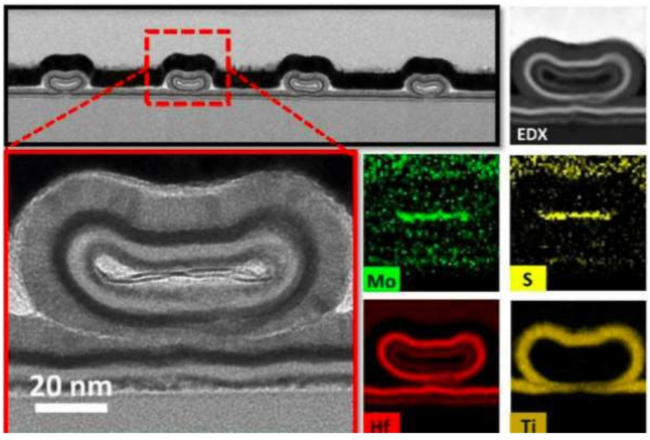

***Fig. 1:** Electron microscopy image of the world's first 2D nanosheet transistor as presented by TSMC at last year's IEDM conference in San Francisco. The active channel of the transistor is a monolayer of MoS2. Furthermore, you can see hafnium oxide as gate dielectric wrapped around the 2D material. In this project you will look at doping, which is important for making n- or p-type transistors, as well as for contacting by metal.*

If interested please contact:

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Location and supervision: You will perform experiments in the cleanroom and labtuin that are located in Spectrum. You will be supervised by Bart Macco.