The Characterization and Metrology of Graphene

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Presentation

Abstract: The semiconductor industry is searching for new switches to replace the transistor. Potential devices based on carrier spin, excitons, and other properties are all being investigated. Graphene is considered a strong candidate for many of these applications. In addition to new materials properties, new phenomena abound at nanoscale dimensions, and graphene is no exception. For example, quantum confinement impacts materials properties and measurement itself. New electrical properties such as the Berry Phase correction to carrier transport measurements are also becoming widely recognized. However, new materials such as graphene are difficult to find, manipulate, and measure. One key question is the number of graphene layers in a sample and the stacking of multilayer samples and the relative mis-orientation between layers. Multiple characterization methods are necessary including transmission electron microscopy (TEM), Low Energy Electron Microscopy (LEEM), nano-Raman, and several scanned probe methods. Amazingly, HR-TEM can image single and multilayers of graphene even determining layer mis-orientation. Modeling of metrology is often overlooked in development of new measurement methods. Multislice simulations are a useful guide in determining TEM capability and imaging conditions. We will show simulation work points to the ability to distinguish stacking patterns. Recent work indicates that LEEM can determine the number of layers and the morphology of a graphene sample. Raman provides an excellent means of determining the number of layers in a stack of graphene. Single electron transistors have mapped electron-hole puddles across a sample area. Optical and electrical properties must be understood before they are measured. This paper will cover the research and development of metrology for new Beyond CMOS materials using graphene as an example.