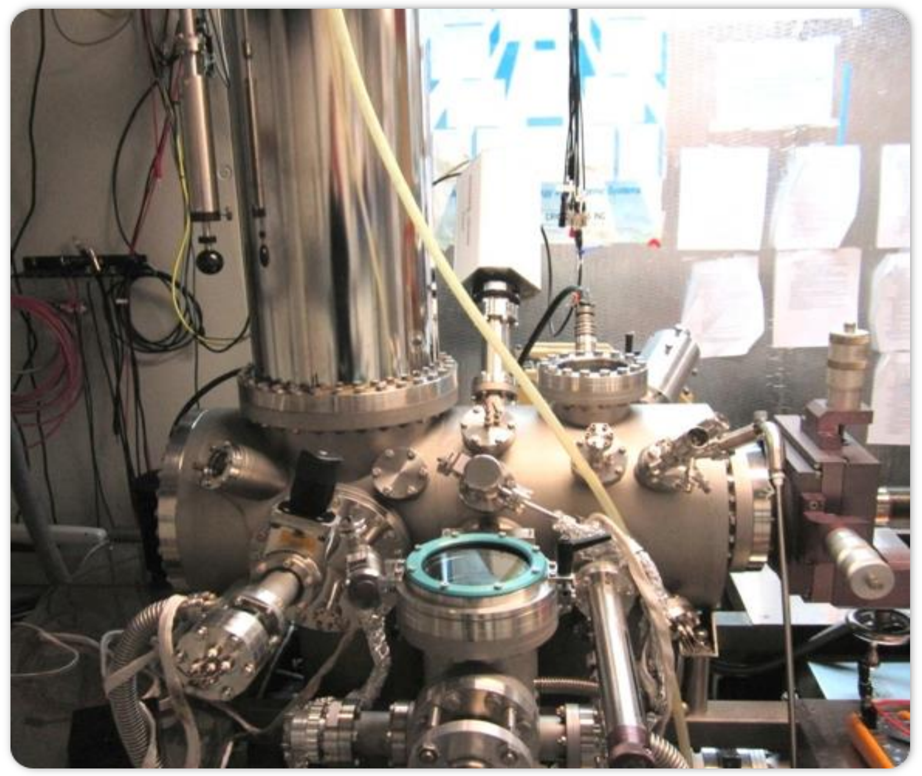
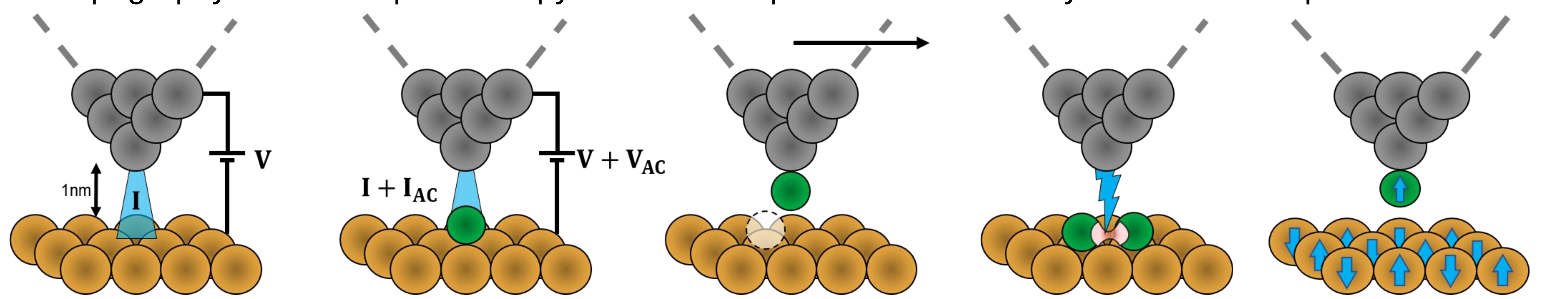
EXPERIMENTAL CONDENSED MATTER PHYSICS

Gupta Group Lab and Research Projects

Commercial LT-STM: 'SPECS'



SCANNING TUNNELING MICROSCOPY TOOLBOX



Topography: Electron tunneling provides atomic resolution imaging

Spectroscopy: dI/dV probes local density of states of sample

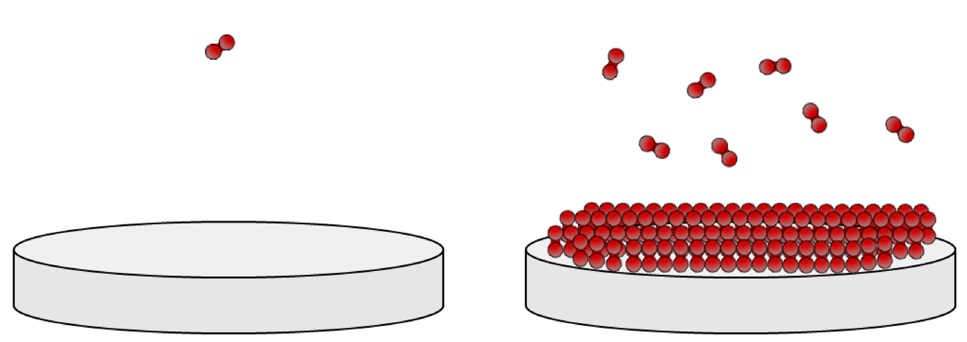
Manipulation: Adsorbates and defects can be moved on the surface

Synthesis: Chemical bonds can be created or destroyed

Spin Resolution: Directly probe the magnetic contrast of the sample

Commercial SP-STM: 'SPARQLIS'

ULTRA HIGH VACUUM (UHV)

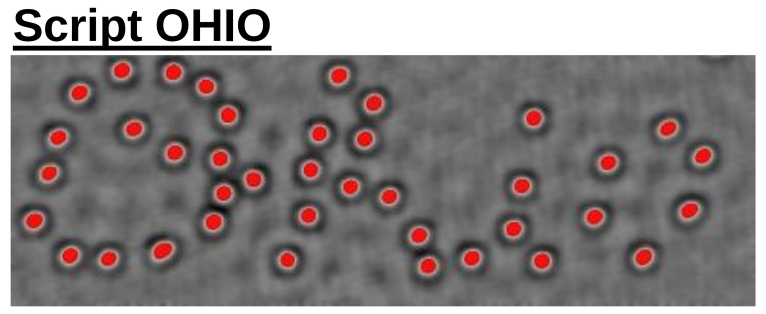


Ultra High Vacuum ($\sim 10^{-10}$mbar)
Time to monolayer coverage = hours – days

High Vacuum ($\sim 10^{-7}$mbar)
Time to monolayer coverage = seconds

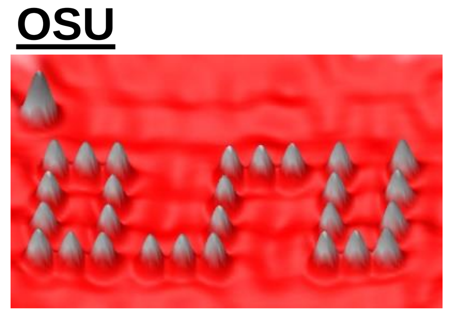
ATOMIC MANIPULATION

Script OHIO



39 cobalt atoms/Cu(111), Artist: Taeyoung Choi

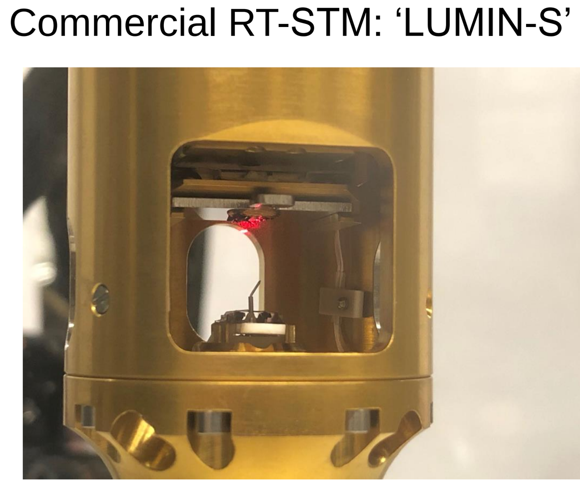
OSU



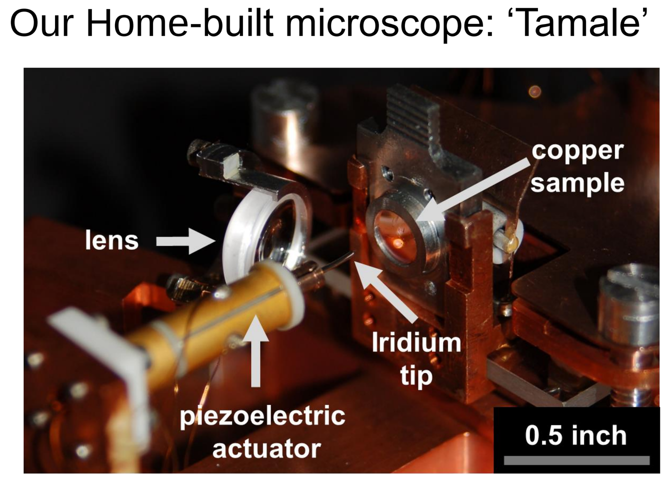
27 cobalt atoms/Cu(111), Artist: Jay Gupta

IN-SITU OPTICS

Commercial RT-STM: 'LUMIN-S'



Our Home-built microscope: 'Tamale'



Jay Gupta

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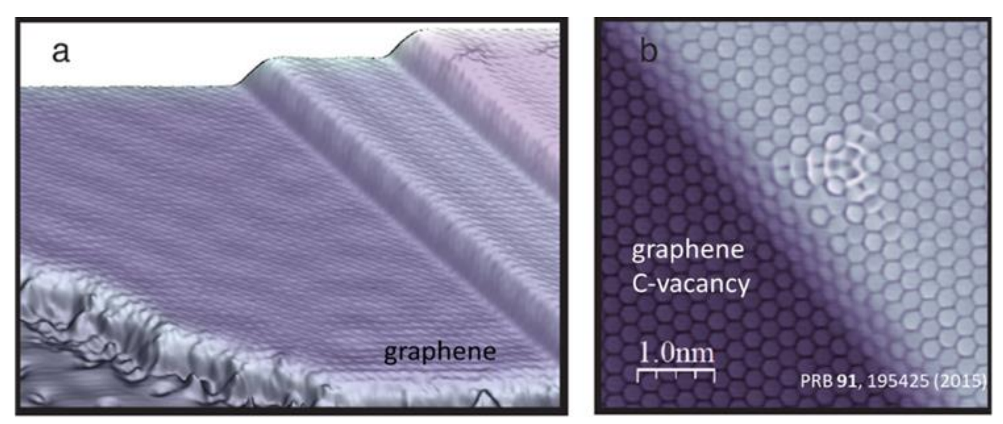
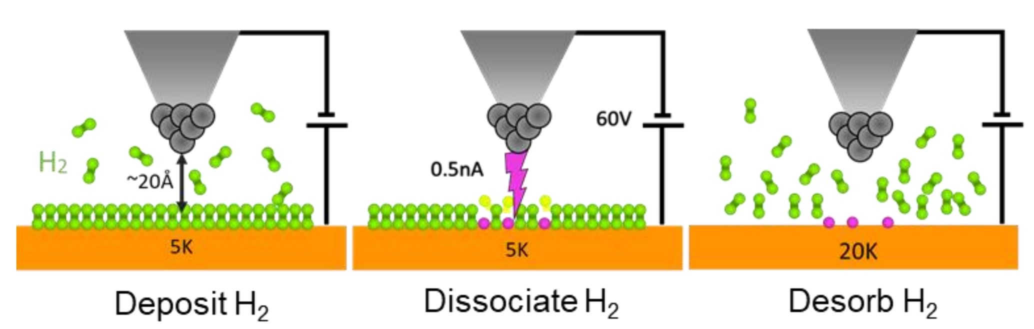
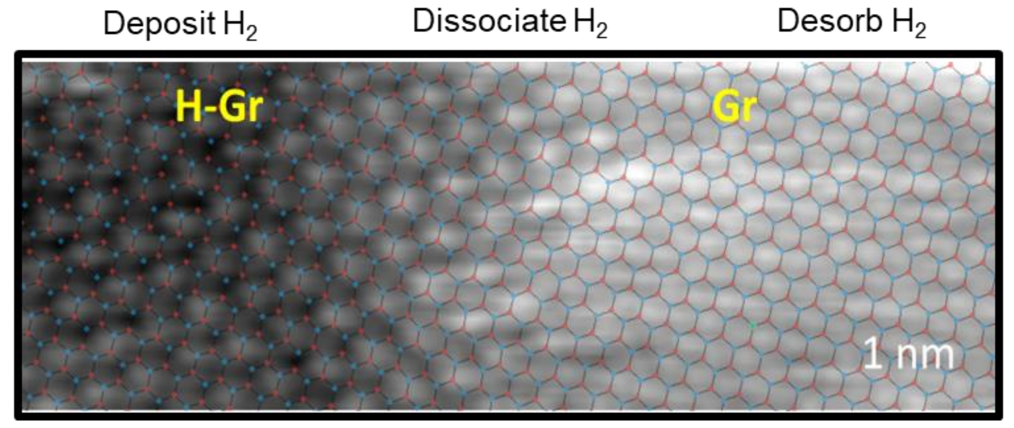
Sara Mueller
Jake Repicky
Rebekah Smith
Robert Walko
Seth Shields
Ryan Rodriguez

2-DIMENSIONAL MATERIALS

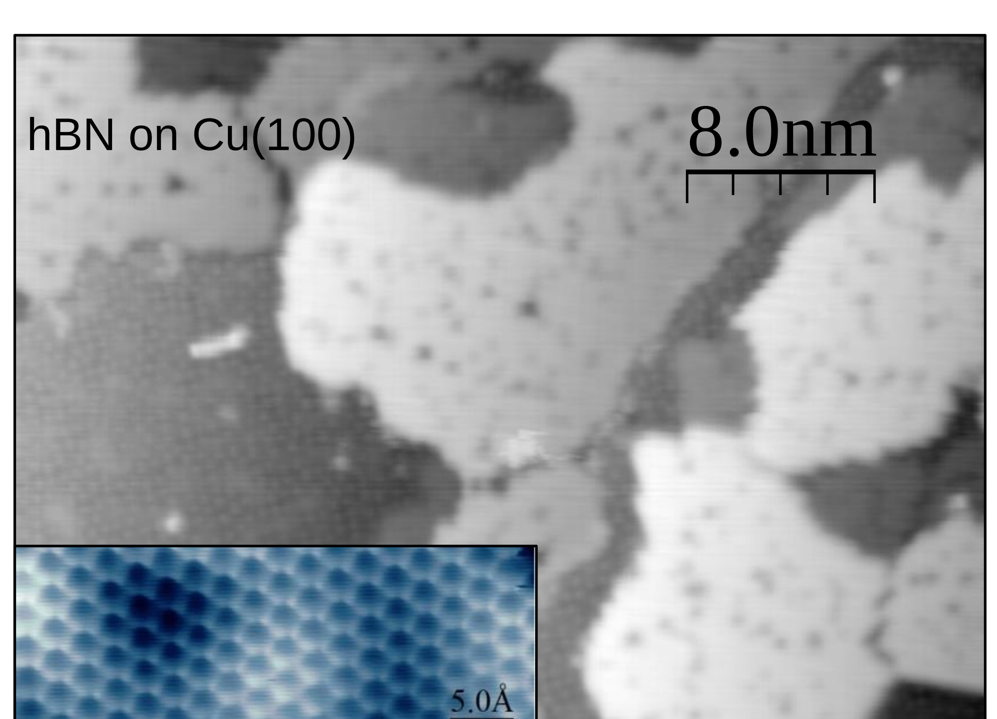


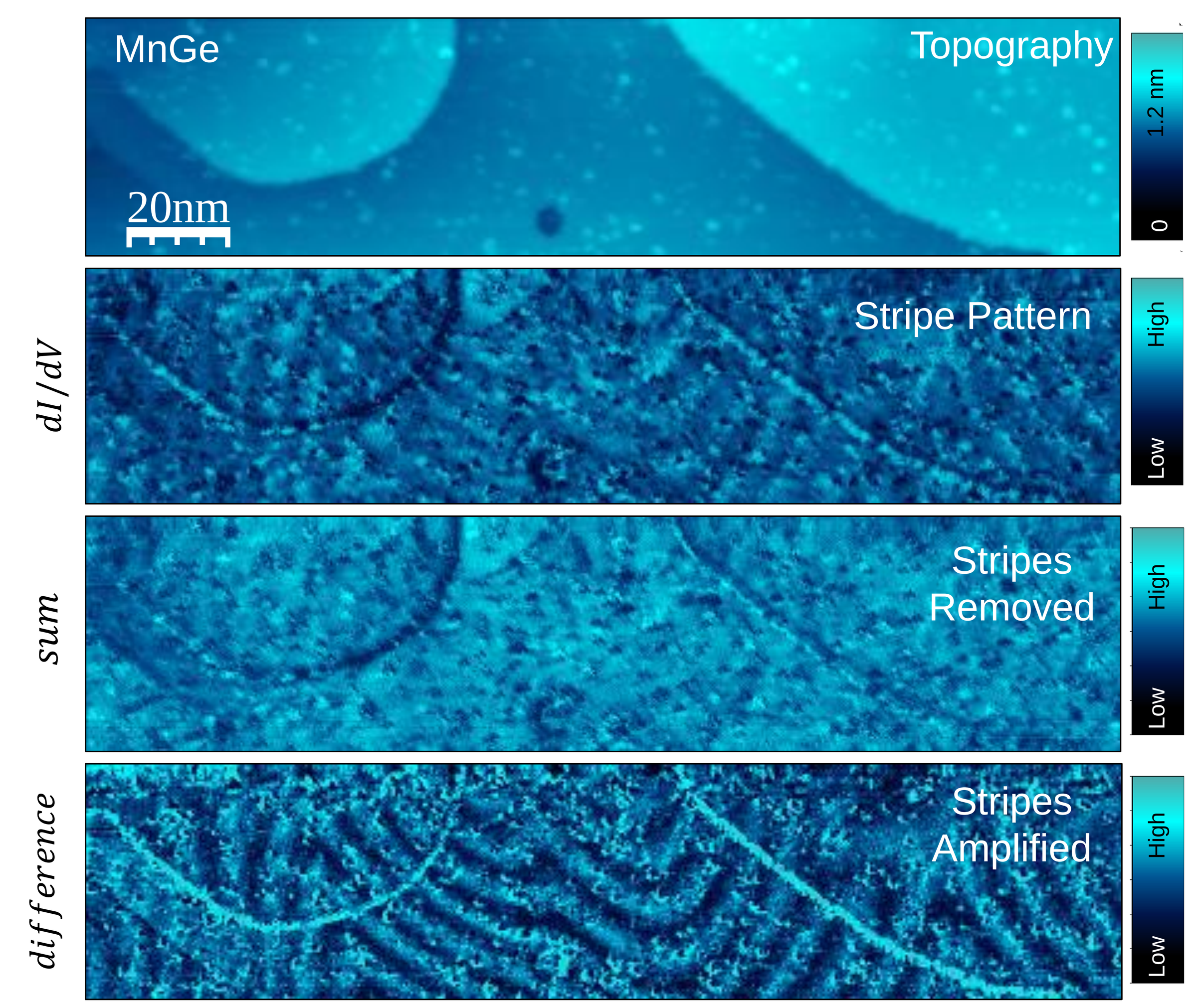
We grow graphene on Cu(111) by dissociating ethylene gas (2×10^{-5} mbar) at nearly 1000°C. This method allows us to produce pristine graphene which can be studied without exposure to air. Then we hydrogenate by dissociating molecular hydrogen using electric fields from the tip.





Following the method we developed for growing graphene, we deposit ammonia borane onto the copper surface and then anneal it at >900C for several minutes, resulting in large islands that start at the step edges and grow out along the terraces.

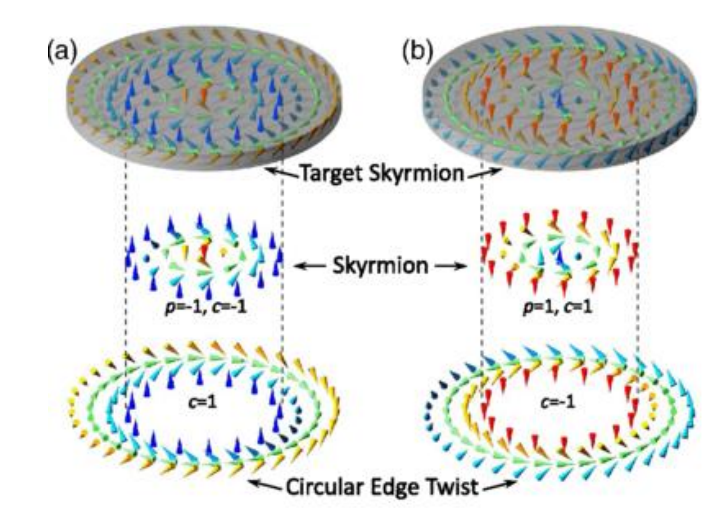




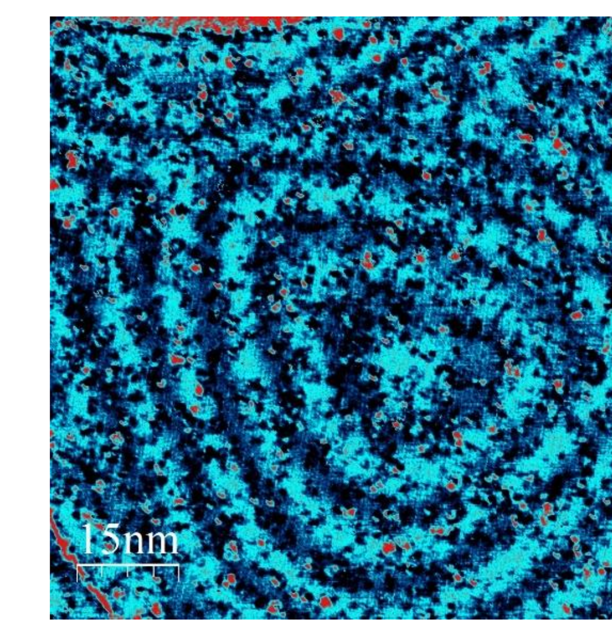
SKYRMIONS AND MAGNETIC TEXTURES

Magnetic skyrmions are topologically protected, particle-like excitations that appear in chiral magnetic systems. Due to their stability and the low-power required to move them through materials, they're a candidate for use in magnetic memory and spin based logic.

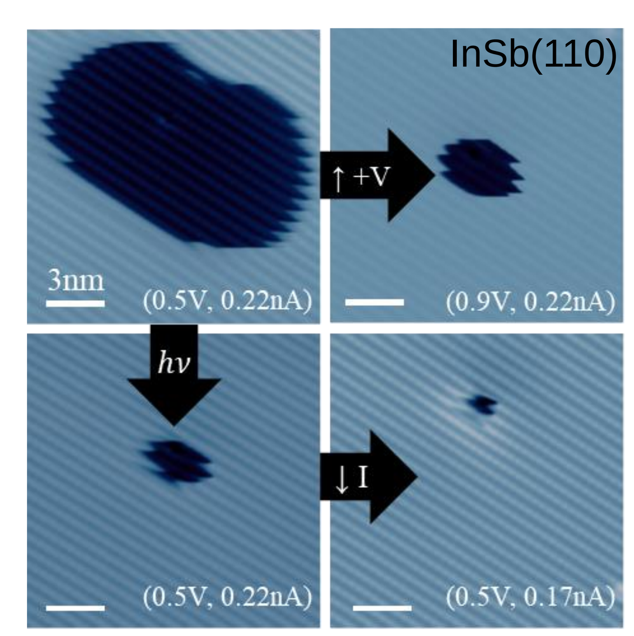
MnGe is a low symmetry material that allows the formation of magnetic skyrmions. Because of its strong spin-orbit coupling, skyrmions form a 3D lattice instead of a 2D sheet. With SP-STM we can directly observe winding of the spins that give rise to these skyrmions, and how the presence of the surface itself affects the properties that make them useful for devices.



PRL *119*, **19**, (2017).

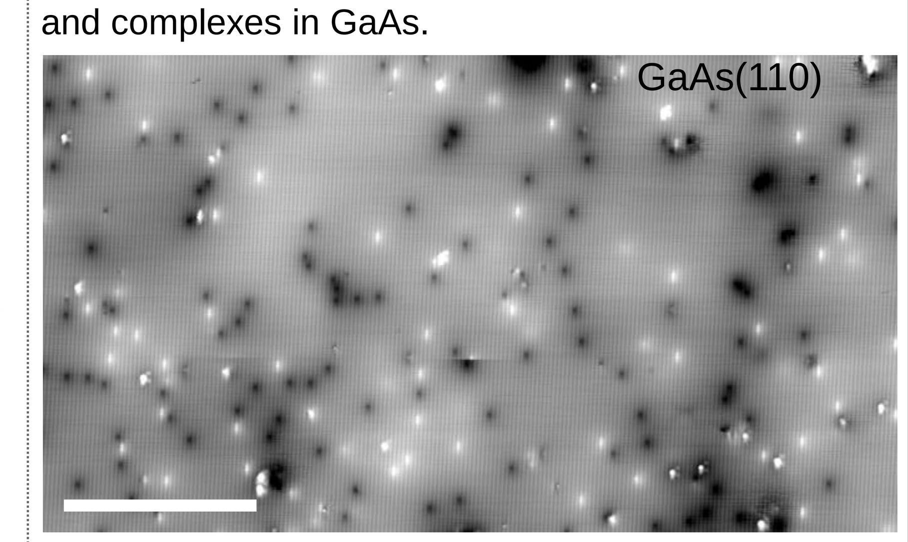


DEFECTS IN SEMICONDUCTORS

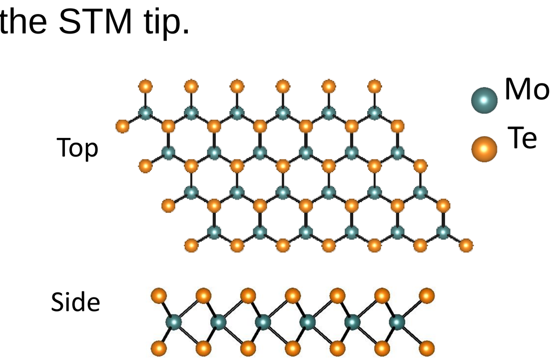


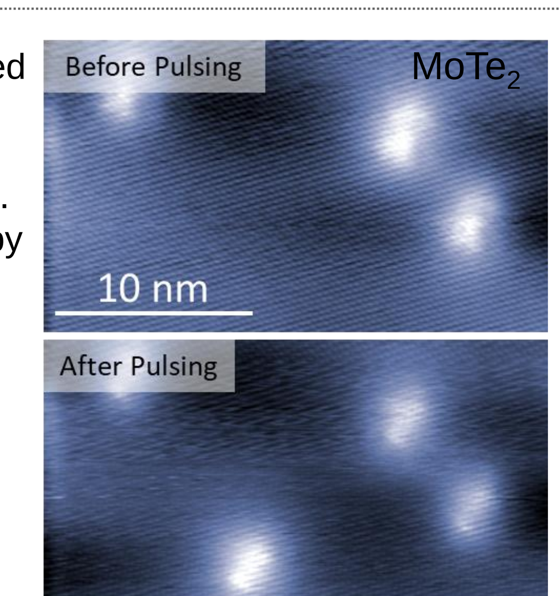
InSb is a narrow gap semiconductor with high carrier mobility making it a good choice for next generation electronics. Adatoms on the surface image as a large 'crater' under certain tunneling conditions. The crater can measure as deep as 2Å indicating a change of the surface conductance by a factor of 100. The feature is tunable with different tip conditions and under laser illumination.

We have an integrated experimental and theoretical program aimed at understanding individual impurities and complexes in GaAs.

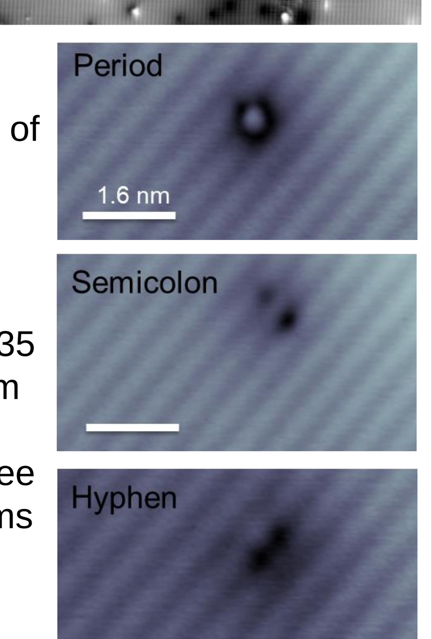


Native defects in 2H-$MoTe_2$ are imaged as bright protrusions and can be manipulated on the surface and between van der Waal coupled layers. Their charge state can be controlled by the STM tip.



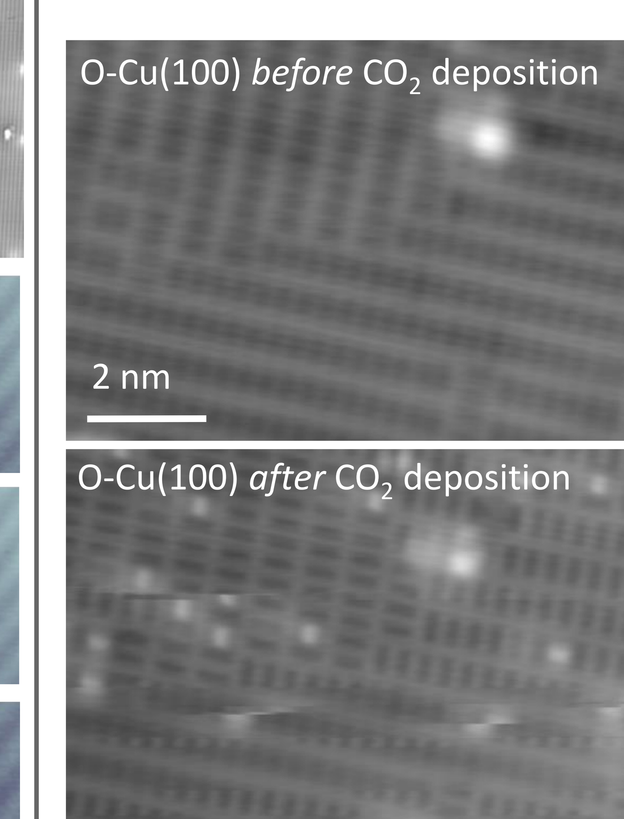


Er-doped GaAs is of particular interest because of its energetically sharp Er^{3+} intra 4f-shell transition and readiness of Er atoms to substitute in GaAs. This transition emits light at 1.535 µm which is in the minimum loss region of silica optical fibers. In our studies, we see three features of Er adatoms on the GaAs(110) surface.



CARBON SEQUESTRATION

Copper oxides are of interest for CO_2 reduction to methanol and water. We investigate where the CO_2 sticks on the oxide surface to inform further chemistry studies.



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