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(G) Remote-plasma synthesized few-layer tungsten semicarbide: the effect of strain

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The vastest majority of the attempts at synthesizing novel two-dimensional (2D) materials have been relying on growth methods that work under thermodynamic equilibrium conditions, such as chemical vapor deposition, because these techniques have proven themselves successful in yielding a plethora technologically attractive, albeit thermodynamically stable, 2D materials. Out of equilibrium synthesis techniques are more rarely used for 2D materials, but this comes with limitations on the variety of 2D systems that can thus be obtained. For example, 2D tungsten semi-carbide (W2C) is a metallic quantum material that has been theoretically predicted, but was yet to be experimentally demonstrated, because the corresponding full carbide (WC) is energetically favored under thermodynamic equilibrium conditions, such as chemical vapor deposition. Here, we report a novel dual-zone remote plasma deposition reactor that was specially conceived to grow 2D carbides out of thermodynamic equilibrium. As far as tungsten carbide is concerned, this has led to tungsten carbide deposits with well-tuned ratios of W and C precursors, as demonstrated by optical emission spectroscopy (OES) of the plasma precursors, which has ultimately led us to obtain few-layer 2D W2C. In the second part of our talk, we will discuss the behavior of remote-plasma grown W2C 2D crystals under strain, and their investigation with scanning tunneling microscopy (STM) and spectroscopy (STS). We show that, in agreement with theoretical predictions, plasma-grown W2C offer tunable density of electronic states at the Fermi level, a property that may be potentially uniquely suited for obtaining fractional quantum Hall effects, superconductivity, and quantum thermal transport. Collectively, our study points at the critical relevance of out-of-equilibrium remote-plasma techniques towards the growth of unprecedented 2D materials.

Keyword-1

Remote plasmas

Keyword-2

Plasma vapor deposition

Keyword-3

Tungsten semicarbide

Primary authors: STOCEK, Noah (University of Western Ontario); Dr ULLAH, Farman (University of Western Ontario); FANCHINI, Giovanni (University of Western Ontario)

Presenter: STOCEK, Noah (University of Western Ontario)

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