EFFECTS OF RADIOFREQUENCY PLASMA TREATMENT ON MECHANICALLY EXFOLIATED GRAPHENE OXIDE PLATELETS

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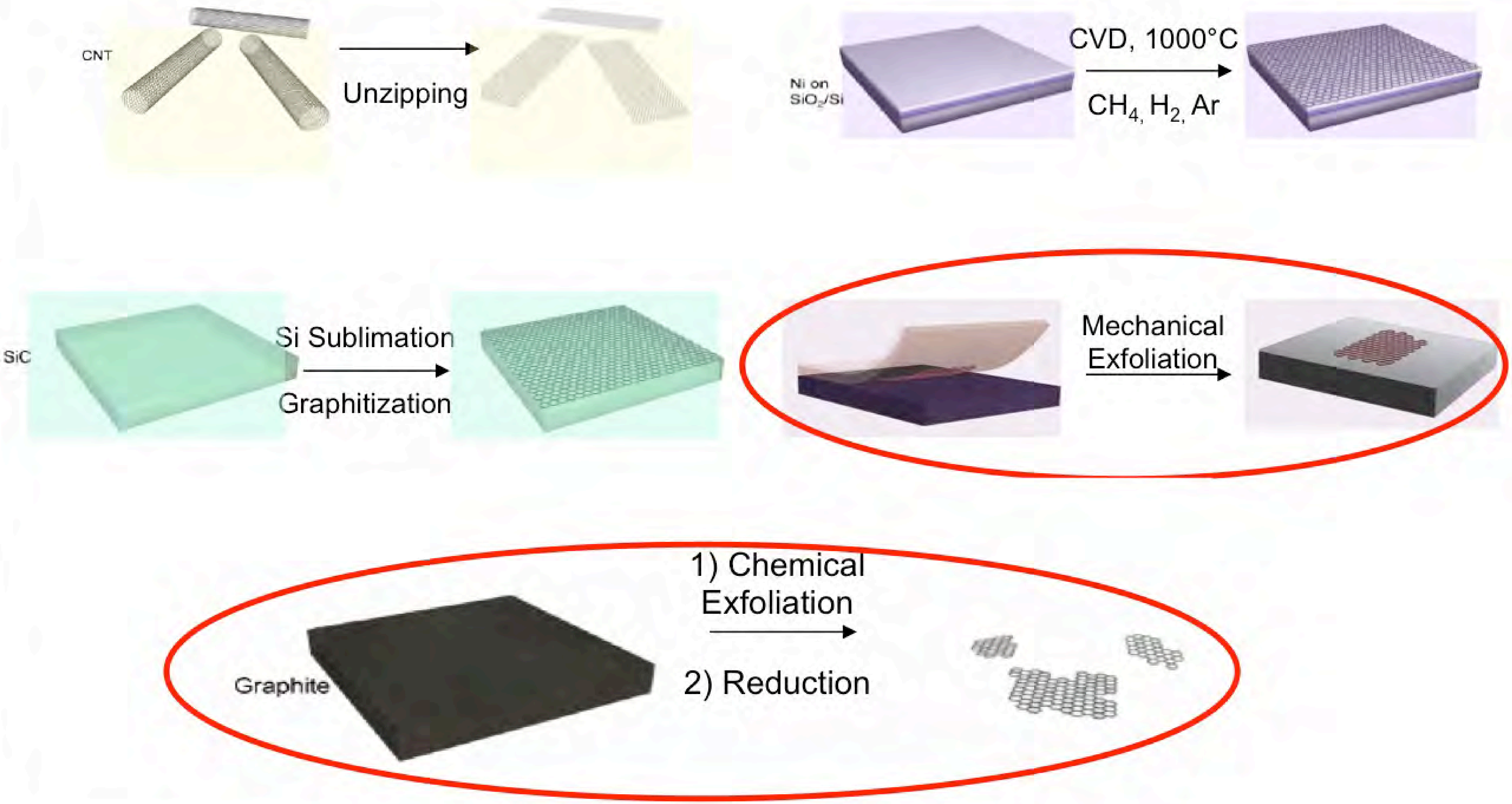
OUTLINE

- Introduction: what's the best way to produce graphene?
- Use of graphene oxide platelets (GOPs): properties and processing parameters
- Exfoliation of GOPs by plasma treatment
- Characterization of exfoliated GOPs
- Conclusions

INTRODUCTION:
PRODUCTION of GRAPHENE SHEETS



GRAPHENE VS. GRAPHENE OXIDE PLATELETS

MECHANICAL EXFOLIATION

- Easy and fast process
- High quality single-layer flakes
- Flakes too small for industrial application

CHEMICAL EXFOLIATION

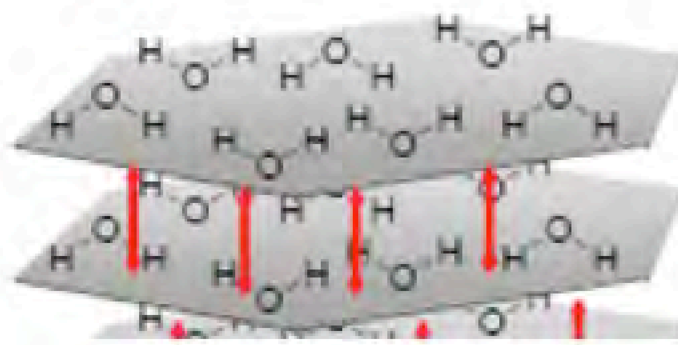
- Low cost of starting materials (i. e. graphite and/or graphite oxide)
- Large scale applications
- Folded final material consisting of stacked flakes

Use of mechanical exfoliation of GO sheets to obtained large flakes to be thinned…

PRODUCTION of GOPs

Graphite

↓



Graphite Oxide

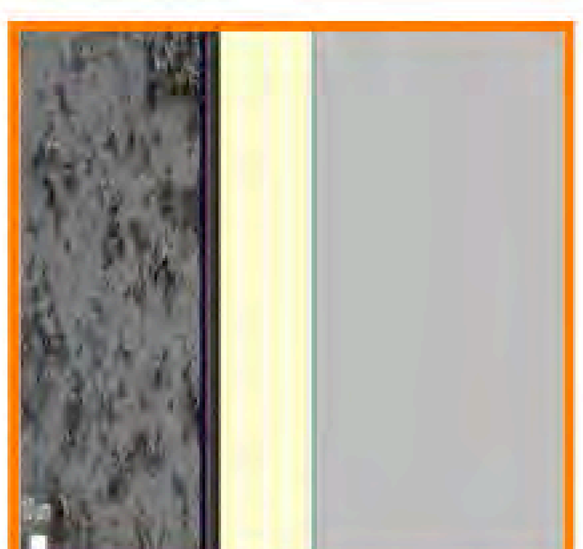
↓

GO Dispersion

GO Film ← → GO-host Solution

↓

rGO Dispersion → GO-host Solution

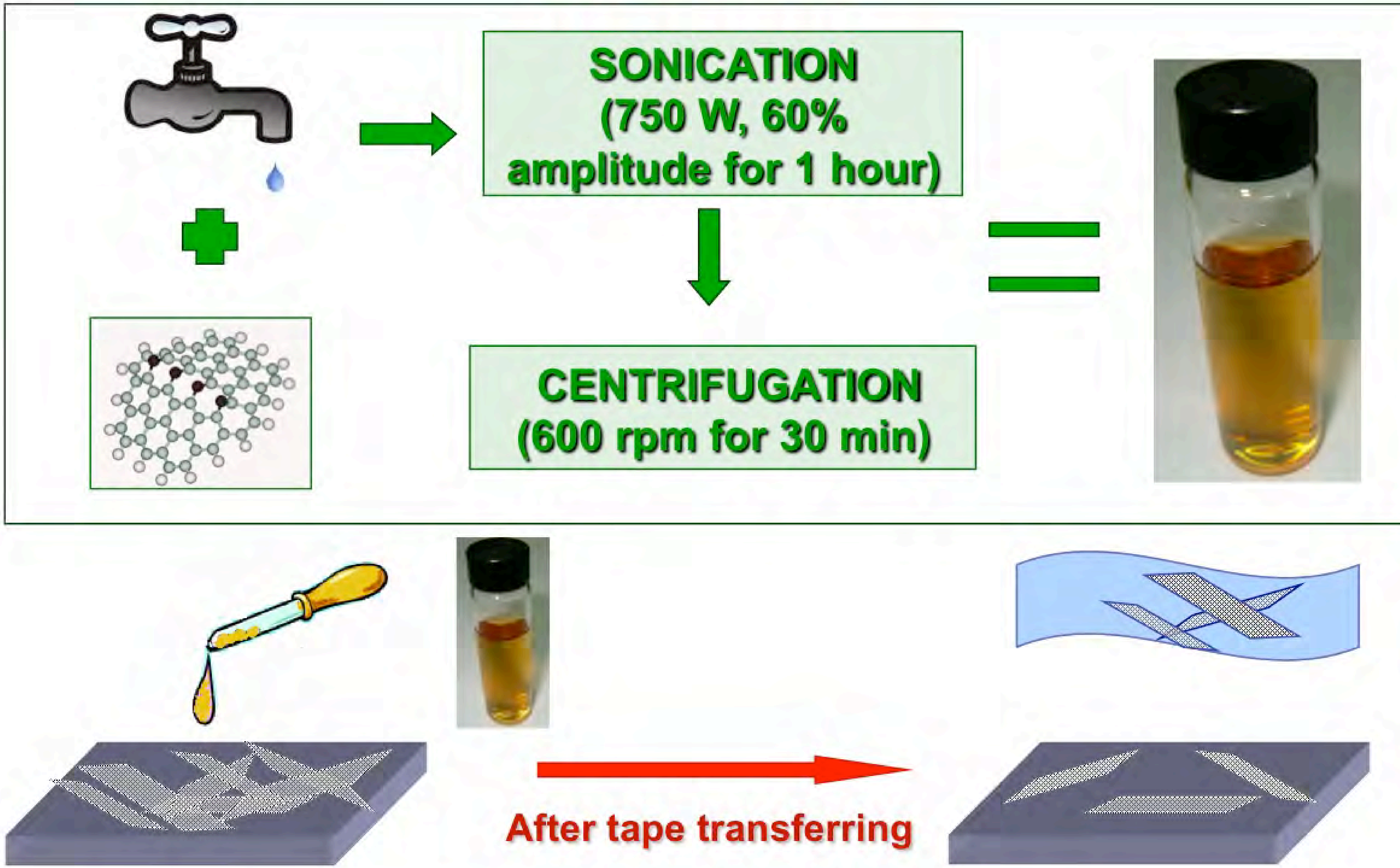


GO Film ↓ rGO Film

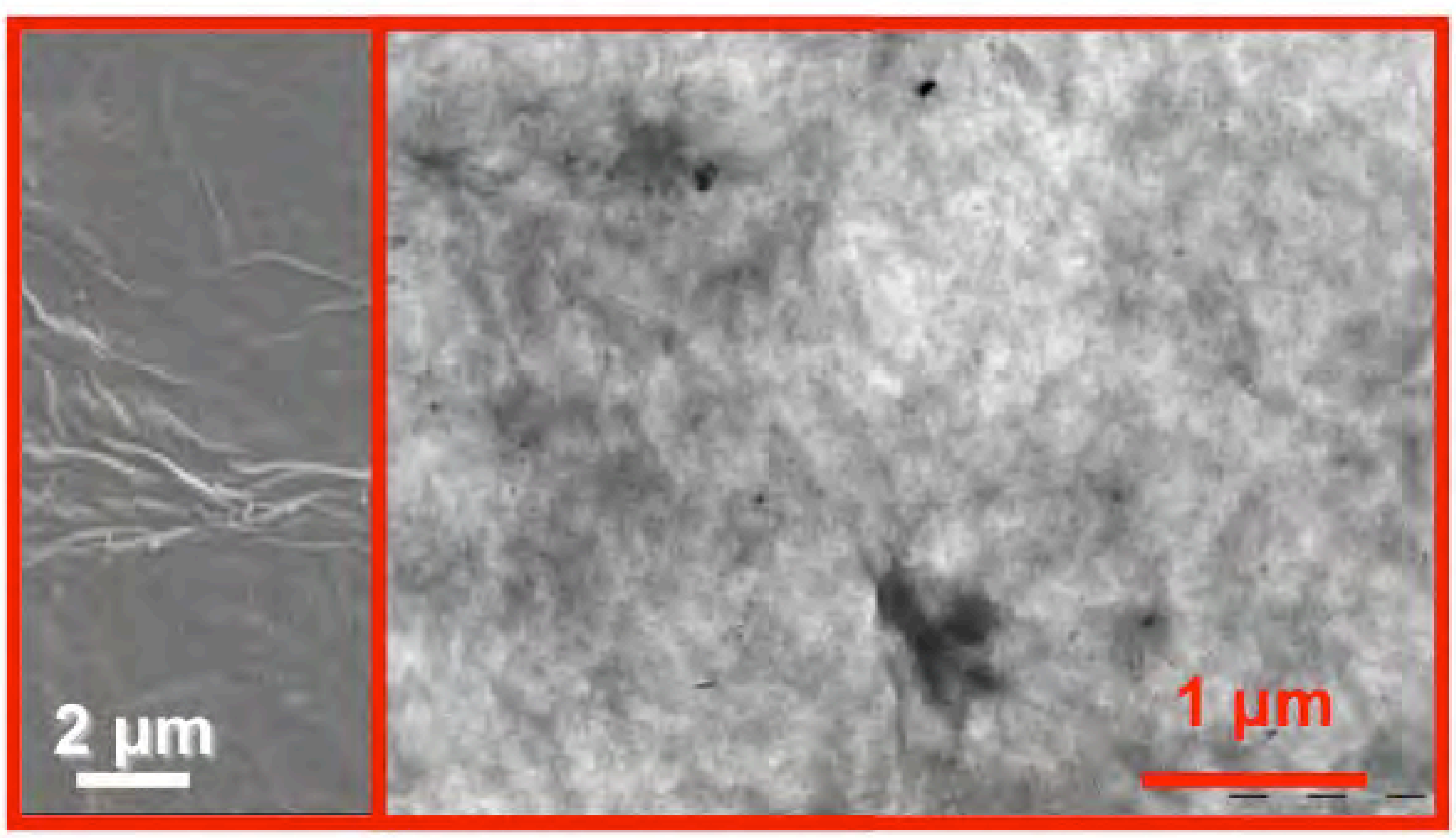
rGO Dispersion → rGO Film

GO-host Solution ↓ GO-host Solution ↓ rGO Composite Film

PRODUCTION and PREPARATION of GOPs



PRODUCTION and PREPARATION of GOPs



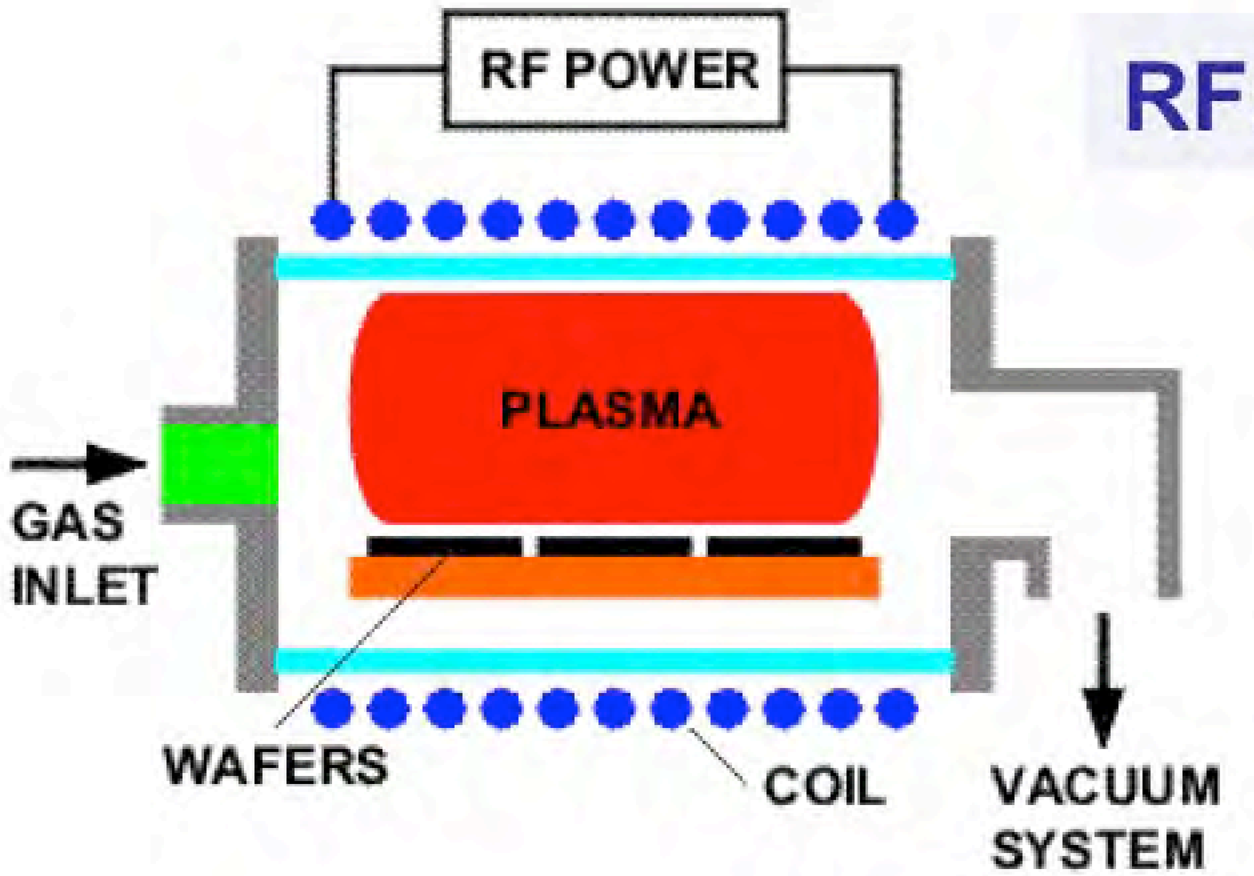
ARGON PLASMA TREATMENT (Why?)

- Argon is a noble gas
- Argon has low ionization-energy (1520,6 kJ/mol)

PLASMA

- Low cost process
- Possibility to be scaled up industrially
- Possibility to control the exfoliation degree

ARGON PLASMA TREATMENT (Why?)



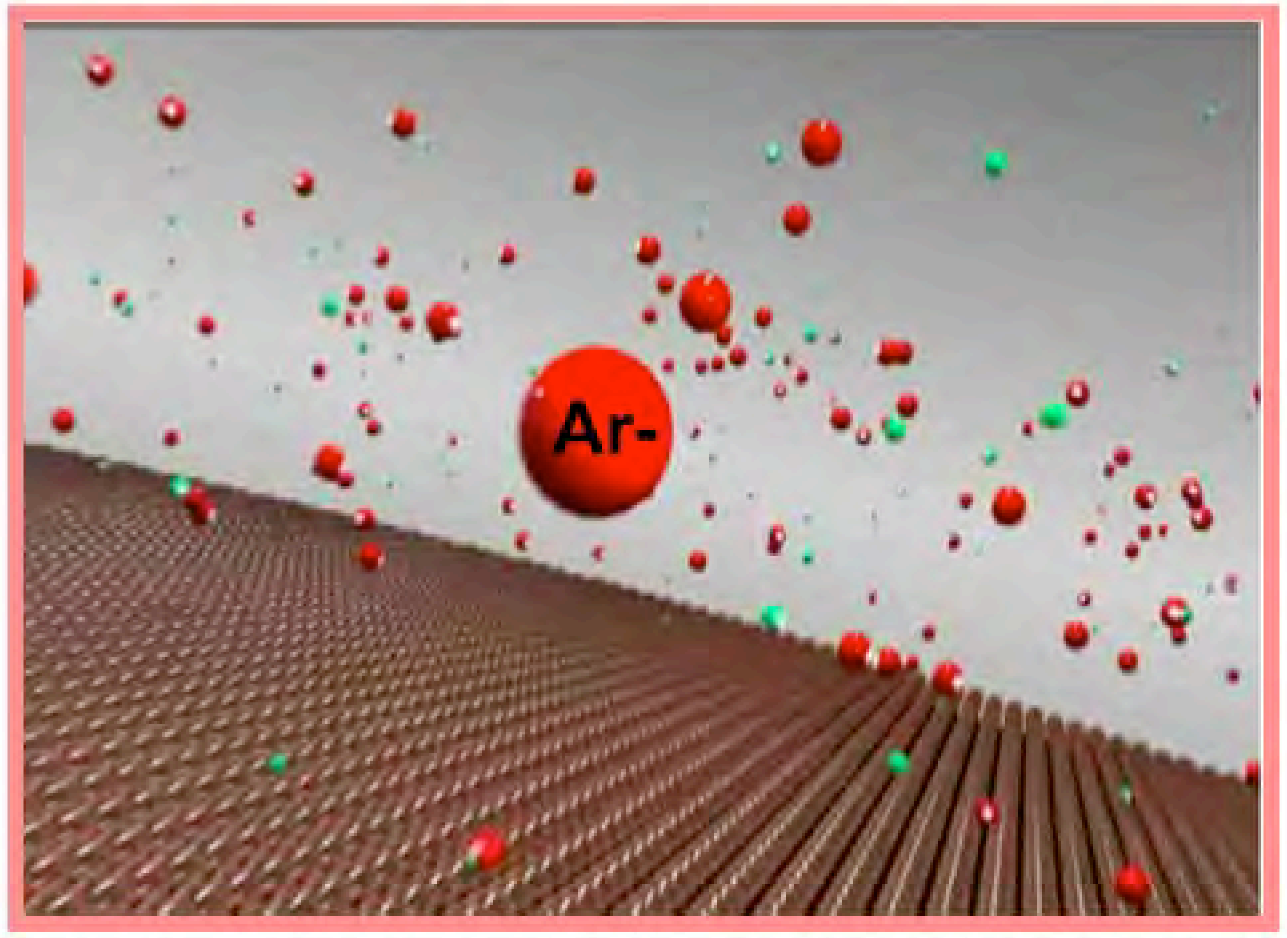
RF: results in the partial ionisation of the gas

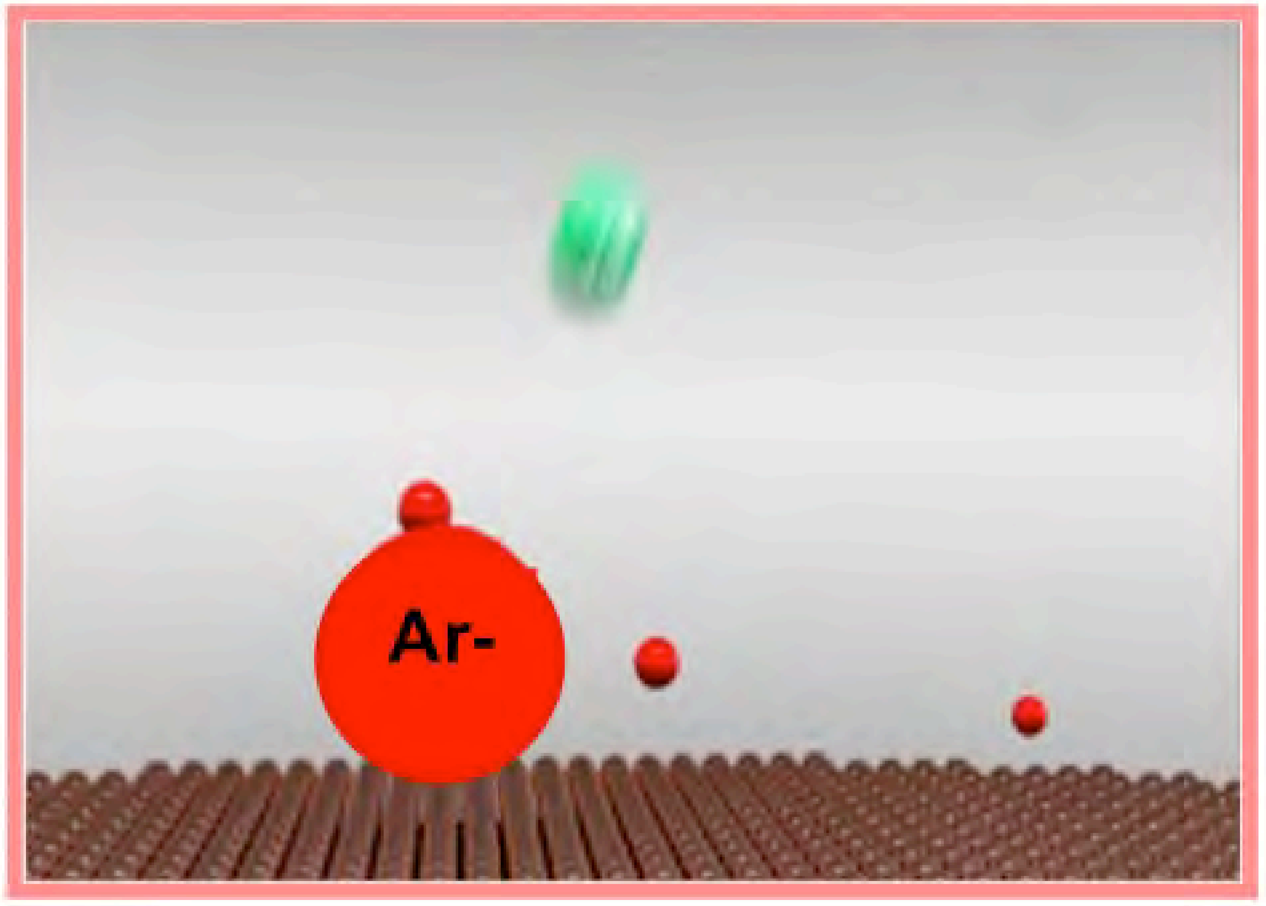
- Ar -> Ar+ + e

During a RF period electrons and ions accelerate towards the electrodes

RF is the right frequency (13.56 MHz) to preserve longer the ionisation process

ARGON PLASMA TREATMENT (Why?)



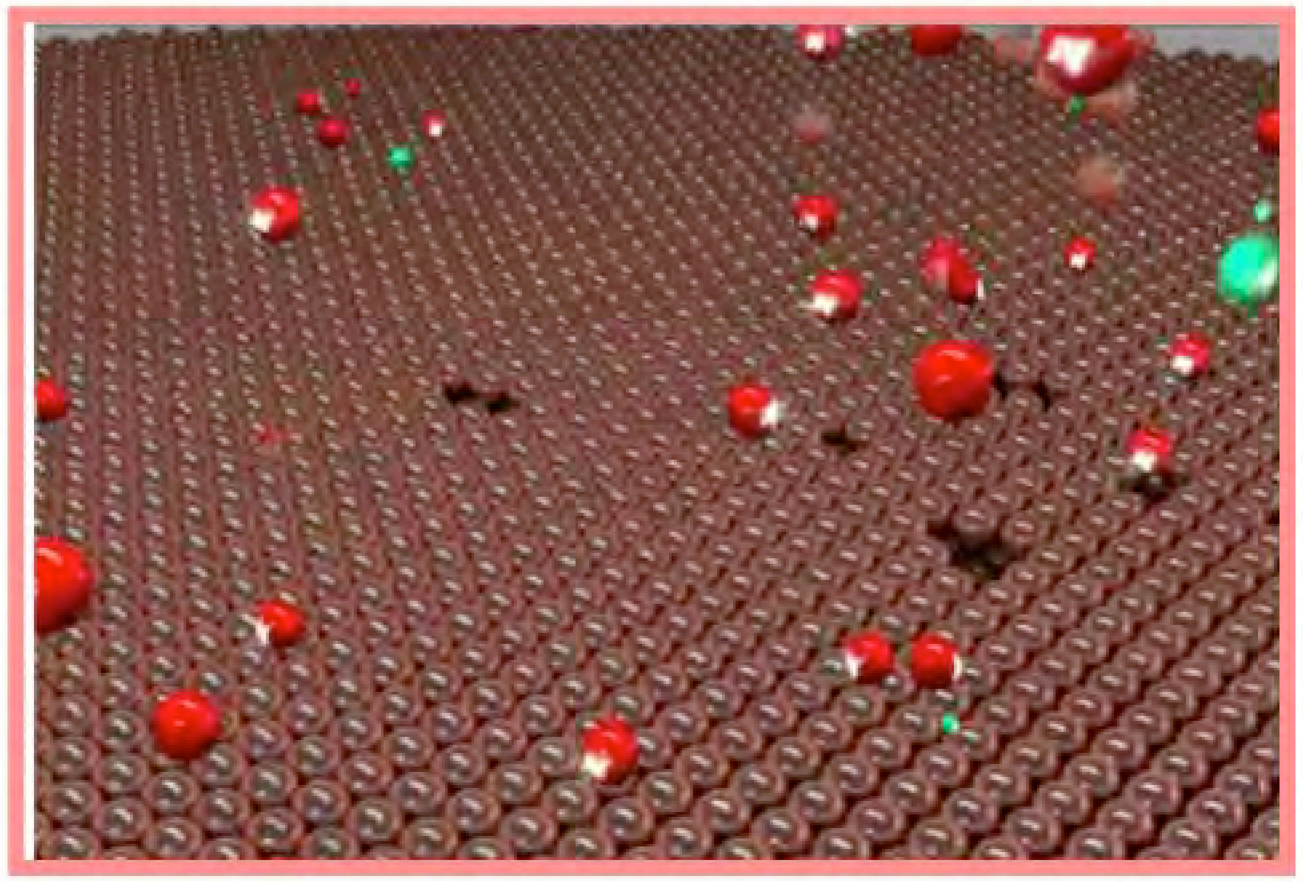


Pressure: 0,2 mTorr

Flow rate: 20 sccm

Power: 25 W

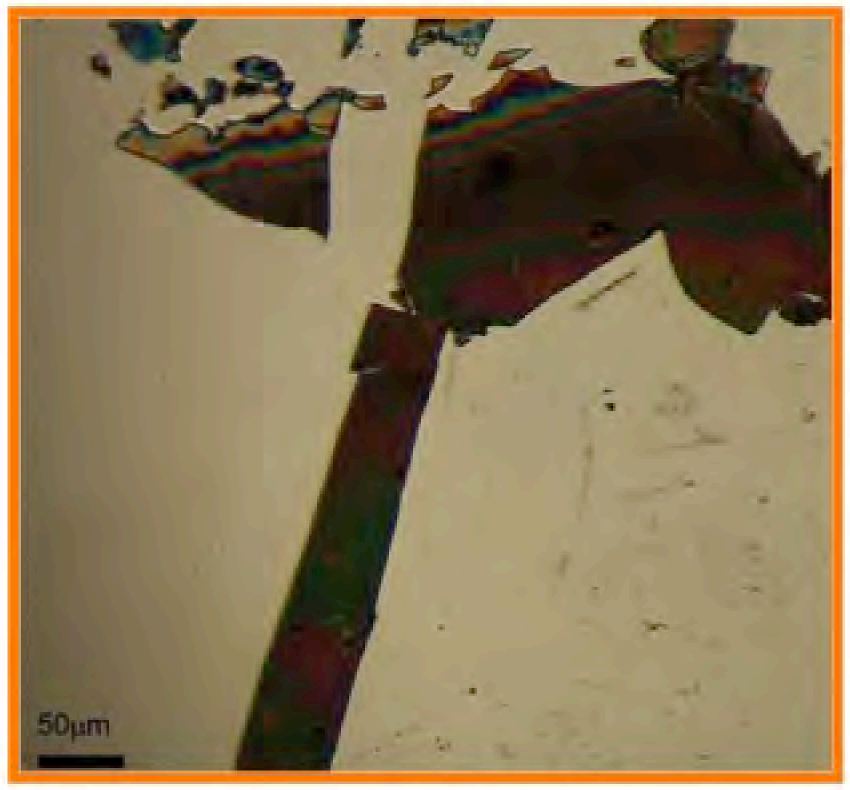
Bias: 200 V



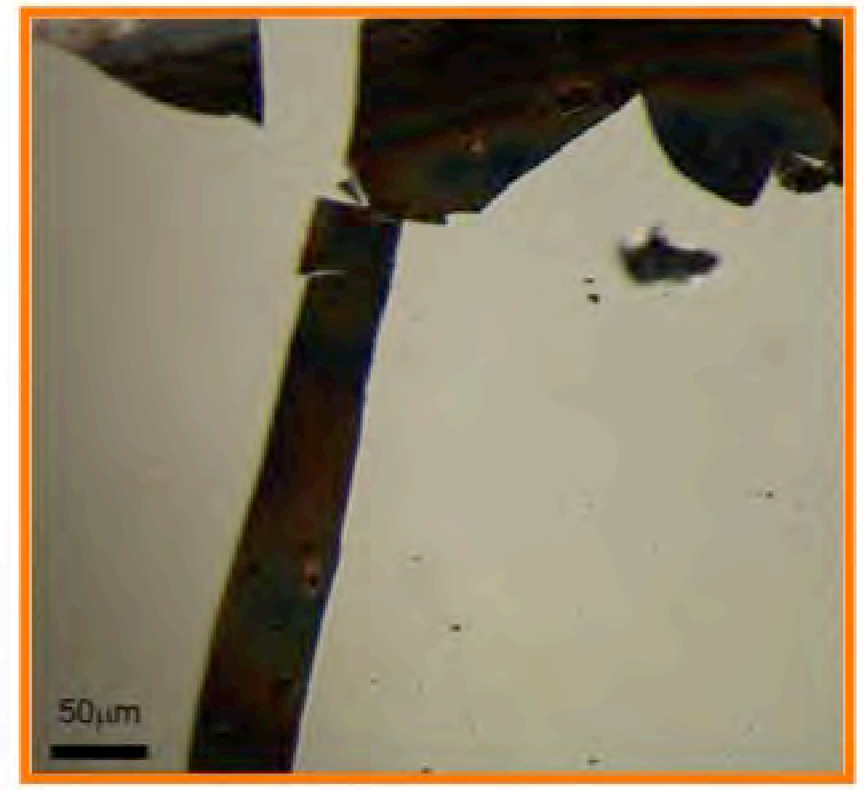
Time of treatment:

5', 20', 40'

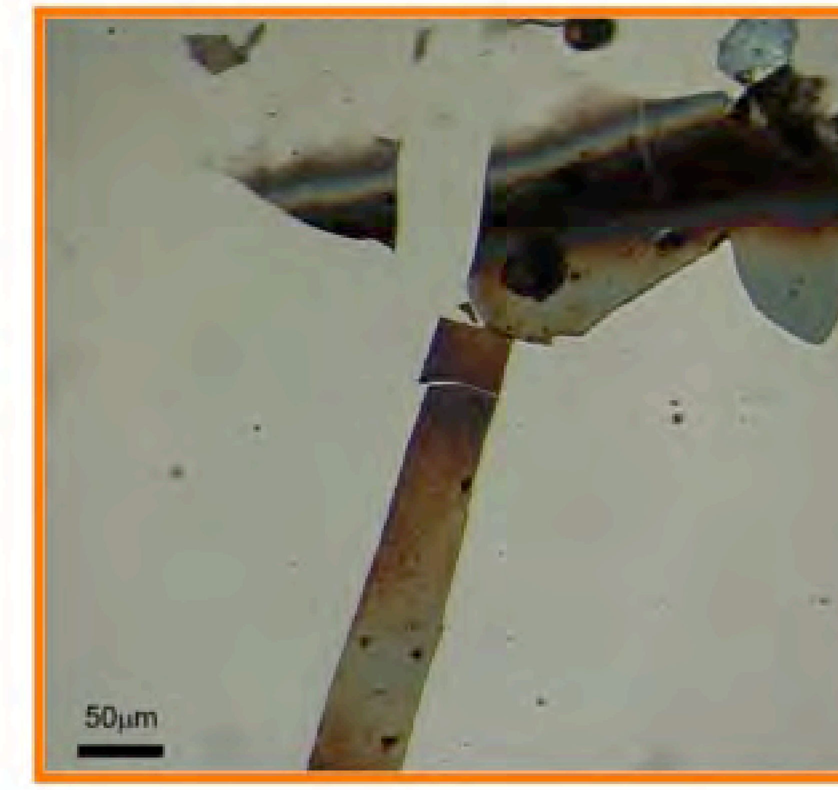
EXFOLIATION



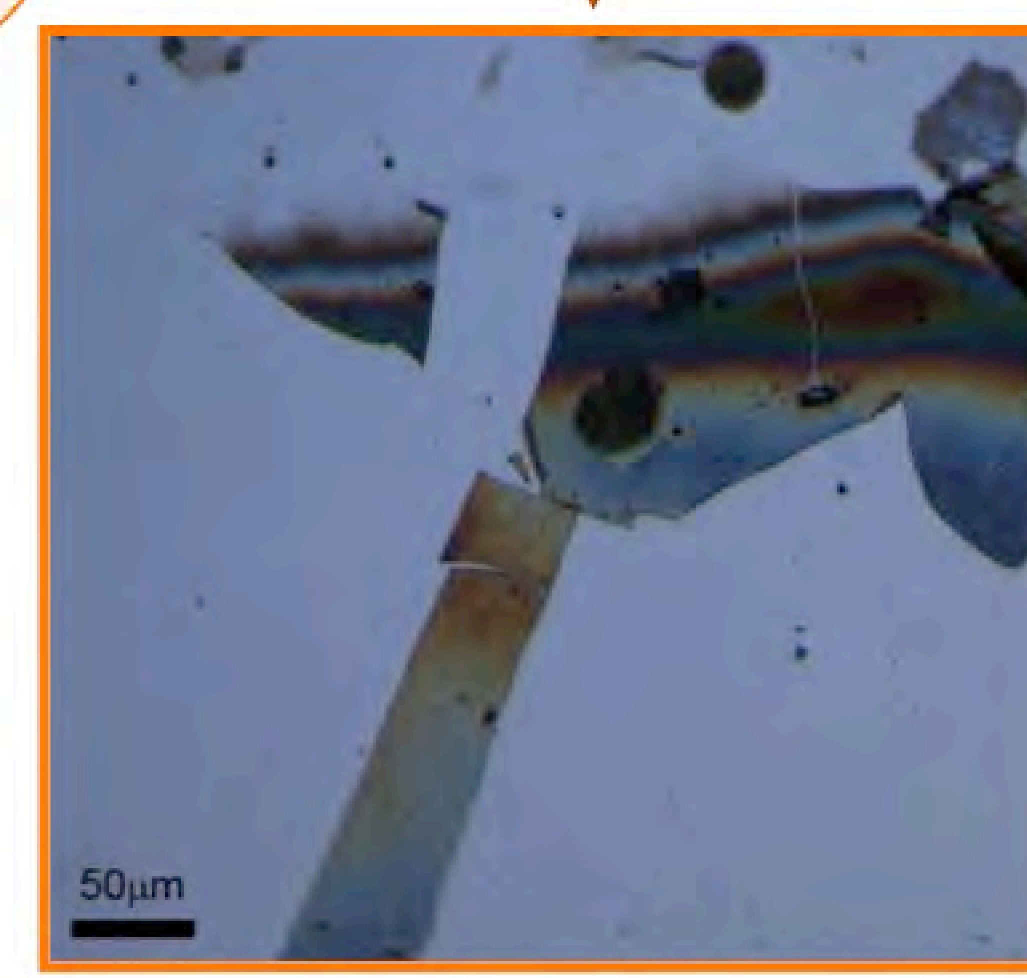
5 '



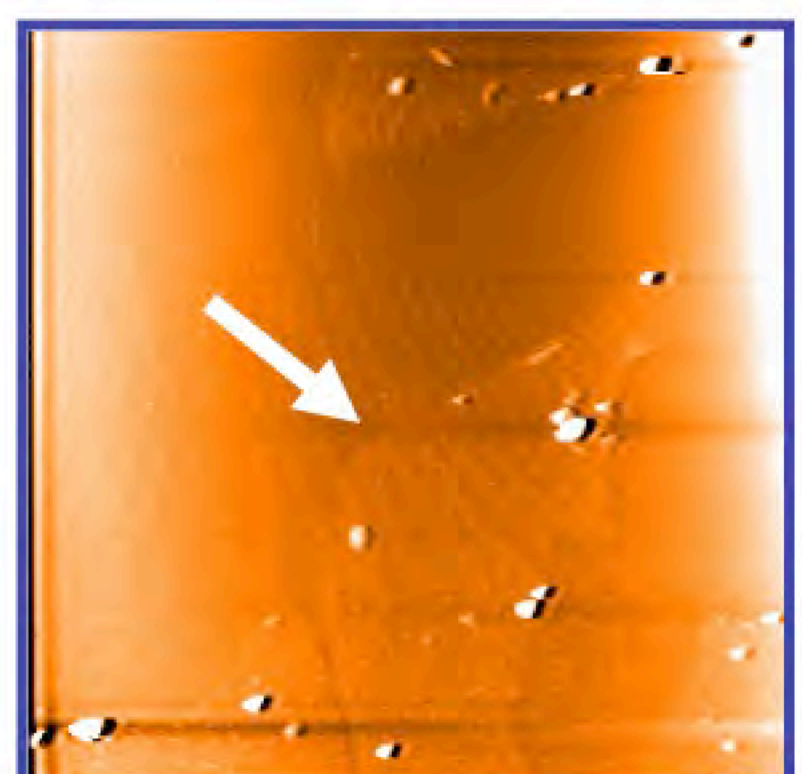
20 '



40 '



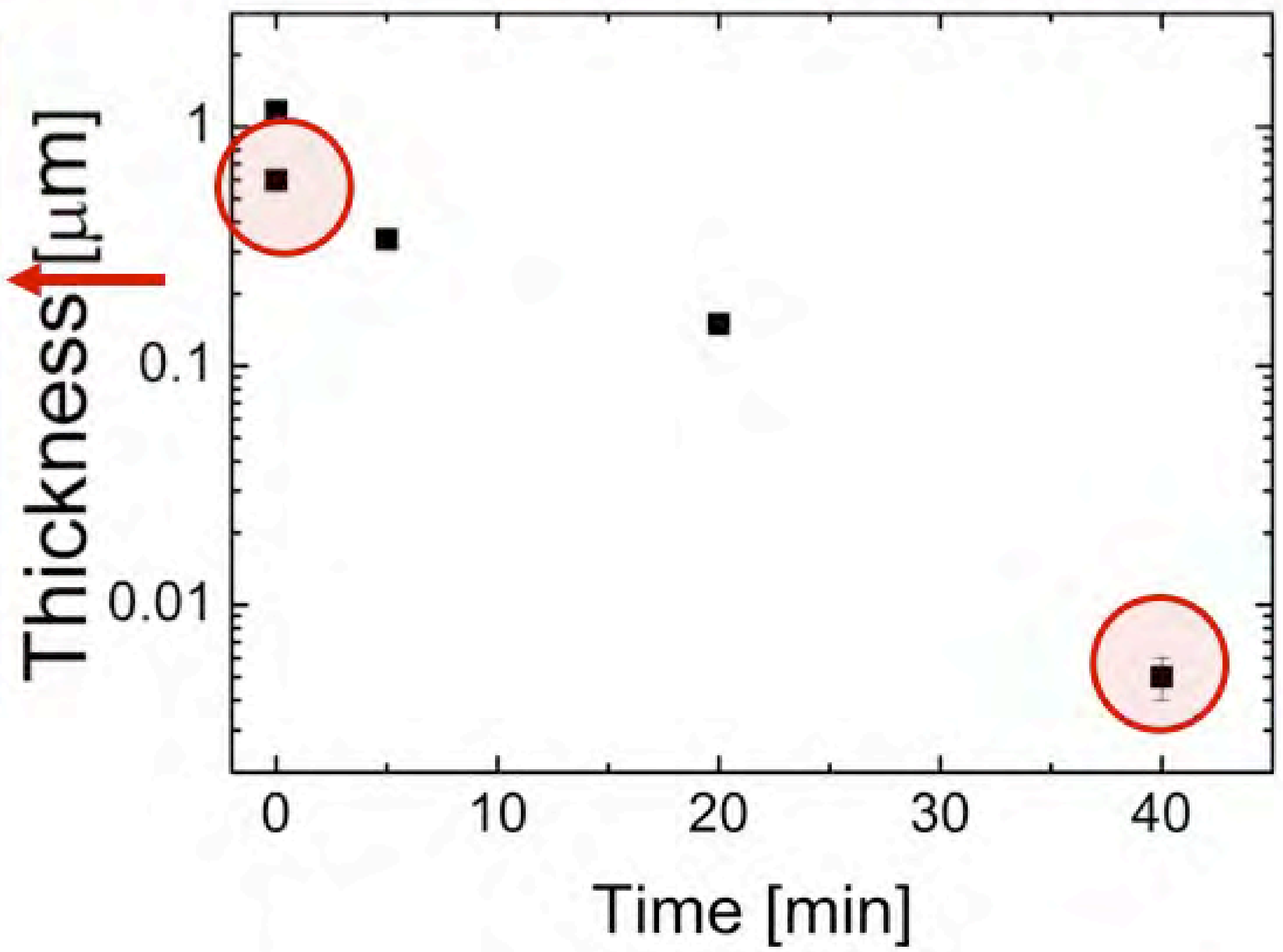
Plasma effects on morphology and thickness

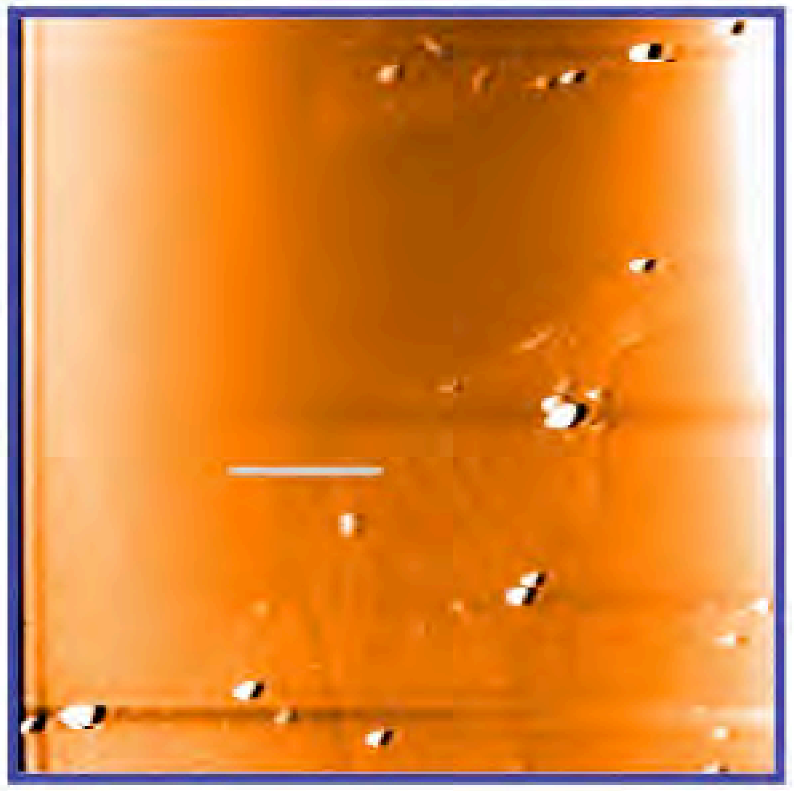


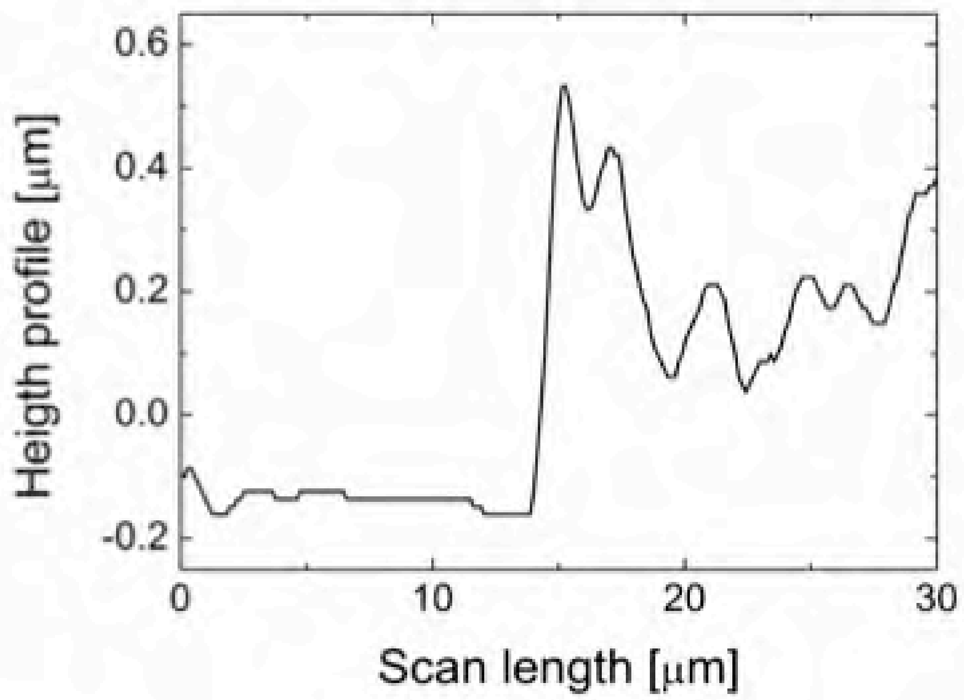
AFM images
(70 μm X 70 μm)

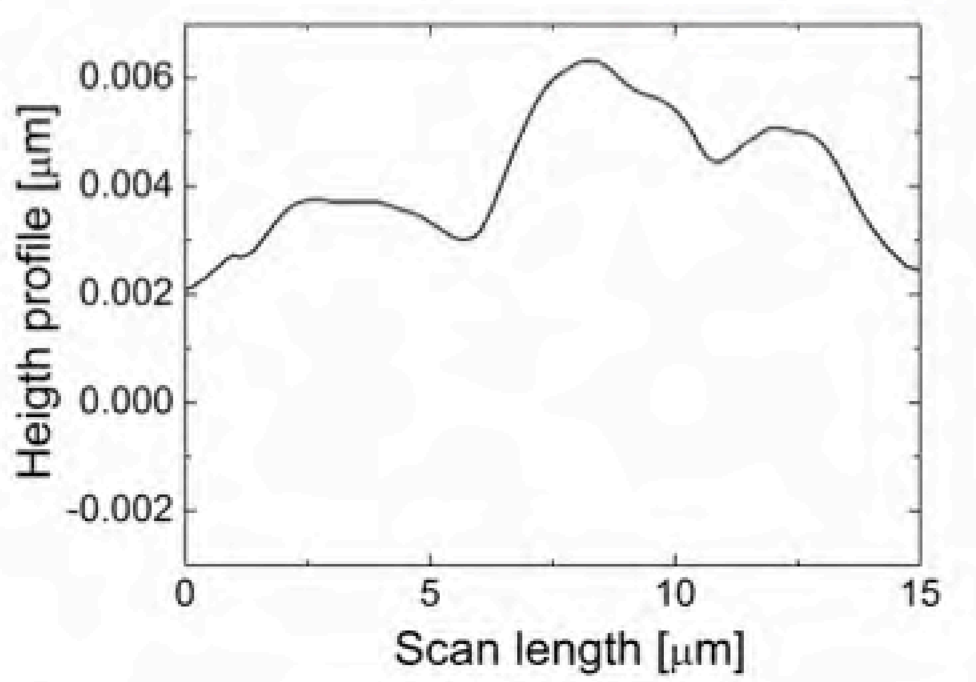
M. Cardinali et al., Chem. Phys. Lett. (in press)

GRADUAL THINNING

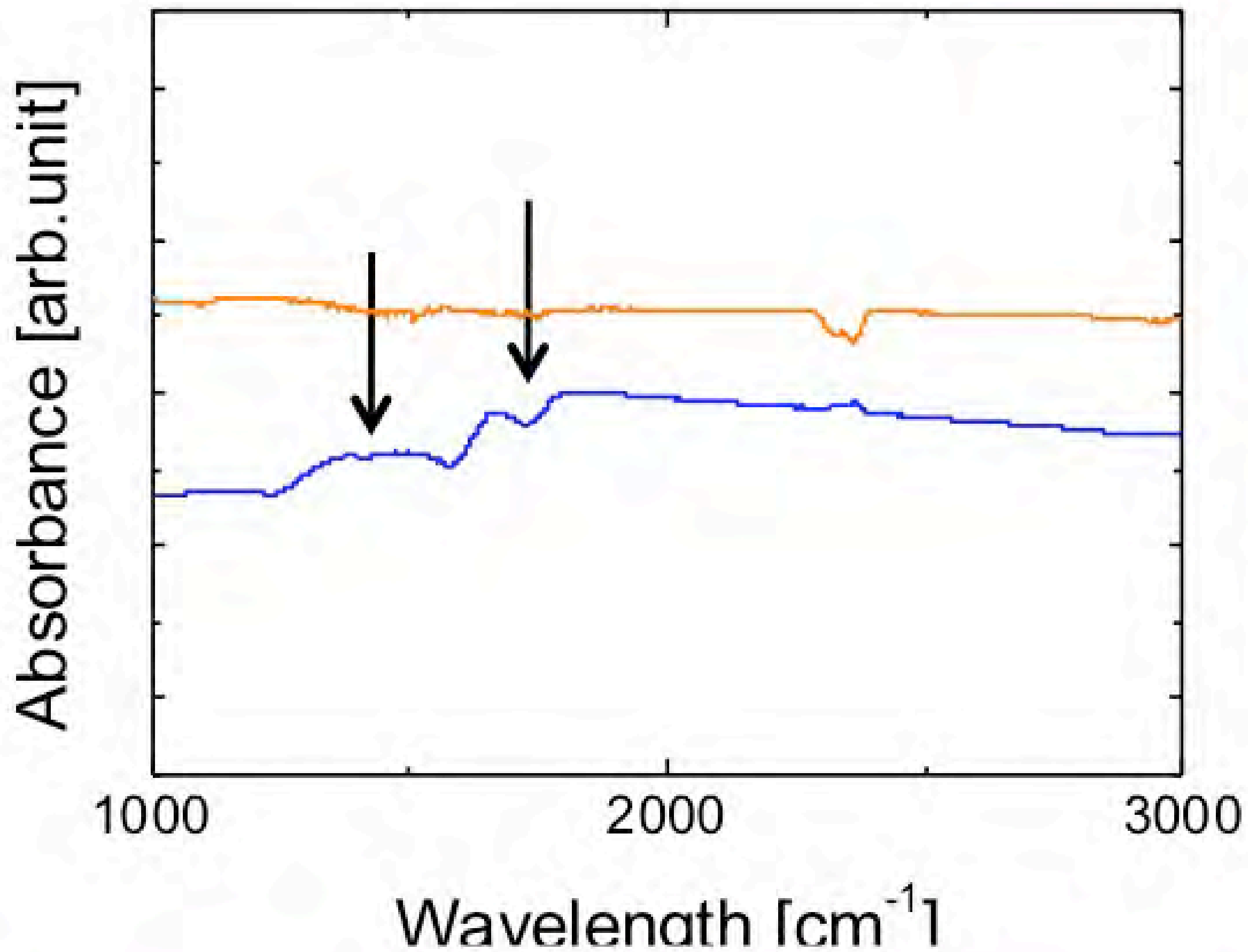






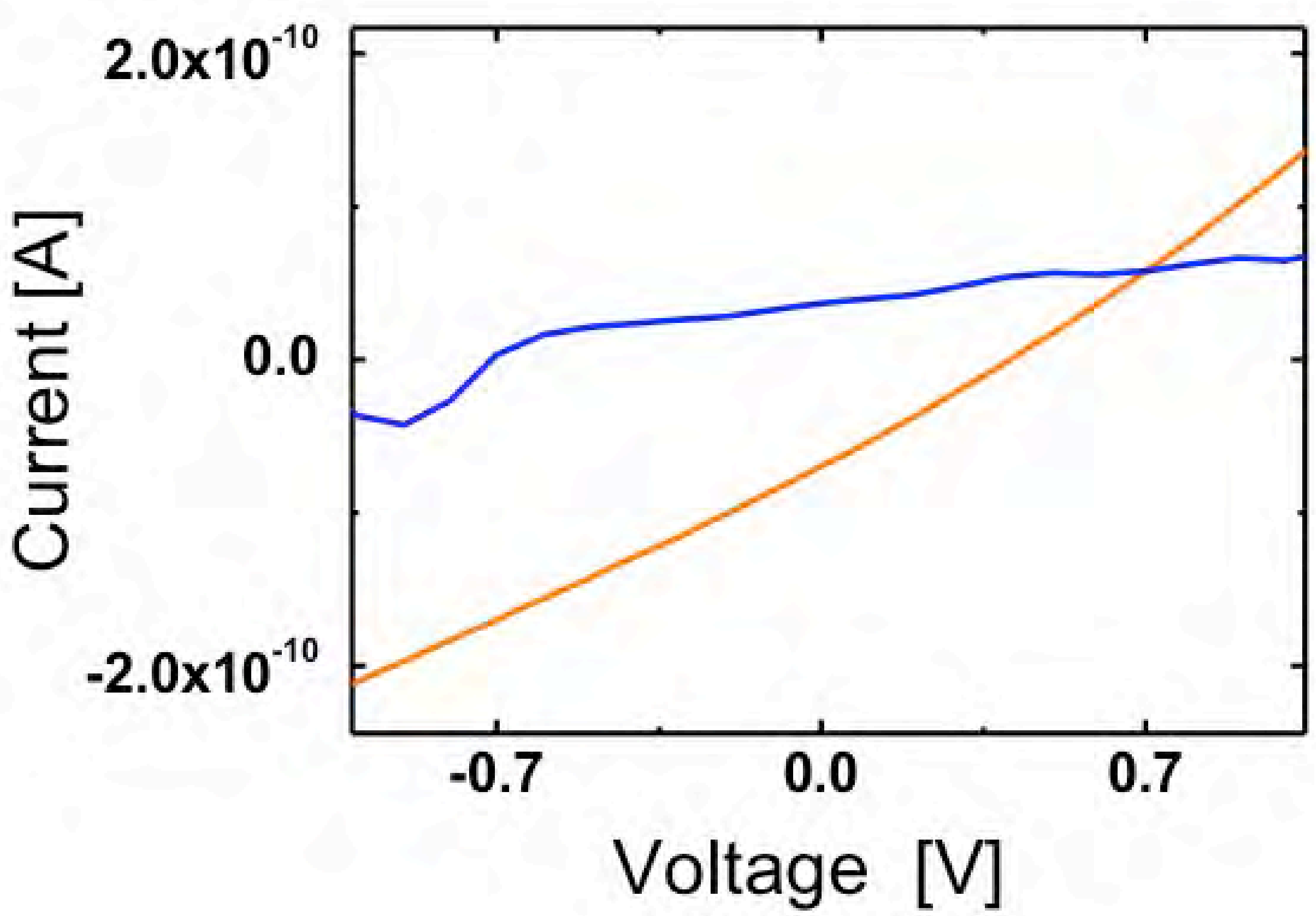


REDUCTION



GOPs after 40' of Ar PLASMA

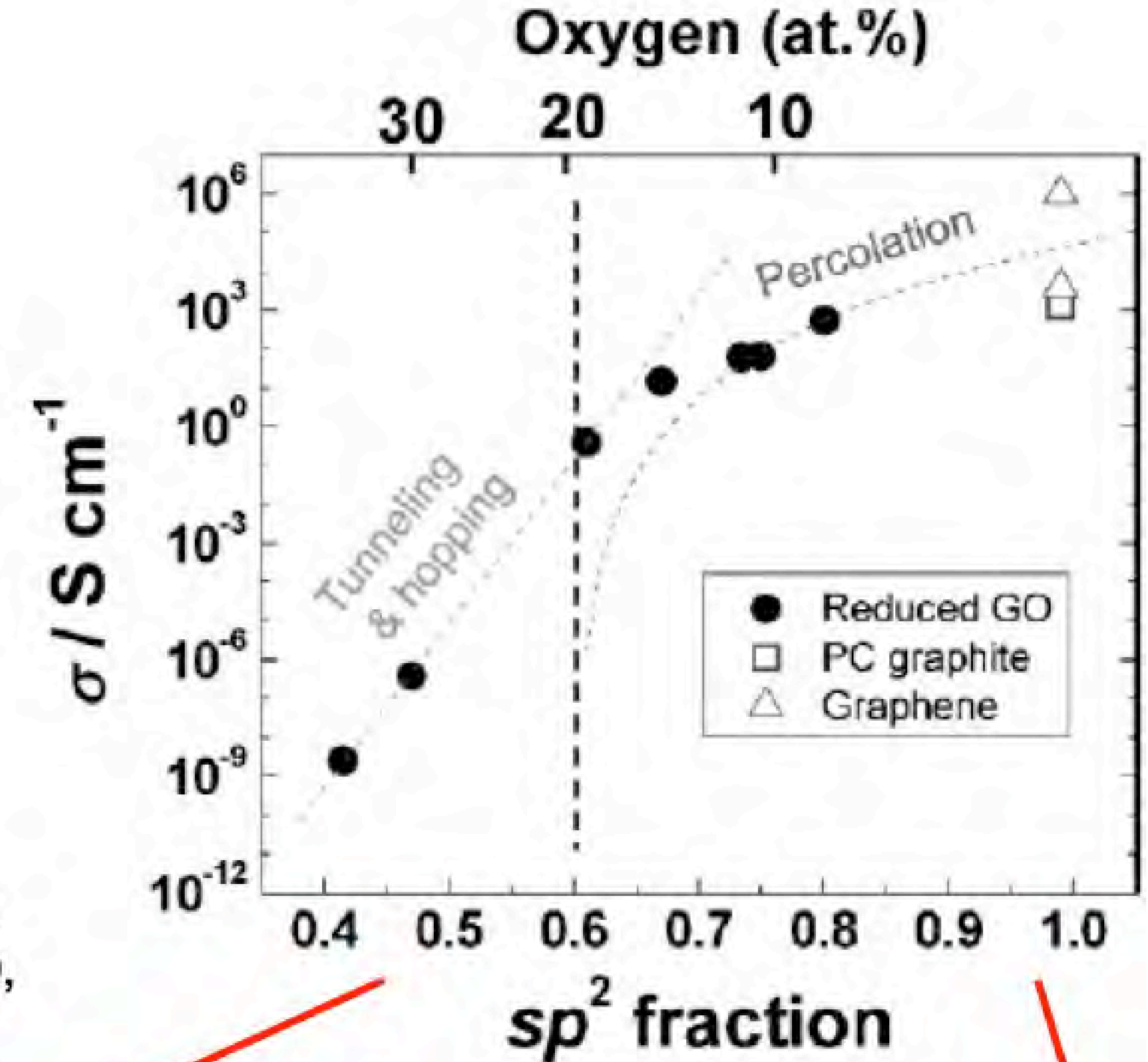
UNTREATED GOPs



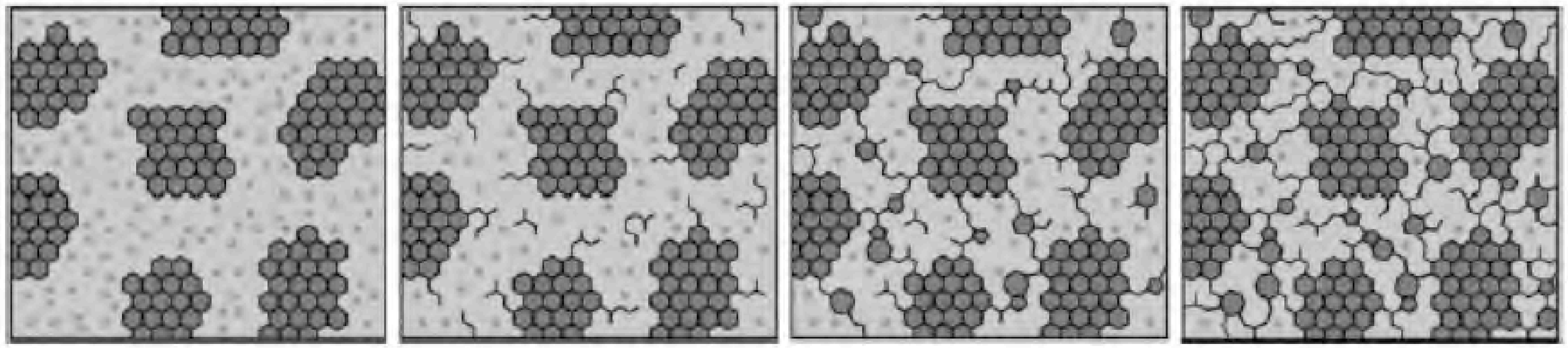
1733 cm^{-1} C=O carbonyl stretching

1412 cm^{-1} O-H deformation vibration

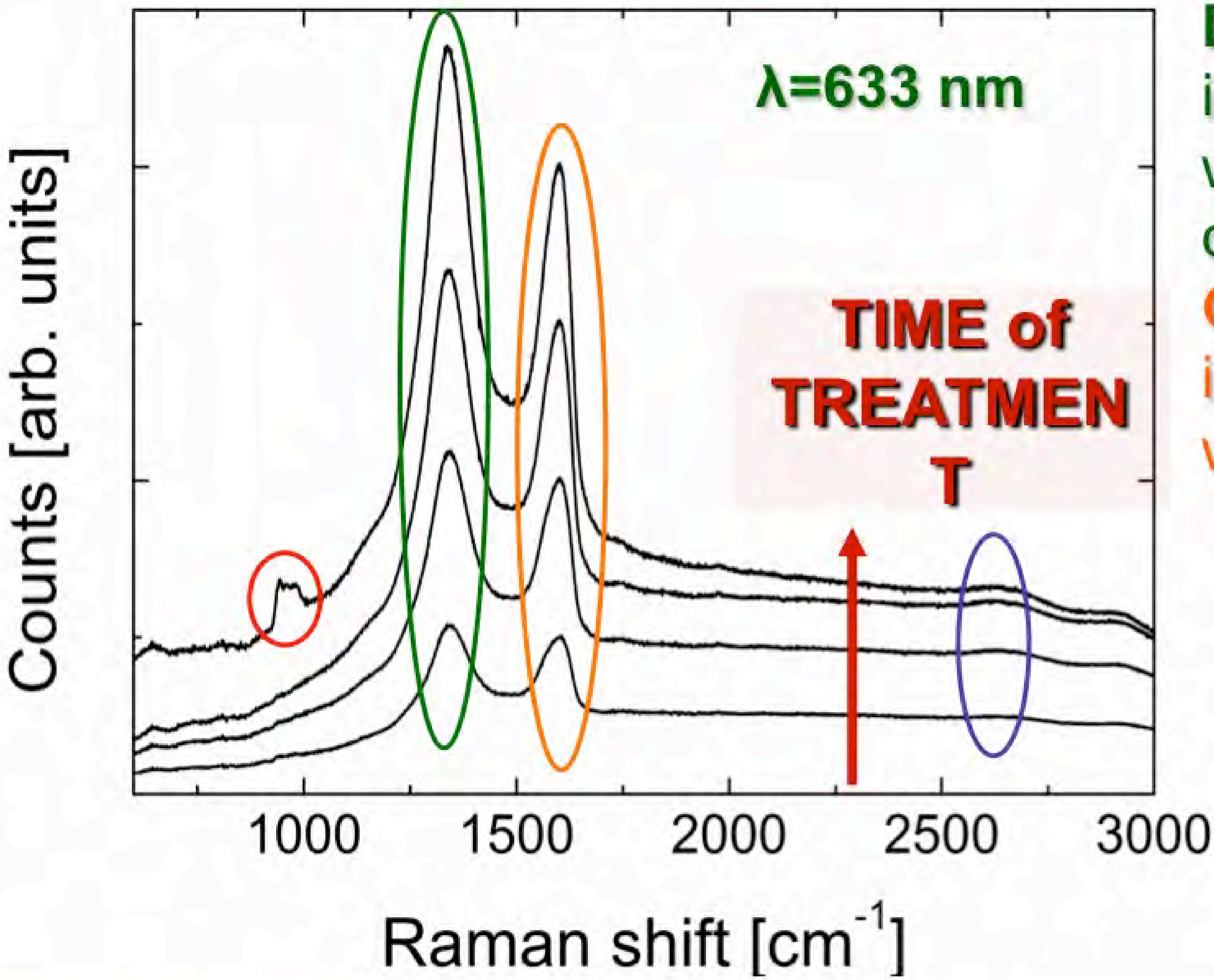
O% from original GOP: 10% Wt (from Cheaptubes)



C. Mattevi et al., Adv. Funct. Mater. 2009, 19, 2577

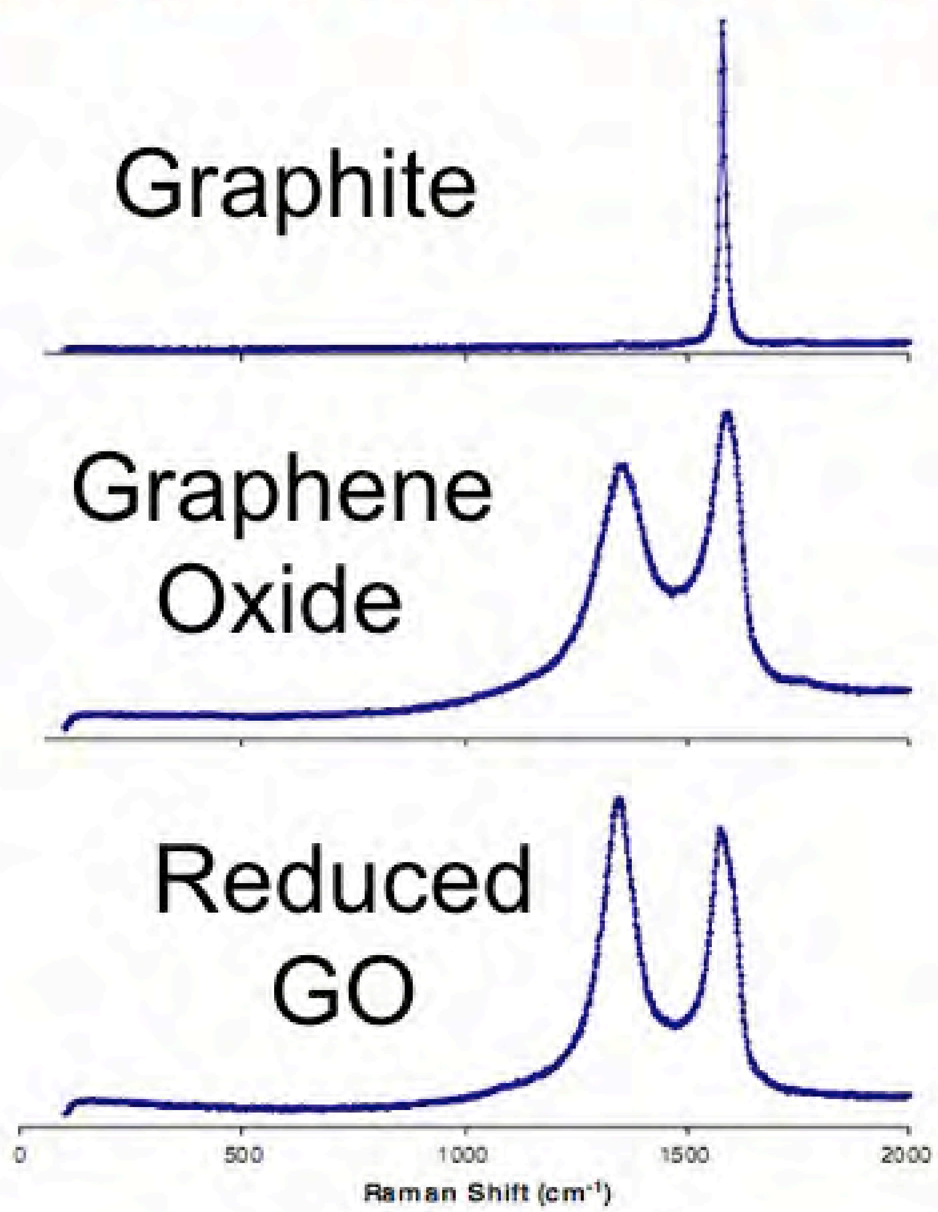


RAMAN



D peak (~1340 cm^{-1}): increases with disorder (i. e. with the plasma treatment), decrease of FWHM

G peak (~1590 cm^{-1}): increases with disorder (i. e. with the plasma treatment)

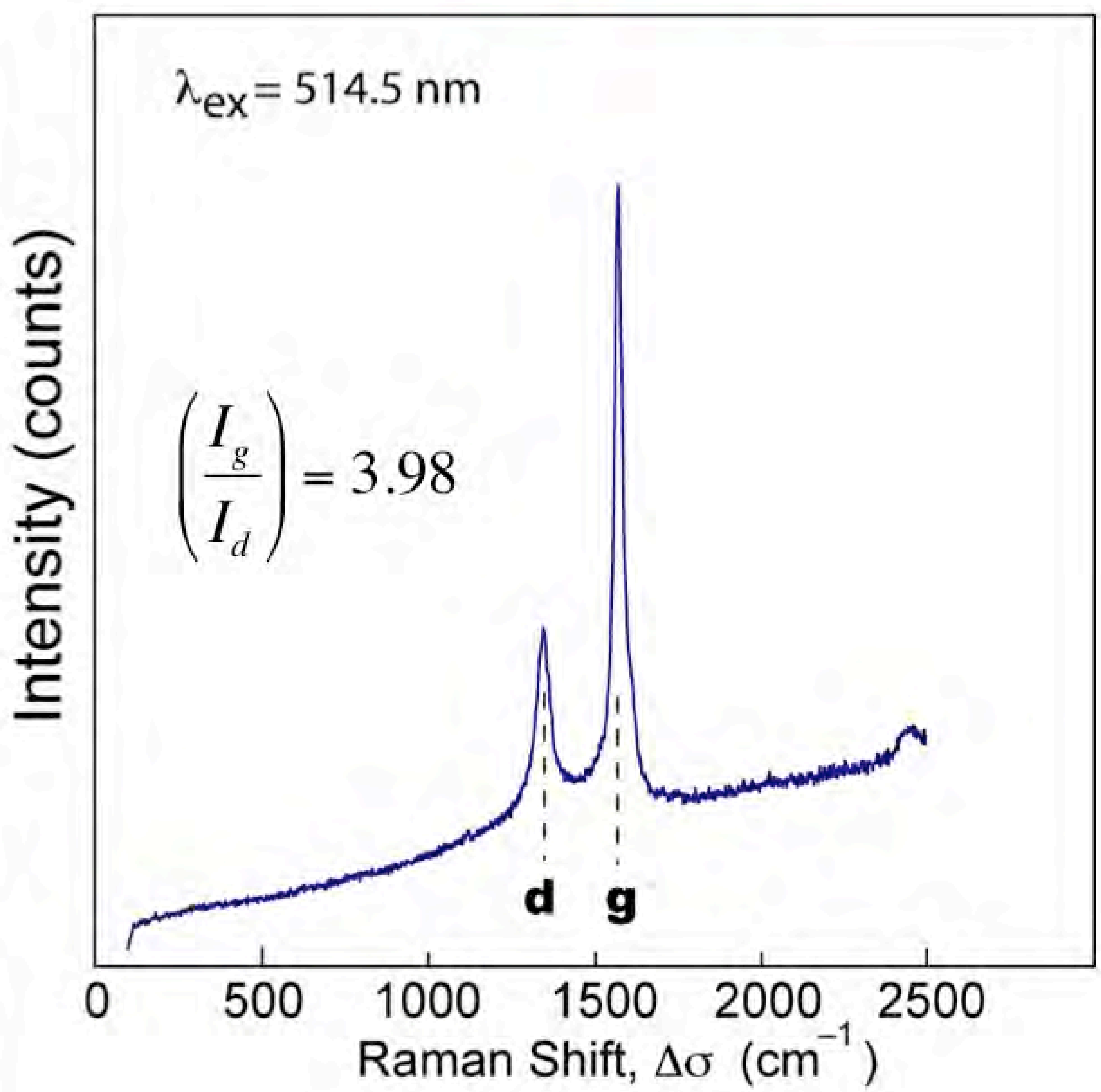


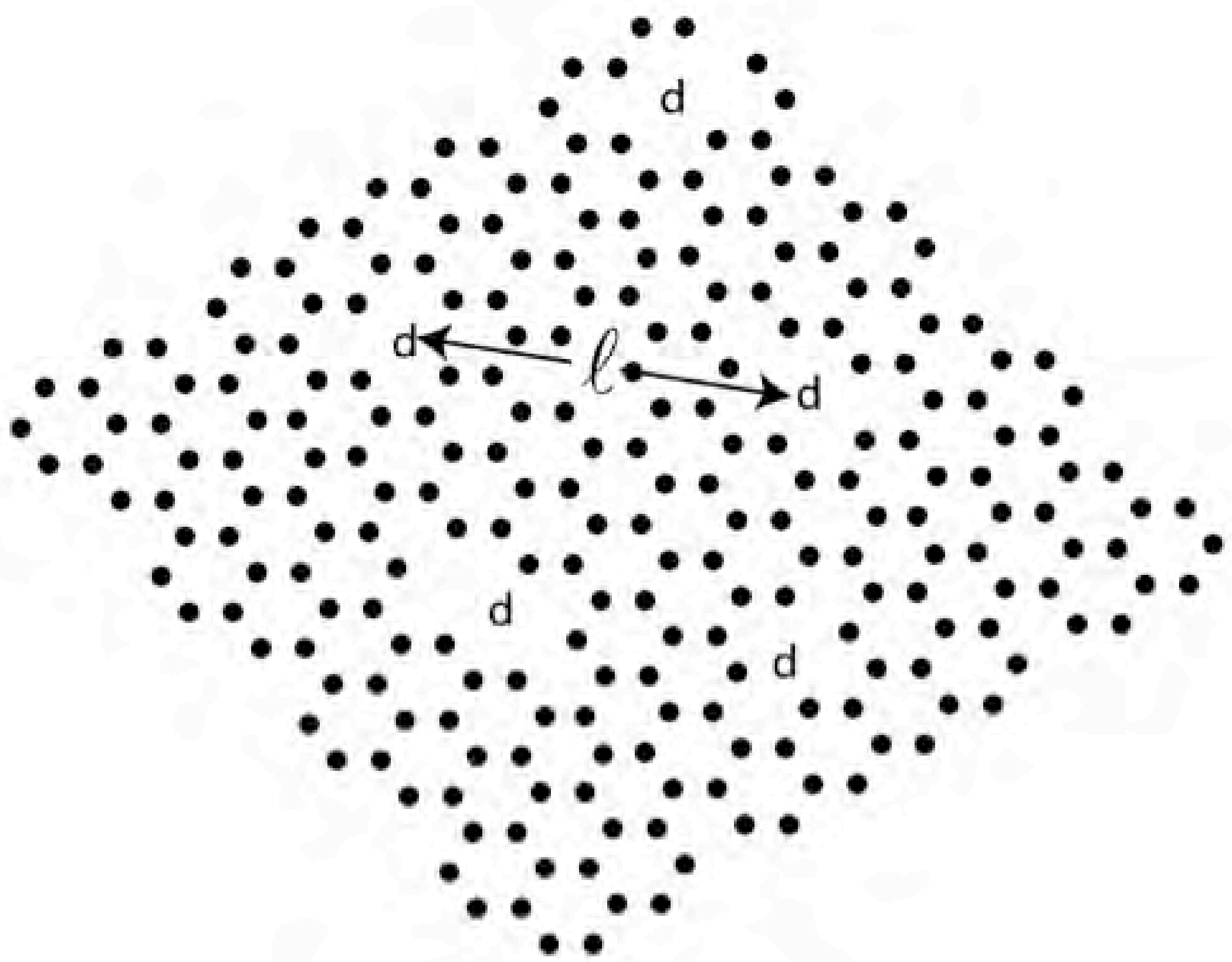
2D peak (~2646 cm^{-1}): induced layering and lattice disorder

Si peak (~960 cm^{-1}): thinning

S. Stankovich et al., Carbon, 2007, 45, 1558

Graphite





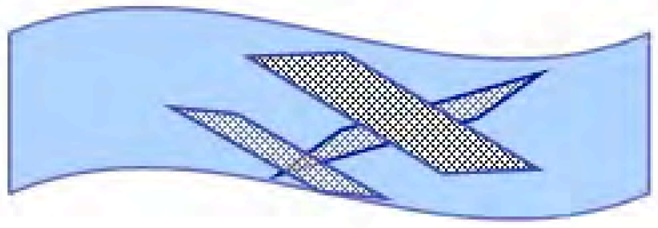
Nanocrystalline graphite has graphitic (**g**) and disorder (**d**) peaks. The characteristic dimension of graphitic domains is given by:

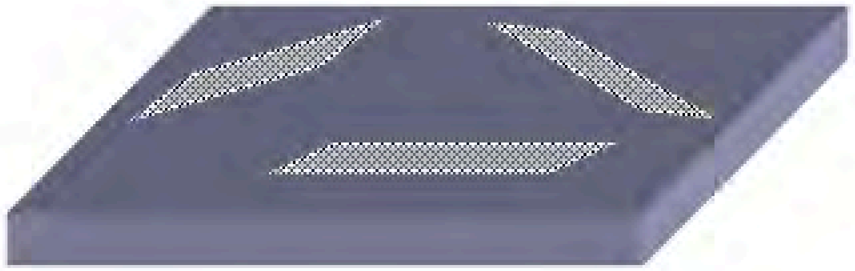
$$\ell(\mathring{A}) = 44\left(\frac{I_g}{I_d}\right)$$

$$= 175\mathring{A}$$

Tuinstra and Koenig, J. Chem Phys. 53 (1970) 1126.

CONCLUSIONS





- Combination of different techniques to produce large GOPs

- Using and tuning of **RF Argon plasma** to exfoliate **GOPs**

- Realization of a procedure **to thin** GOPs

ACKNOWLEDGEMENTS

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