# Growth and characterization of graphene on SiC(0001) and SiC(000-1)


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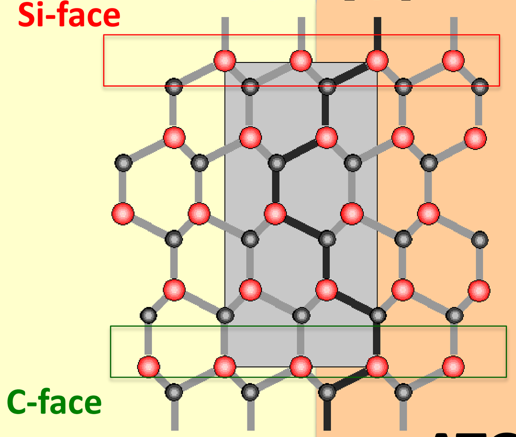
## Graphene on SiC(0001)

### Zerolayer (ZL), monolayer (ML) and bilayer (BL) graphene

- Buffer layer of C atoms arranged in a graphene-like honeycomb structure and covalently bound to Si atoms.
- Better graphene thickness control and uniformity.
- Defined azimuthal orientation with respect to the substrate.
- Ordered stacking of layers..



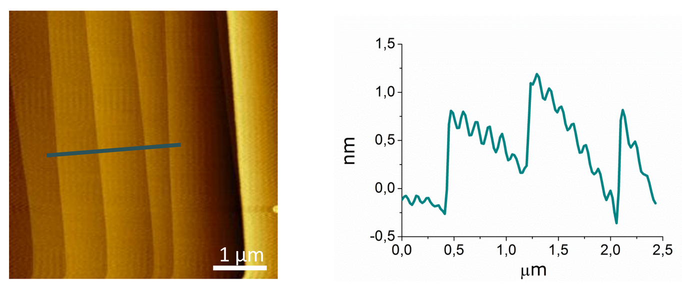

## Graphene on SiC(000-1)

### Few layers (FL) graphene

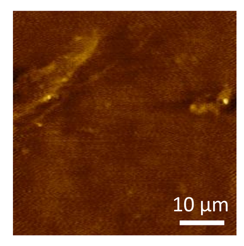
- Difficult control of the number of layers during growth
- Different azimuthal orientations.
- Electronically decoupled graphene layers (turbostatic stacking of graphene layers).
- Higher mobilities.

## ATOMIC FORCE MICROSCOPY (AFM)

### H-etched Si-face

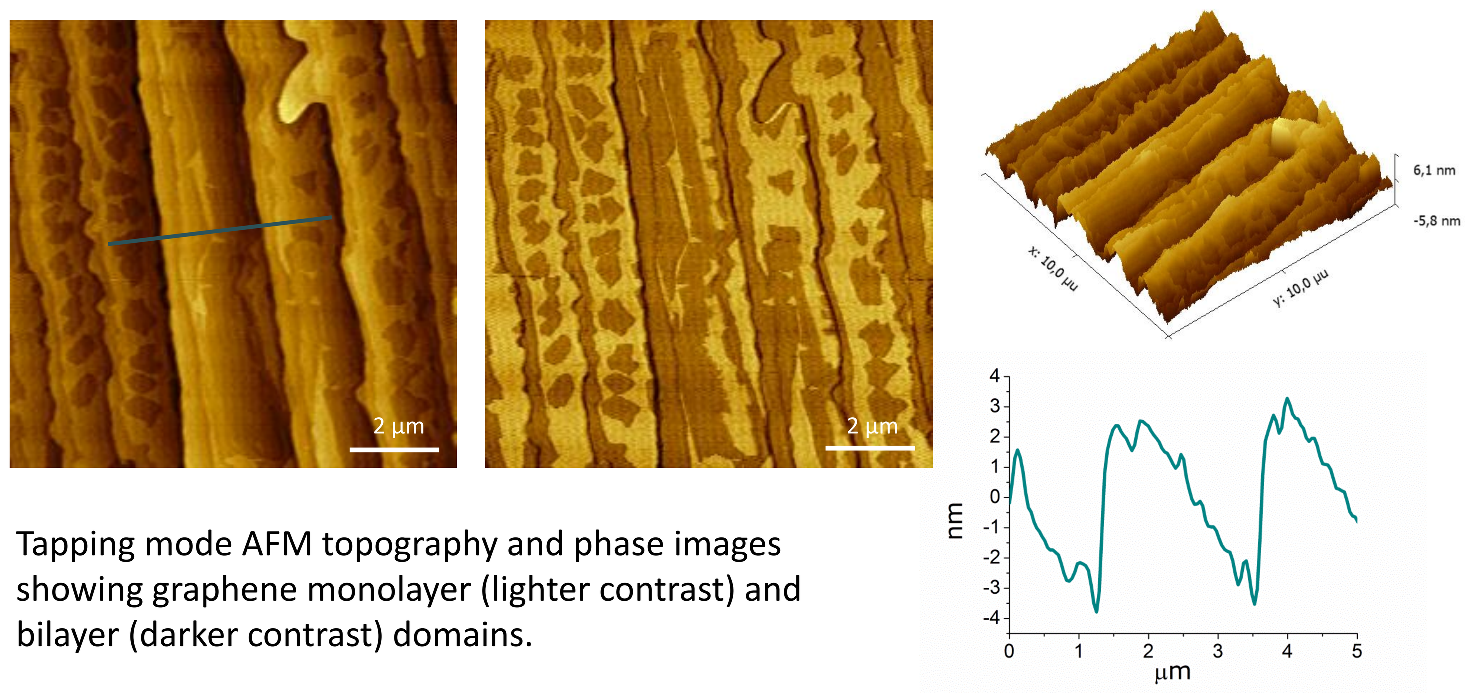



Hydrogen etching removes polishing damages and creates atomically flat terraces separated by steps.




Si face epi-ready SiC substrate

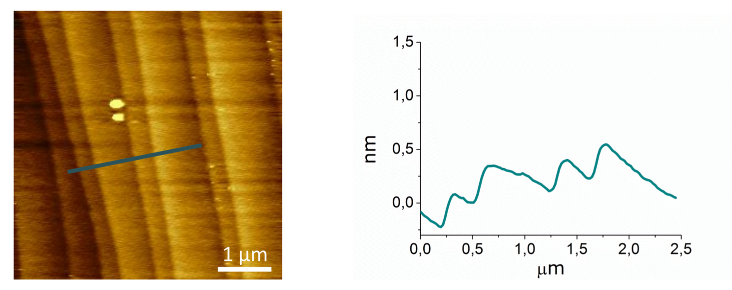
### Epitaxial Graphene growth on Si-face



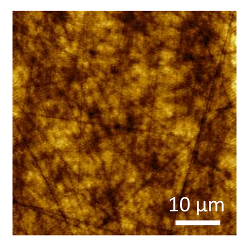

Tapping mode AFM topography and phase images showing graphene monolayer (lighter contrast) and bilayer (darker contrast) domains.

## ATOMIC FORCE MICROSCOPY (AFM)

### H-etched C-face

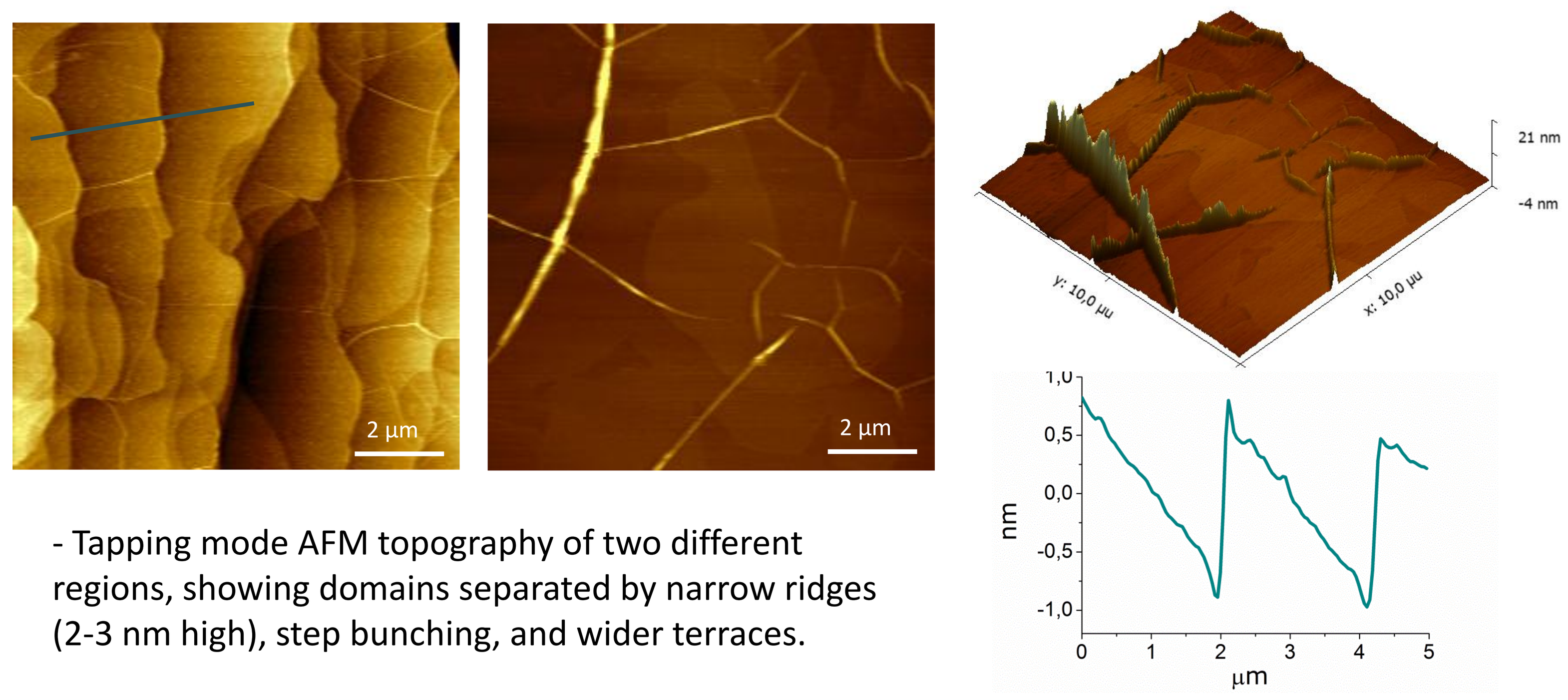



Half or full unit cell high steps after hydrogen etching cover the surface sample.



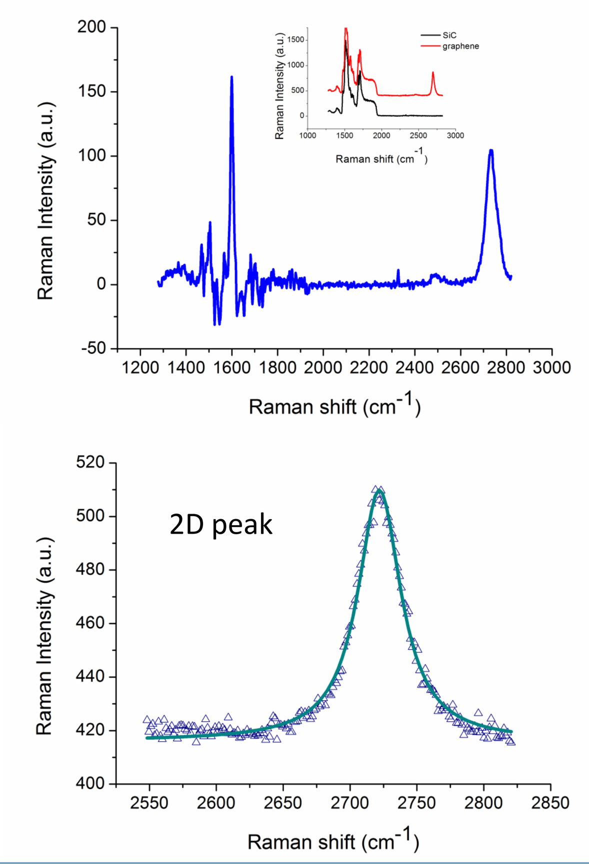

C face polishing scratches on SiC substrate

### Epitaxial Graphene growth on C-face

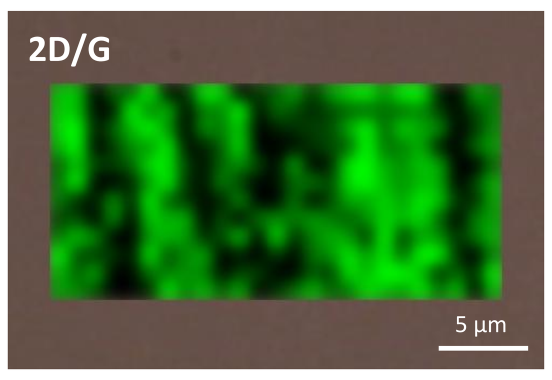



- Tapping mode AFM topography of two different regions, showing domains separated by narrow ridges (2-3 nm high), step bunching, and wider terraces.

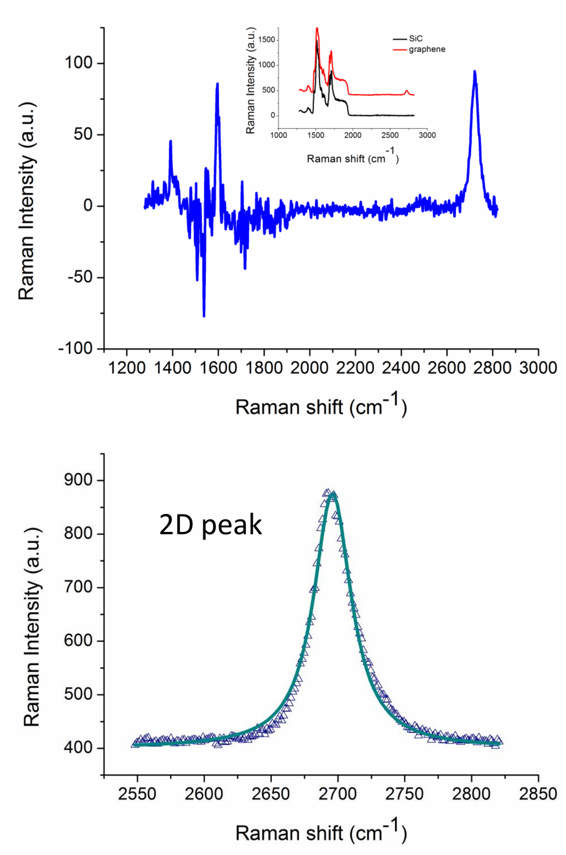
## RAMAN SPECTROSCOPY

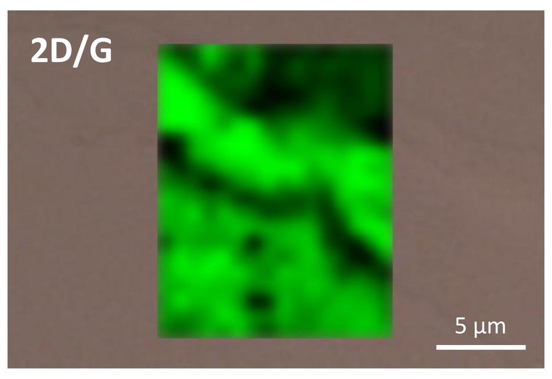



- Raman spectra of graphene measured at 532 nm, after the subtraction of the SiC background signal, show G peak at ~1590 $cm^{-1}$ and 2D peak at ~2700 $cm^{-1}$.
- 2D peak fit with one Lorentian, FWHM 39 $cm^{-1}$.
- 2D/G map shows a high ratio between 0.7 and 1.2 with low values at the terraces edge.



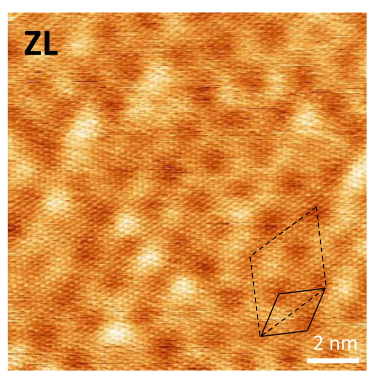

## RAMAN SPECTROSCOPY




- Raman spectra of graphene measured at 532 nm, after the subtraction of the SiC background signal, show G peak at ~1590 $cm^{-1}$ and 2D peak at ~2700 $cm^{-1}$.
- 2D peak fit with one Lorentian, FWHM 34 $cm^{-1}$.
- 2D/G map shows a high ratio between 0.7 and 2.5 with low values at the terraces edge.

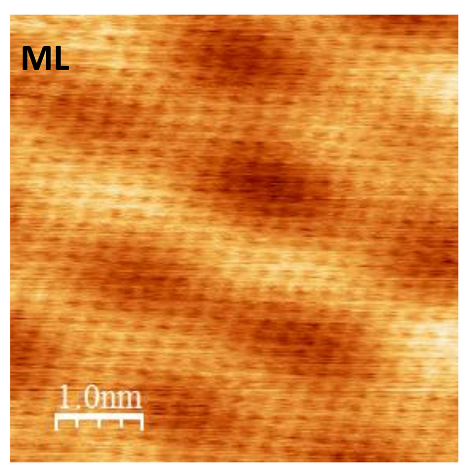
## SCANNING TUNNELLING MICROSCOPY (STM)




The STM image reveals the typical (6√3x6√3)R30° and the (6x6) superstructures which are indicated by the dashed and the solid diamond, respectively.

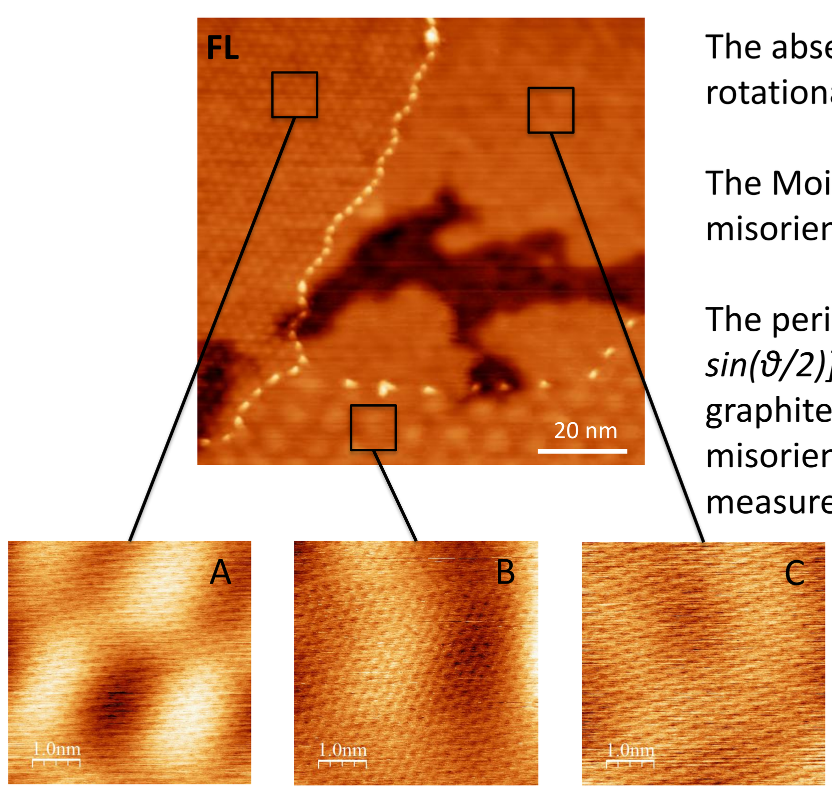
Fig. from S. *Goler et al. Carbon*, 51 249, (*2013*).

The honeycomb lattice signature of graphene is visible on top of the long range superstructure due to the interaction of the ZL with the substrate.




5nm, 0.5V, 500pA

## SCANNING TUNNELLING MICROSCOPY (STM)



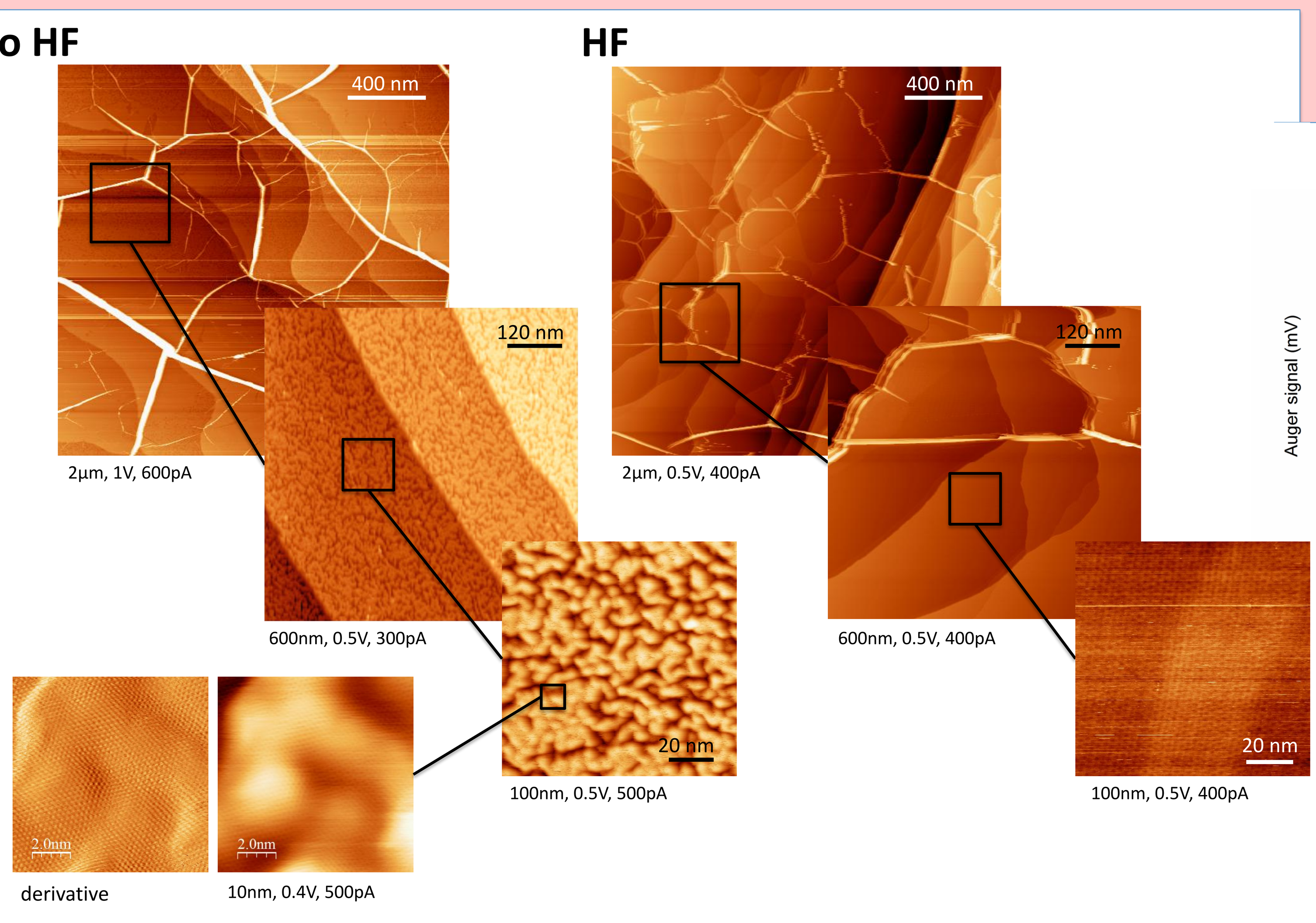

The absence of the buffer layer on the C face causes a rotational disorder due to stacking faults.

The Moiré patterns visible in (A) and (B) are due to misorientation bewteen the two outermost layers.

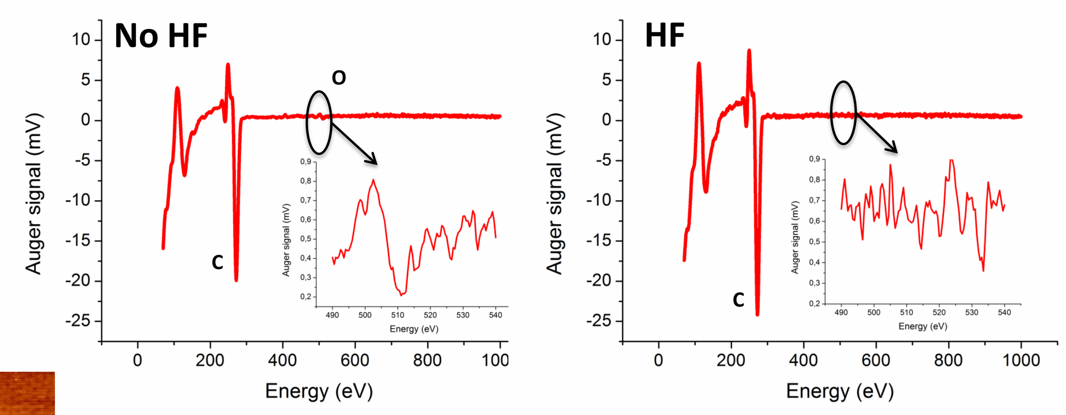
The periodicity *D* of the pattern is given by $D=a/[2 \sin(\vartheta/2)]$, where *a* is the lattice parameter ( *a* is the graphite atomic lattice constant, *0.246 nm*) and $\vartheta$ is the misorientation angle between the layers. From the measured values of *D* we derive $\vartheta_A = 4.8°$ and $\vartheta_B = 1.6°$

There is also an area (C) without Moiré pattern, that probably corresponds to a AB (Bernal) stacking or to small periodicities that are difficult to resolve.

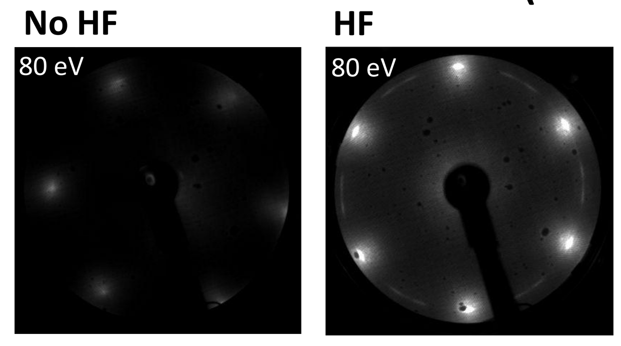
# Effect of HF treatment on graphene on C face




## AUGER ELECTRON SPECTROSCOPY (AES)




## LOW ENERGY ELECTRON DIFFRACTION (LEED)




### No HF-treated sample

- >50% corrugated "worm-like" area in the large scale STM.
- on a smaller scale STM reveals a highly corrugated surface, graphene is however continuous and defect free.
- O Auger signal visible.
- the LEED pattern lacks of sharpness.

### HF-treated sample

- the surface is flat as revealed by larger and smaller scale STM images.
- oxygen completely removed by HF as confirmed by Auger analysis.
- typical LEED patter of FL graphene on C-face with diffraction spots indicating several preferred orientations.