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Engineering Dirac materials

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One of the main impetuses for studying graphene stemmed from analogies between the low-energy physics of the material and relativistic quantum mechanics. While the honeycomb lattice of graphene gives rise to the formation of Dirac cones, features that do not exist in conventional two-dimensional (2D) semiconductors, the absence of an electronic gap and a weak spin−orbit coupling hamper its extensive use in electronic and spintronic applications. During this talk, I will discuss strategies to overcome this issue. First, I will consider a suspended graphene monolayer on SiO_2 nanopillar arrays to form a puckered graphene-on-lattice. Based on multiple scanning probe tools such as tip enhanced-Raman spectroscopy (TERS), infrared near-field microscopy (s-SNOM) and four-point probe transport measurement with scanning tunnelling microscopy (STM), I will explain the interplay between the strain and the electrical resistance in the suspended graphene sheet. I will show that a thermally activated transport occurs and results from a low charge carrier density and a periodic change of the chemical potential induced by the interaction of the graphene monolayer with the nanopillars. Then, I will focus on the nanoperforation of III-V semiconductor heterostructures to produce artificial honeycomb lattices. I will describe the fabrication process to obtain Dirac cones large enough to be measured and assess the robustness of the Dirac cones with respect to small distortions of the honeycomb lattice.

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Development of a hybrid metrology combining AFM and SEM techniques for measuring the characteristic dimensions of a nanoparticle population

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This study proposes a novel approach of hybrid metrology combining AFM (Atomic Force Microscopy) and SEM (Scanning Electron Microscopy) measurements for measuring the characteristic dimensions of nanoparticles (NP) in 3D with controlled uncertainties. This method takes advantage of the complementary nature of both techniques: SEM gives no quantitative information about the NP heights whereas the uncertainty associated with AFM measurements of NP maximum point is close to 1.5 nm [1]. Conversely, the lateral dimensions measured by AFM are impacted by tip / NP convolution whereas SEM of latest-generation SEM equipped with FEG (Field Emission Gun) can reach a resolution of 1 nm in the XY plane. In order to check the consistency of measurements performed by AFM and SEM, a comparison of the mean diameter of spherical silica NP measured by both techniques had been carried out in a previous study [2]. However, this comparison had not been performed exactly on the same population. In the meantime, a specific repositioning device consisting of silicon wafer with lithographed landmarks has been developed to easily find an area of interest. Henceforth, it is possible to determine the AFM height and SEM lateral diameter on the same set of NP. The proof-of-concept has been tested on various samples of silica NP synthesized by Stöber method [3] and reference silica NP with sizes ranging from 5 nm to 110 nm. Although the spherical nature requires equality between AFM height and SEM lateral diameter, a systematic discrepancy was observed, especially for smaller NP.

An analogy with PSL (polystyrene latex) NP presenting known deformation [4-5] suggests that mechanical properties of NP could play a role in measured discrepancies. But, the main contributions come from the sphericity deviation of smaller silica NP as well as their orientation on the substrate.

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Microstructural investigation of nickel deposits obtained by pulsed current

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The synthesis of nickel by pulse electrodeposition has attracted much attention during the last decades. Pulse electrodepotion has been reported to improve the deposition process and deposit properties such as porosity [1], ductility [2], hardness [3] and surface roughness [3].It has been reported that pulse plating strongly modifies the properties, the structure, the surface morphology and the macroscopic characteristics of nickel coatings. In the present research nickel deposits were produced by pulse current electrodeposition from watts bath. The optimization of the conditions of deposition was established and the influence of pulse parameters, on the grain size, surface morphology and crystal orientation was determined. The morphology of the coatings was characterised by observations in scanning electronic microscopy (SEM). X-ray diffraction in symetric mode was also used to evaluate the structure and principal crystallographic orientations of the deposits**.** The results obtained, showed that the development in pulsed induced a marked improvement in the morphology and grain refinement