

A surface science approach to SEY studies.

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A. Di Trolio and R. Cimino

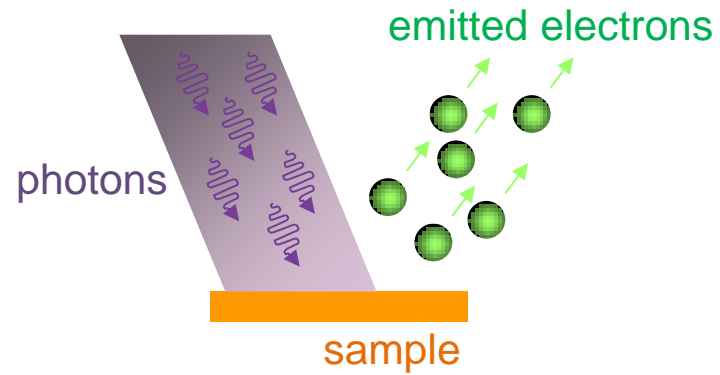


CNR-Istituto dei Sistemi Complessi, Roma, Italy

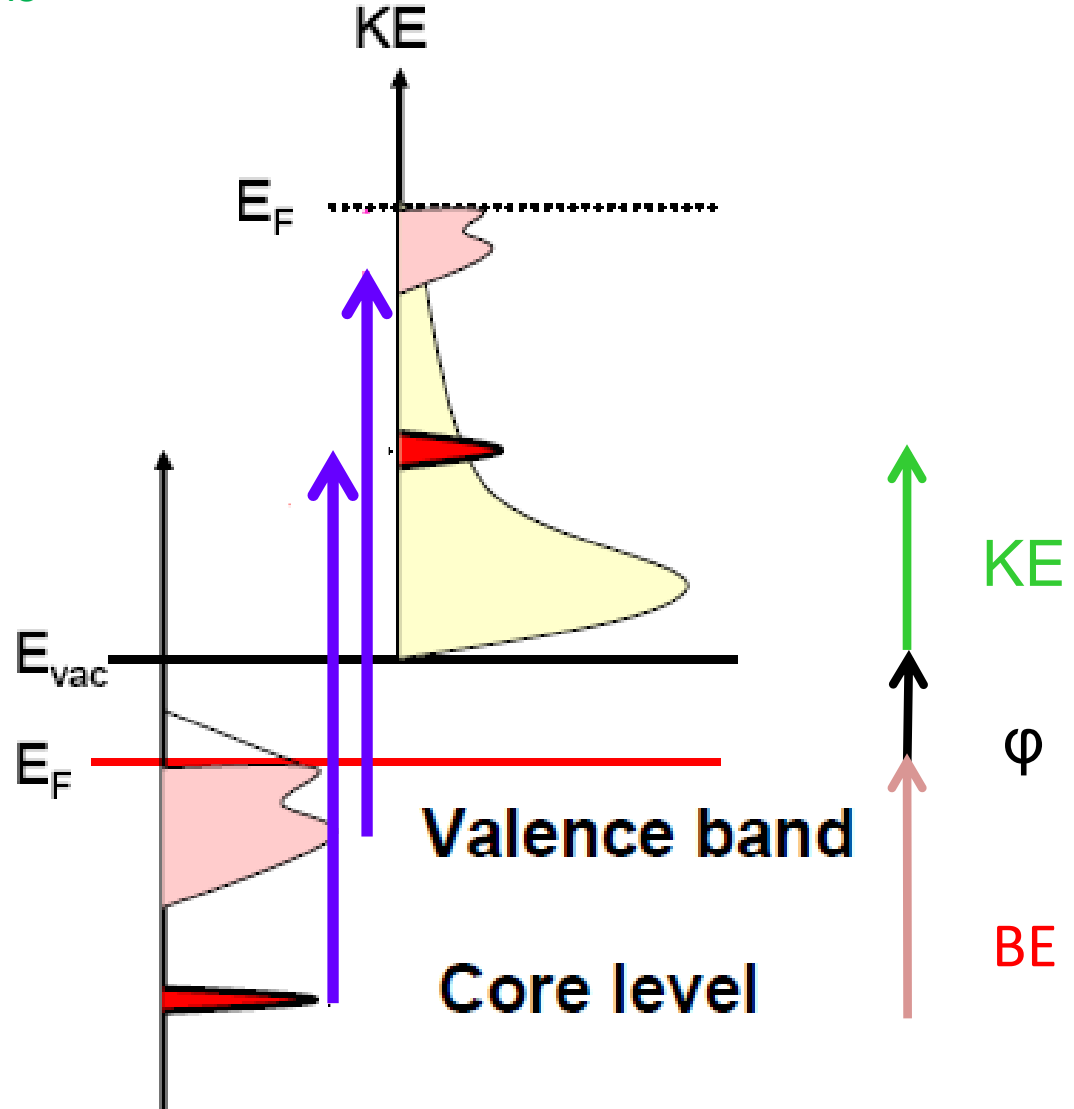


INFN-LFN, Frascati (RM), Italy

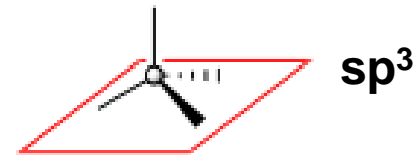
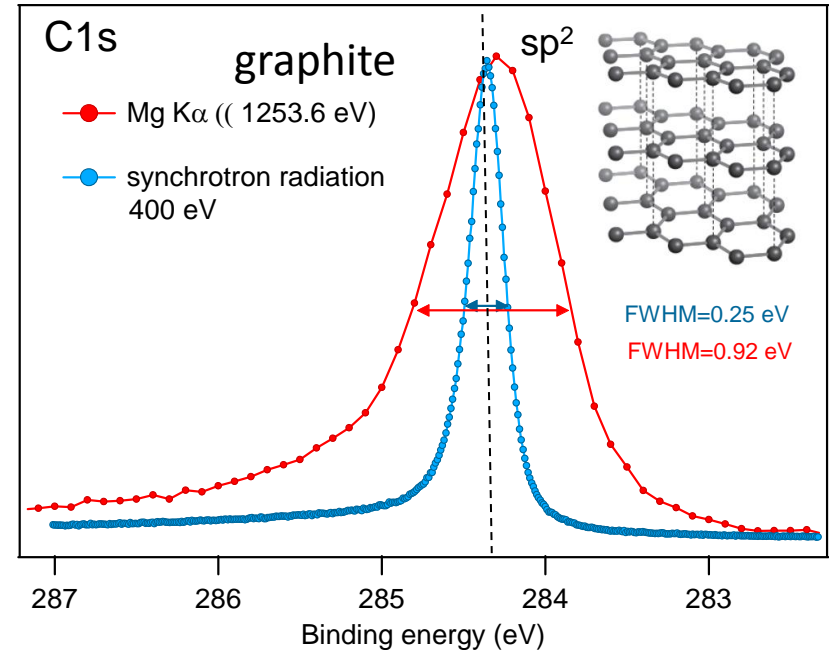
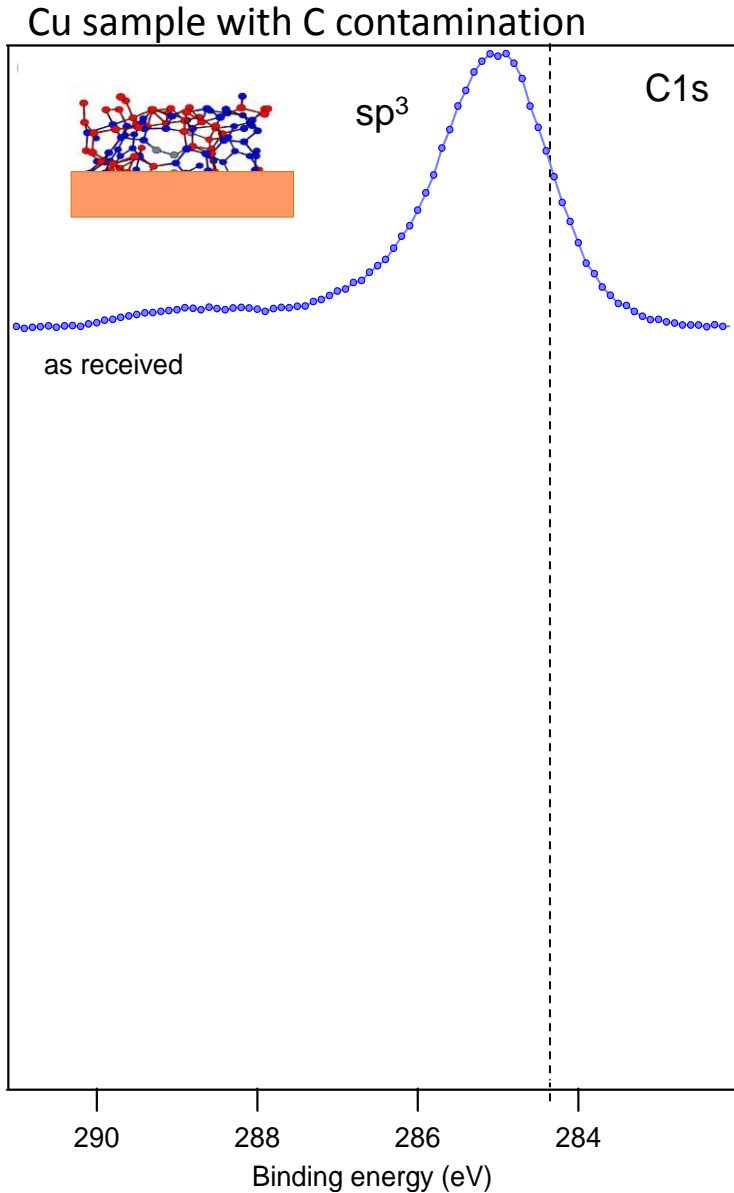
Photoelectron spectroscopy (UPS-XPS)



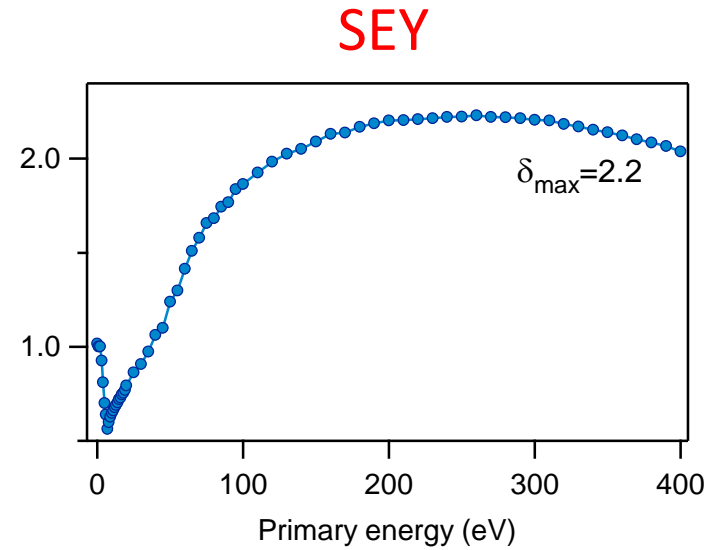
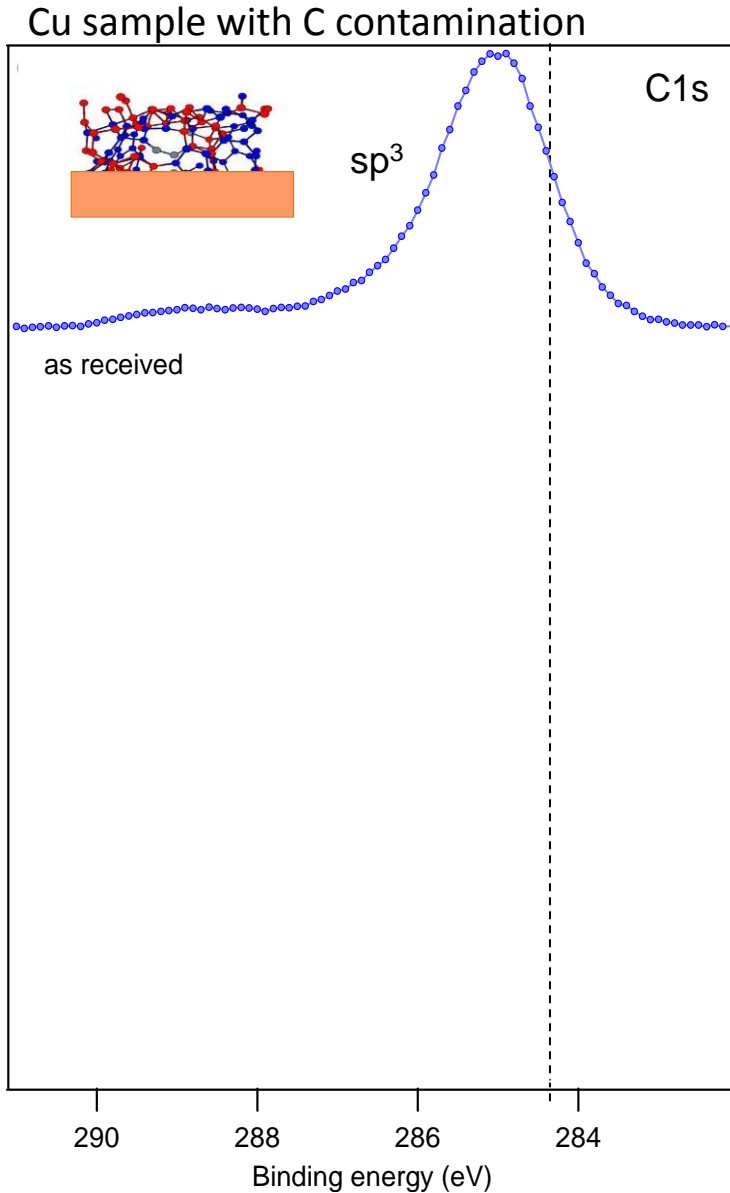
$$KE = h\nu - BE - \phi$$



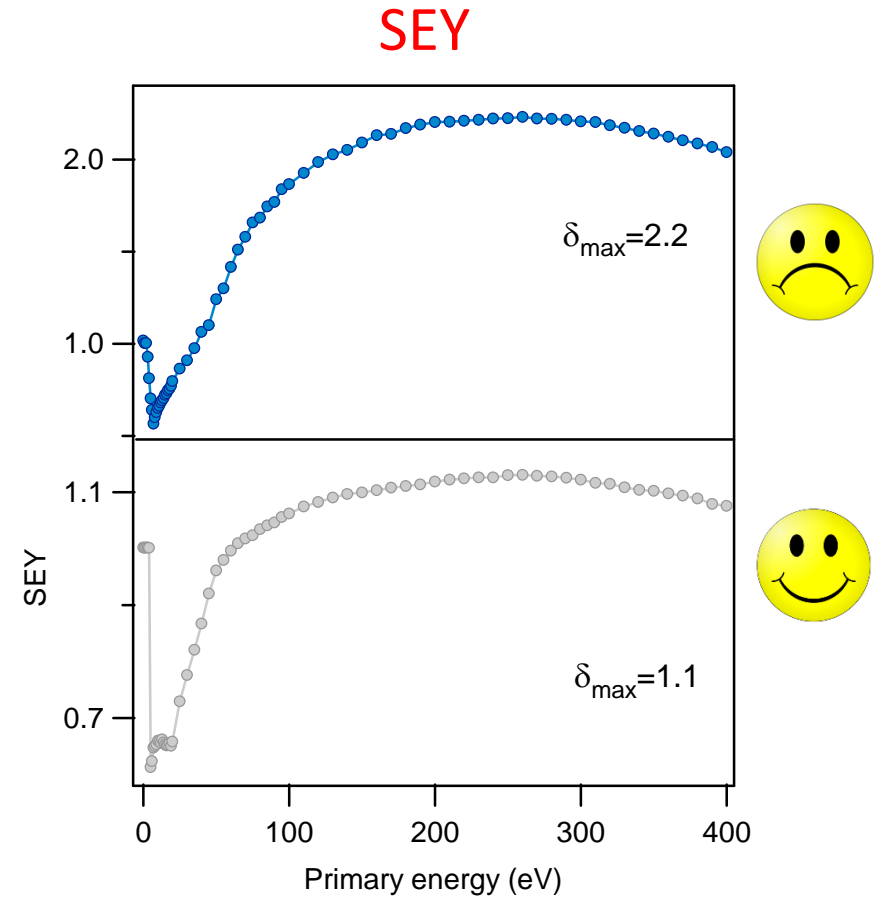
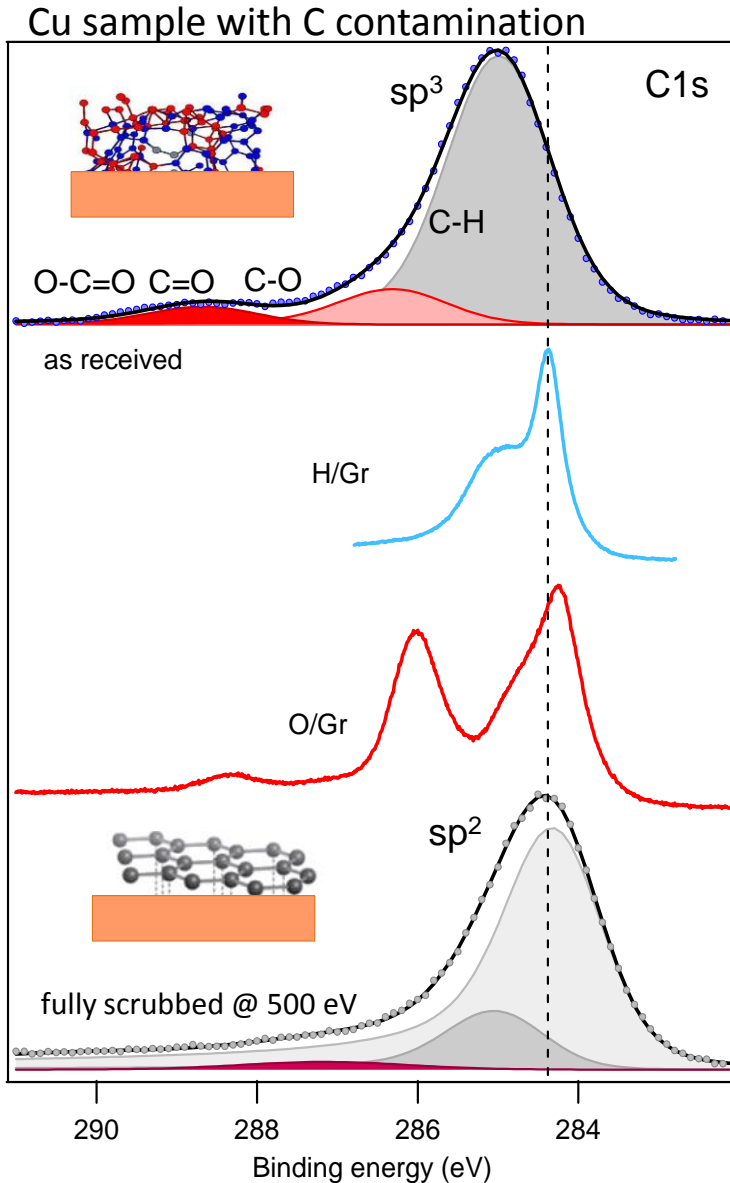
SEY of 'technical' surfaces



SEY of 'technical' surfaces



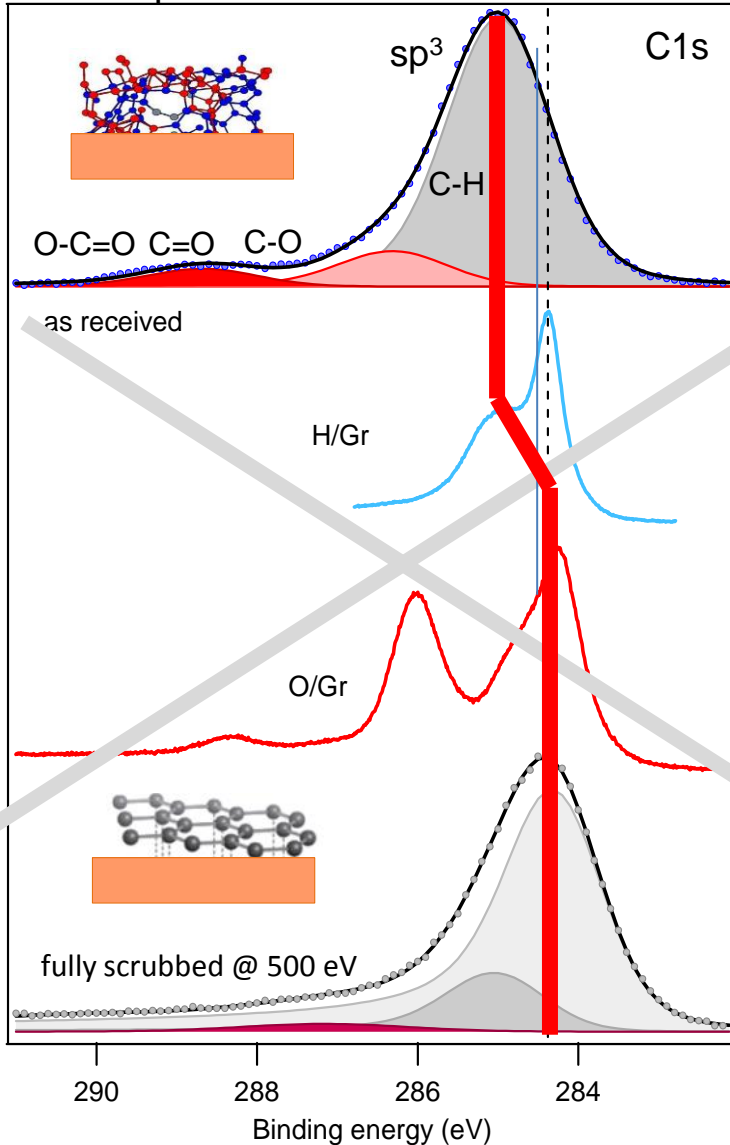
SEY of 'technical' surfaces



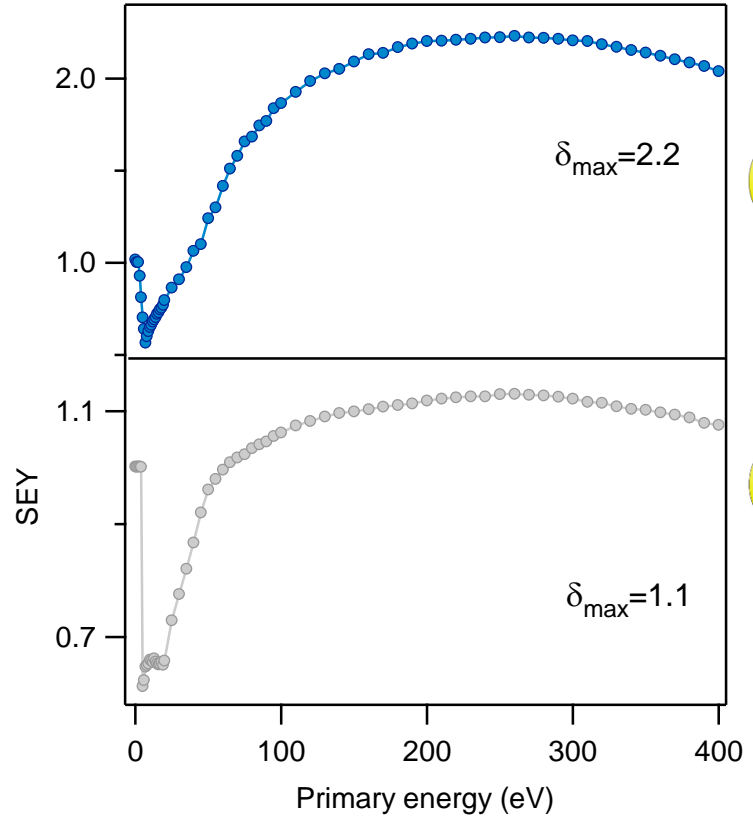
chemical and structural effects

SEY of 'technical' surfaces

Cu sample with C contamination



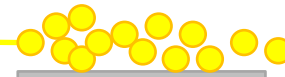
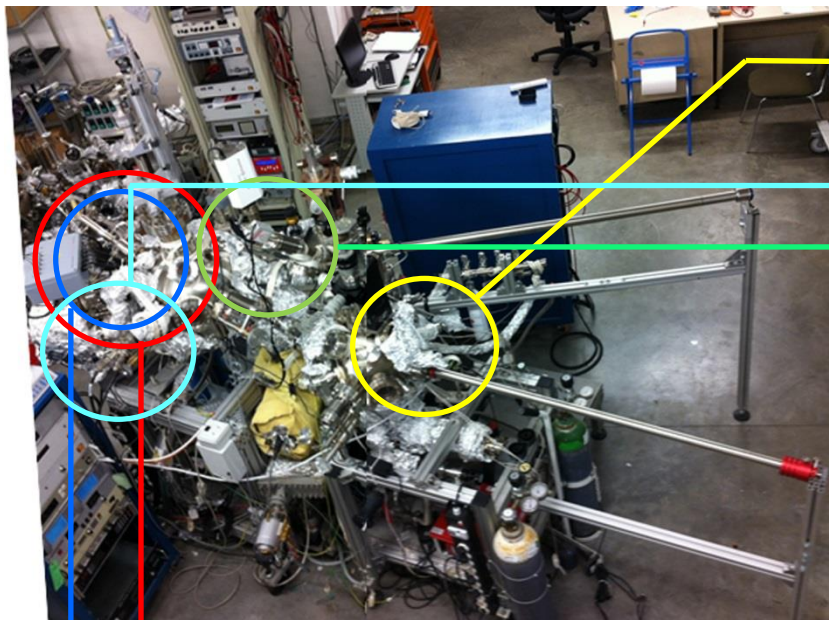
SEY



chemical and structural effects

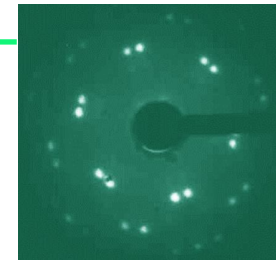
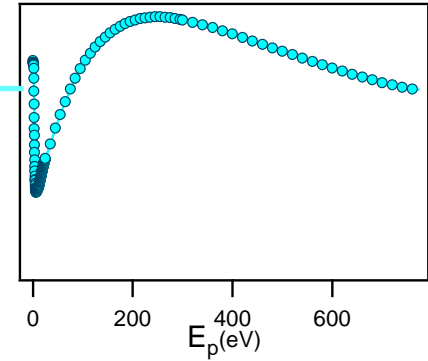
- How good does the crystalline structure of the 'graphitic layer' have to be in order to have a low SEY?
- What happens to the SEY if defects are generated in a good graphitic crystal?

Material Science Lab @ LNF-INFN Frascati

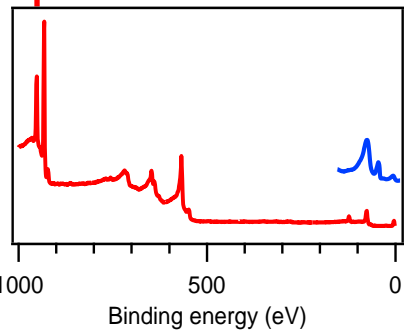


material growth (CVD, MS)

secondary electron yield

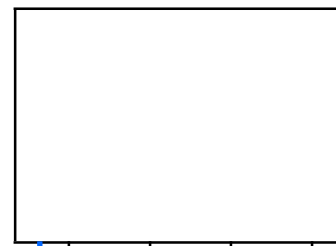


low Energy Electron Diffraction



X-ray photoelectron spectroscopy

UV photoelectron spectroscopy



Binding energy (eV)

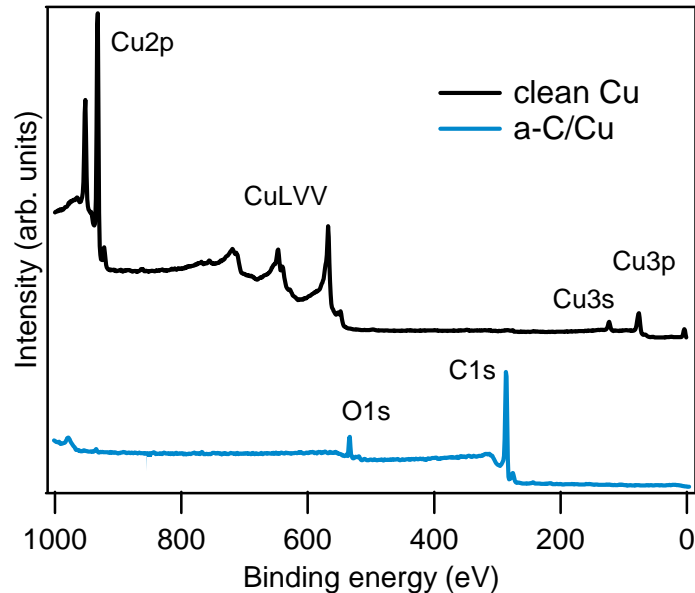
UHV growth by means of physical evaporation, CVD, magnetron sputtering

Characterizations :
in situ: SEY, XPS, UPS, LEED
ex-situ: micro-Raman

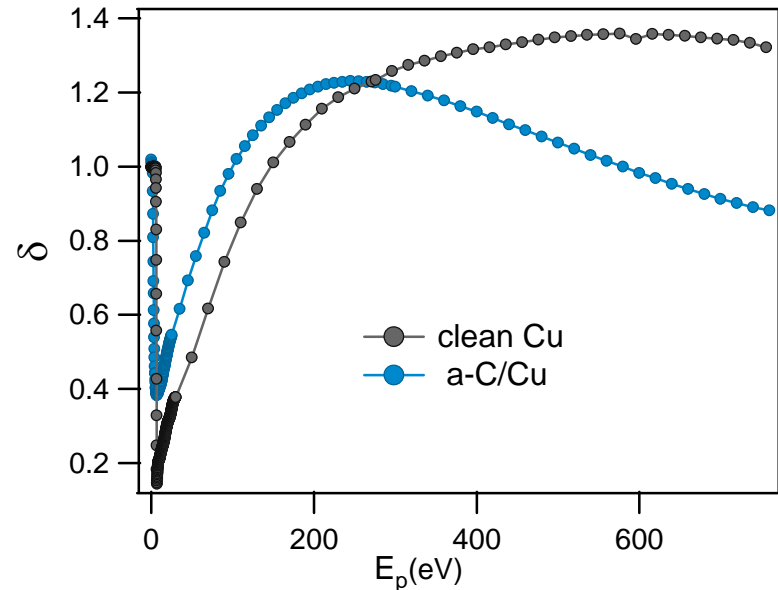
SEY vs. graphitization for a-C films

$h\nu=1486.7$ eV

XPS



SEY



ultra high vacuum

RF magnetron sputtering 50W p(Ar) 6×10^{-2} mbar

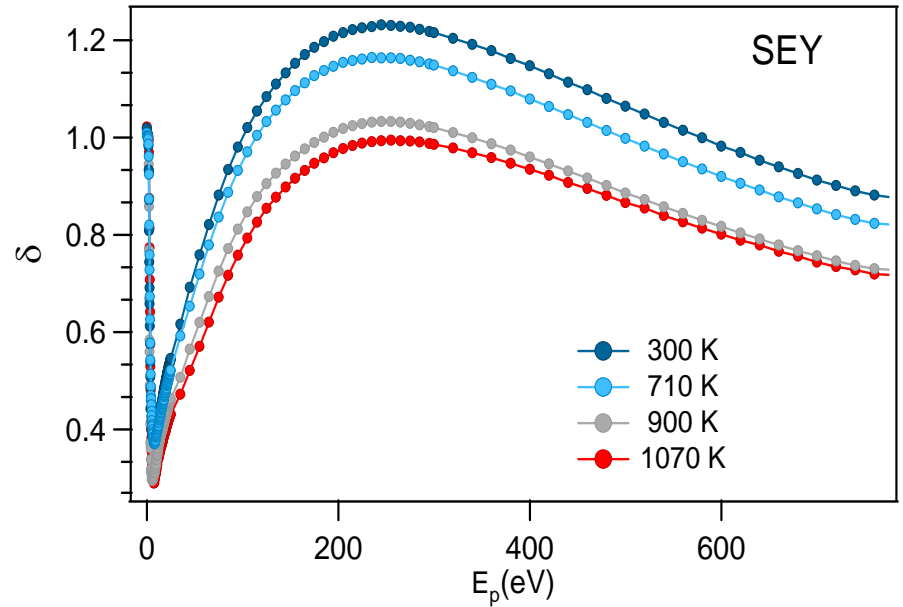
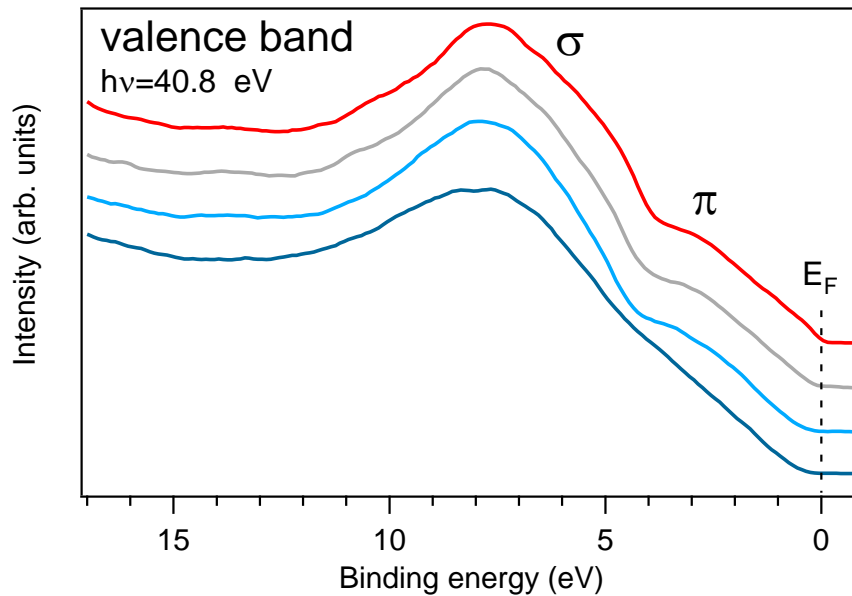
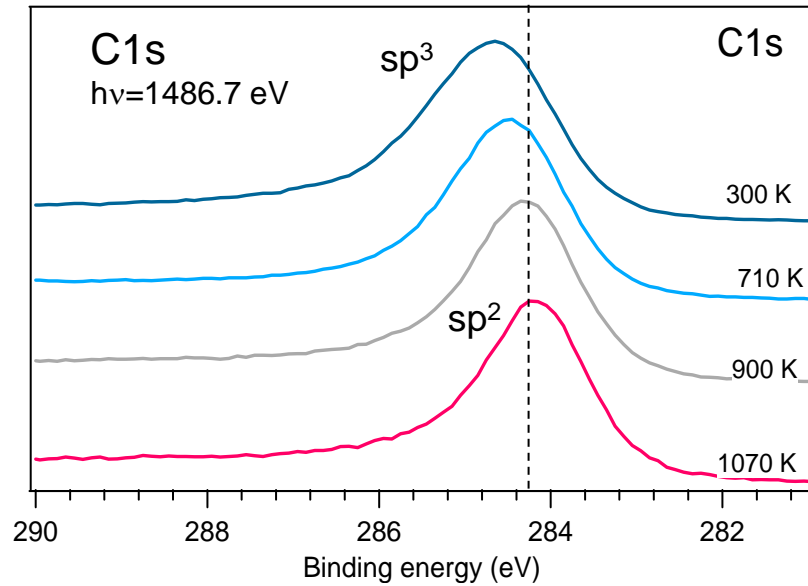
a-C (~ 20 nm)/poly Cu

A-C film thickness ~ 30 nm

Cu: $\delta_{\max}=1.36$

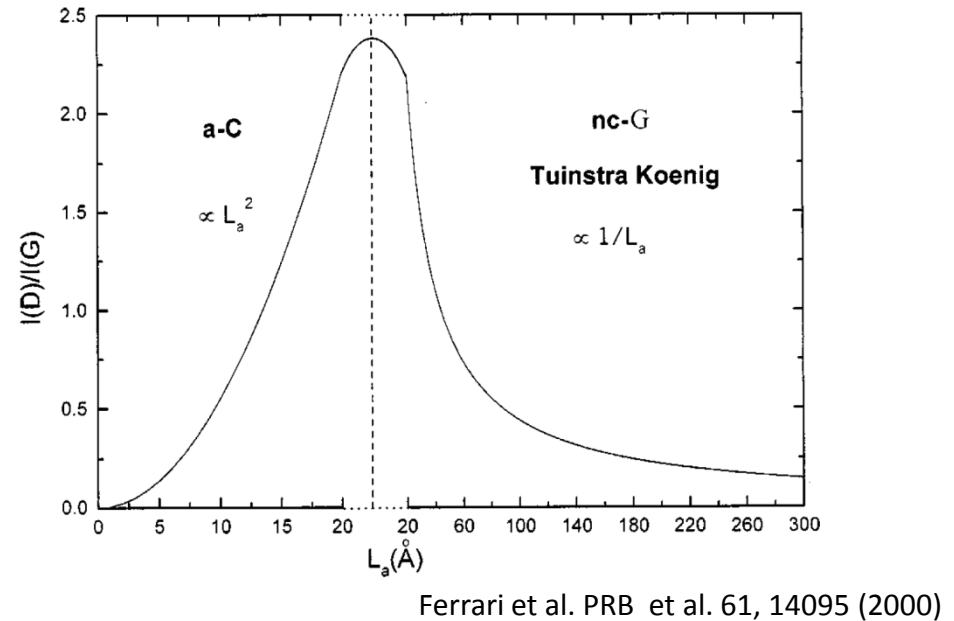
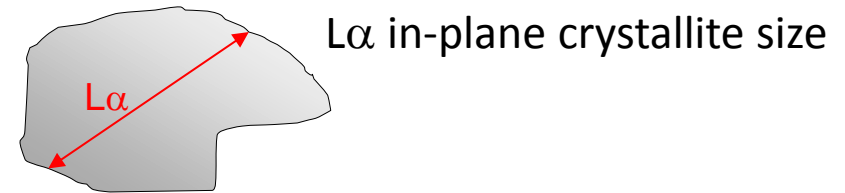
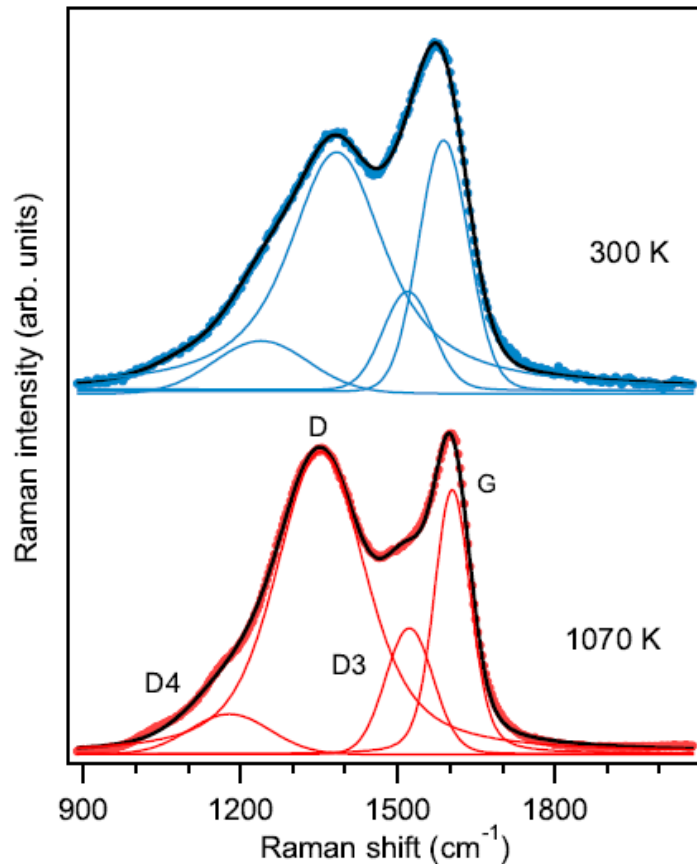
a-C: $\delta_{\max}=1.25$

SEY vs. graphitization for a-C films



$$\delta_{\max}=1$$

SEY vs. graphitization for a-C films

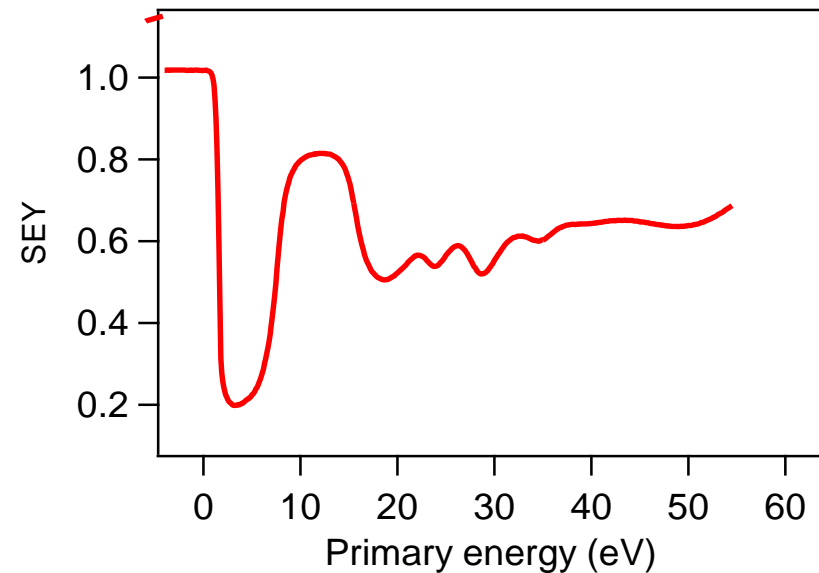
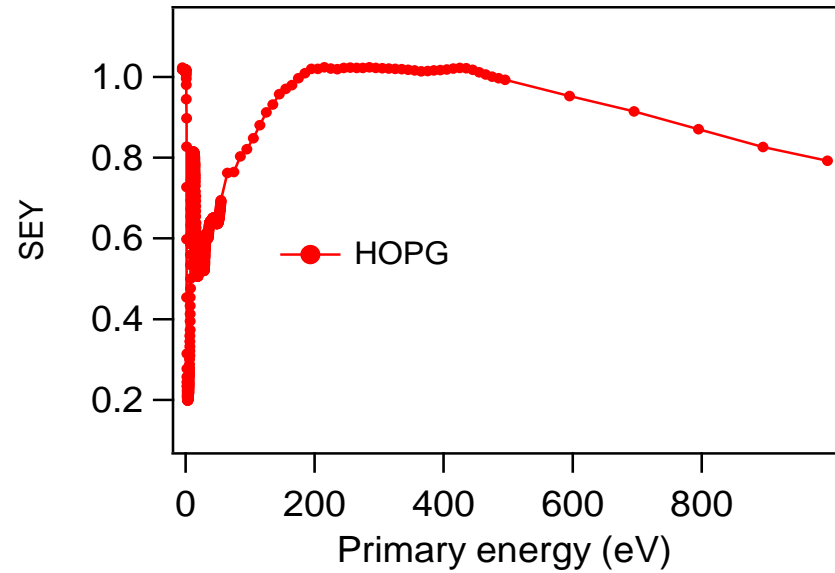
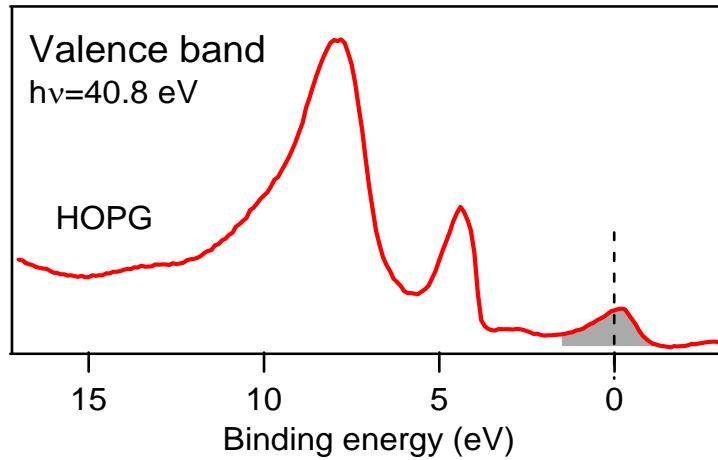
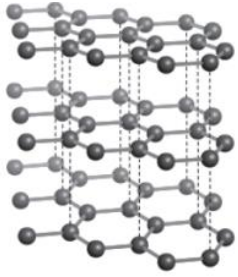


Aromatic clusters of a few nanometers are sufficient to lower the macroscopic SEY to the level of graphitic carbon with much higher structural ordering.

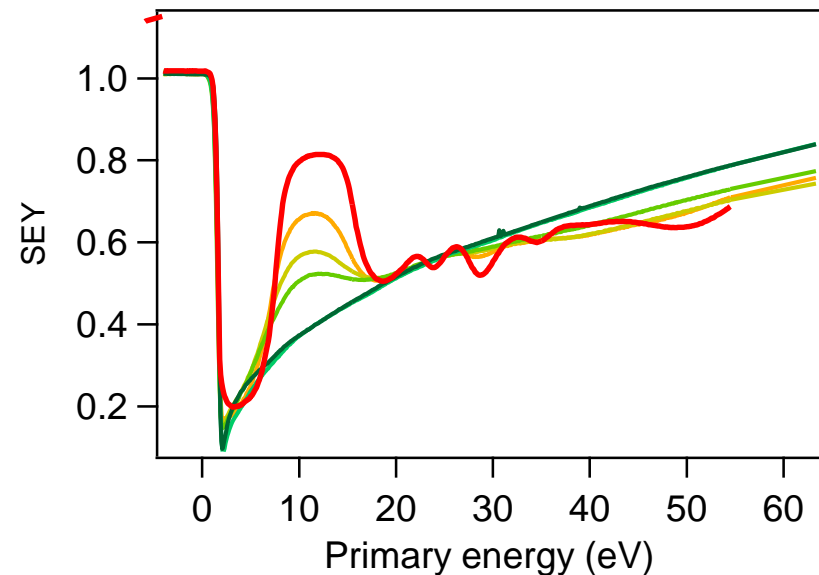
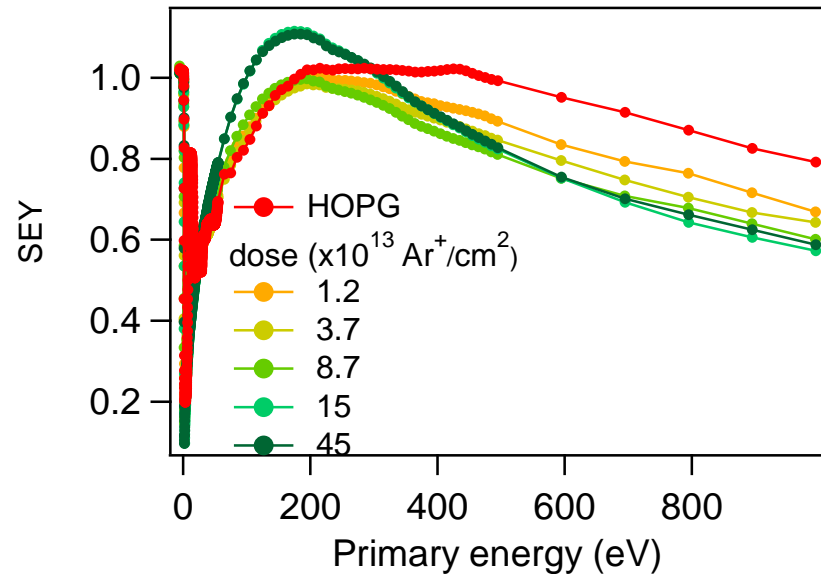
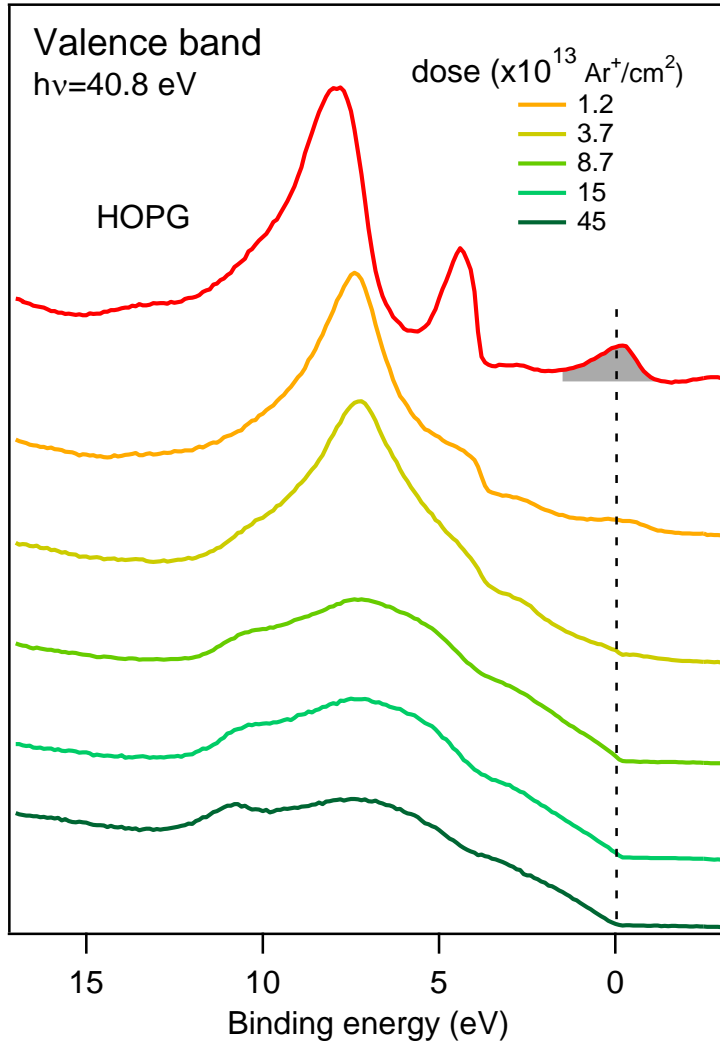
It is likely that the enhanced scattering at the grain boundaries provides an additional contribution to reduce the number of secondary electrons emerging from the surface.

- How good does the crystalline structure of the 'graphitic layer' have to be in order to have a low SEY?
- What happens if defects are generated in a good graphitic crystal?

Highly oriented polycrystalline graphite (HOPG)

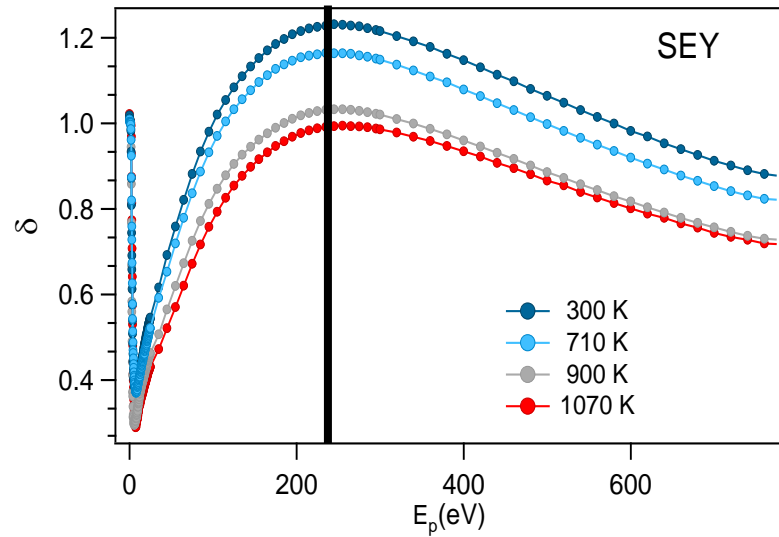


Effect of structural defects in graphite

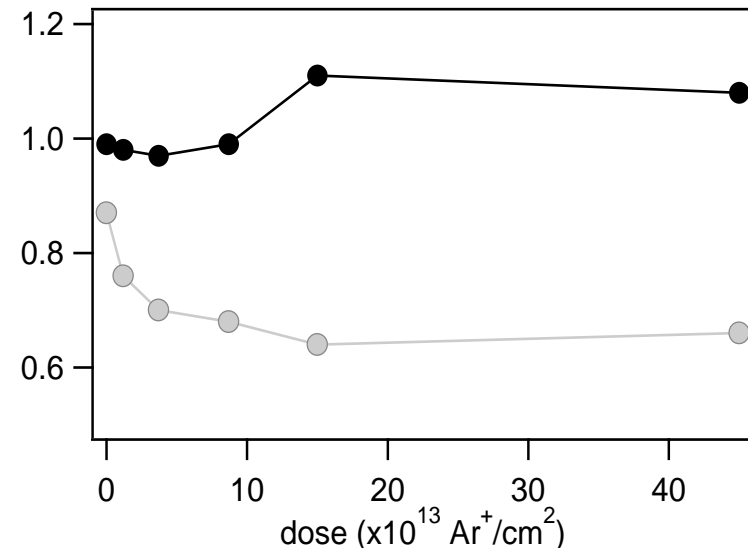
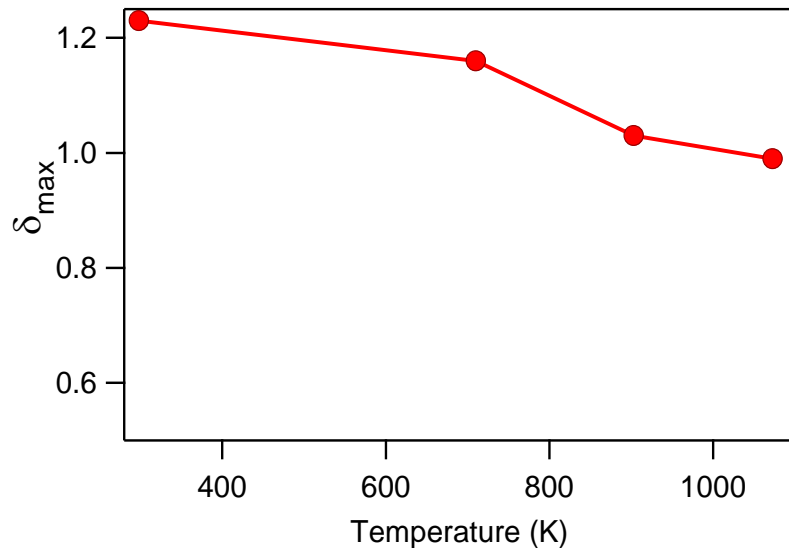
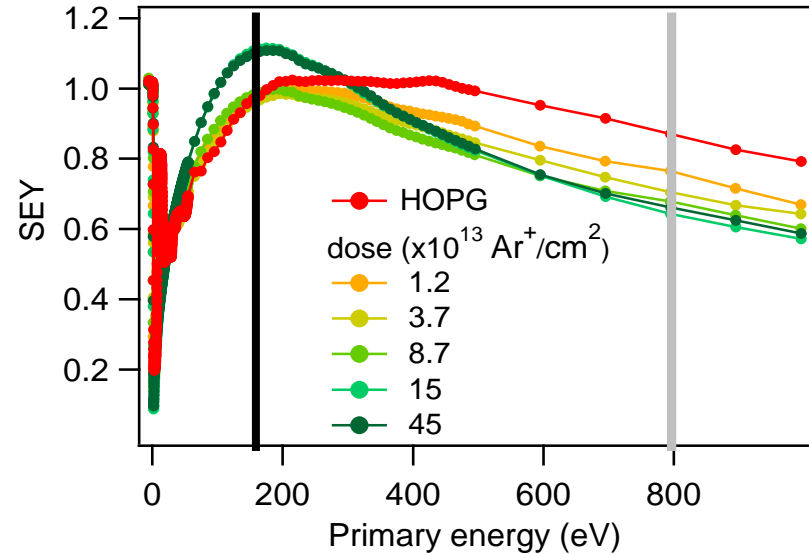


SEY vs. surface process

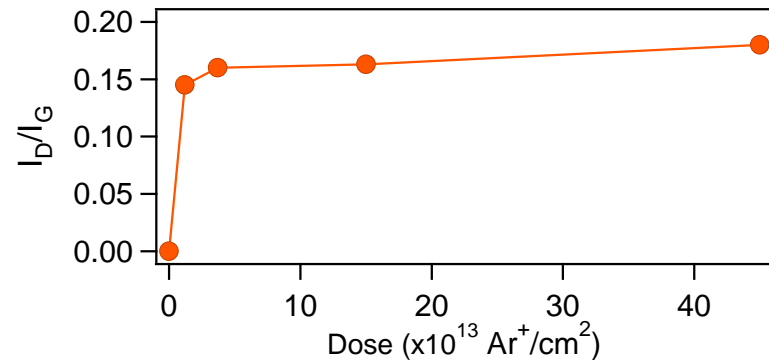
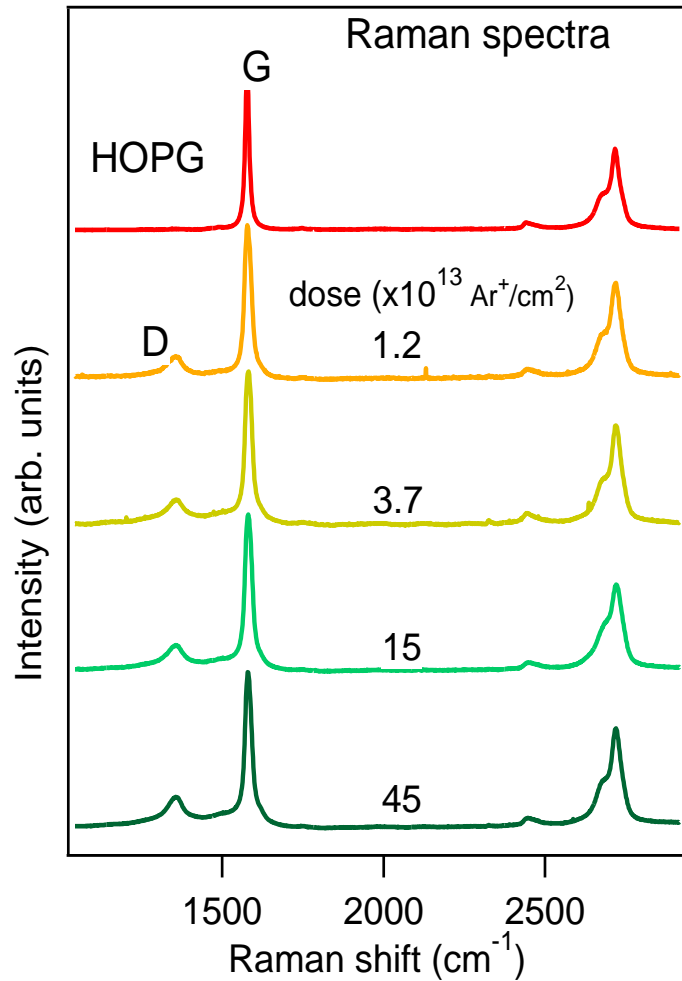
thermal annealing of a_C films



Ar⁺ sputtering of HOPG



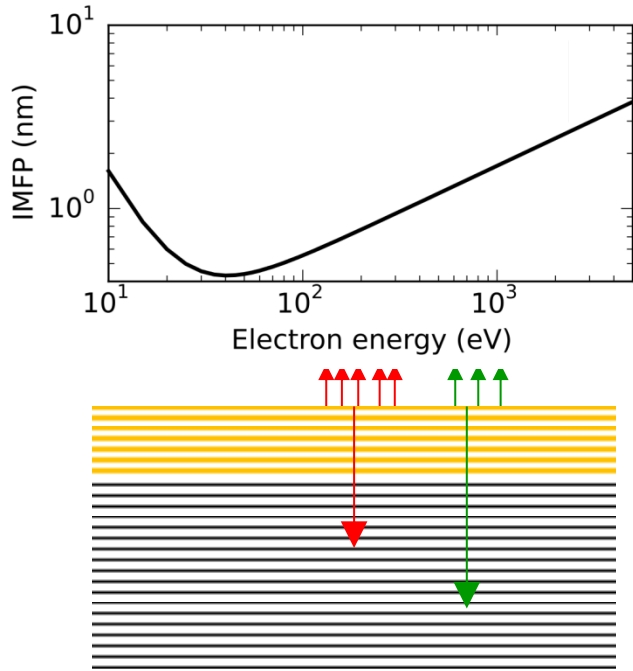
Effect of structural defects in graphite



Ar ion penetration depth $\sim 1.9 \text{ nm}$

Raman sampling depth $\sim 500 \text{ nm}$

SEY of defected graphite

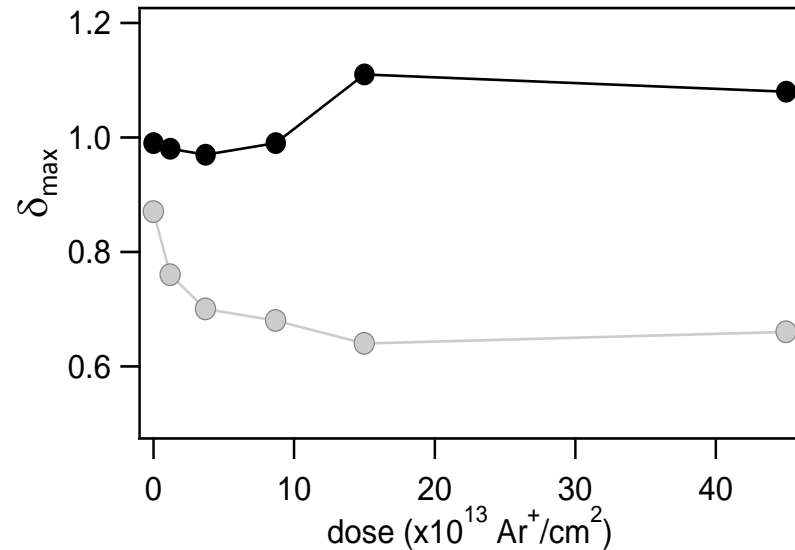
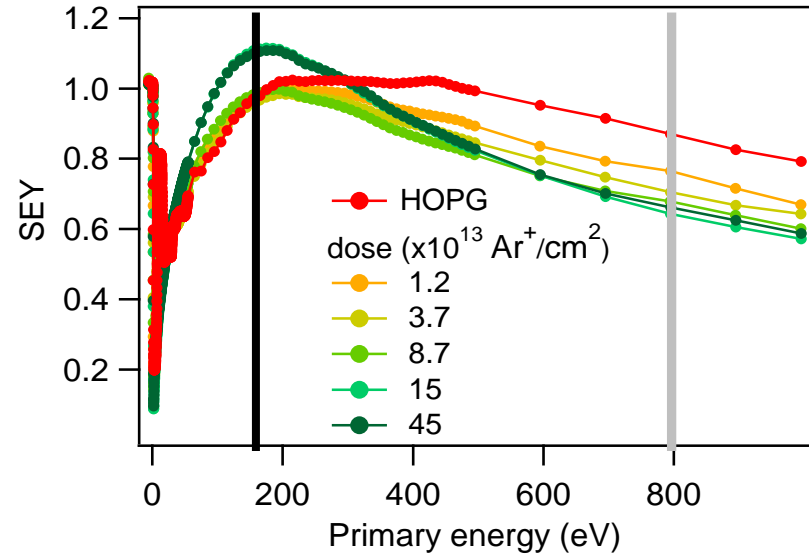


electron penetration depth in graphite

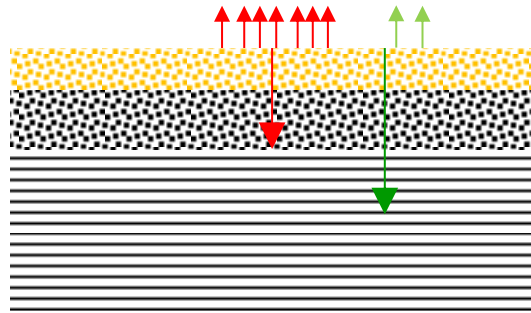
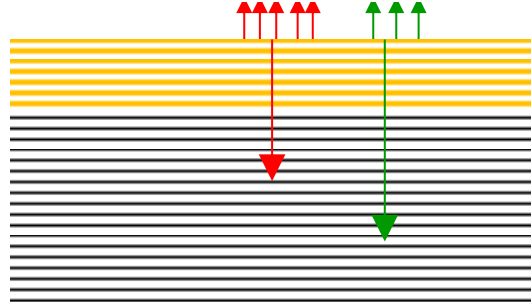
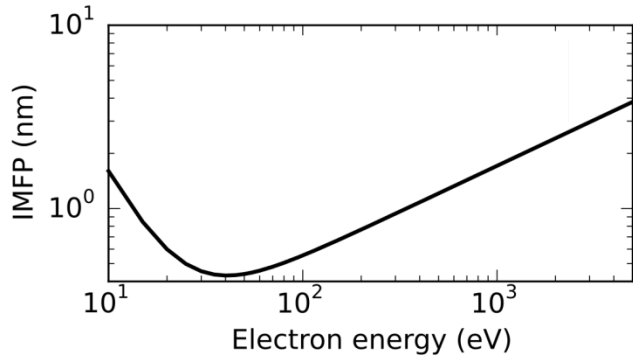
~2nm @ 200 eV

~30 nm @ 1000 eV

Ar⁺ sputtering of HOPG



SEY of defected graphite

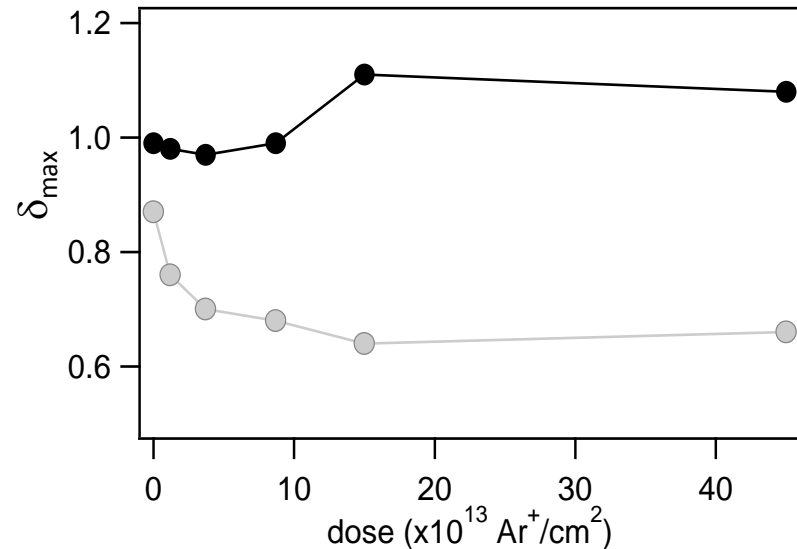
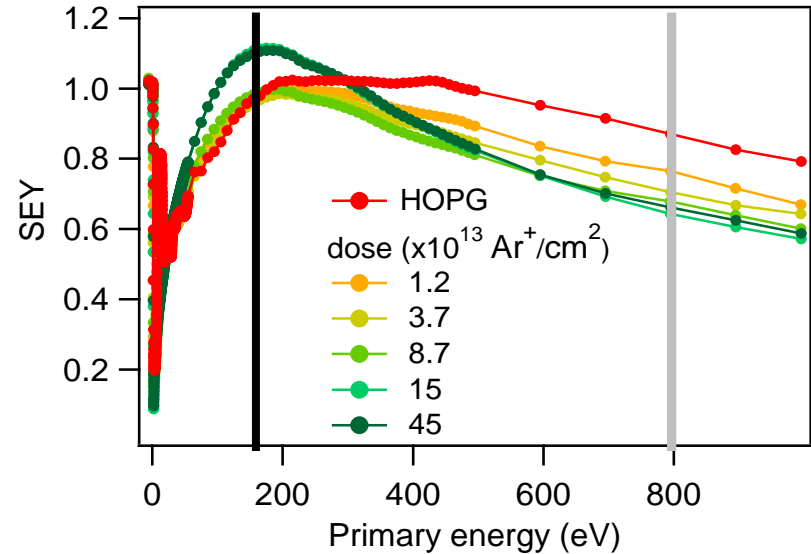


electron penetration depth in graphite

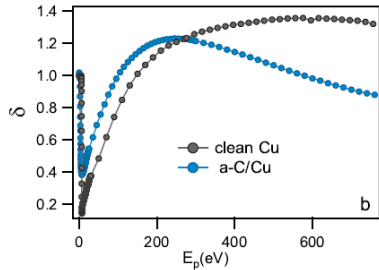
$\ll 2\text{ nm}$ @ 200 eV

$\ll 30\text{ nm}$ @ 1000 eV

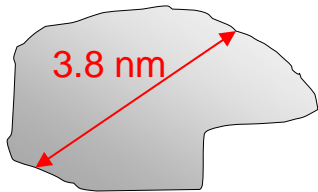
Ar⁺ sputtering of HOPG



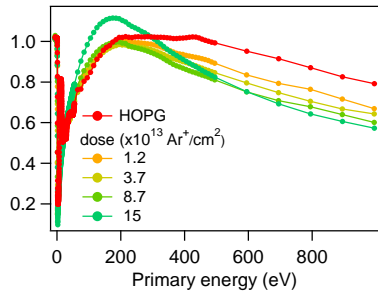
Conclusions



A few nm layer of amorphous C deposited at RT is capable of lowering the δ_{\max} value of a clean copper surface, hinting to a more dramatic effect on technical surfaces, which exhibit a much higher SEY.



A moderate structural quality of the C layer is sufficient for a considerable SEY decrease as aromatic clusters of limited size approach the secondary emission properties of graphite.



The amorphization of HOPG changes the SEY curve, but the SEYmax values remain relatively stable and low (<1.1). SEY at high primary electron energies (<500 eV) decreases with increasing crystalline disorder.

These results indicate the importance of studying the stability and aging of carbon based coatings and suggest that these effect should be considered in simulations where SEYcurves are parametrized.



Thanks for your attention!