Probing Graphene at the Atomic Scale with Scanning Tunneling Microscopy in Ultra-High Vacuum and Low Temperature

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Graphene, a single layer of carbon atoms in a honeycomb arrangement, is revealing, in the last few years, its high potential. Many extraordinary properties have been discovered and many other are emerging as a result of the huge experimental and theoretical efforts devoted to this material. In this talk some of our recent work [1-6] on the investigation of graphene systems at the atomic scale by means of scanning tunneling microscopy (STM) in ultra-high vacuum and at low temperature will be reviewed. First, the influence of point defects on the properties of graphene is focussed. Such a general and fundamental issue is addressed by our work for atomic vacancies in graphene systems [1-3]. Introducing vacancies by irradiation on carbon-based systems had been shown to be an efficient method to vary its mechanical behavior, tune its electronic properties and even to induce magnetism in otherwise non-magnetic samples. While the role played by these vacancies as single entities had been extensively addressed by theory, experimental data available referred to statistical properties of the whole heterogeneous collection of vacancies generated in the irradiation process. In our recent works we have shown how to overcome this limitation: single vacancies on graphene layers by Ar^+ ion irradiation are created and then we have investigated, using STM, the impact of each of such single vacancies in the electronic and structural properties of several graphene systems as HOPG, Graphene/Pt(111), and graphene on SiC surfaces. In the second part of the talk, a new method for nanopatterning graphene with 2.5 nm precision will be presented [6]. With this aim, bottom-up and top-down approaches are merged. Essentially the method consists in selectively removing with the STM tip, and with high reproducibility and precision, some metal nanoclusters from arrays previously deposited on graphene moirés on Ir(111) used as templates. As a result, graphene regions presenting large differences in their electronic structure can be combined at the atomic scale. This novel nanopatterning method could, thus, pave the way for the design of nanometric graphene-based devices with specific functionalities.

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