

Exciting Solids:

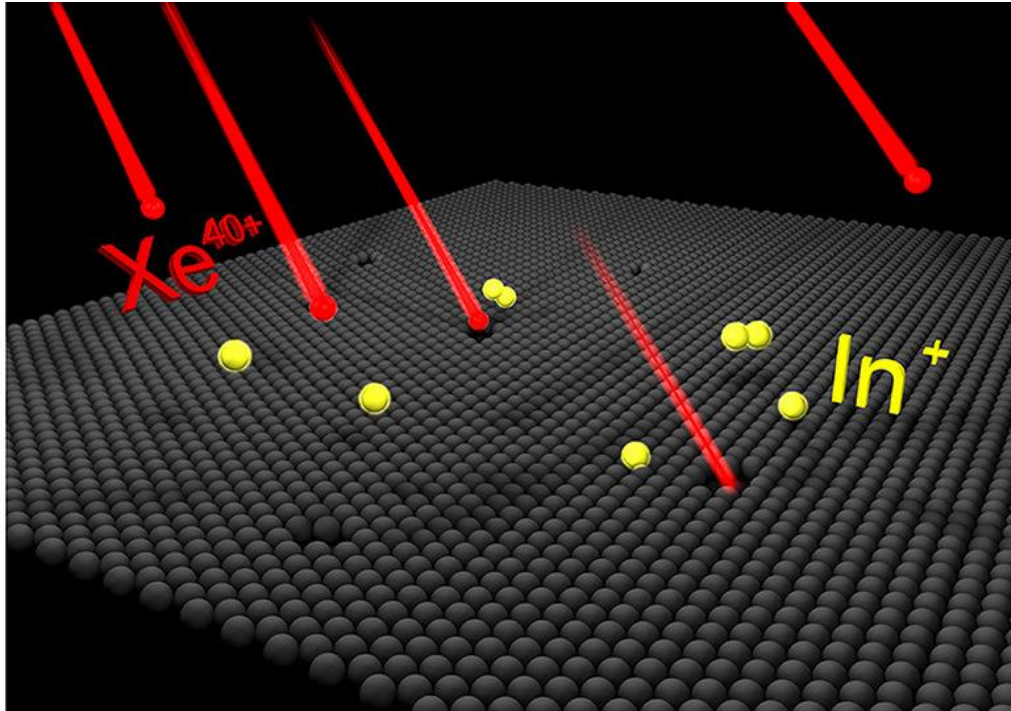
Nanoengineering of surfaces and 2D materials via electronic excitation

Marika Schleberger

26 SEP > 1 OCT 2021 Autrans-Méaudre en Vercors, FRANCE

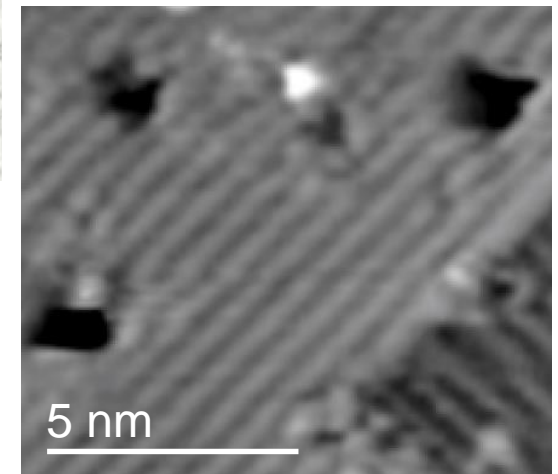
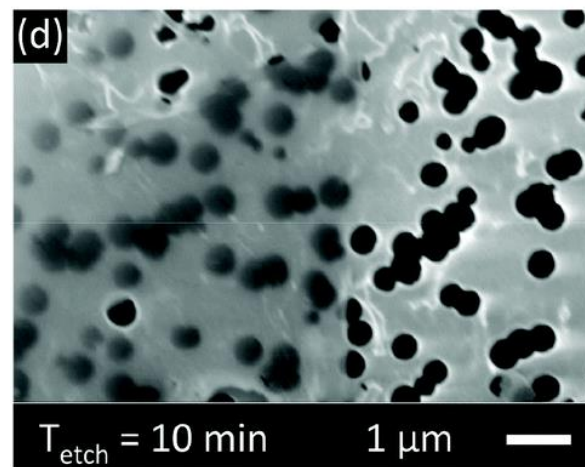
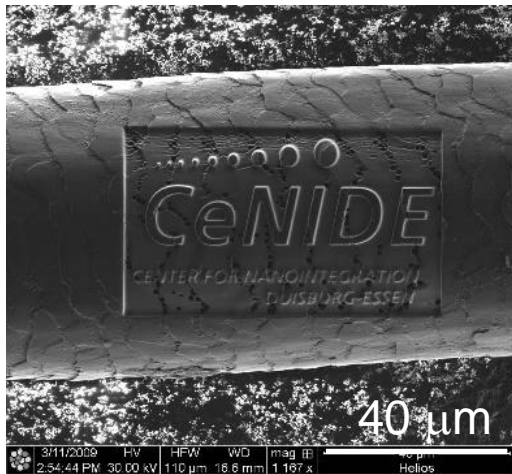
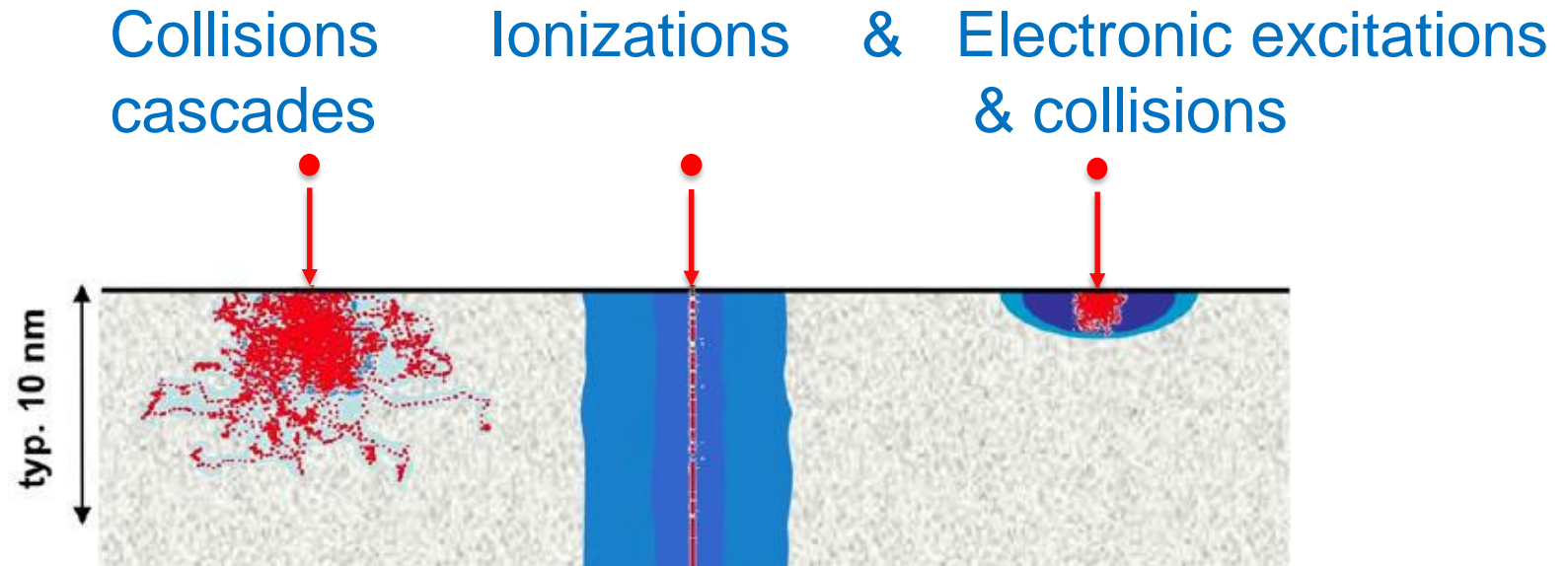
XXIInd COLLOQUE GANIL

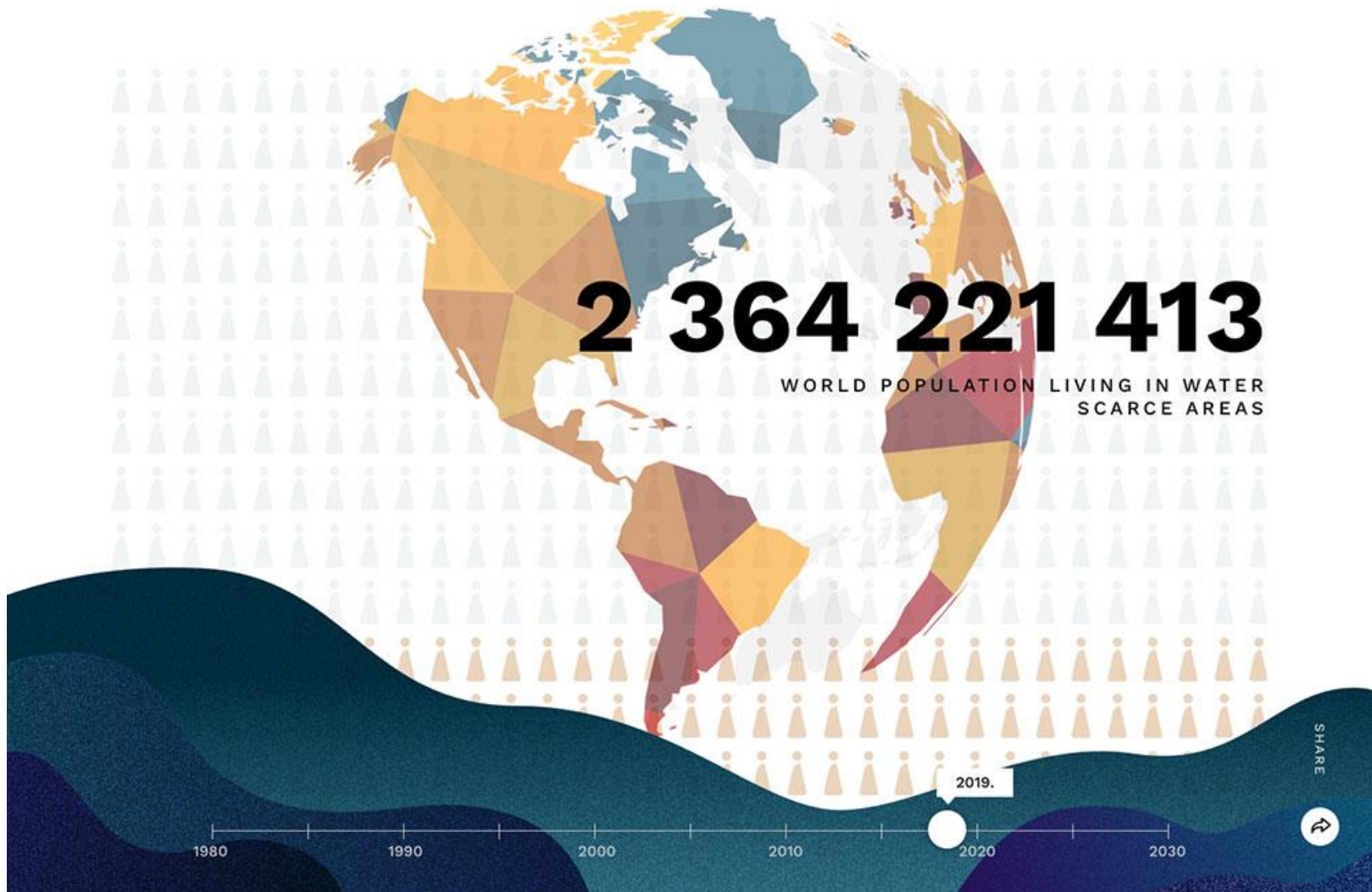


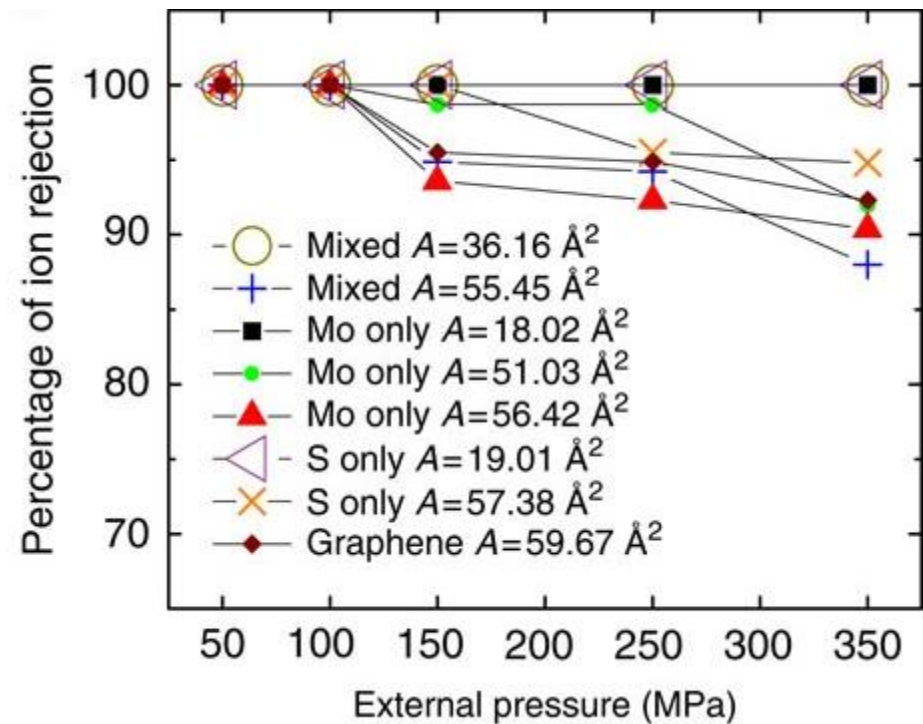
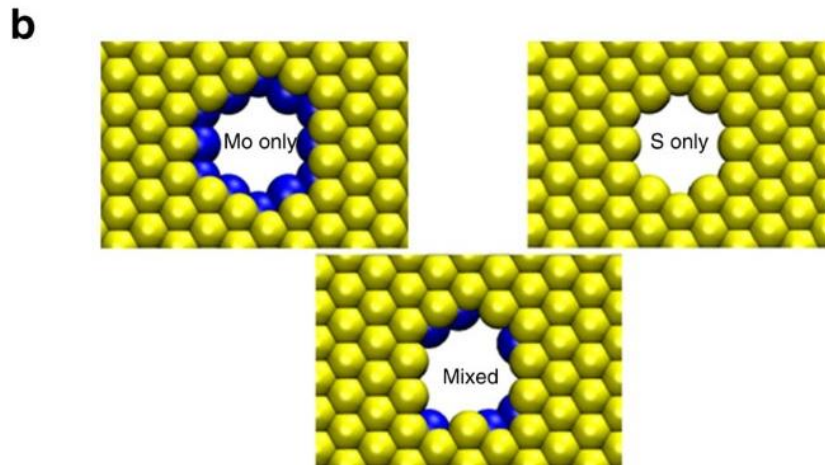
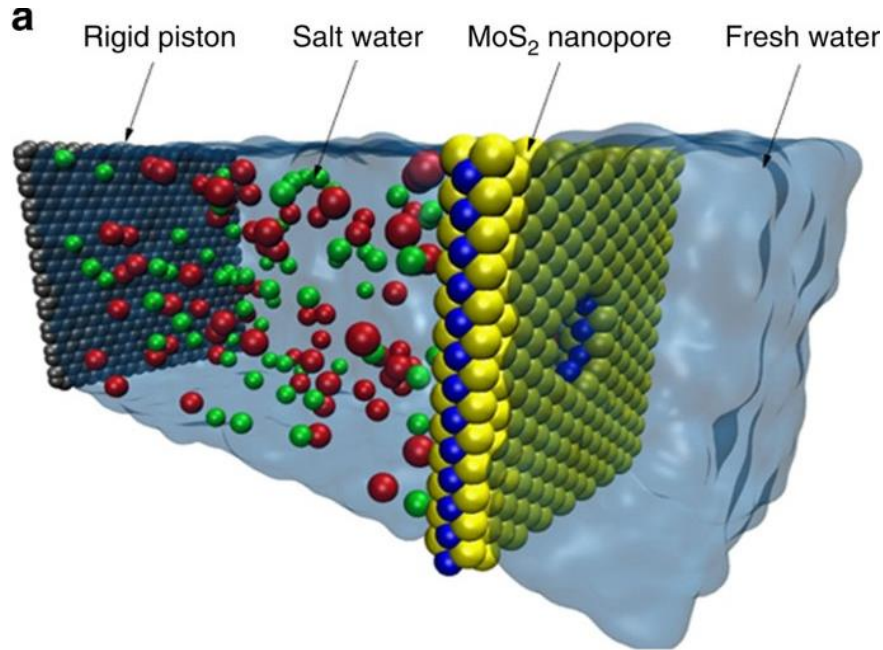


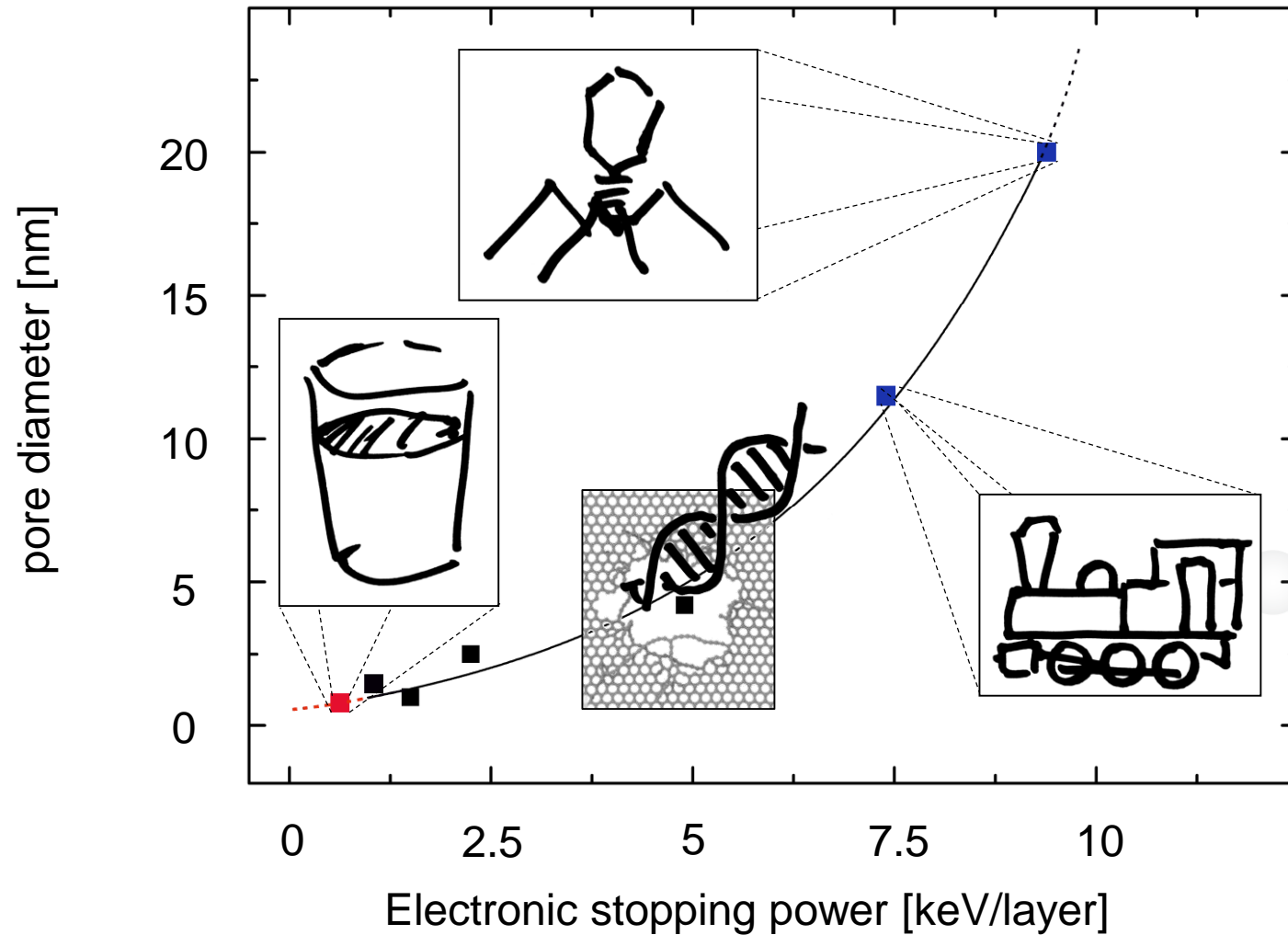
Energy deposition by

- Nuclear stopping $dE_n/dx \Rightarrow$ billiard
 - Electronic stopping $dE_e/dx \Rightarrow$ electron excitation & atom ionization
-
- Ratio can be tuned by ion's mass, charge state, and velocity ...

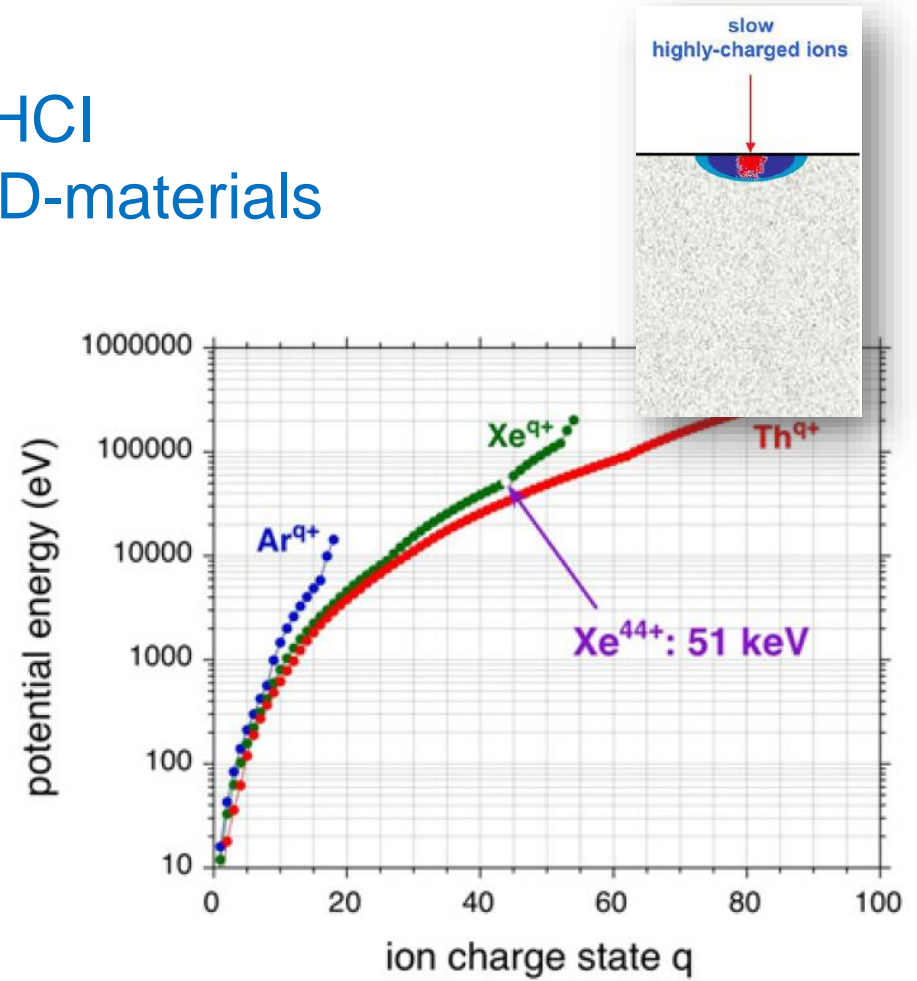
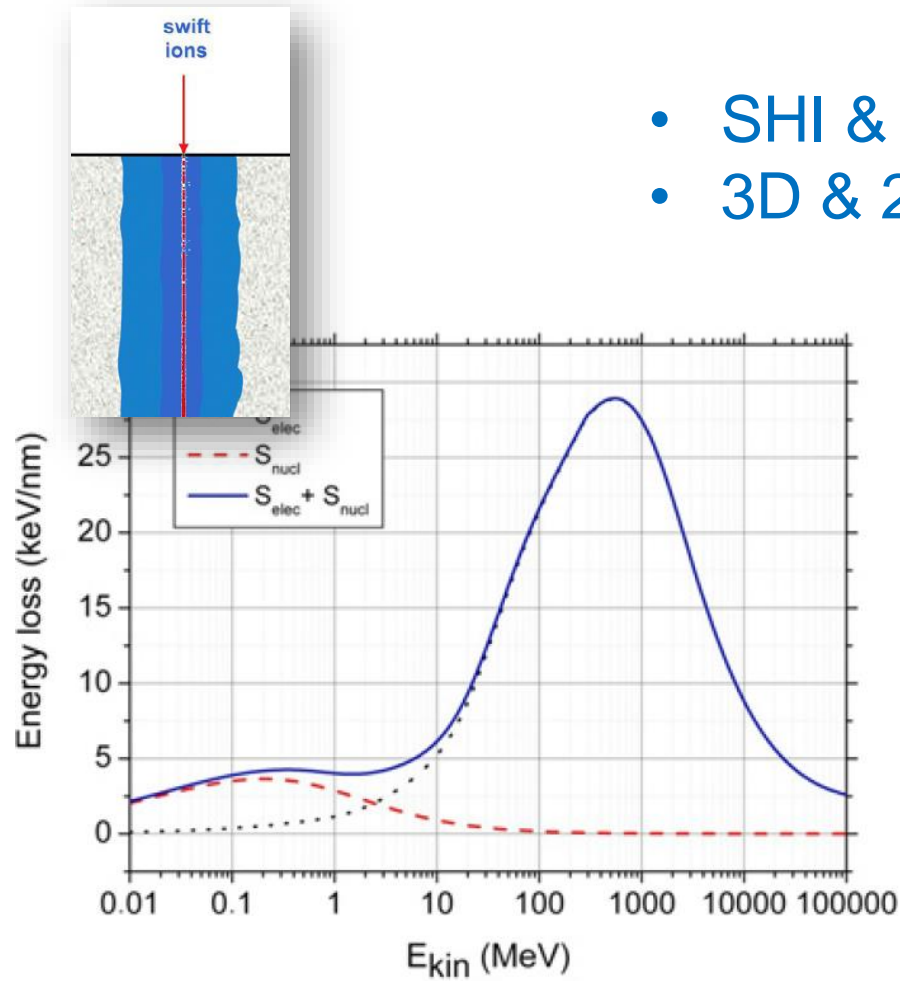


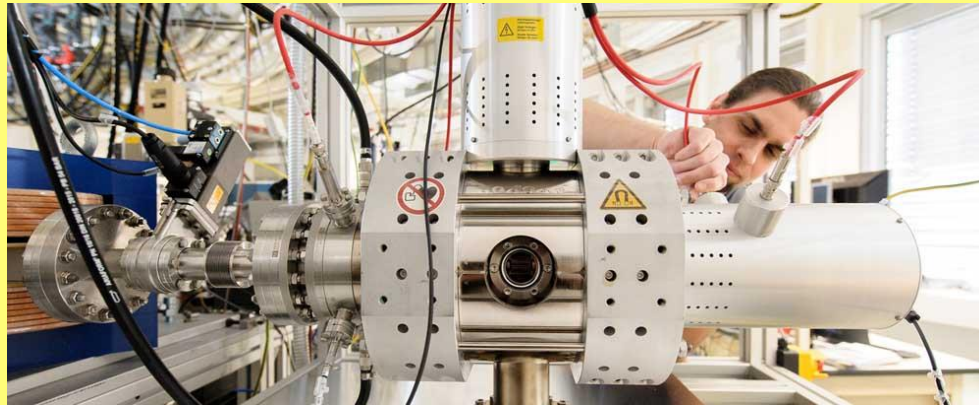






- SHI & HCI
- 3D & 2D-materials





HICS beamline, $E_{\text{pot}} \sim 40 \text{ keV}$ (UDE, Germany)

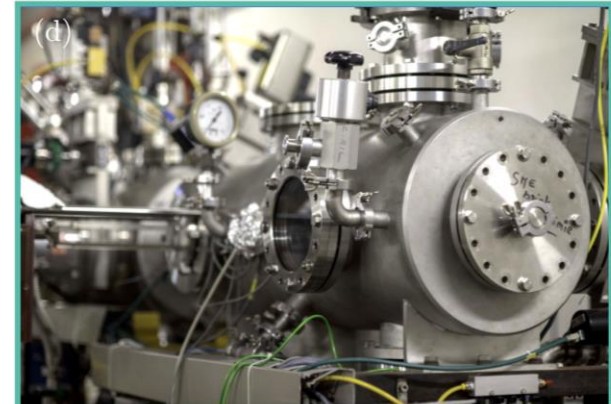
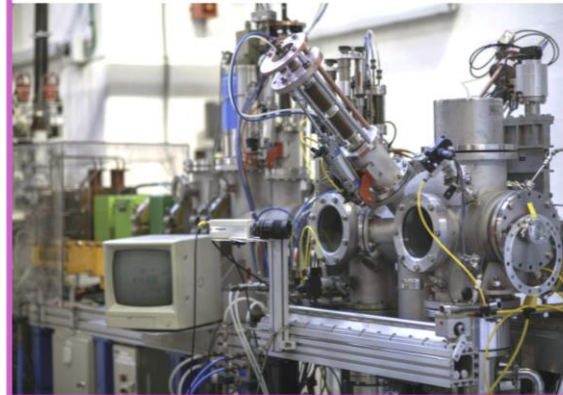


(b) 6 MeV EN Tandem VdG, $E_{\text{kin}} \sim 30 \text{ MeV}$
RBI (Zagreb, Croatia)



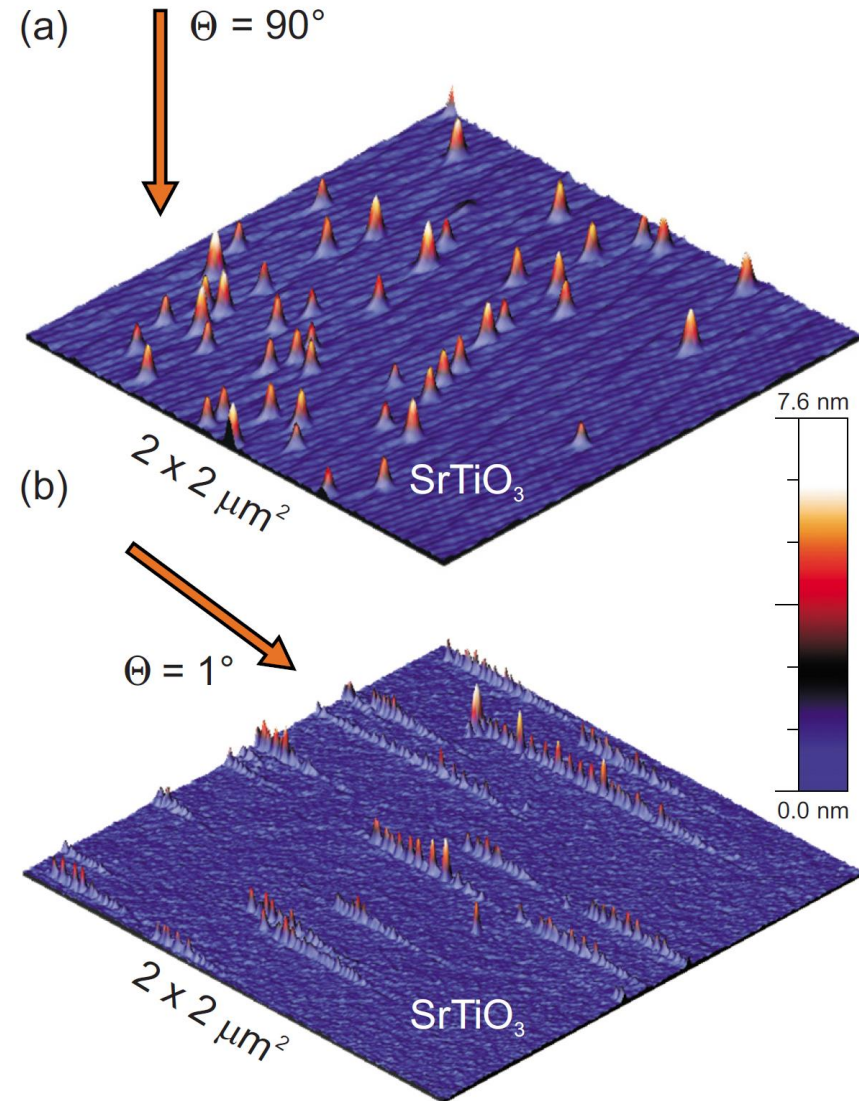
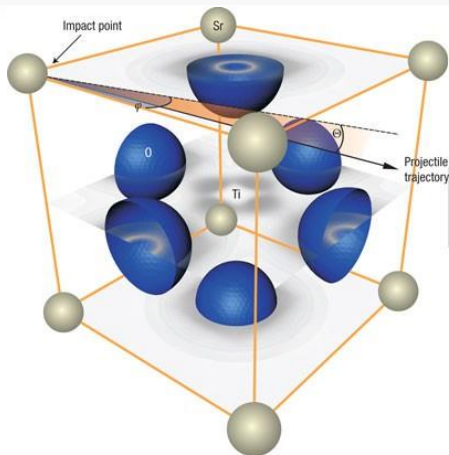
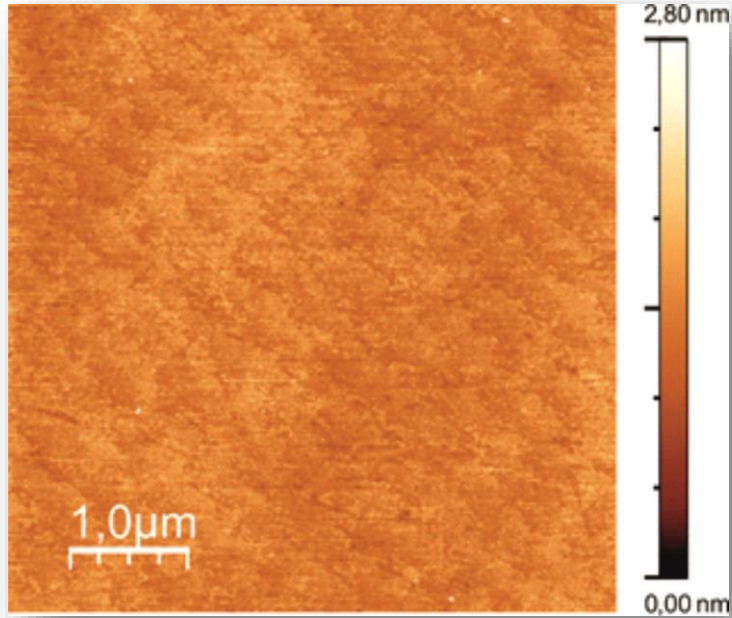
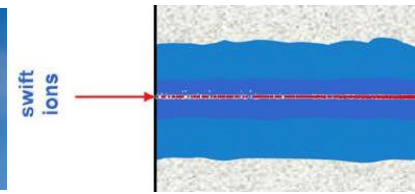
M branch, UNILAC (GSI)
(Darmstadt, Ger) $E_{\text{kin}} \sim 1000 \text{ MeV}$

(c) IRRSUD beamline, $E_{\text{kin}} \sim 100 \text{ MeV}$
GANIL (Caen, France)

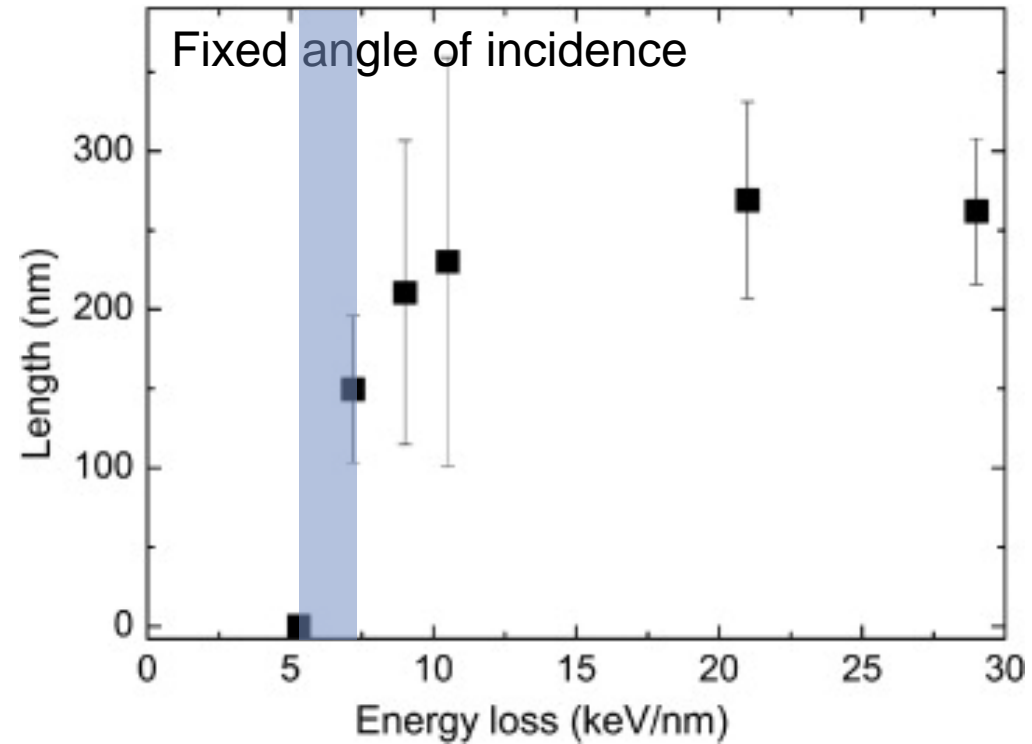
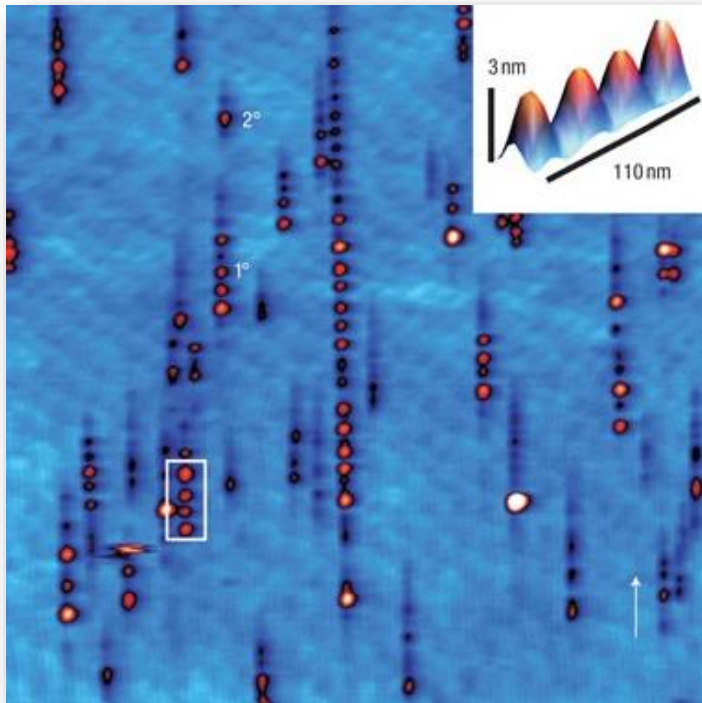
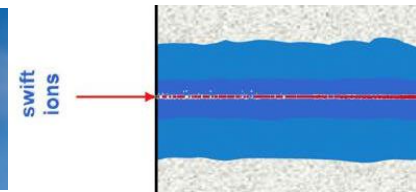


(d) SME beamline, $E_{\text{kin}} \sim 1,000 \text{ MeV}$
GANIL (Caen, France)

Ion Induced Surface Tracks



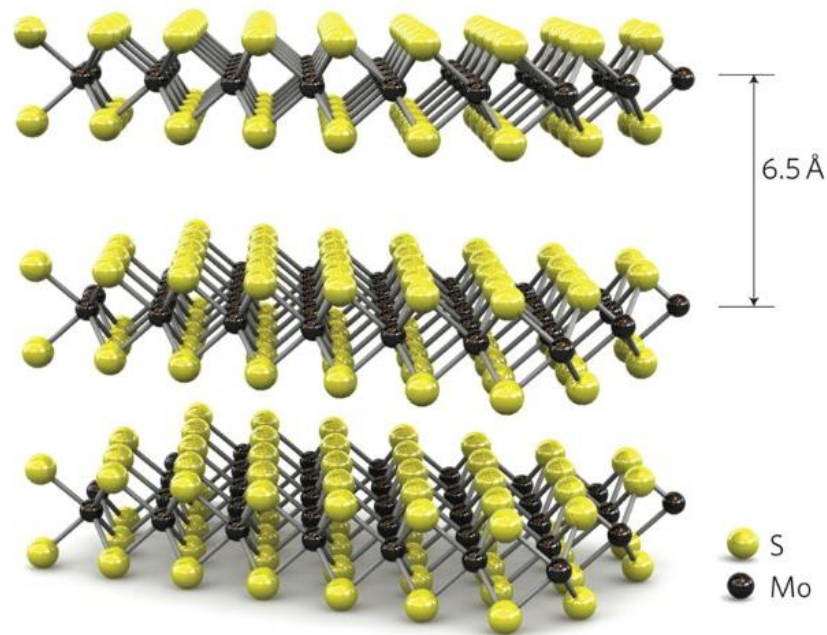
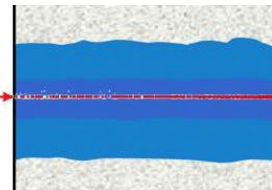
Ion Surface Tracks in 3D: Threshold



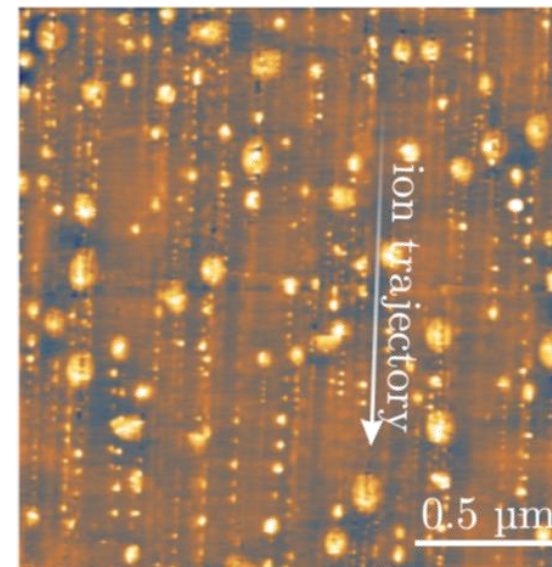
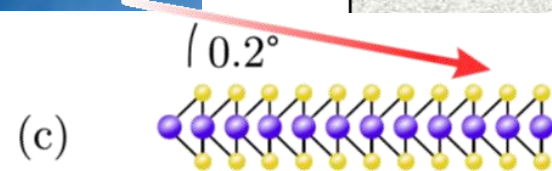
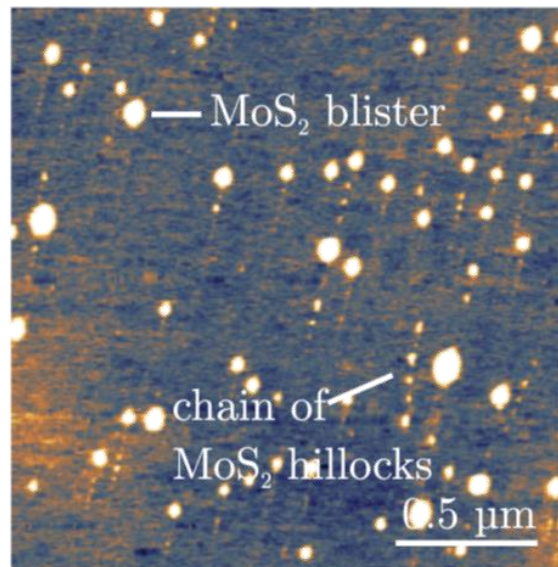
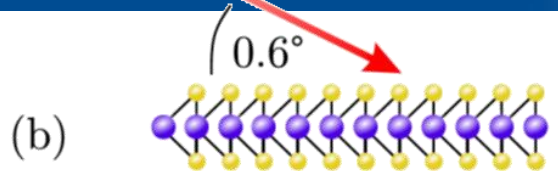
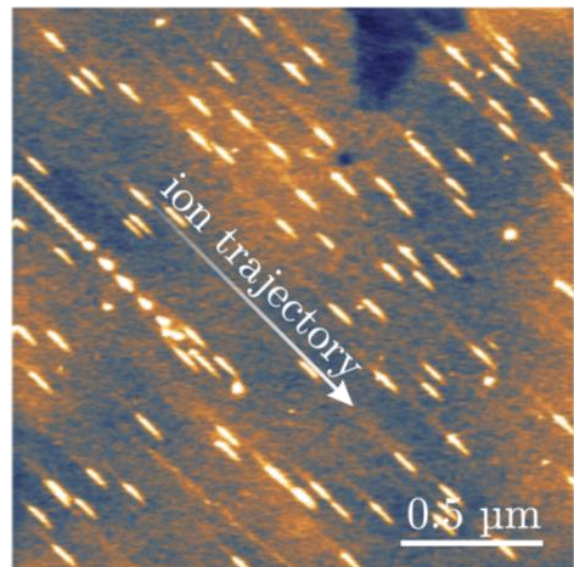
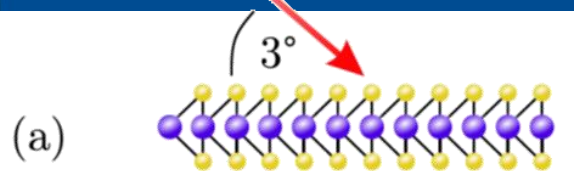
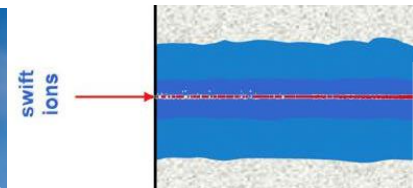
$dE/dx = 7 \text{ keV/nm}$
required for appearance of tracks

Ion Surface Tracks in 3D: MoS₂

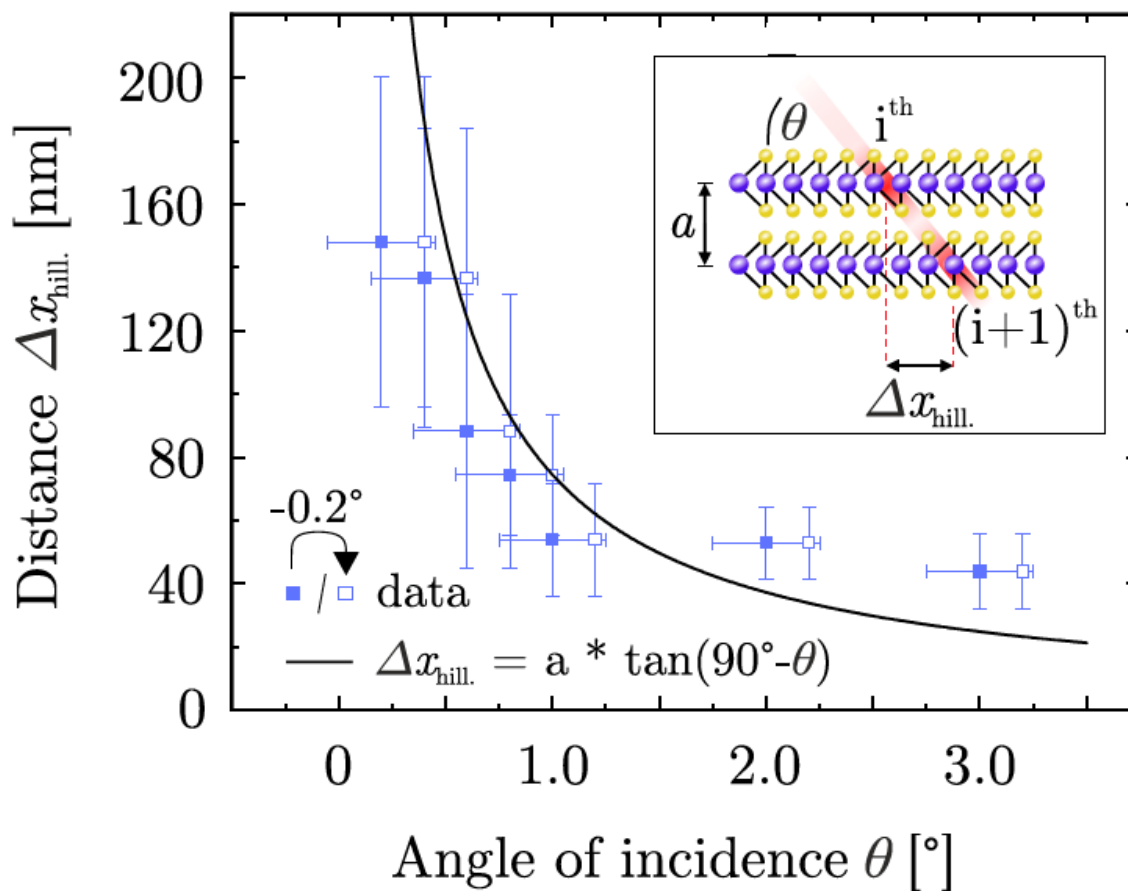
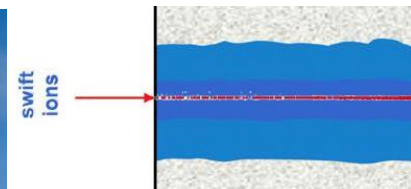
swift ions



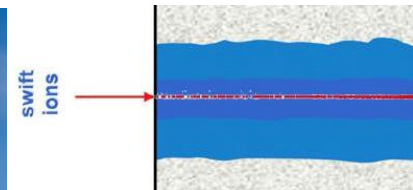
Ion Surface Tracks in 3D: MoS₂



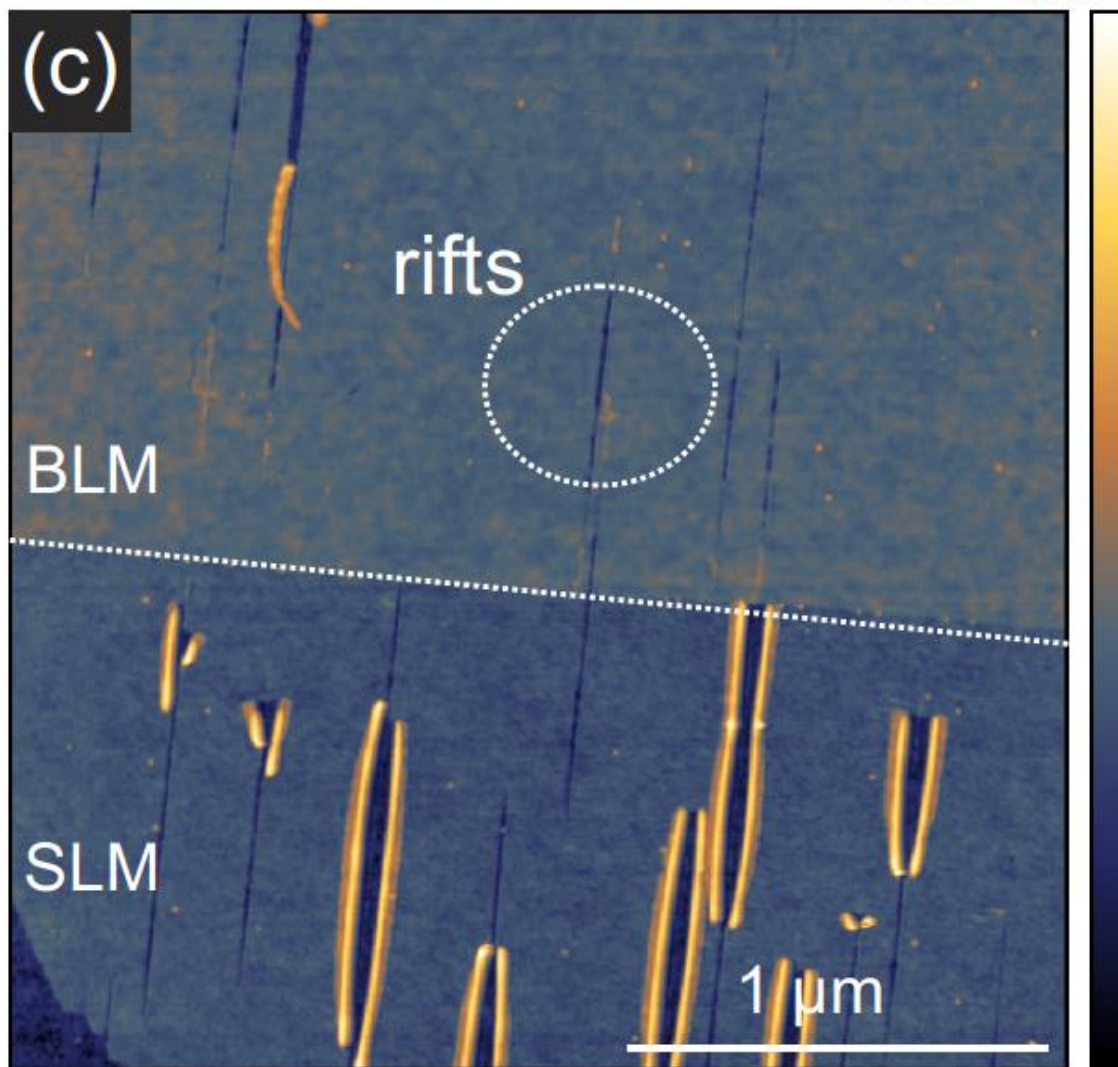
Ion Surface Tracks in 3D: MoS₂



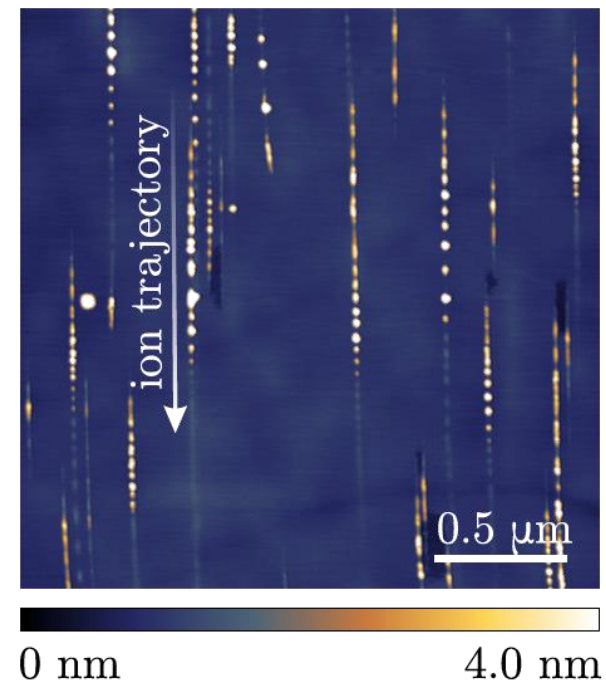
Ion Surface Tracks in MoS₂: From 3D to 2D



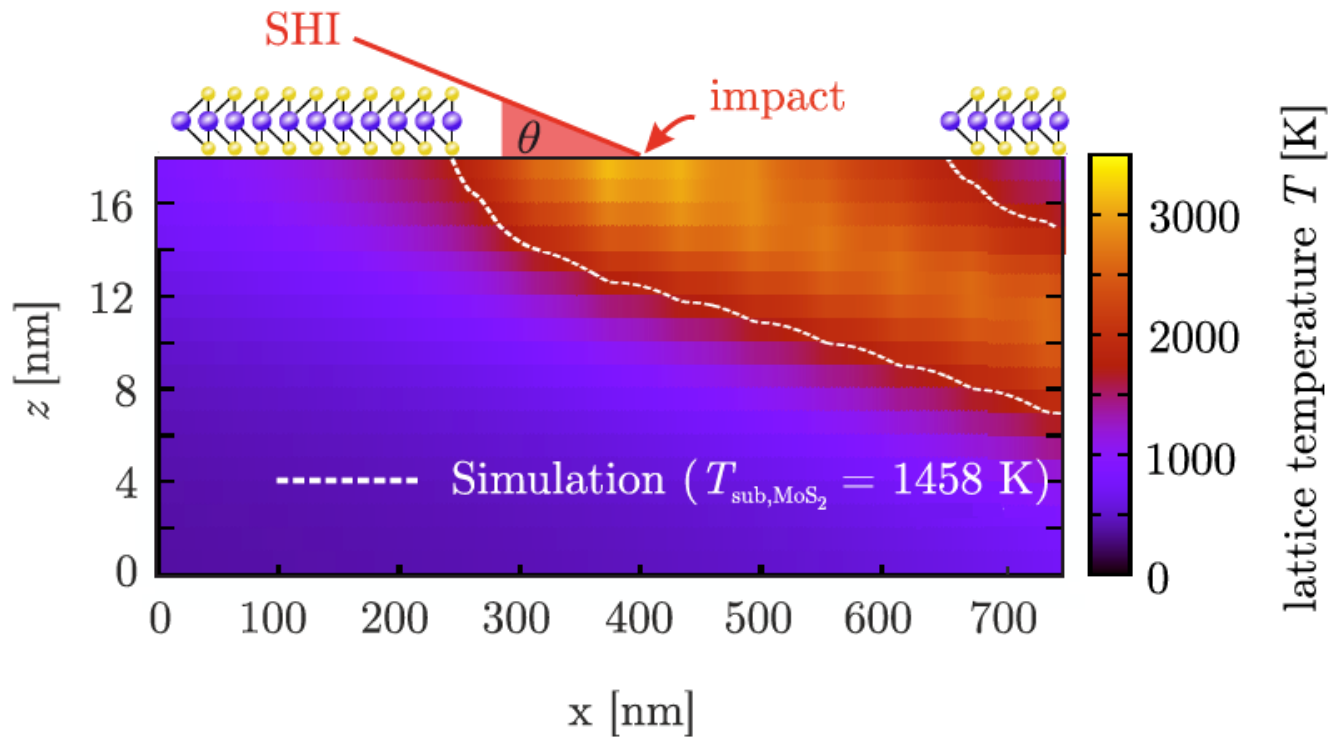
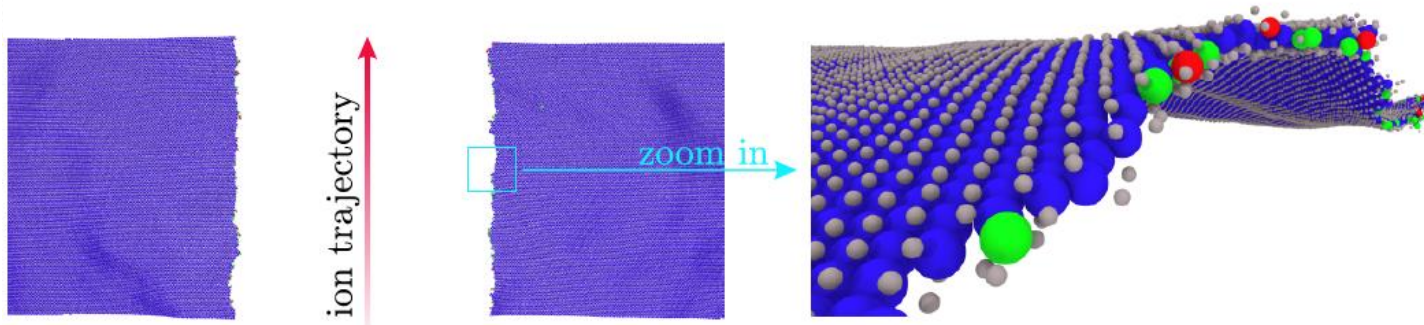
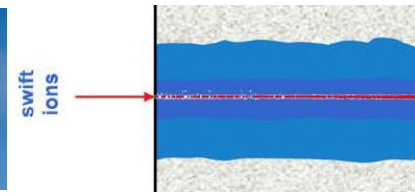
9.9 nm



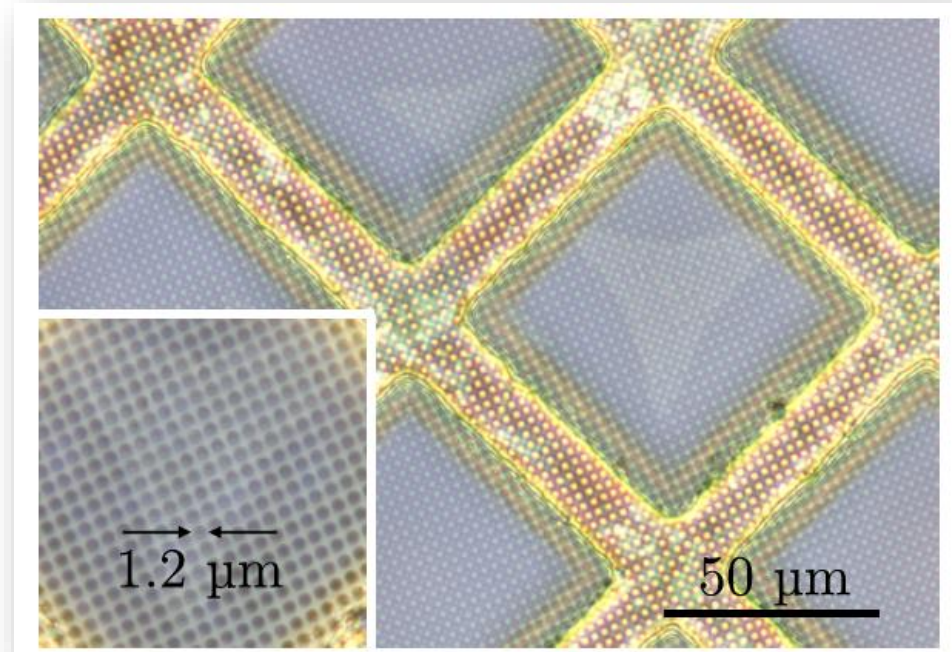
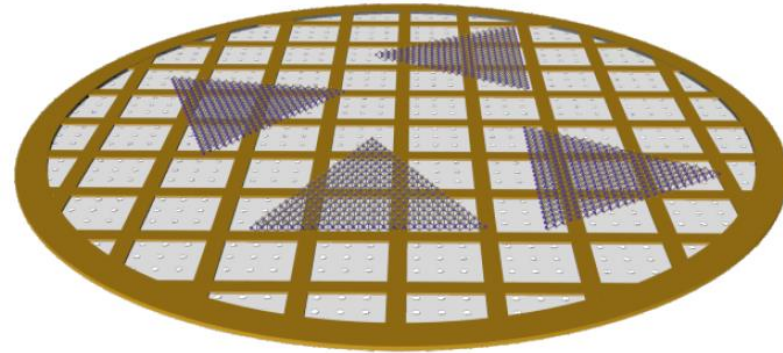
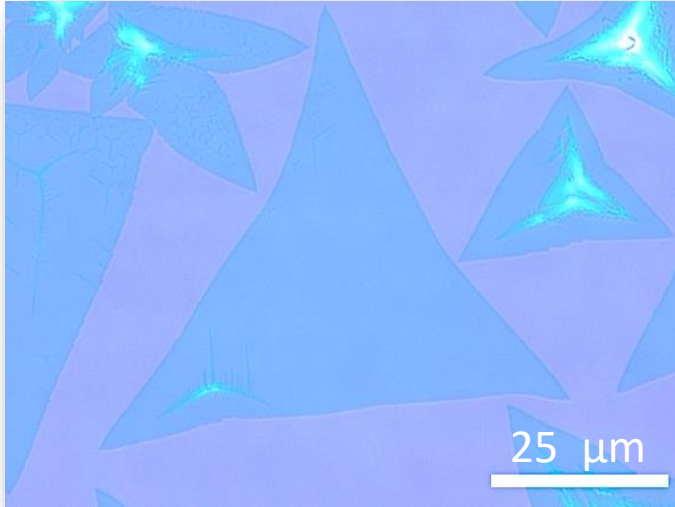
(f) Bulk MoS₂



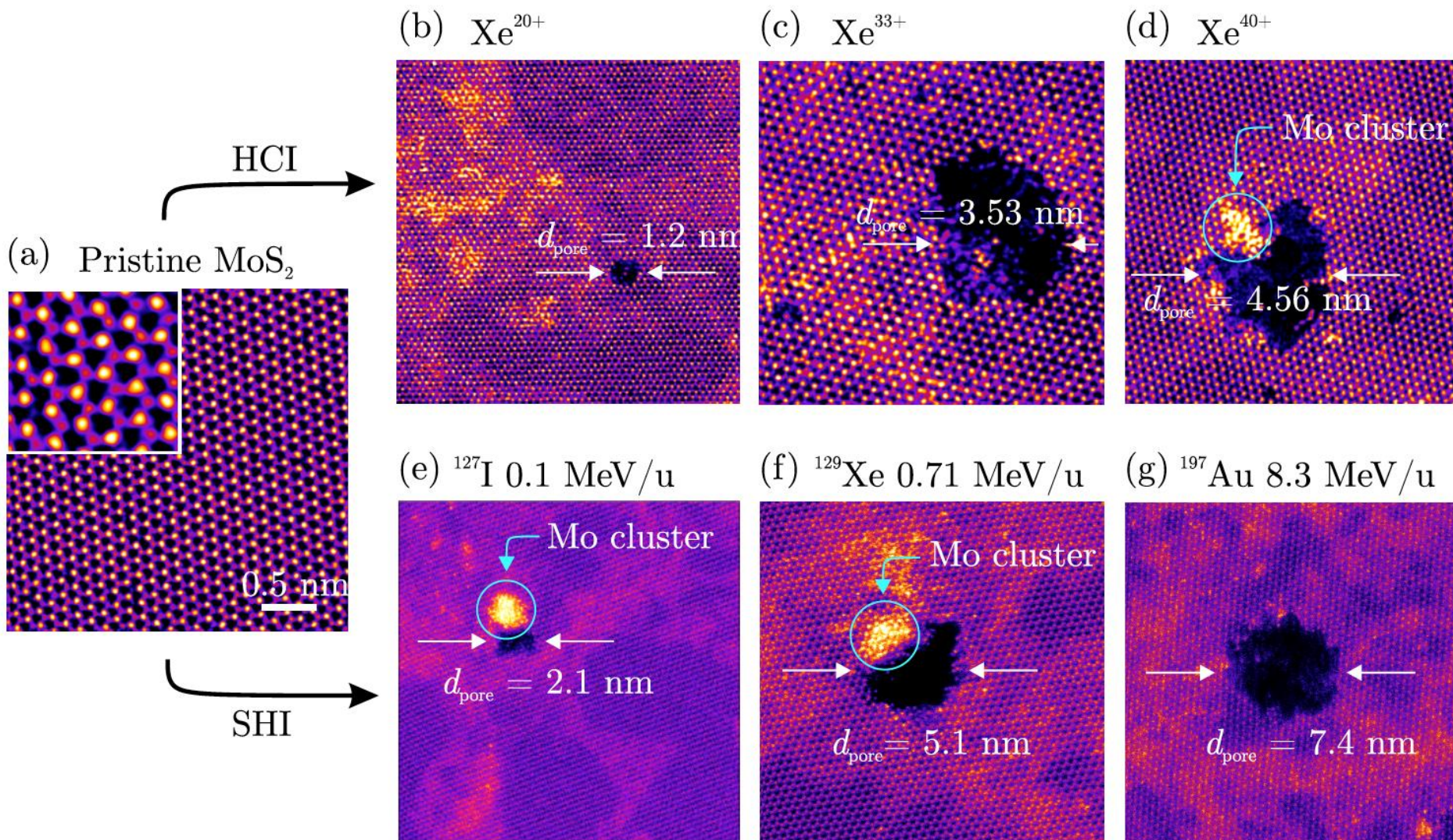
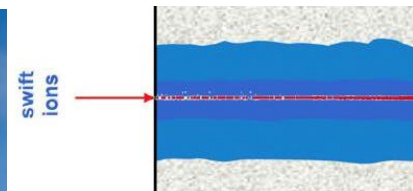
Ion Surface Tracks in 2D: The substrate



2D suspended monolayer preparation



Kinetic energy



Take-Home-Message

Electronic excitation by ion irradiation is a fantastic tool for **Nanoengineering**

- Nanometer scale
- Precise
- Reliable
- It works great but we do not know exactly how

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