INDUSTRIAL PILOT PROJECT

High quality grown 3D graphene-on-SiC sensors utilizing synchrotron photoelectron spectroscopy methods

THE INDUSTRIAL CHALLENGE

Securing high-quality growth of graphene on ultra-thin membranes and on vertical side walls of SiC is significant since it would enable integration of the sensors in multiple systems (e.g. the fabrication and evaluation of 3-axis Hall sensors) for Graphensic – A company focused on growth of graphene and device fabrication. Due to the small dimensions of the SiC cavities, a particularly challenging aspect is to evaluate the quality of graphene at their side walls.

WHY USING A LARGE-SCALE FACILITY

Taking advantage of the small lateral footprint of the x-ray beam (< 50 µm) of synchrotrons in combination with its high flux and the precise sample scanning, photoelectron spectroscopy (PES) makes possible to obtain a detailed understanding of the quality of the graphene in the entire graphene structure (vertical walls included). By using both high-resolution x-ray core level spectroscopy and x-ray absorption spectroscopy (XAS) we can obtain a detailed characterization of a 3D membrane regarding thickness (no. of atomic layers), as well as the orientation, and quality (defects) of the material across the cavity.

HOW THE WORK WAS DONE

Graphene (Gr) membranes were grown on ultra-thin SiC cavities and characterized during a two days beamtime using PES at the FlexPES beamline of the MAX IV laboratory. Figure 1(a) shows a sketch of one of the geometries used for the measurements. The cavity was only 1.5mm in diameter and 350µm deep.

THE RESULTS AND EXPECTED IMPACT

Figure 1(b) shows the corresponding C 1s intensity map with spatial resolution of 60 µm measured at a binding energy of 284.1 eV, which is the characteristic binding energy for graphene. Notice, however, that an entire C 1s spectra was measured in each point. Figure 1c shows selected and characteristic C 1s spectra measured inside, outside, and at the side wall of the cavity. Clearly, the spectrum acquired at the cavity contains both graphene and carbide.

In addition, Si 2p spectral mapping (not shown) showed significant amounts of SiO_2 everywhere on the surface at low photon energies, where the probing depth is short due to low energy of the created photoelectrons. This is clear evidence for oxidation below the graphene/carbide membrane.

Although the graphene at the vertical walls of SiC cavitities wasn't sufficient for 3-axis Hall sensors, through x-ray absorption spectroscopy enabled us to follow the orientation and quality along a line across the cavity (not shown).

Altogether, the methodology developed for characterization of 3D graphene objects at the FlexPES beamline proved useful and can now also be used as tool for others who want to characterise 2D films machined into 3D structures with photoelectron spectroscopy and x-ray absorbtion spectroscopy at the MAX IV laboratory.

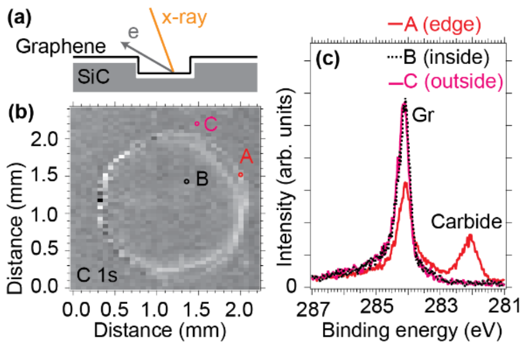

Figure 1 (a) Measurement geometry. (b) A resulting C 1s image map. (c) A representative C 1s spectra from the image.

"The characterization made possible by the MAX IV Laboratory enables us to develop truly nanoscale 3D devices"
/Amer Ali, Graphensic

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