NEWS & EVENTS

Helium Ion Beam Causes Sheets of MoS_2 to Twist

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A team of researchers in the Schools of Physics and Chemistry, together with the Advanced Microscopy Laboratory in CRANN and AMBER, have published a paper in the Journal of Applied Physics showing that a high energy helium ion beam can be used to cause twisting of two adjacent layers of MoS_2. Misaligning layers of 2D materials has become a huge research area in recent years since small changes in orientation can totally alter the physical performance. This is a critical finding for those making devices from such ultra-thin materials, especially using ion beams.

The team was led by Dr. Pierce Maguire and Prof. Hongzhou Zhang in the School of Physics who used the *Zeiss ORION Nanofab* to modify their samples with an ion beam. They worked with Dr. Niall McEvoy's group in the School of Chemistry to use the emerging technique of ultra low frequency Raman spectroscopy to measure the vibrations between sheets of material. Normally such sheets vibrate with respect to each other in two ways, in-plane (shear mode) and out-of plane (layer breathing mode). However, the shear mode intensity was found to decline very rapidly with increased ion beam exposure, suggesting that the ion beam caused the three-atom-thick sheets to twist.

This was confirmed by high resolution transmission electron microscopy performed in the Advanced Microscopy Laboratory. Given the sensitive nature of the sample, expert preparation for microscopy was essential. Fortunately, a combination of focused ion beam, plasma cleaning and low energy argon polishing (as well as the requisite technical support) were all readily available at the AML.

Low Frequency Raman Modes
Shear and layer breathing modes in bilayer MoS_2. Illustration by Jakub Jadwiszczak.

"The interaction of layers in 2D materials is critically important and to-date we have known very little about how they behave when damaged", said Dr. Pierce Maguire of the School of Physics, TCD and lead author of the JAP paper. *"Now we know a lot more about how changes to crystal structure and orientation can change the*

fundamental behaviour of such materials. Here in TCD, the stars aligned for this project. We had access to high quality samples, nanoscale modification techniques, atomic resolution imaging and powerful spectroscopy tools. The expertise in the AML for electron microscopy and sample preparation is second-to-none. I don't think we could have done this investigation anywhere else in the world."

High Resolution Transmission Electron Microscopy
Image through bilayer MoS_2 with platinum nanoparticles below, acquired using the AML's FEI Titan 80-300 by Clive Downing (AML) & Dr. Pierce Maguire.

Link to the *Journal of Applied Physics* paper: https://aip.scitation.org/doi/abs/10.1063/1.5086366.

Additional Notes

The Advanced Microscopy Laboratory (AML) is part of the CRANN Institute and is a custom-designed, 6,000 square foot facility, located in the Trinity Technology and Enterprise Campus. Access is available to all TCD students and staff. It provides training and support for users across a wide variety of microscopy tools with 24/7 access which allows trained users to come and do their own research at their own pace. Additional information can be found at: https://www.tcd.ie/crann/aml/.

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