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Nanostructures in two-dimensional materials sculpted with electrons and applications

Understanding, shaping and manipulating matter at atomic scale remains one of the major contemporary challenges in science and technology. In this respect, electron beams constitute the power tools to shape materials with atomic resolution inside a transmission electron microscope (TEM). I will describe experiments where we push the limits of device size to atomic scale, and expand their function and precision, while addressing fundamental questions about structure and properties at nanometer and atomic scales. Experiments are performed *in situ or ex situ TEM. In situ TEM* experiments include the study of electrons flow in nanowires in novel two-dimensional materials including graphene, molybdenum disulfide and phosphorene, as a function of their structure as they are nanosculpted down to zero width. We reveal the electrical current scaling with size and atomic structure and develop methods to realize pristine and highly conducting sub-10-nm-wide wires. *Ex situ TEM* include the ultrafast, all-electronic detection and analysis of biomolecules or nanoparticles by threading them through tiny holes – or nanopores – in thin membranes, including efforts towards mapping a human genome under 10 minutes. As particles are driven through nanoholes in solution, they block the current flow resulting in current reductions from which particle's physical and chemical properties are inferred, where are are improving the temporal and spatial resolution and sensitivity. I will also describe alternative uses of nanoholes such as electrically controllable chemical nanoreactors, and explore the use of nanoholes created in two-dimensional nanowires to highly localize and probe molecules.

References

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Figures

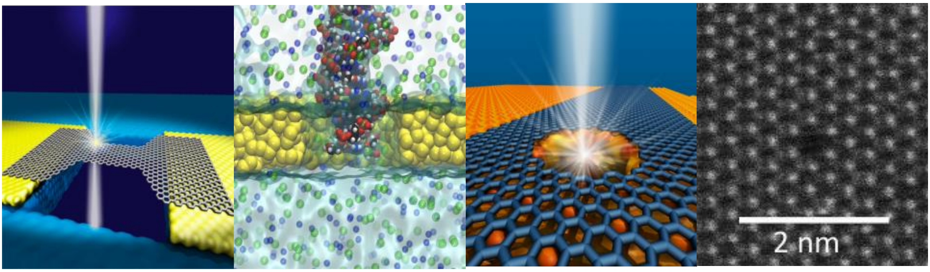

Figure 1: From left to right: illustrations of graphene nanoribbon sculpting with the electron beam; passage of a DNA molecule through a ~ 1nm-thick silicon nanopore; nanohole drilling through graphene nanoribbon transistor; one-atom-large hole in a MoS_2 sheet.