DOCTORAL DEFENSE

Reconfigurable Graphene Complex Oxide Nanostructures

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May 29, 2020
10:00AM

Zoom ID: 916 880 2489

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Abstract: Graphene and complex-oxide heterostructures collectively exhibit nearly all of the known major properties in solid-state materials. Our goal is to integrate these two materials to create new emergent properties and functionalities. A new wet graphene transfer method is developed and used to integrate graphene with the complex-oxide system LaAlO$_3$/SrTiO$_3$. Interactions between the graphene and LaAlO$_3$/SrTiO$_3$ interface are controlled at nanoscale dimensions using a conductive atomic force microscopy technique developed previously for the complex-oxide interface. The resulting hybrid structures exhibit novel and useful electronic and optical properties, many of which depend critically on controlling the chemical potential of graphene relative to the charge-neutrality point. The local density of states can be altered in graphene by programmable changes of the conductance of the complex oxide interface. In one experiment, an edge-mixed quantum hall effect is observed in sketched graphene/complex-oxide p-n junction devices. Magnetotransport measurements of superlattice structures show characteristic interference features that can be associated with the periodically patterned interface. Frictional drag measurements between single-layer graphene and a conductive LaAlO$_3$/SrTiO$_3$ interface is also performed in these hybrid devices. The metallic behavior and high transparency of graphene make it an ideal top electrode for controlling magnetic properties at the LaAlO$_3$/SrTiO$_3$ interface. We discuss possible new directions based on this highly versatile hybrid material platform.