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Growth, characterization and applications of metal oxides on graphitic systems

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Since the discovery of graphene and its impressive properties, the combination of different materials with graphitic systems, such as graphene or graphite, has attracted much attention for different technological applications. Nevertheless, the interface interaction between materials and systems on such nanostructures plays a fundamental role, and can be seen as a direct manifestation of Herbert Kroemer's (Nobel Laureate in Physics, 2000) statement "The interface is the device", beautifully summarizing that their combination essentially results in complex systems that are more than just the sum of the properties of the individual constituents.

This work covers three different cases. The two first consist of a fundamental study of the interactions between CoO and ZnO with highly oriented pyrolytic graphite (HOPG) and graphene supported on polycrystalline copper (G/Cu), respectively. Firstly, by near ambient pressure X-ray photoelectron spectroscopy, we studied the carbon gasification reaction of highly oriented pyrolytic graphite catalyzed by CoOx nanoparticles, giving rise to nanopatterning at lower temperatures than using metallic nanoparticles. This reaction occurs at much lower temperatures because of the weakening of the carbon σ bonds by the initial wetting CoO layer formed at the CoO early stages of the growth on the HOPG surface. In the second place, by combining μ-Raman and X-ray photoemission electron microscopy in the same areas of samples, we have been able to determine the initial chemical, electronic and structural state of pristine graphene grown by chemical vapor deposition on polycrystalline copper, and to infer the complex influence on the ZnO early stages of growth and its interaction with the environment. Finally, the last case consists of the development of free-standing ultrathin (~2 nm) films of Al_2O_3, which were mechanically robust and transparent to electrons. Their applicability was proved by environmental X-ray photoelectron measurements of air at normal conditions ($\geq$1 bar), demonstrating its potential use in the characterization of solid-gas and solid–liquid interfaces by different synchrotron-based techniques.

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