Condensed Matter Seminar

Physics and applications of 2D crystal semiconductors: Graphene and transition metal dichalcogenides

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Room 184 Nieuwland Science Hall

2D crystal semiconductor materials such as graphene and the transition metal dichalcogenides offer a new platform for realizing low-power and high performance electronic and optical devices. Recent experimental findings suggest transition metal dichalcogenides are well-behaved semiconductors, down to the monolayer thickness. These initial demonstrations suggest a host of device possibilities, most of which are currently at nascent phases. Certain aspects of charge transport physics in these materials are novel, such as the strong dependence of mobility on dielectric environments, and the rather low saturation velocities due to the high effective mass. The physical origins of these transport peculiarities will be discussed. While these properties may restrict high-performance in-plane normal FETs, large-area electronics can take advantage of the fact that the transport properties are still superior to organics. For such applications, multilayer 2D crystal semiconductors offer additional benefits. Low-power tunneling transistors (for example for sensing applications) are a distinct possibility with single-layers. However, out-of plane transport opens up a whole new realm of possibilities ranging from high-performance tunneling FETs to ultra high-speed RF transistors. These possibilities will be realized only if rapid material advances in chemical doping control, growth of stacked heterostructures, and selective etching and processing procedures are developed. These issues will be discussed. But the true applications of any new material system are gauged by the new applications it creates, rather than replacing old technologies. To that end, I will also discuss electronic device possibilities based on dynamic symmetry breaking, which is an example of exploiting the truly unique properties of 2D crystal semiconductors.

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