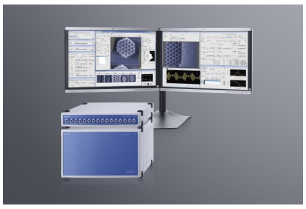

Application Note #000002

KeyWords
Nanonis, BP5, LT-STM,
Graphene, Artificial Atom

Nanonis ™

Realization of a tunable artificial atom at a supercritically charged vacancy in graphene

Single-atom vacancies in graphene exhibit a rich variety of electronic phenomena ranging from mid-gap states to Kondo screening. Here we report on a new phenomenon showing that vacancies can host a positive charge which can be built up gradually by applying voltage pulses with the tip of a scanning tunneling microscope (STM). The response of the conduction electrons to this charge, which is monitored with scanning tunneling spectroscopy, exhibits an unusual electron-hole asymmetry. On the p-doped side screening is weak. In this regime, as the charge is increased its interaction with the conduction electrons undergoes a transition into a regime where itinerant electrons are trapped in quasi-bound states (QBS) resembling an artificial atom. We observe the equivalent of the atomic 1S and 2S states as well as the emergence of a new satellite of the 1S state resulting from the broken sublattice symmetry at the vacancy site. In contrast, on the n-doped side screening is very efficient: as soon as the n-doped regime is entered the charge is screened and the QBS disappear. We show that the QBS are gate tunable and that the trapping mechanism can be turned on and off, providing a new mechanism to control electrons in graphene.

This is the first observation ever of a stable and tuneable charged vacancy in graphene and could allow researchers to fabricate artificial atom arrays for performing the electronic equivalent of optical operations.

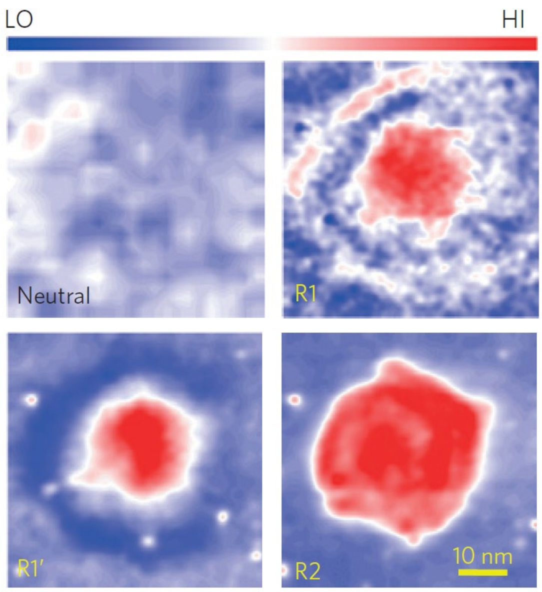

Figure 1. Spatial evolution (dI/dV map) of the atomic collapse state. Top left: map of neutral vacancy taken at -91 meV. The other panels represent maps of the charged vacancy in Figure 1 taken at the energies corresponding to R1 (-91 meV top right), R1' (-25 meV, bottom left) and R2 (50 meV, bottom right). Experimental parameters: Vb=-200mV, I=20 pA, Vg=-54V.

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Nanonis Modules in use

- Nanonis Base Package
- LabVIEW Programming Interface

System

- Home-built low temperature STM

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