Researchers measure and model inhomogeneous energy landscapes in graphene

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(PhysOrg.com) -- If graphene is to live up to its promise as a revolutionary component of future electronics, the interactions between graphene and the surrounding materials in a device must be understood and controlled.

Researchers at the NIST Center for Nanoscale Science and Technology have successfully measured and modeled how electrons in graphene respond to impurities in an underlying substrate, explaining key differences in the response of graphene that is one versus two layers thick.

The ability of electrons to screen, or damp, the electric fields due to impurities is characterized by an electrostatic screening length. In order to screen the impurities, the screening length must be significantly shorter than the separation between the impurities. When placed on a substrate, electrons in monolayer and bilayer graphene respond differently to substrate impurities because differences in symmetry change the screening length.

For two layers of graphene, the electrons have a small screening length and therefore rearrange easily to screen the impurities. For monolayer graphene, the unusual symmetry of its two-dimensional honeycomb atomic lattice causes the energy of the electrons to increase linearly with momentum, similar to “massless” particles such as photons.

The CNST theory shows that the screening length for massless electrons is similar to the spacing between the substrate impurities, making it much more difficult for the electrons to rearrange. Substrate impurities cause electron scattering and thereby reduce device performance in both monolayer and bilayer graphene; by explaining the response to impurities, this work provides insight into methods to control such scattering and improve graphene device performance on a range of substrates.

More information: Mechanism for puddle formation in graphene, S. Adam, S. Jung, N. N. Klimov, N. B. Zhitenev, J. A. Stroscio, and M. D. Stiles, Physical Review B 84, 235421 (2011). prb.aps.org/abstract/PRB/v84/i23/e235421

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