中央大學物理學系

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Colloquium

Visualizing Dynamic Molecular Manipulation on a Graphene Field Effect Transistor

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Abstract :

Harnessing electric fields at the nanoscale to manipulate molecular motion unlocks new prospects for nanotechnology. By coordinating molecular movements, we can build novel nanostructures, promote mass movement, and alter device characteristics. As we scale down electronic devices to nanometers, their interactions with nearby electric fields and currents grow crucial. To fully grasp these tiny-scale dynamics, we need advanced microscopy methods capable of capturing individual molecule movements while also analyzing the local electronic structure. In my presentation, I'll introduce an innovative approach aimed at manipulating the charge and spatial distribution of individual molecular adsorbates on a graphene field-effect transistor (FET) observed through a scanning tunneling microscope. Once the molecules get charged, they behave like ions on the surface which can be controlled by the surface electrochemical potential. Activating a gate electric field causes F_4TCNQ molecules on the device's surface to switch between a charge-neutral self-organized solid phase and a negatively-charged correlated liquid phase. This shift in molecular arrangement on the surface also impacts the device’s conductivity, demonstrating Fermi level-pinning by molecular orbitals. Furthermore, we created stop-motion footage of the molecular distribution changes by sending brief current pulses through the graphene FET. This allows us to track the diffusion as well as non-equilibrium phase transition dynamics. These observations offer insights into controlling nanoscale molecular movements with external electric fields and adsorbates in the dynamical equilibrium.