# Graphene formation by electron beam induced deposition.

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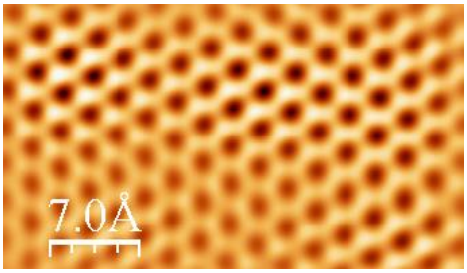
In this work, we analyze the carbonaceous films grown on Cu(111) by means of electron beam induced deposition (EBID) [1] using ethylene as a precursor gas.

The study was performed for two different precursor gas pressures in an UHV chamber, and two substrate temperatures. In the whole set of experiments, we started with a clean Cu(111) sample and the other parameters involved in the process such as the energy and current density of the electrons were kept constant.

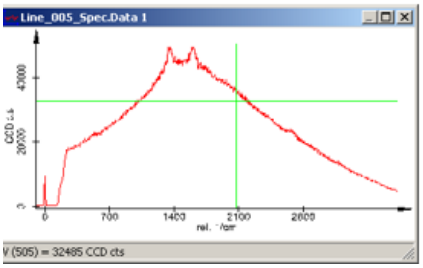
To characterize the films during the formation process we used *AES* (Auger Electron Spectroscopy) and *EELS* (Electron Energy Loss Spectroscopy). These techniques allow us to determine the relative amount of carbon deposited on the surface, and to establish the type of carbon atoms bonds at the surface. We found that there is no influence of the substrate temperature on the amount of carbon deposited at low exposures. However, at high ethylene exposures, the amount of carbon deposited decreases if the substrate temperature increases. An analysis of the $C_{KLL}$ line shape of the final Auger spectra measured after each deposition demonstrates that the chemical structure of the surface carbon compounds is the same for all the samples grown by EBID.

The rate of carbon deposition is constant for the first 4000 L, regardless of ethylene pressure (P) and substrate temperature (T). Above this level of exposure, some dependence with P and T is observed. Both, AES and EELS spectra indicate a majority of $sp^2$ bonds in the carbon structures formed on the surface, consistent with the formation of a graphitic compound (or graphene).

Scanning tunneling microscopy (STM) and Raman spectroscopy were used as complementary, but decisive, techniques to assess the structured of the obtained films (see figure). From all the results obtained we can conclude that the carbonaceous films are formed by patches of defective few layer (1-2) graphene.




*STM image of the sample obtained by EBID.*




*Raman signal obtained, consistent with the formation of graphene.*

References
[1] S.J. Randolph, J.D. Fowlkes and P.D. Rack, Focused, Nanoscale Electron-Beam-Induced Deposition and Etching, Critical Reviews in Solid State and Materials Sciences, **31** 55-89 (2006).