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MIKMEKOVA, Eliska
FRANK, Ludek, PATAK, Ales
Institute of Scientific Instruments of the CAS, v.v.i., Kralovopolska 147, Brno 612 64, Czech Republic

eliska@isibrno.cz

Ultra-low energy SEM/STEM of graphene

The development of new types of materials such as 2D crystals (graphene, MoS_2 , WS_2 , h-BN, etc.) requires also the development of new surface sensitive techniques for their characterization. Regarding to “surface” sensitivity, the (ultra) low energy electron microscopy can be a very powerful tool for precise study of these atomic-thick materials and can confirm their predicted physical phenomena occurred on the surfaces. Modern commercial scanning electron microscopes enable imaging and analysis of samples by low energy electrons even at very high magnification. In the case of the SEM, resolution even below 1 nm can be achieved at low landing energy of electrons. [1]

Since specimen contamination increases with increasing electron dose and decreasing landing energy, specimen cleanness is a critical factor in obtaining meaningful data. A range of various specimen cleaning methods can be applied to selected samples. Typical cleaning methods, such as solvent rinsing, heating, bombarding with ions and plasma etching have their limitations. Electron-induced in-situ cleaning procedure can be gentle, experimentally convenient and very effective for wide range of specimens. Even a small amount of hydrocarbon contamination can severely impact the results obtained with low energy electrons. During the scanning of surfaces by electrons, the image usually darkens because a carbonaceous layer gradually deposits on the top from adsorbed hydrocarbon precursors. [2] This effect is called electron stimulated deposition. The surface diffusion of hydrocarbon molecules around the irradiated area serves as a source of additional precursors, responsible for even darker frame of the contaminated field of view. On the other hand, the effect of electron stimulated desorption occurs at the same time, especially at low energies, so fundamental question arises what process, deposition or desorption, will dominate. Examination of the phenomena taking place on surfaces bombarded with very slow electrons may open the door to many surface studies outside an ultrahigh vacuum. [3] [4]

References

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Figures

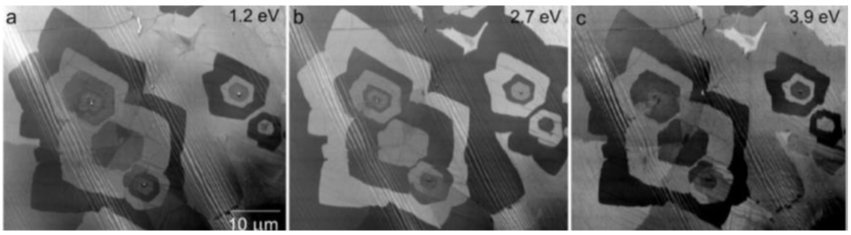

Figure 1: Graphene multilayers observed by ultra-low energy SEM: 1.2 eV (a), 2.7 eV (b), 3.9 eV (c)