Electronic states of a few layer graphene by NEXAFS-TXM: Mapping polarization dependence of the carbon K-edge

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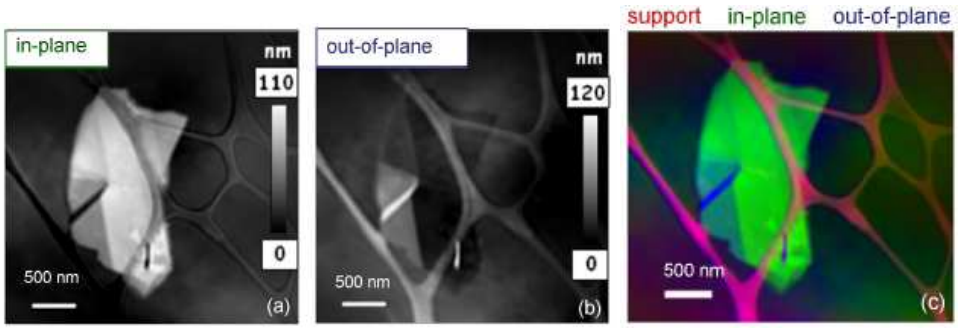
The near-edge X-ray absorption fine structure technique (NEXAFS) is ideally suited to study graphene-based materials, because the C K-edge is very sensitive to the bonding environment, providing diagnostic information about the structure, defects and doping. Using the NEXAFS method electrons are excited from the initial K-shell state into σ^* and π^* final states, depending on the orientation of the incident photon polarization with respect to the basal plane. The peak positions and lineshapes of the observed NEXAFS resonances represent, to first approximation, a replica of the unoccupied density of states, modified by core-hole interactions. In a graphene-based material the C 1s $\rightarrow \pi^*$ exhibits strong linear dichroism. By using linearly polarized X-rays, we can probe local anisotropy and structural order by varying its relative orientation to a chosen axis of the sample.

Here we combine NEXAFS with transmission X-ray microscopy[1] to study an isolated, free-standing flake. The assignment of the most intense peaks was straightforwardly obtained by comparing the peak positions of the graphene band structure. A pre-peak structure was associated to metal doping due to the presence of metal impurities in the raw material used.

References

1. **Guttmann, P., Bittencourt, C., Rehbein, S., Umek, P., Ke, X., Van Tendeloo, G., Ewels, C.P. and Schneider, G.**, "Nanoscale spectroscopy with polarized X-rays by NEXAFS-TXM", *Nature Photonics*, **6**, (2012), 25-29.



Component map of (a) in-plane (σ) and (b) out-of-plane (π) bonds; (c) colour-coded composite of the maps for lacey carbon (red), in-plane (green) and out-of-plane (blue), derived from a three component fit of the carbon K-edge image sequence.