International Conference on

DIAMOND AND CARBON MATERIALS & GRAPHENE AND SEMICONDUCTORS

July 17-18, 2017 Chicago, USA

Suspended graphene and nanoscrolls explored by nanofocused x-rays

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C tructure determination of crystal lattice parameters and orientation with high precision is rather straightforward for bulk 3D-materials. X-ray diffraction proved especially powerful in this respect across the years. On the contrary, structural determination of 2D crystals with the help of x-rays is more demanding. So far, exploiting interferences between a crystalline substrate and graphene, it was possible to accurately determine the lattice parameter of graphene, averaged across the ~1cm2 surface of a sample. Such studies are however restricted to graphene samples of macroscopically uniform crystalline orientation. However most graphene samples of relevance for potential applications (micro-electronics, telecom, displays) exhibit in homogeneities, as they are composed of single-crystal grains (~10µm), each having different crystalline orientation and strain. Finely characterizing such structural features requires probing suspended graphene with the help of nano-shaped beams. Using, electron beams instead of nanofocused x-rays, we managed to conduct simultaneously small and wide angle x-ray scattering (SAXS/WAXS) characterizations with high resolution in reciprocal space and an unprecedented resolution of 200nm in real space, Accordingly we were able to map the structural variations in two- dimensions, revealing in this way strain maps for the suspended few-layer graphene membrane and the morphological features at the edges of the flakes, where it forms scrolls with a typical length of the order of 10µm and a diameter of the order of 10nm. The orientation of the nanoscrolls could for instance be resolved. Our complementary analysis with spatially-resolved Raman spectroscopy provides the unique opportunity to unambiguously determine the Grüneisen parameters of graphene, linking the deformation to the energy of its vibration modes, without any particular assumption. These experiments pave the way to advance in-situ experiments and for exploring 2D crystals and their phase transitions using synchrotron radiation especially with the future upgrade programs in the European Synchrotron for outstanding expected brilliance.



Biography

Gilbert Chahine is a Research-Engineer at the CNRS and working on the BM02 beamline at the European Synchrotron (ESRF) in Grenoble France. After a PhD in Materials Science with the highest distinction degree at the CEA in France, during his Post-doc he developed a new x-ray imaging technique (KMap) along with user-friendly software for the analysis of 5D data sets. This technique is now highly requested by a large community of researchers form international institutes to perform new types of experiments such as in situ and operando strain imaging, with the highest available resolution, of nano devices for photonics, photo voltaics and optoelectronics. Besides coordinating several projects involving international academic and industrial institutions in the field of strained semiconductors, he became interested in adapting the latest advances in synchrotron x-ray sources for a direct model-free in-depth probe of 2D materials' local structure for a better understanding of their properties.

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