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S E M I N A R
aus
Halbleiterphysik und Nanotechnologie

Mo, 22.03.2021, 12:00 Uhr, (Seminar via Zoom)

"Atomic-scale carving of nanopores into a van-der-Waals heterostructure with slow highly charged ions"

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Ions in high charge states are an ideal tool for surface sensitive modification and perforation of thin layers on the nanoscale. The neutralization of the ions is accompanied by the release of the initially stored potential energy in the order of several 10keV into the electronic subsystem of a solid surface. Depending on the electronic response of the surface, the target may be sputtered/perforated (semi-conductors or insulators) or stays intact (metals).
Here I will show our recent results on perforation of mono-, bi-, and tri-layer MoS_2 on top of a single graphene layer [1]. The topmost MoS_2 layer of this freestanding van-der-Waals heterostructure can be perforated with high efficiency using highly charged ions, whereas the graphene stays intact. Even more interesting, if the layer order is reversed and the graphene faces the ion beam, no damage is observed in neither layer. Similar to studies on electronic sputtering in a transmission electron microscope [2], graphene can shield susceptible layers underneath by effectively absorbing the deposited (potential) energy and dissipates it into a larger area before the material disintegrates.
Our study shows that highly charged ions can be used to address individual layers with monolayer precision for modifications on the nanoscale. Pores can be induced in freestanding susceptible layers or carved into the very surface layer leaving the layers underneath virtually undamaged.

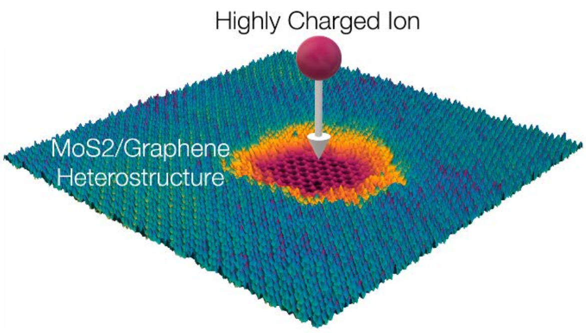

Figure 1 Pseudo-3D representation of a Scanning Transmission Electron Microscopy (STEM) image after the impact of a 180keV Xe^{38+} ion. Here, a trilayer-MoS_2 on top of graphene is shown, where the first and second MoS_2 layers are perforated, but the third layer stays intact (purple).

[1] Schwestka, J.; Inani, H.; Tripathi, M.; Niggas, A.; McEvoy, N.; Libisch, F.; Aumayr, F.; Kotakoski, J.; Wilhelm, R.A., *ACS Nano* **14**, 10536 (2020)
[2] Zan, R.; Ramasse, Q. M.; Jalil, R.; Georgiou, T.; Bangert, U.; Novoselov, K.S., *ACS Nano* **7**, 10167 (2013)