Graphene thin films and their interaction with metallic nanoparticles*:*
Materials, characterization and applications

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Abstract
In this presentation, we will review our recent work on large-area graphene thin films, collections of single-layer, few-layer, and multilayer graphene platelets assembled on a variety of substrates by cost-effective and widely scalable solution-processing methods. We will focus on the fact that their excellent optical electronic and thermal properties can be further enhanced through deposition of metallic nanoparticles (Me-NP) on their surfaces. Me-NP deposition on graphene can be achieved by a variety of methods, including thermal evaporation, sputtering, or organometallic precursors.[1-3] Metals strongly interacting with graphene form chemical bonds and carbides, but weakly interacting metals result in doping, without substantially altering the electronic band structure of graphene [4].

One important motivation to investigate graphene decorated with Me-NPs is to achieve precise doping of this material at the nanoscale, which is critical for several applications. Although large metallic thin films on graphene are known to move the Fermi level above or below the Dirac point,[4] little has been done to study these effects when large-area graphene thin films are contacted with particles of nanometer diameters at varying concentrations, and to investigate the nature of such phenomena. We will present in detail some recent results [1] on the local effect of copper nanoparticles (Cu-NPs) on the Fermi energy of graphene domains in large-area graphene thin films, with theoretical calculations corroborating our Kelvin-probe force microscopy experiments to demonstrate that the Fermi level shifts in the presence of Cu-NPs, which breaks the electron-hole symmetry due to weak Van der Waals interactions between the graphene backbone and Cu, even in the absence of chemical bonding and charge transfer. This is in contrast to previous predictions for large and flat metallic contacts.[1]

In the last part of our presentation we will show how deposition parameters control the nucleation of Cu-NPs on graphene thin films, in a way that, under specific growth situations close to thermodynamic equilibrium, periodic superlattices of Cu-NPs on large-area graphene thin films can be obtained.Theoretical calculations suggest a lowest formation energy for Cu-nanoparticle arrays aligning along armchair crystallographic directions, indicating that their self-assembly is energetically more favorable. Applications of periodic superlattices of Cu-NPs on graphene will be discussed in conjunction with scanning near field optical measurements. Their behavior as evanescent waveguides will be demonstrated.[2]

References
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