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Electronic transport in graphene structure: from weak to strong localization regimes

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Graphene, often named the wonder material for its many fascinating properties, has sparked out intense research activities over the last decade. Electronic transport in graphene became rapidly an important research field because of the early reported extremely high charge carrier mobility which triggered large expectations for nanoelectronic devices. Besides mobilities, graphene samples can exhibit particularly long electronic coherence lengths which allow for phase-related quantum transport phenomena such as the weak and strong localization transport regimes. This makes graphene a remarkable playground for fundamental studies of localization theory in low-dimensional systems. In this presentation, using tight-binding models enriched by first principle calculations, and a real-space Kubo-Greenwood method, multiscale simulations of the electronic transport in various graphene-based systems will be discussed. Such an approach allows for computing transport properties of systems containing millions of atoms reaching therefore the experimental sample size. In order to tailor graphene properties, chemical and/or structural modifications are widely used. However, such modifications act as scattering defects and usually deteriorate transport properties. Open a band gap while maintaining good mobility is a typical illustration of this dual problem. The influence of various chemical and structural defects will be analyzed. In particular, the consequences of unbalanced sublattice nitrogen doping in graphene and the case of highly defective graphene structures exhibiting strong Anderson insulator behaviors will be examined. Defects being even more detrimental for transport in 1D structures, a synthesis method that is free of defects is highly desirable. A solution is provided by a bottom-up chemistry approach where precursor monomers are self-assembled. The electronic transport and the potential for nanoelectronics of such defect-free carbon ribbons will also be discussed.