Synthesis and Specroscopy of Graphene and Related Nanostructures

Narek Margaryan

PhD in Physics

n.margaryan@yerphi.am

A. ALIKHANYAN
National Laboratory

Graphene Production

Micromechanical cleavage

Sticky tape

SiO_2

Carbon segregation metal

Metal substrate

Heat

Carbon segregation SiC

(0001) Si-Face

4H-SiC

(000$\bar{1}$) C-Face

SiC
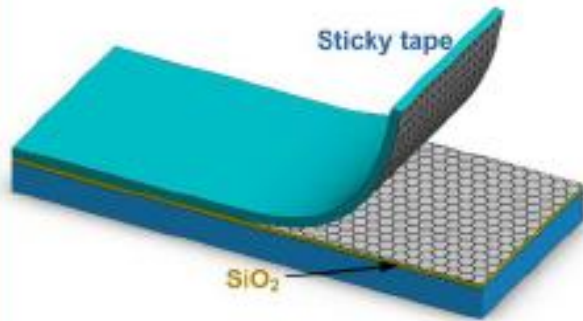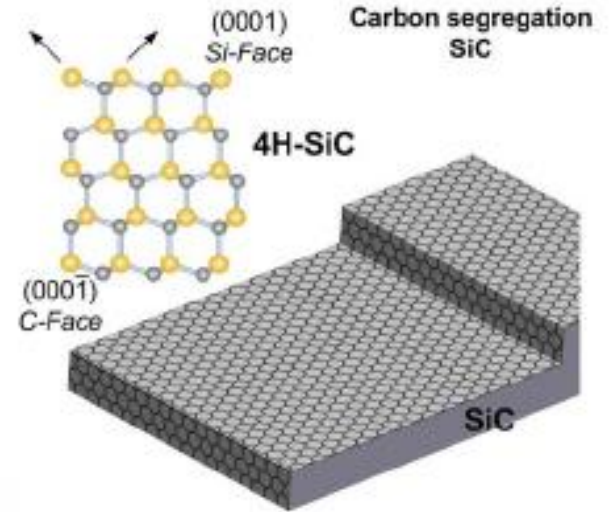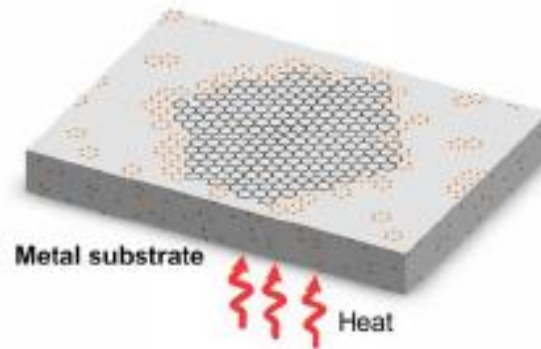
Chemical Vapour Deposition

Hydrocarbon gas

Metal substrate
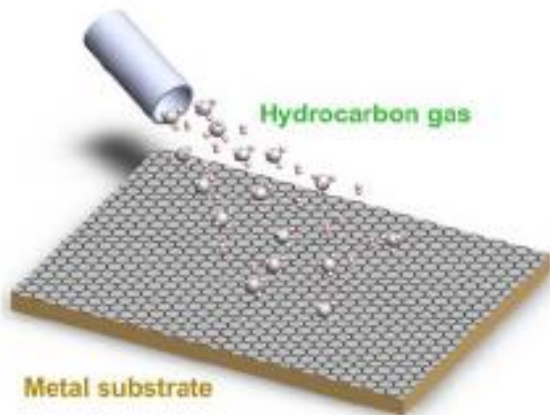
Chemical synthesis

Substrate
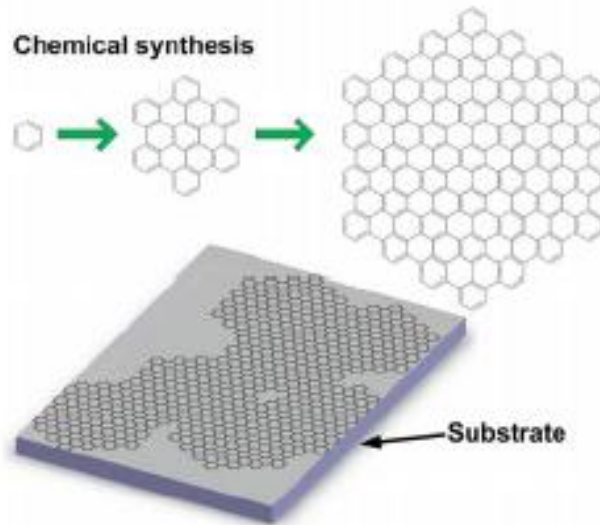
Liquid phase exfoliation

Dispersed graphene flakes

Ultrasound
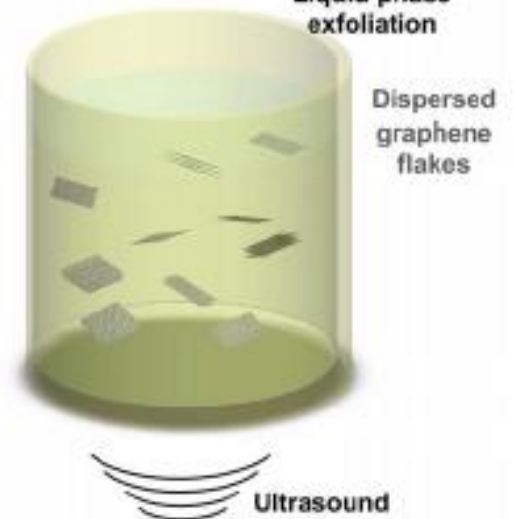
Quality versus cost for graphene synthesis techniques
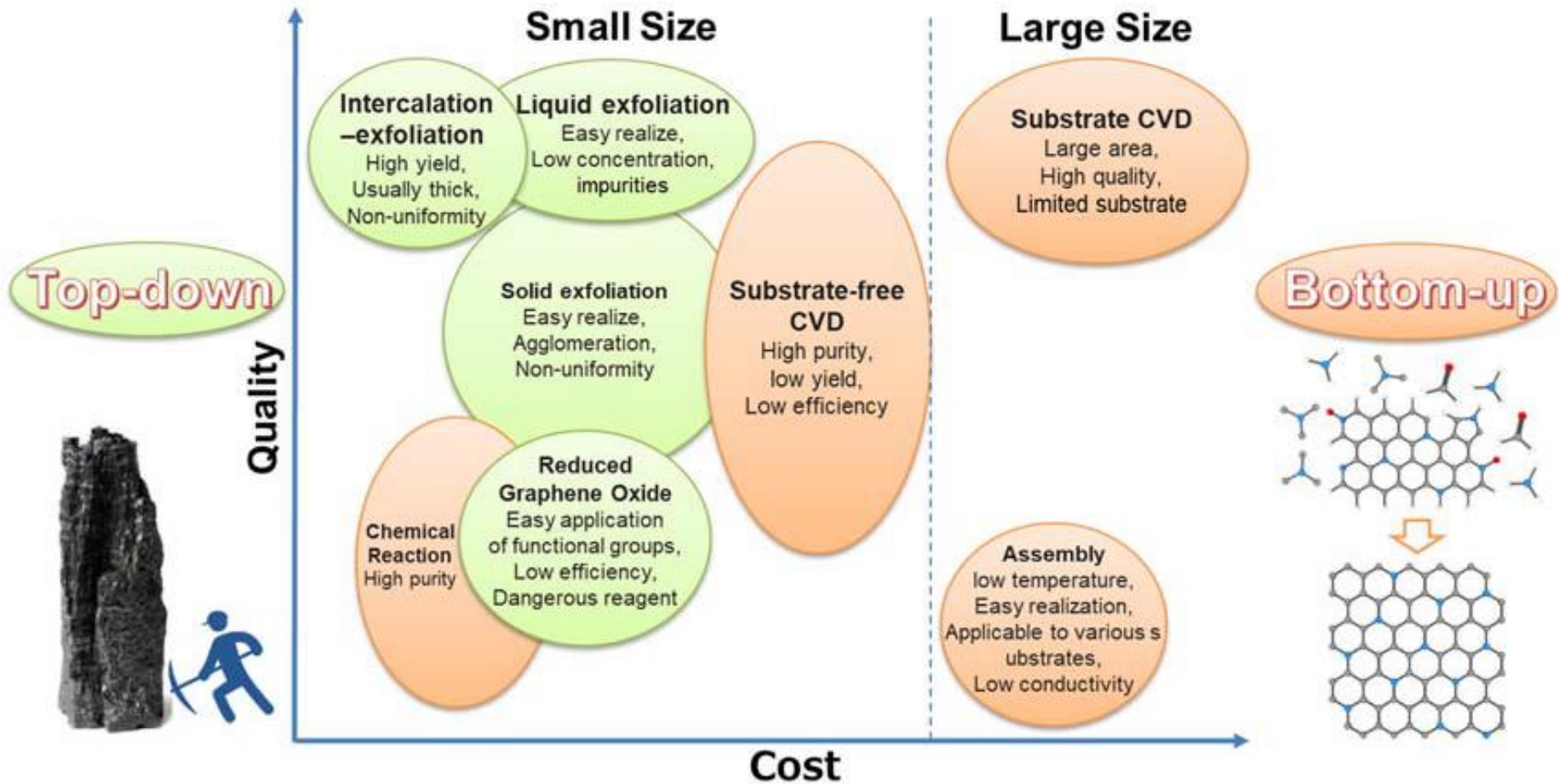
EXFOLIATION IN LIQUID

(a)   (b)   (c)   (d)
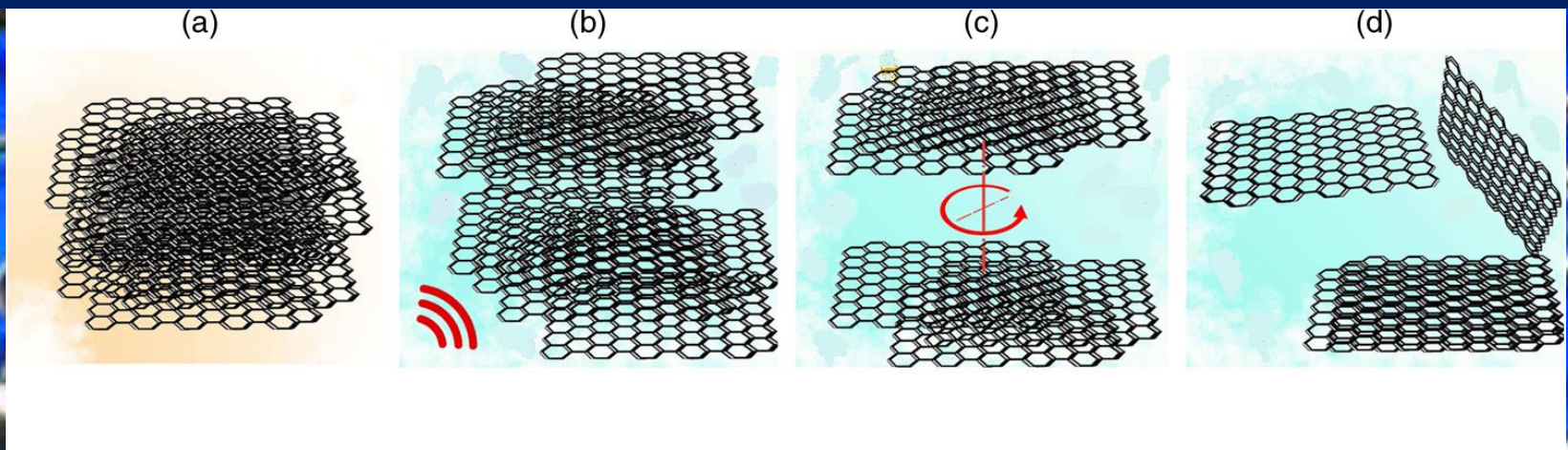
PICTURES OF THE OBTAINED FILMS
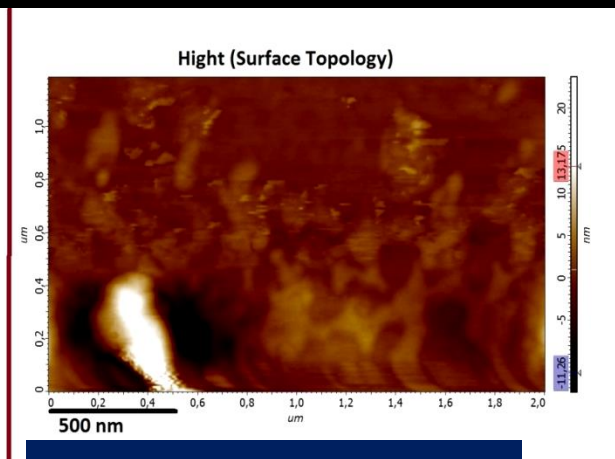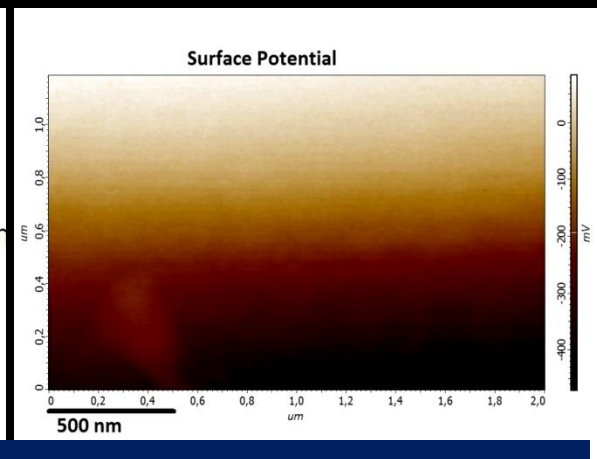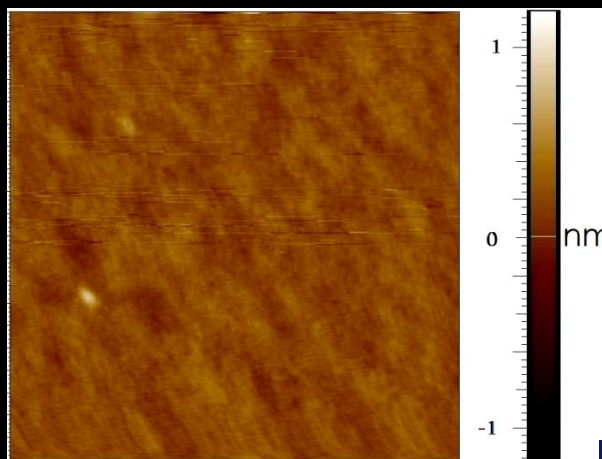

Only due to the reflection of light from their surface, graphene layers are noticeable (in both cases).
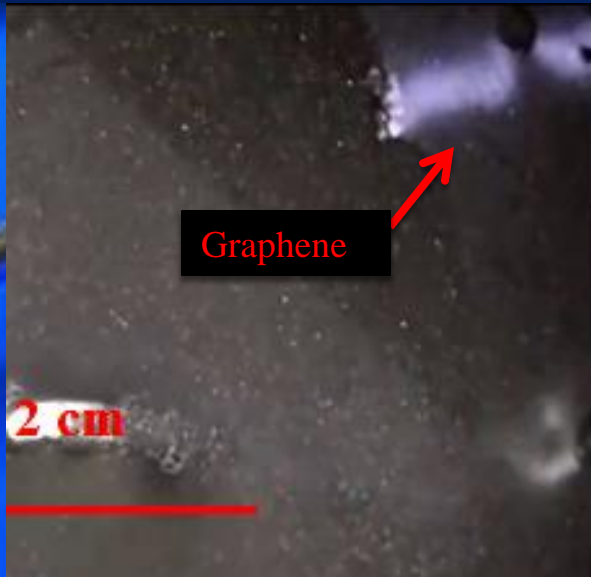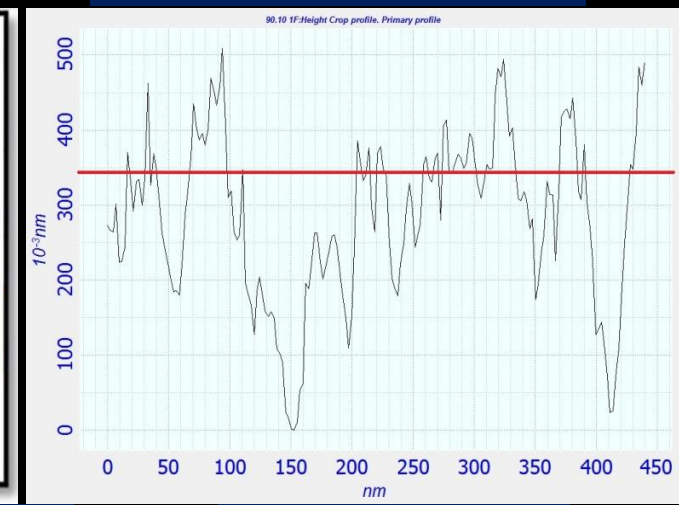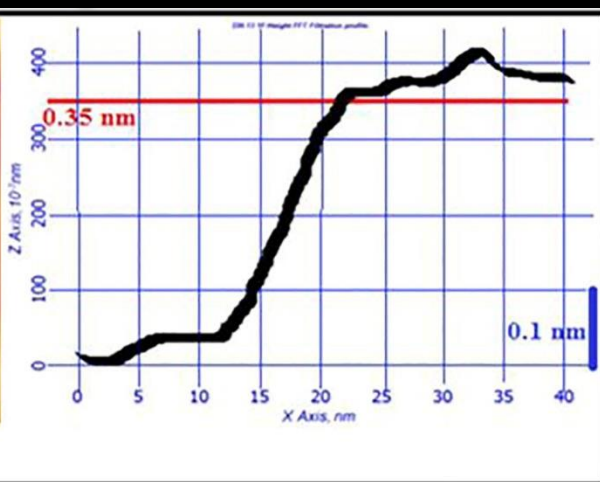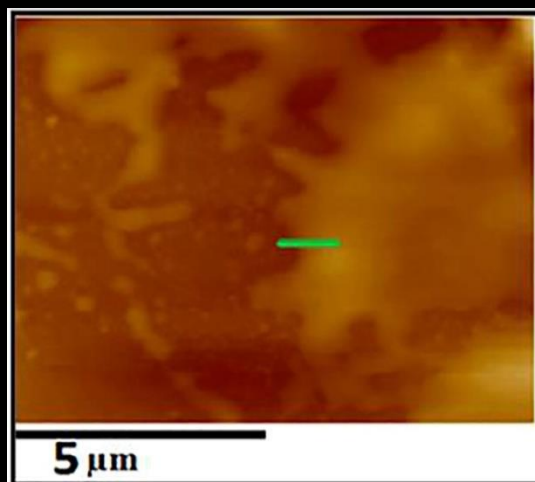
Graphene on liquid surface
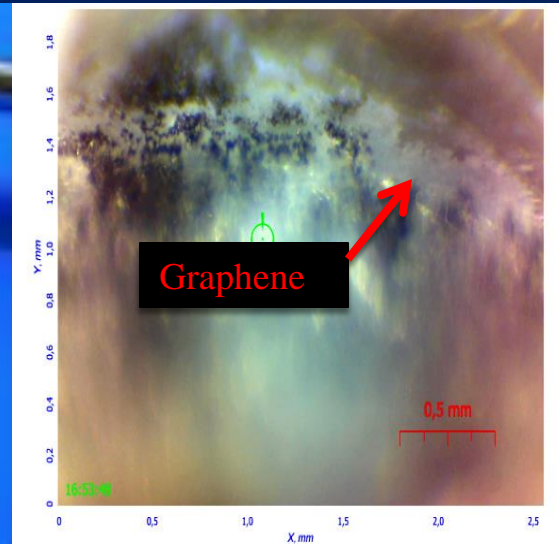
Graphene on silicon surface, under USB microscope

AFM Study

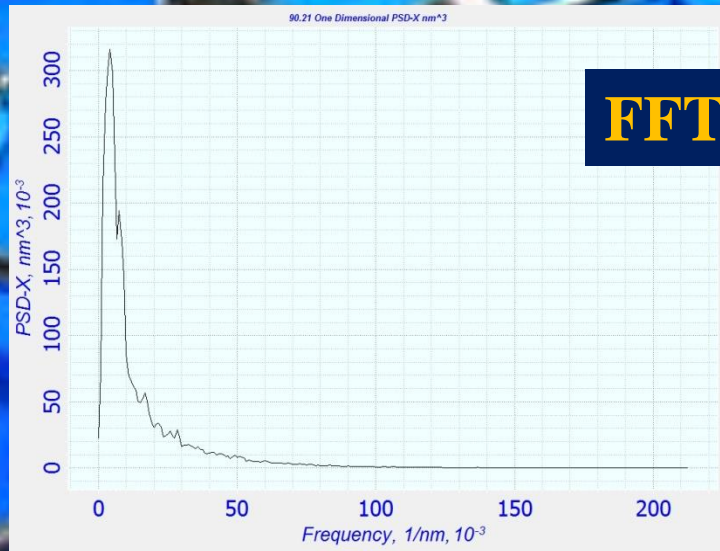Potential Transition at the Film Boundary

Fractal Borderline

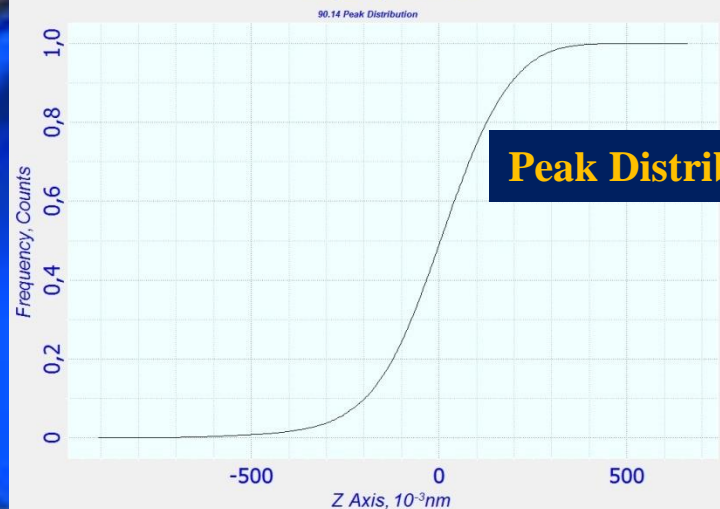Line Scan Direction

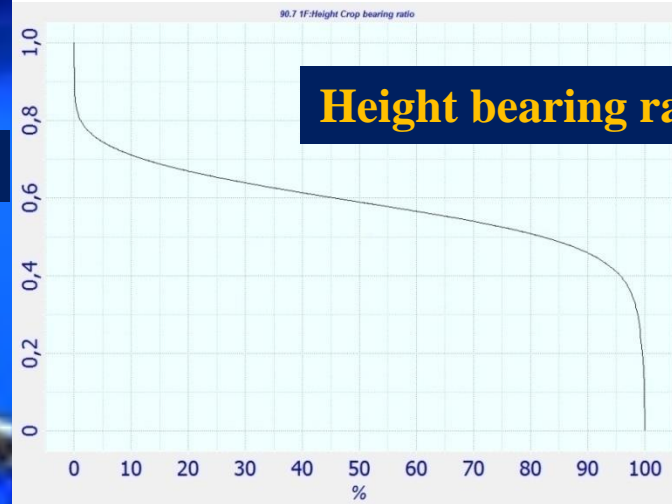Layer Thickness Estimation

Line Scan

AFM Image Analysis

AFM Study of CNT-s And GQD-s
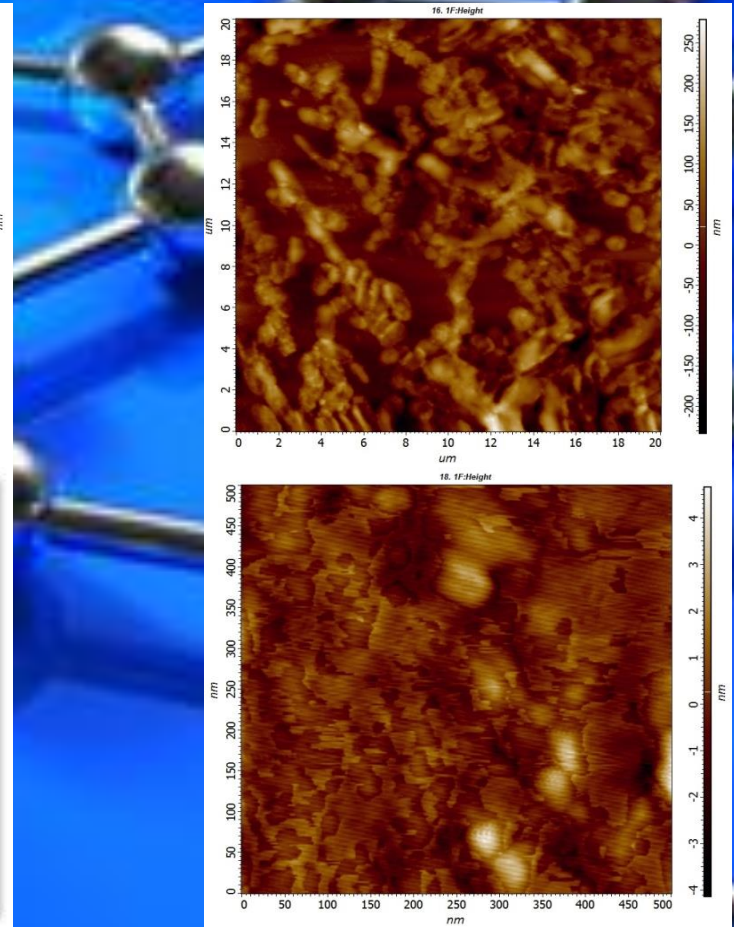
There are obtained Carbon nanotubes and graphene based quantum dots, which are distributed chaotically.

Band Structure and Lattice Properties
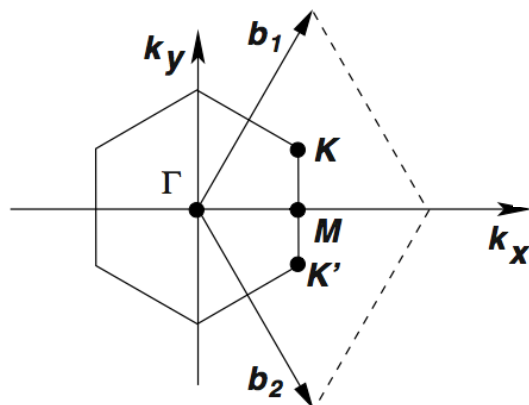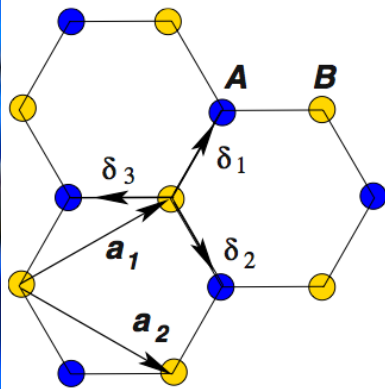
$$\mathbf{a}_1 = a\left(\frac{\sqrt{3}}{2}, +\frac{1}{2}\right) \ , \ \mathbf{a}_2 = a\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$$

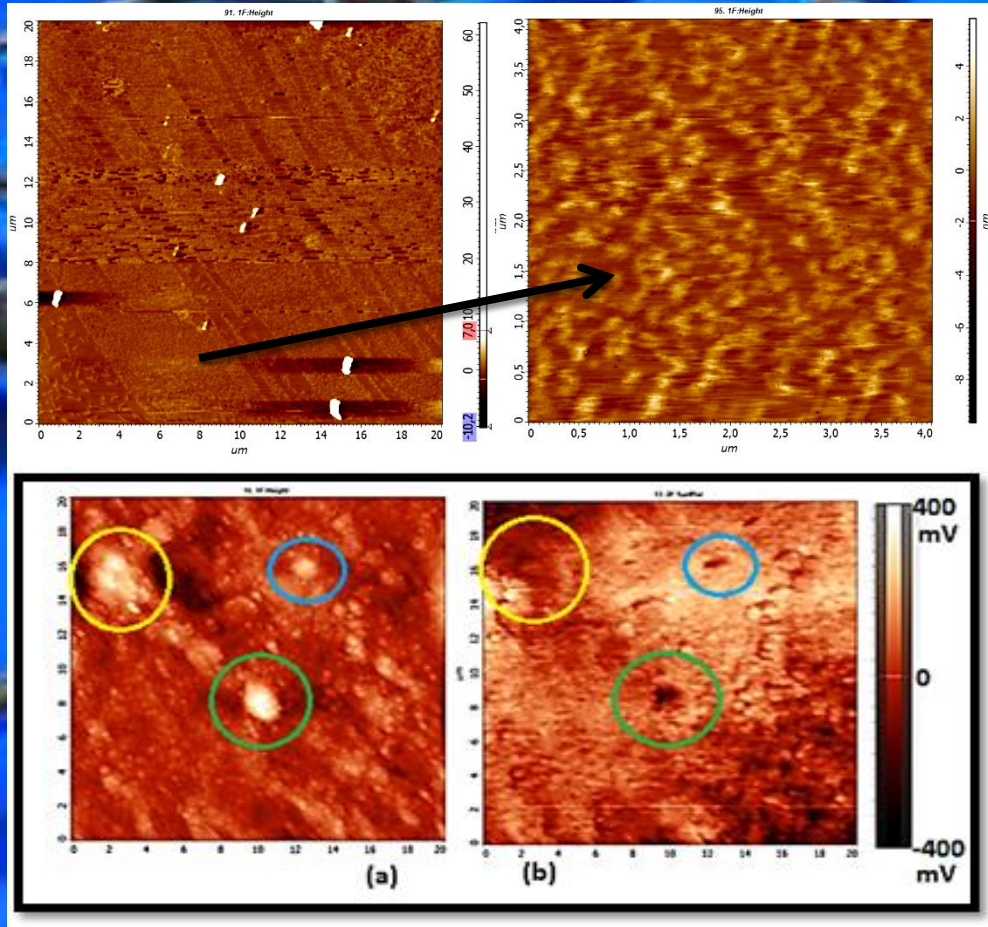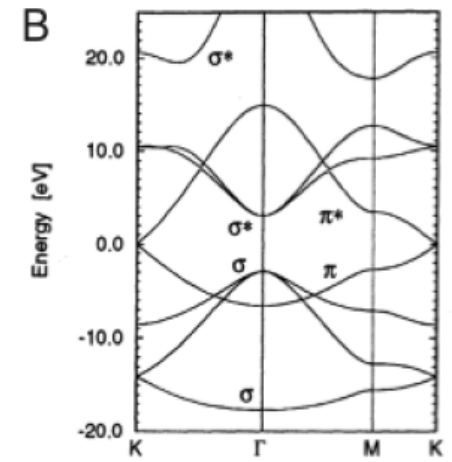$$\mathbf{b}_1 = \frac{2\pi}{a}\left(\frac{1}{\sqrt{3}}, +1\right) \ , \ \mathbf{b}_2 = \frac{2\pi}{a}\left(\frac{1}{\sqrt{3}}, -1\right)$$
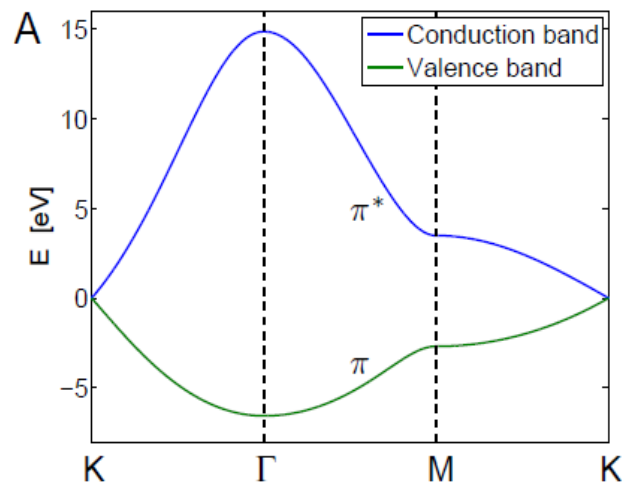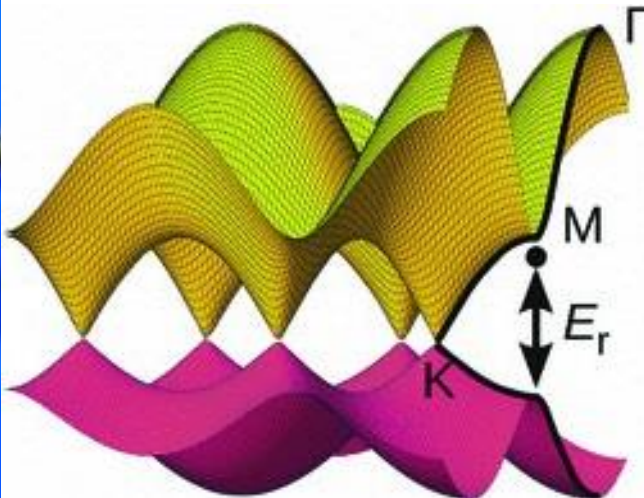
(a) A $\pi - \pi^*$ band diagram of graphene calculated from a tight-binding model.
(b) Band diagram from Saito which shows both $\pi - \pi^*$ and $\sigma - \sigma^*$ bands.

Optical Absorption

Why?

How?

Graphene on NaCl substrate
Graphene on amorphous sapphire

272 nm

235 nm

Absorbance (arb. units)

200 250 300 350 400 450 500 550 600

Wavelenght (nm)

K' M K
K Γ K'
K' K

π

4,6 eV

E_F

(eV)

π

K Γ M K

Wave Vector
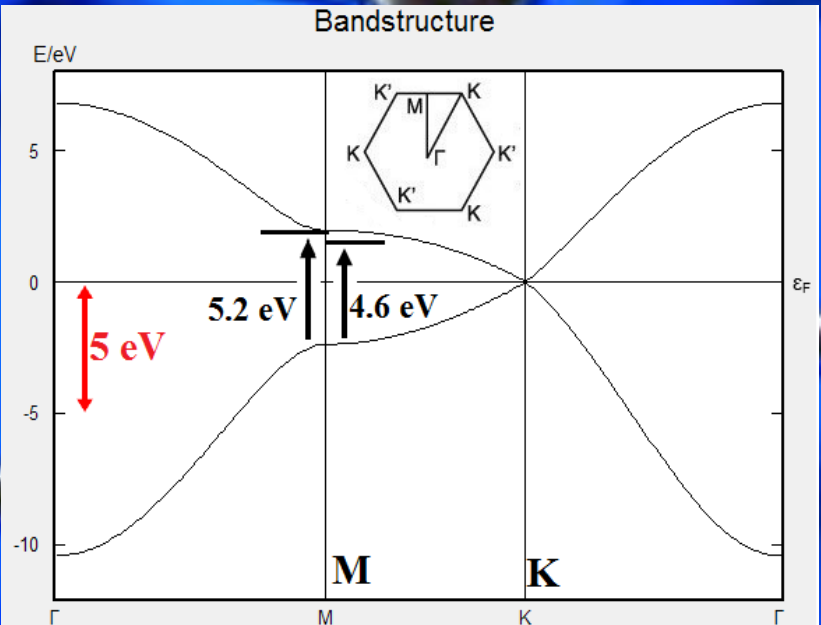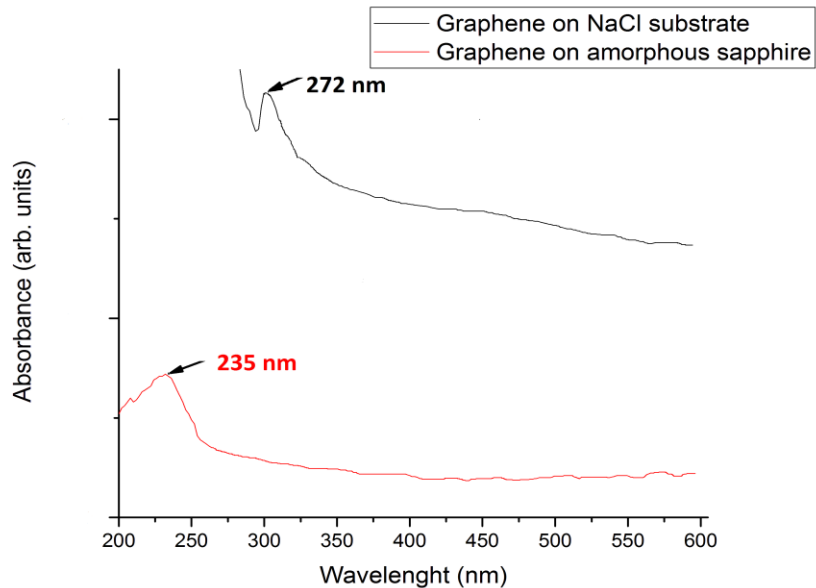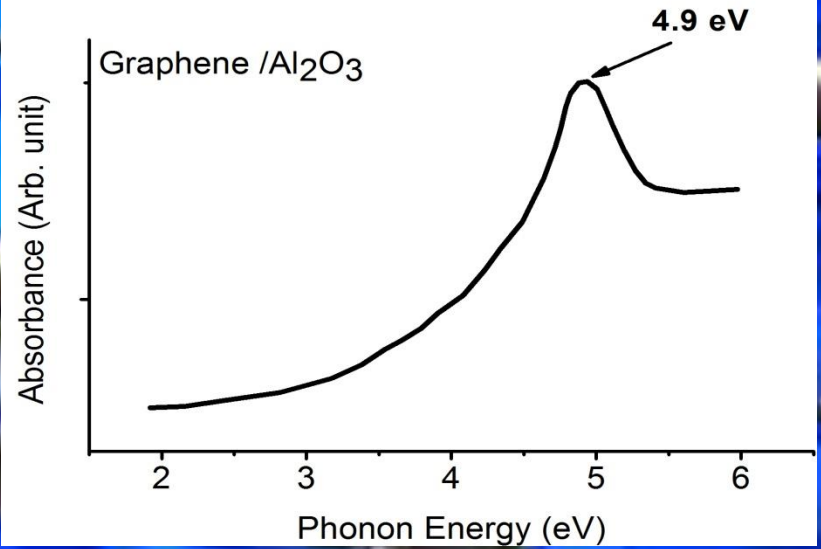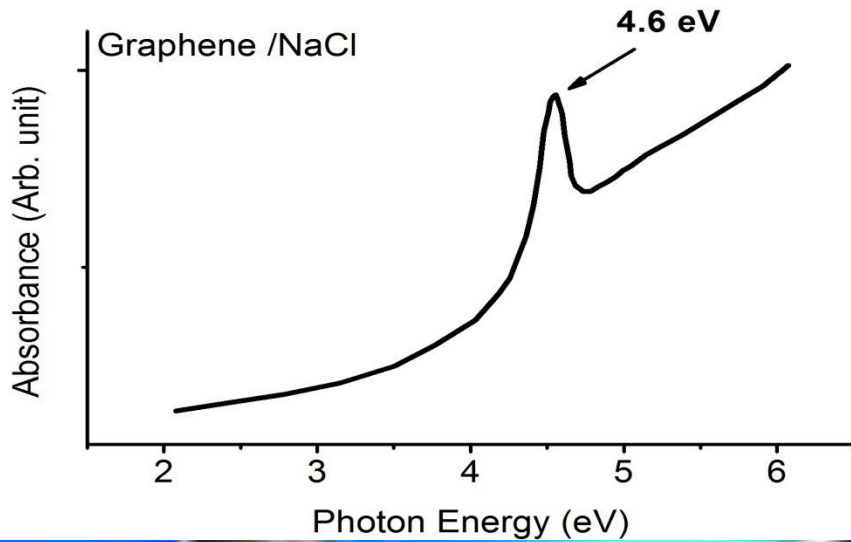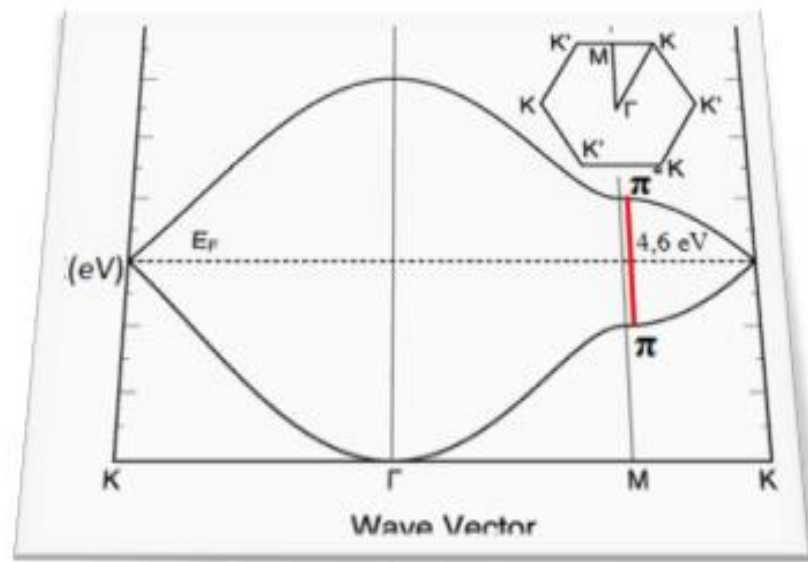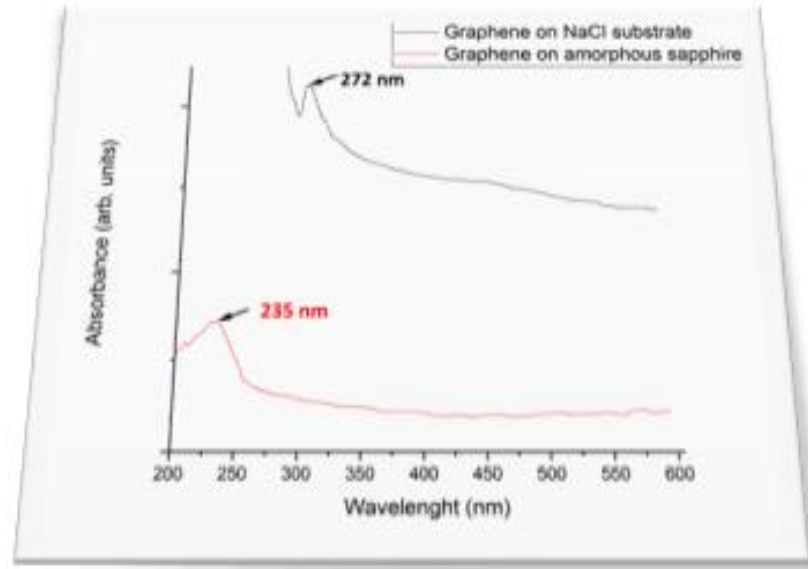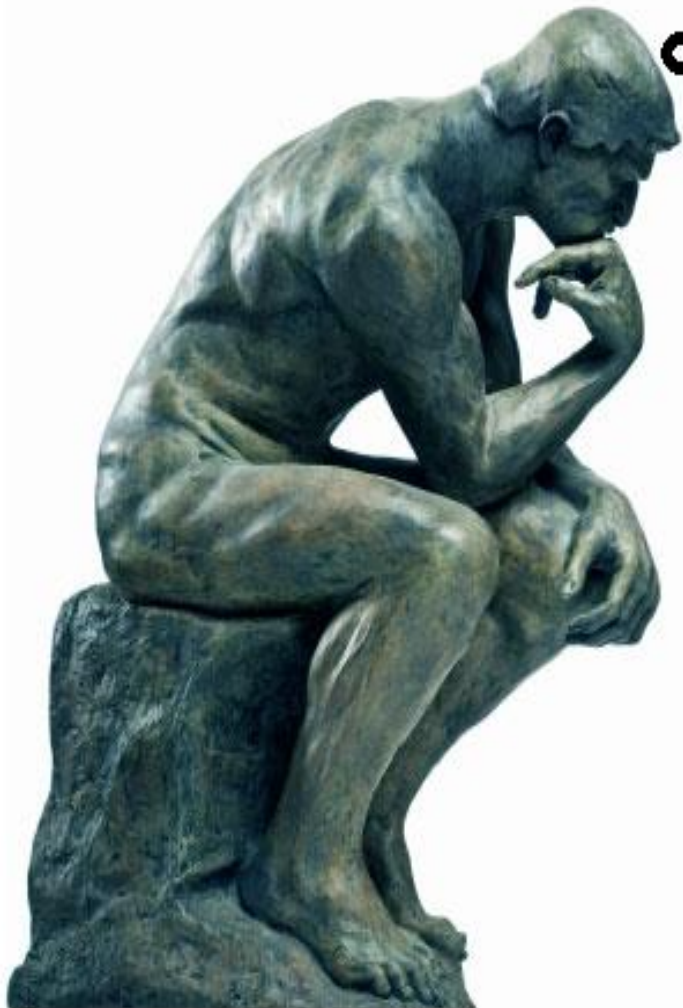
Raman spectra for MLG ribbons with different number of layers
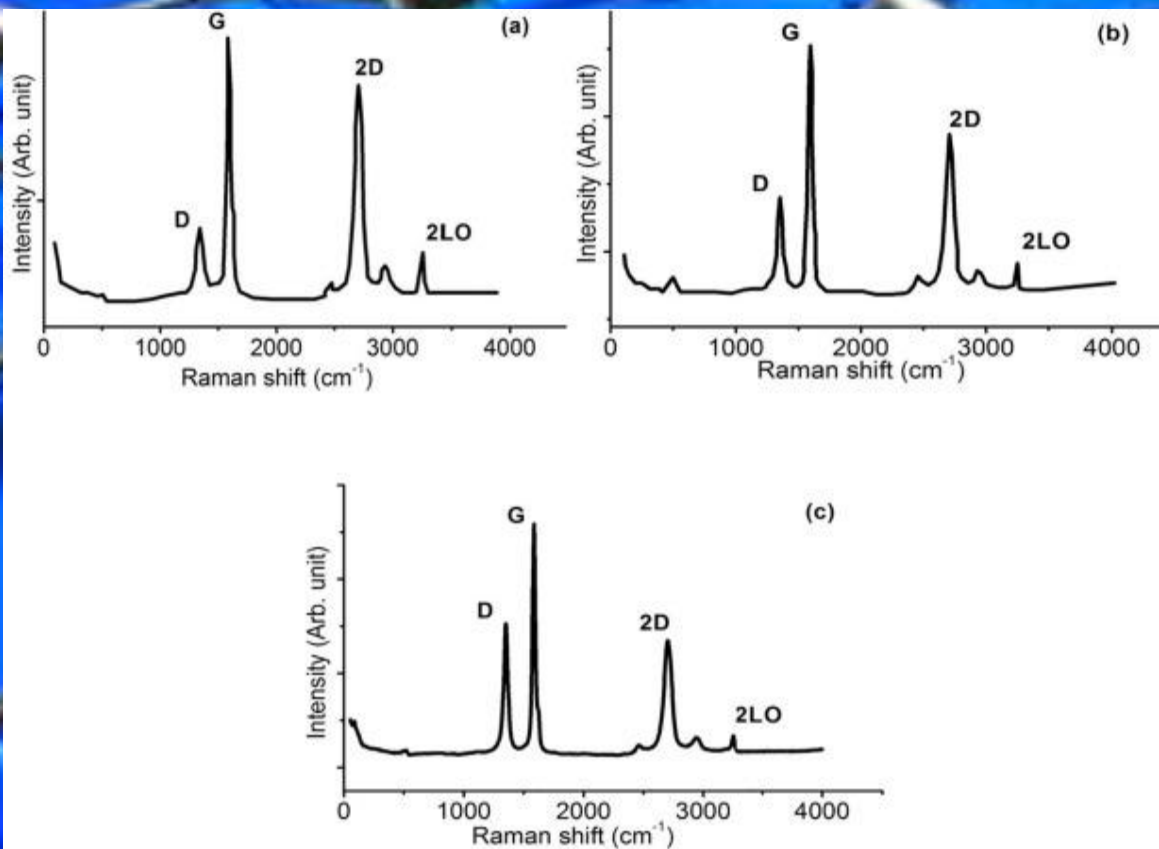
$I_D/I_G = 0.26$, $I_D/I_G = 0.38$
$I_D/I_G = 0.56$

1. Typical for SP2 carbon, 2D peak has symmetric form.

2. Because of their fractal nature, in Raman spectra of   formed layers characteristic peak of defect is expected.
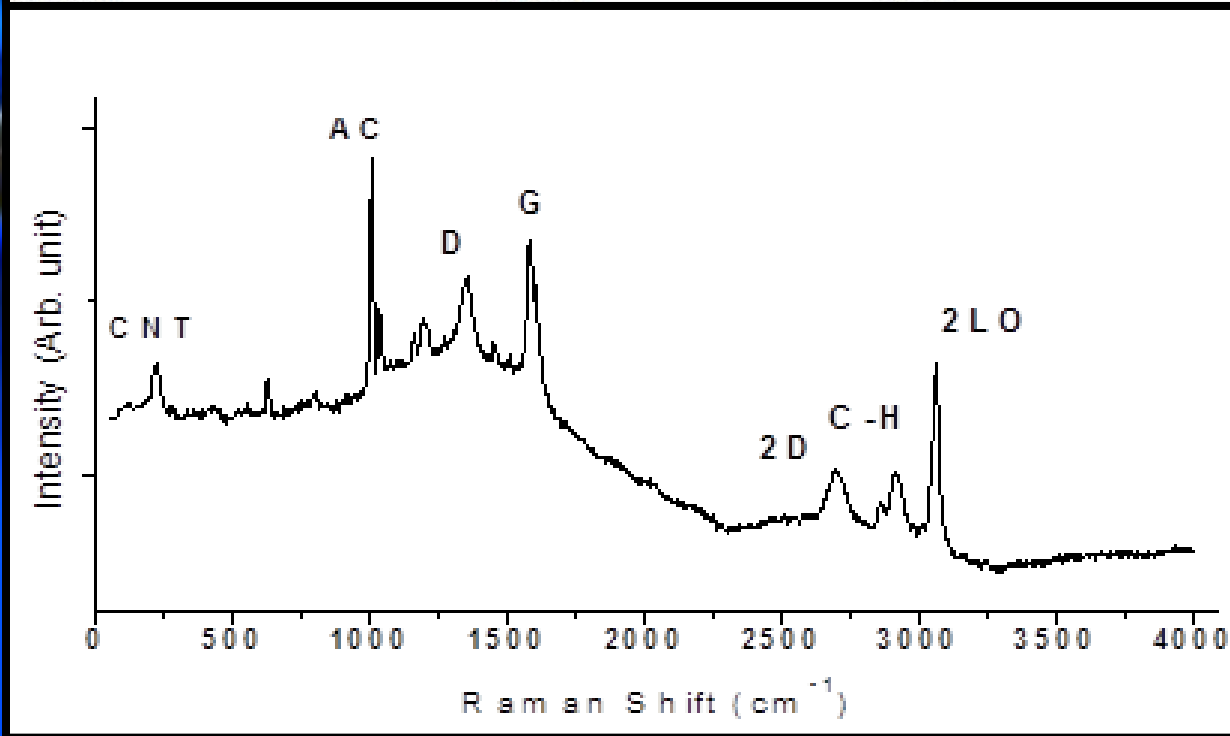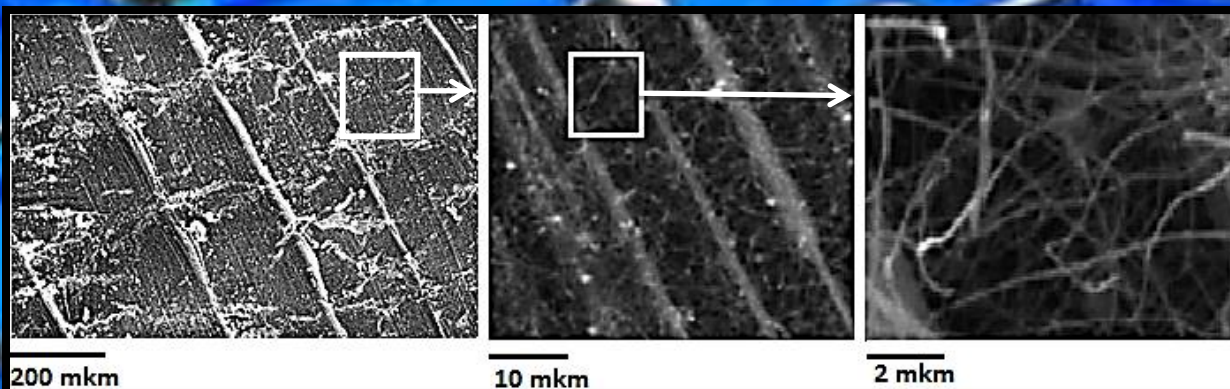
Narek Margaryan, Ninel Kokanyan, Edvard Kokanyan

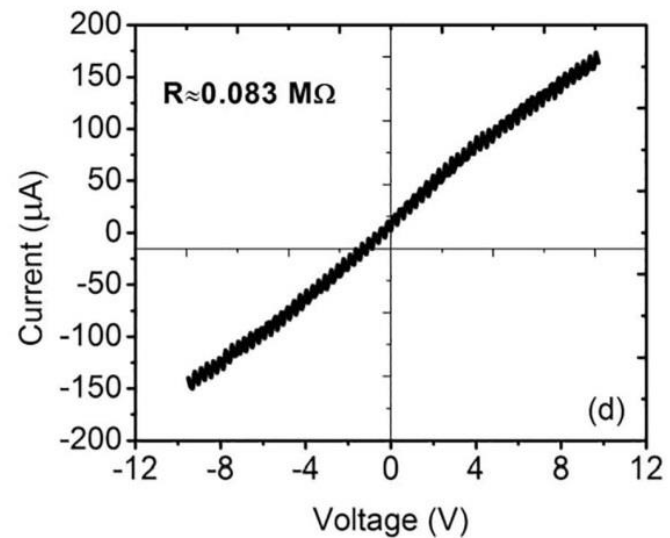 **Low- Temperature Synthesis and Characteristics of Fractal Graphene Layers**

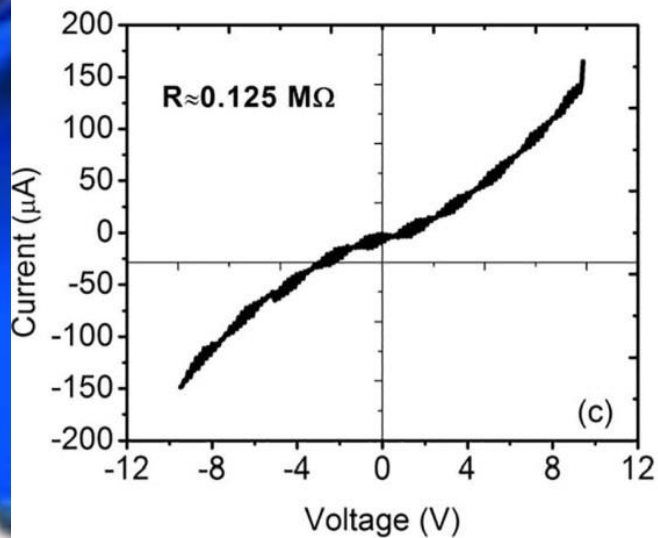# Raman spectroscopy of sampls with folds and CNTs

VA-Characteristics
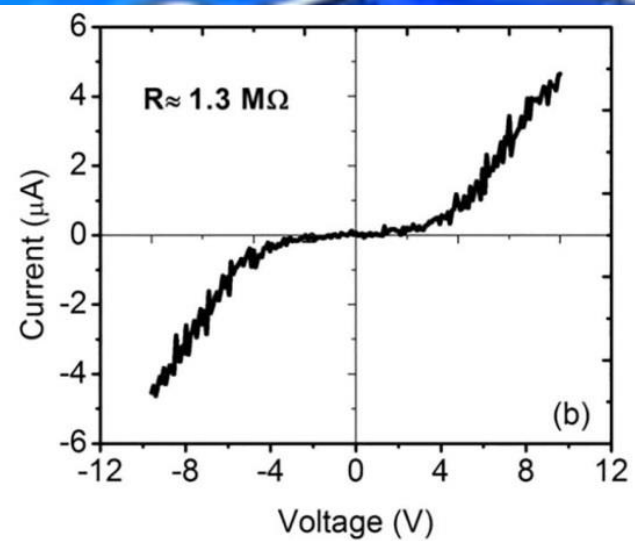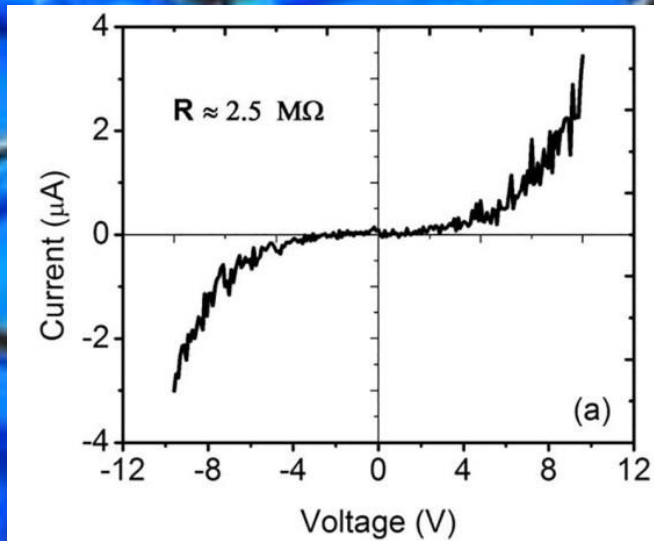
Theoretical Results
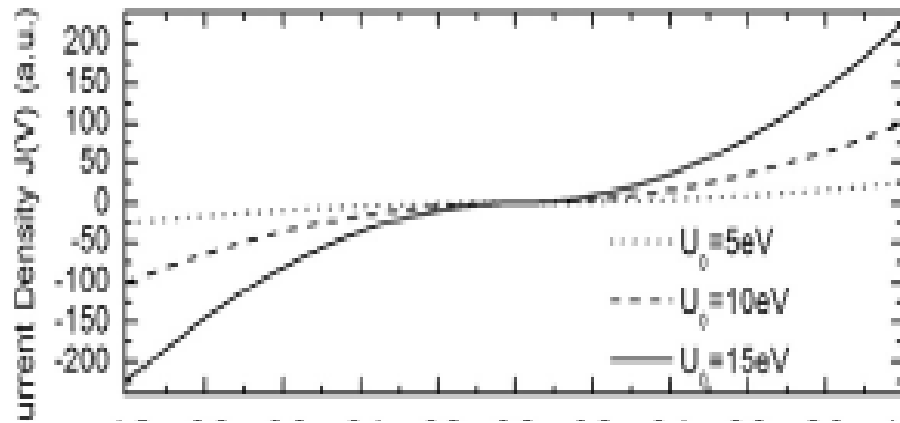
Miguel Saldaña Jimenez, C.A. Dartora* Physica E 59 (2014) 1–5

Legend for figure:
- $U_0 = 5\,eV$ (dotted)
- $U_0 = 10\,eV$ (dashed)
- $U_0 = 15\,eV$ (solid)

Y-axis: Current Density J(V) (a.u.)

Dependence of conductivity on voltage

Y-axis: Conductivity $1/\Omega \times 10^{-7}$
X-axis: Voltage (V)
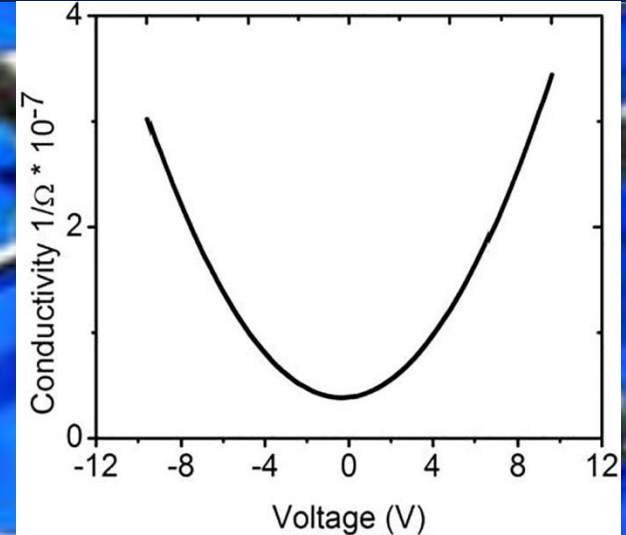
VA-Characteristics for Graphene Based Heterojunction
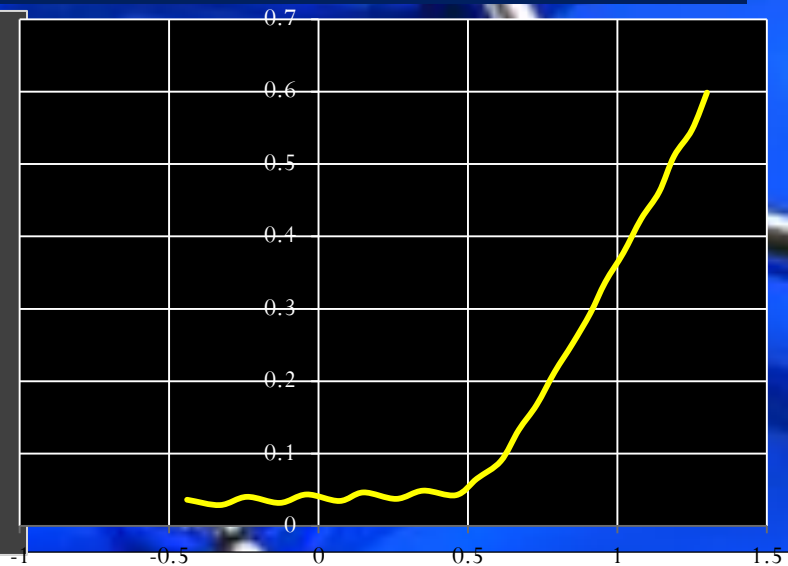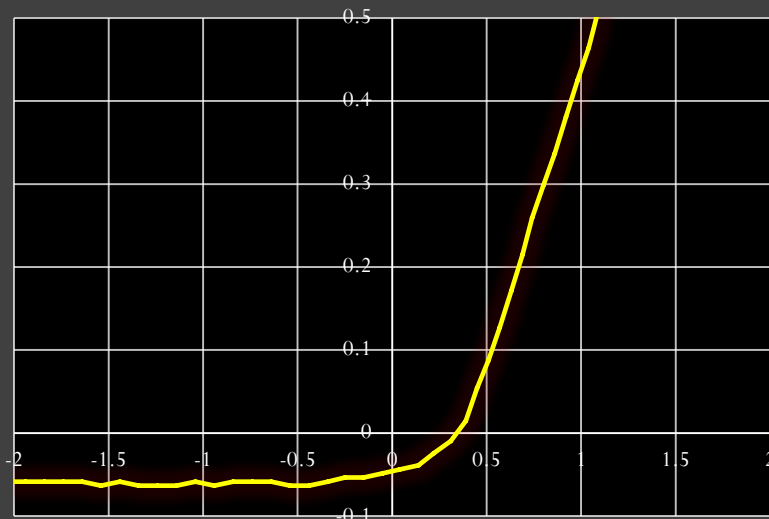
Graphene/LiNbO₃ Hybrid Structures for SAW Sensors

SAW sensor model on Graphene/ LiNbO₃ structure (Nesh ea al 2014)

Raman spector of Graphene/LiNbO3 structure

Conclusion

- Self-organized layers of SP2 carbon are formed, which are fractal in nature.
- Studies of these layers by AFM and SEM show the presence of both single-layer and multilayer graphene. Also, chaotically located carbon nanotubes and quantum dots based on graphene are noticeable.
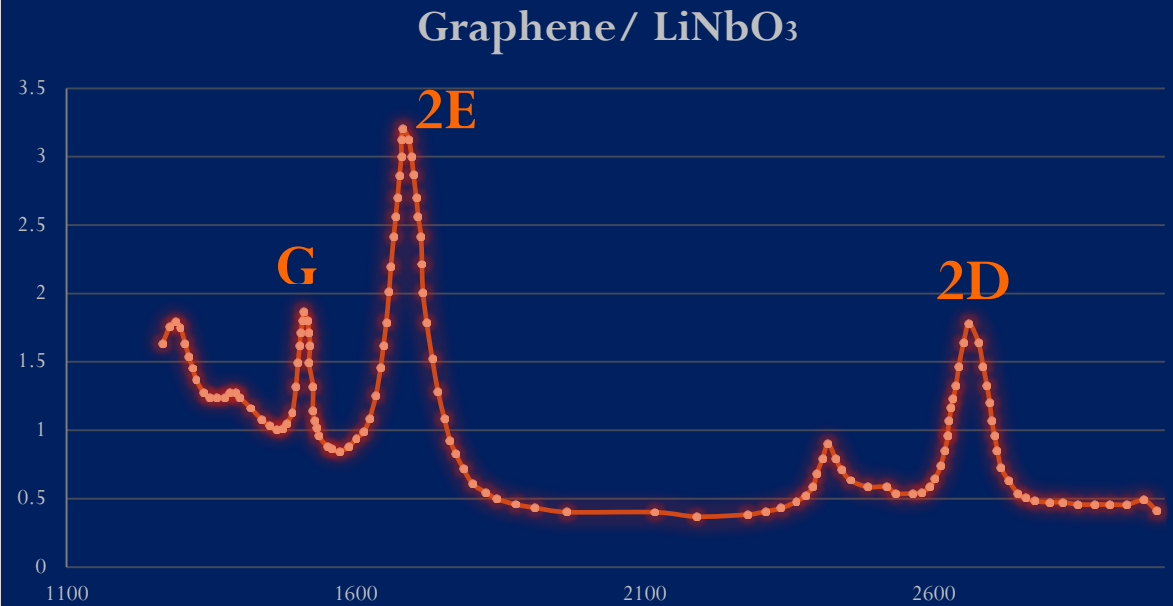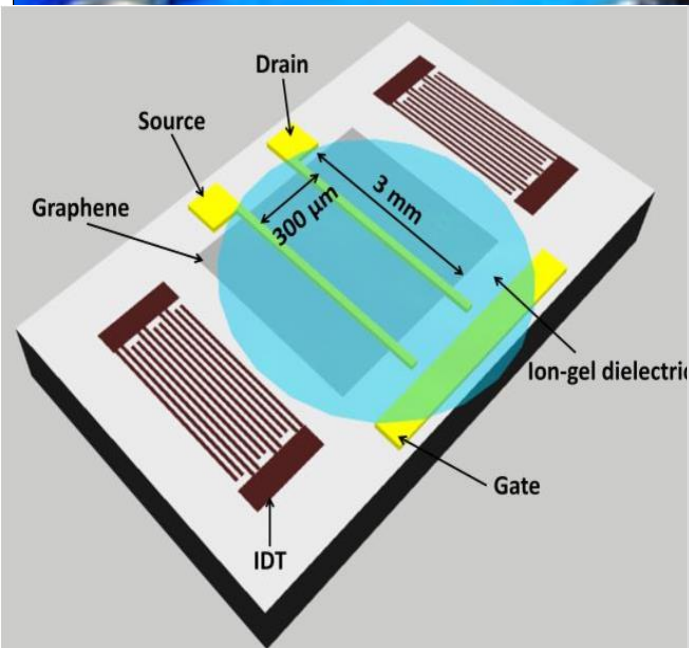- When studying the optical absorption spectrum of these layers, one can observe a peak in the ultraviolet range, which is characteristic of the exciton transition around point M in the Brillouin zone.
- The current-voltage characteristics for these layers have a nonlinear form. With the increase in the number of layers, this nonlinearity of the I-V characteristic gradually disappears, and the I-V becomes ordinary ohmic, which, in turn, is characteristic for graphite.
- Graphene/LiNbO3 heterojunctions can be well used as SAW sensor structures.

Շնորհակալություն Ուշադրության համար

QUESTIONS?