

Raman spectroscopy of long isolated graphene ribbons grown on the C face of 6H-SiC

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Outline

Epitaxial growth of graphene on the C face of SiC substrate

Optical properties of graphene

Raman spectroscopy of graphene

Combined microtransmission and microRaman spectroscopy

Summary

Growth conditions

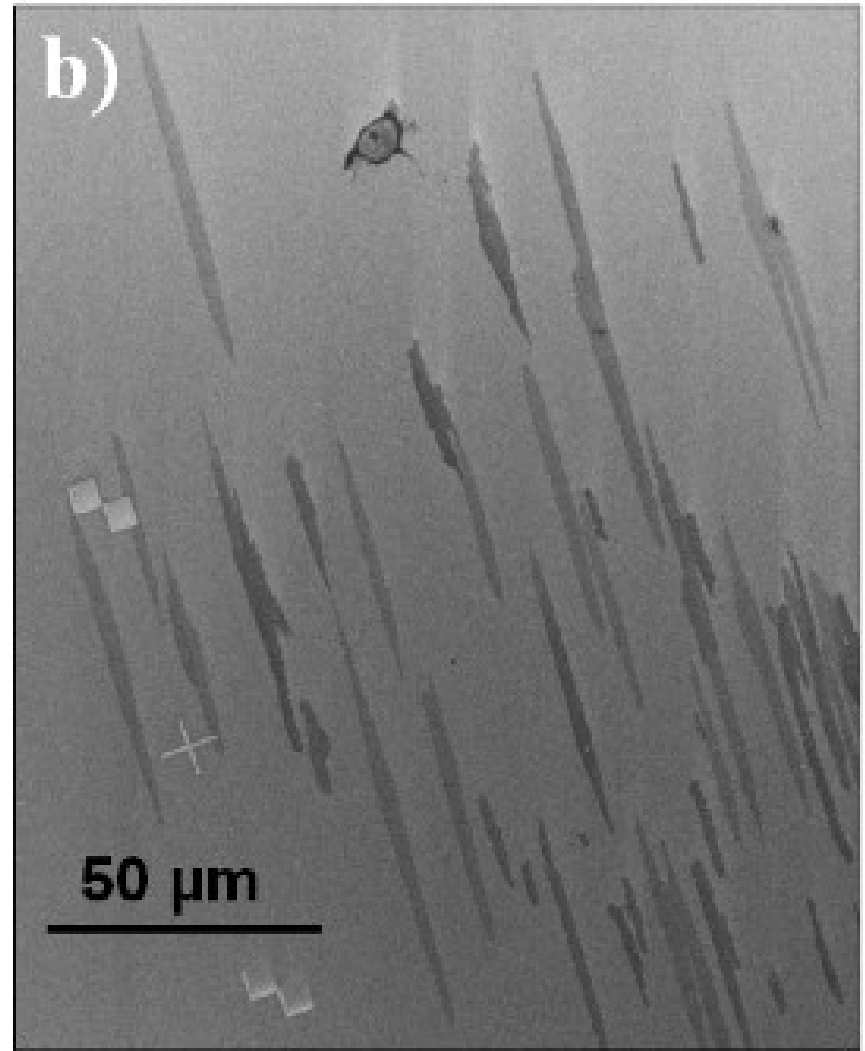
SV-1700°C / C-rich atmosphere

Long isolated FLG ribbons

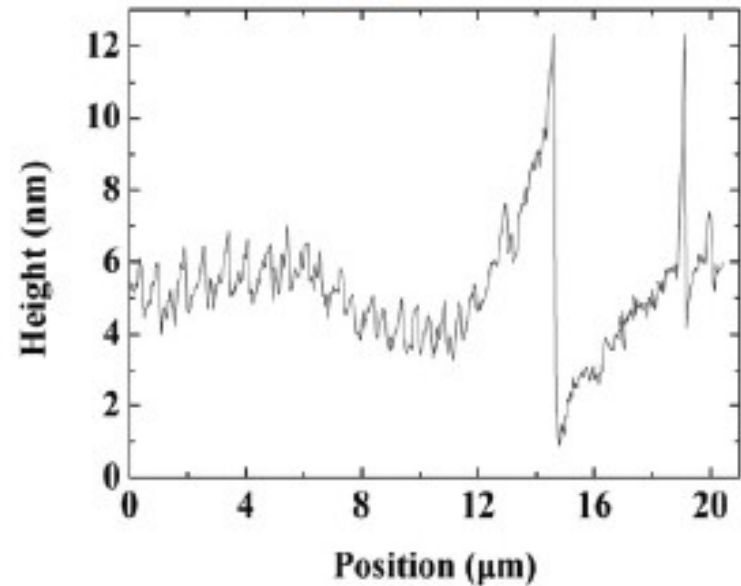
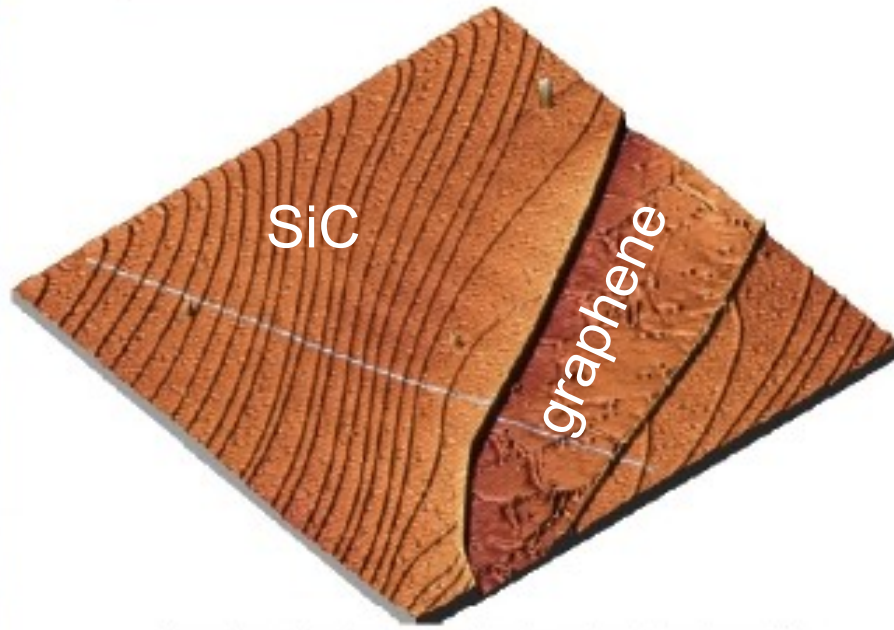
Parallel

Few μm wide

Up to 100 μm long



Epitaxial graphene on C face of SiC



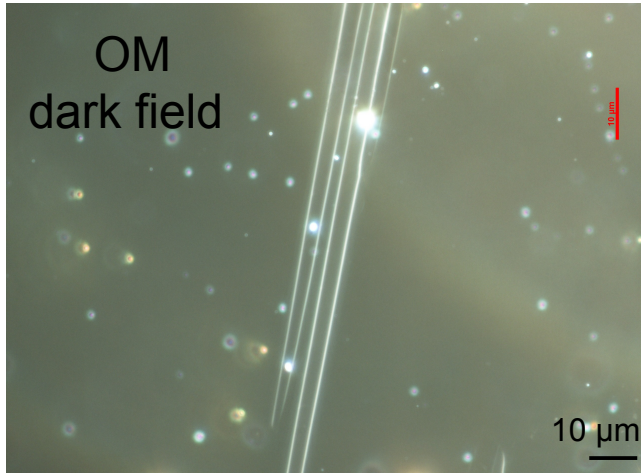
AFM

N. Camara et al.,
Phys. Rev. B
80, 125410 (2009)

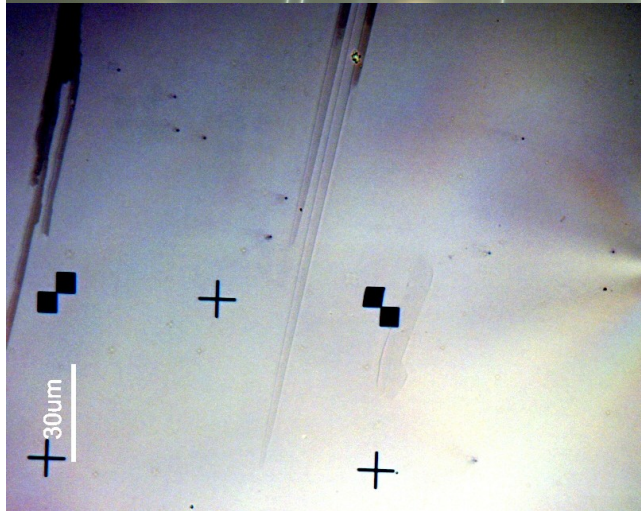
SiC surface reconstruction (step bunching)

Graphene grows on larger terraces

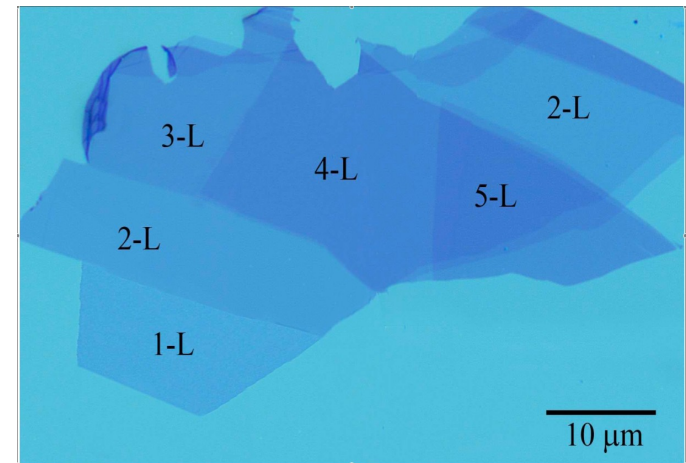
Optical Microscopy



graphene / SiC
no optical contrast



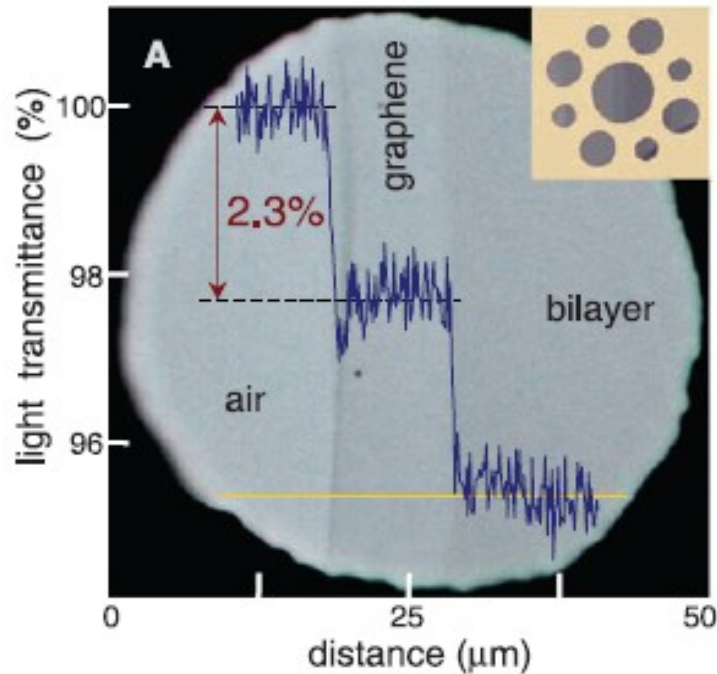
exfoliated graphene / SiO₂ / Si



M. Bruna S. Borini arXiv:10002.4942v1

Transmission of graphene

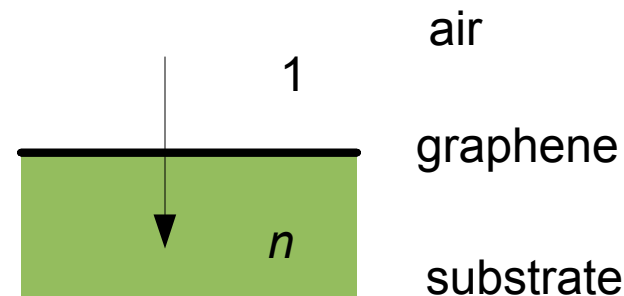
Free standing, in air ($n=1$)



R.R. Nair *et al*, Science **320** 1308 (2008)

Graphene optical conductivity

$$\sigma = \frac{\pi e^2}{2 h}$$

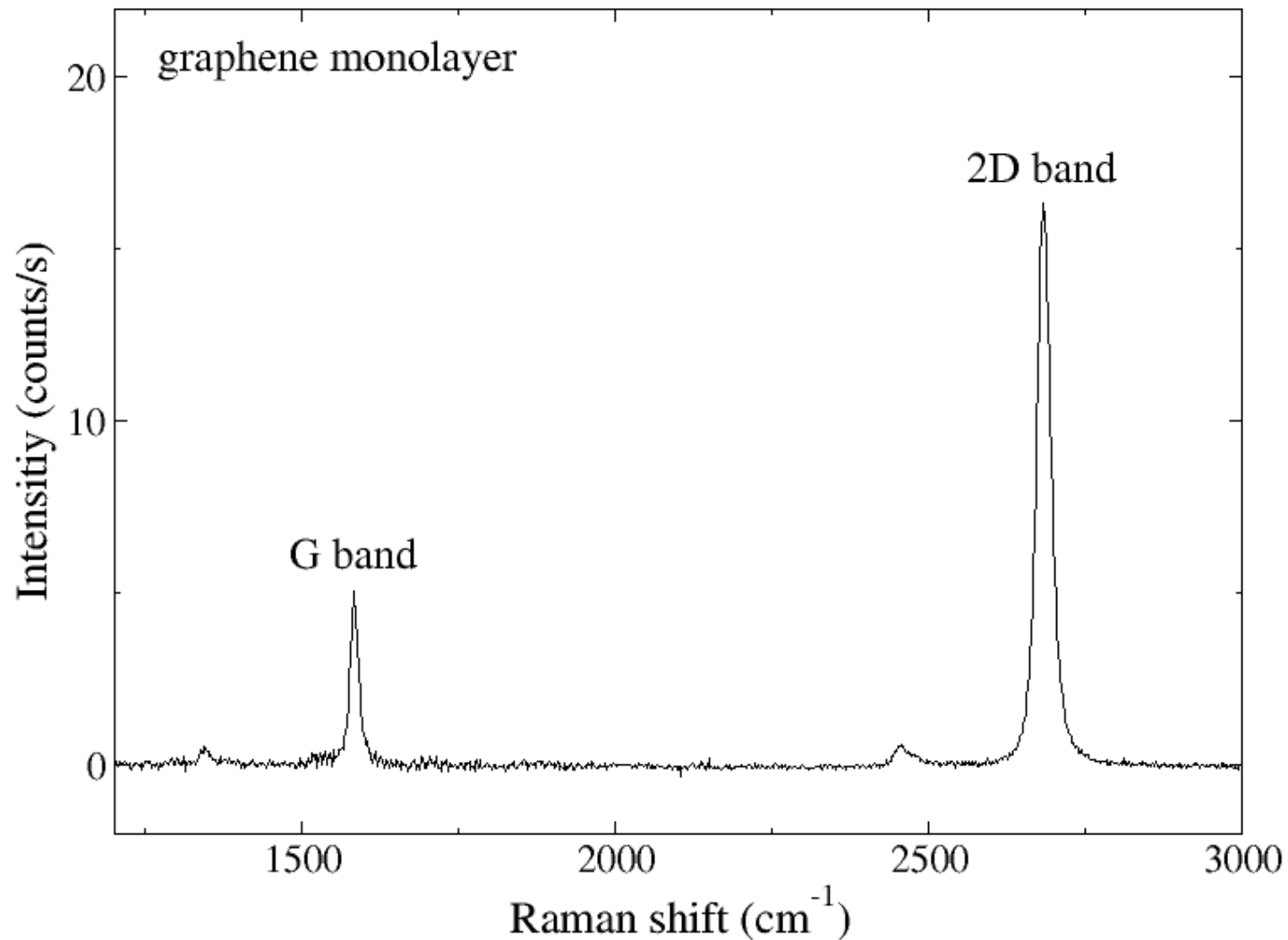


$$R+T+A=1 \quad T = \frac{4n}{\left| 1 + n + \frac{\sigma}{\epsilon_0 c} \right|^2}$$

T. Stauber *et al*, Phys. Rev. B **78** 085432 (2008)

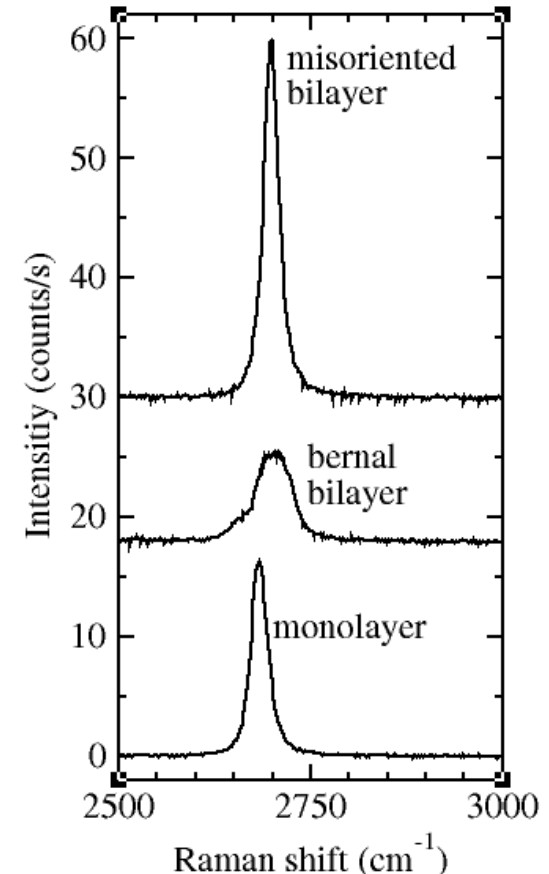
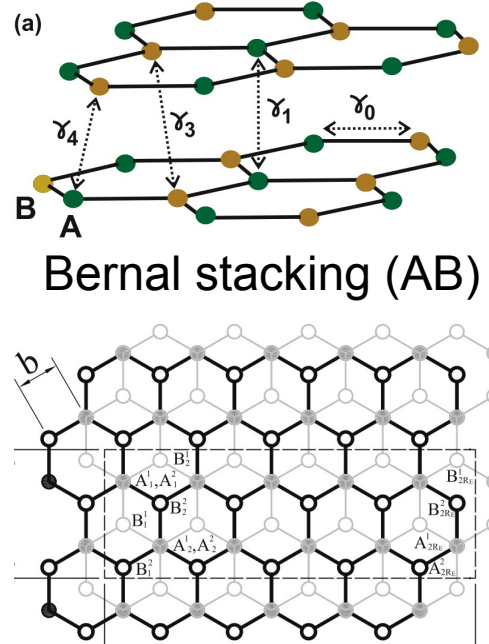
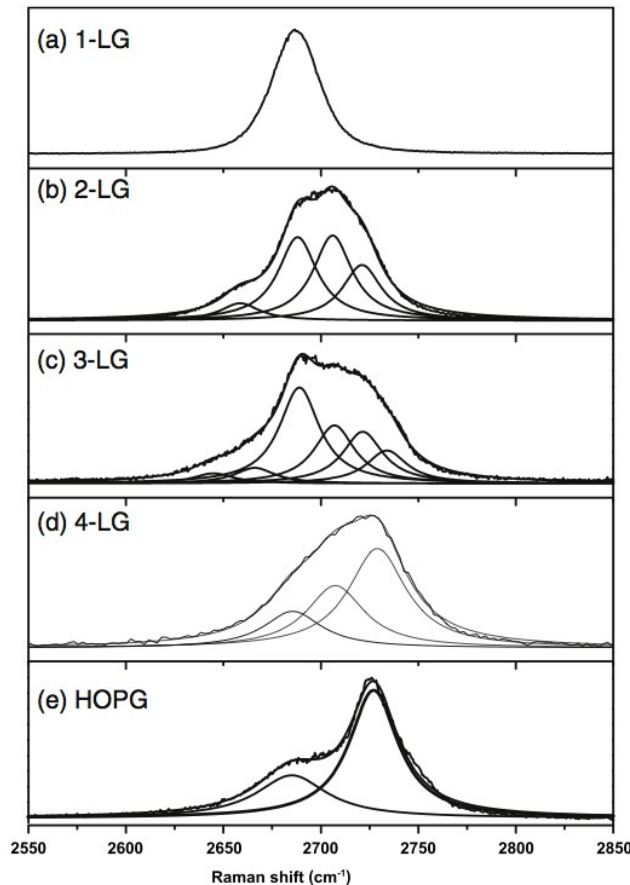
The absorptance A is proportionnal to the number of graphene sheets

Raman spectroscopy of graphene



Raman spectroscopy of graphene

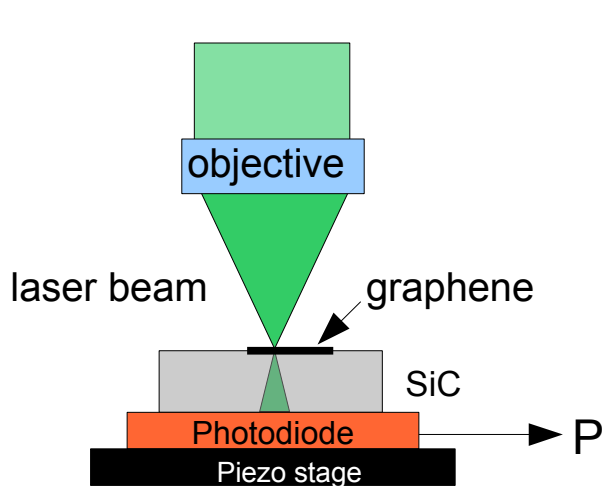
2D band depends on the thickness and the stacking



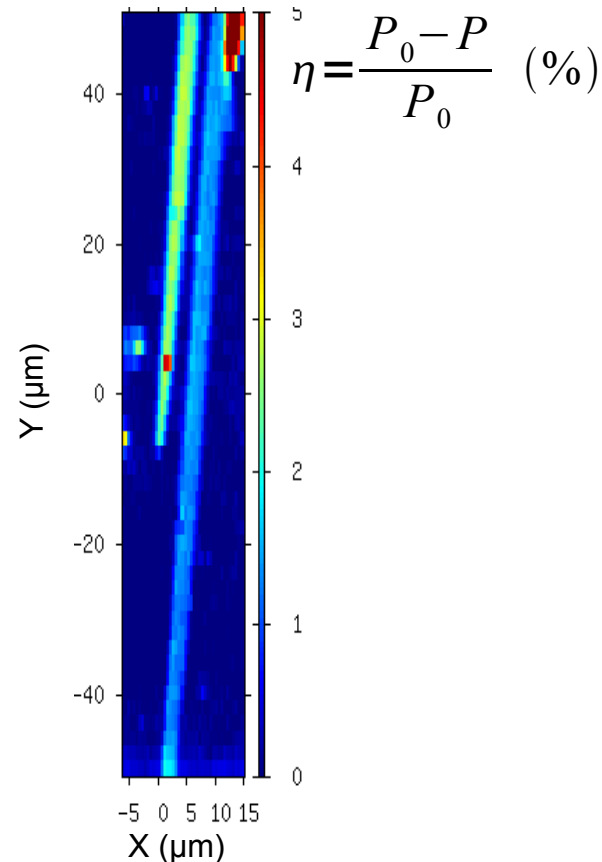
L.M. Malard et al., Phys. Rep.
473, 51 (2009)

misoriented bi-layer same as monolayer
except for intensity

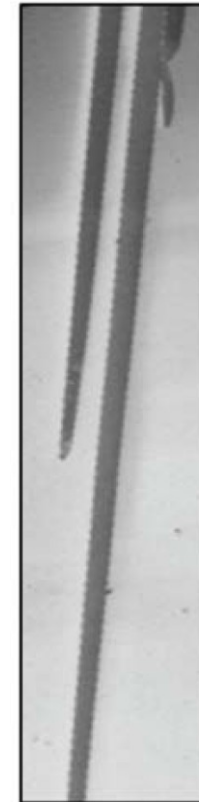
Combined Transmission/Raman



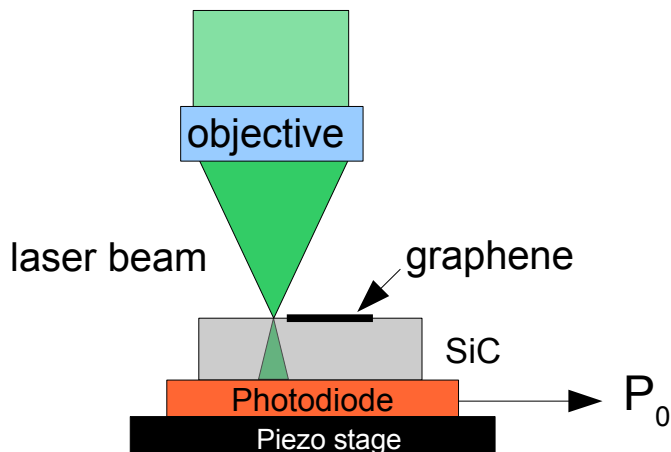
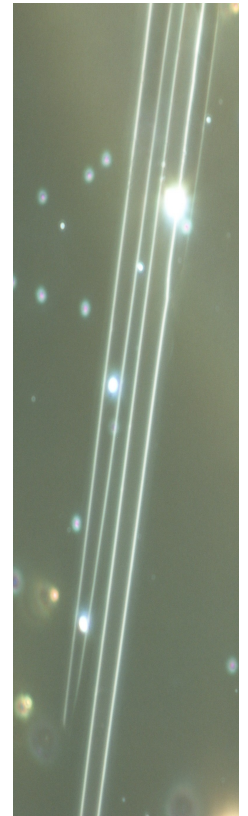
relative extinction coefficient



SEM



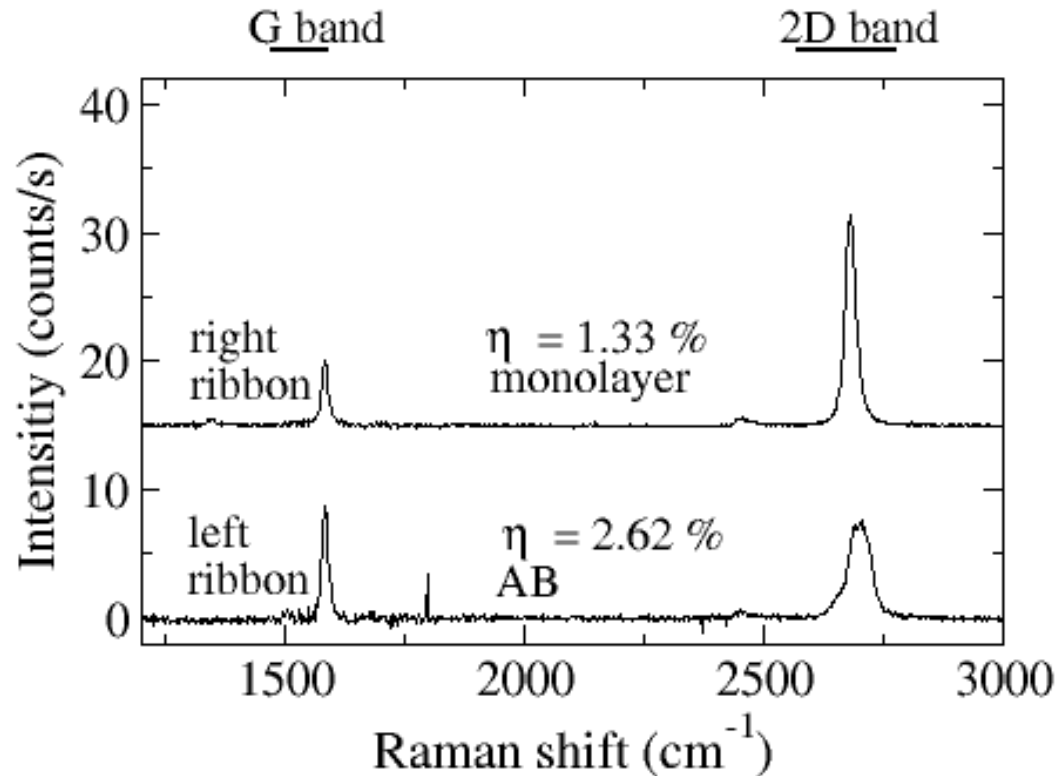
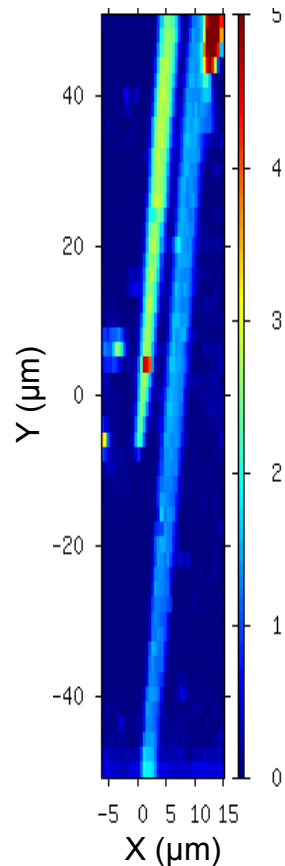
Dark Field OM



Theory : $\eta_{th} = 1.23\%$ monolayer / SiC
 $\eta_{th} = 2.44\%$ bilayer / SiC

Combined Transmission/Raman

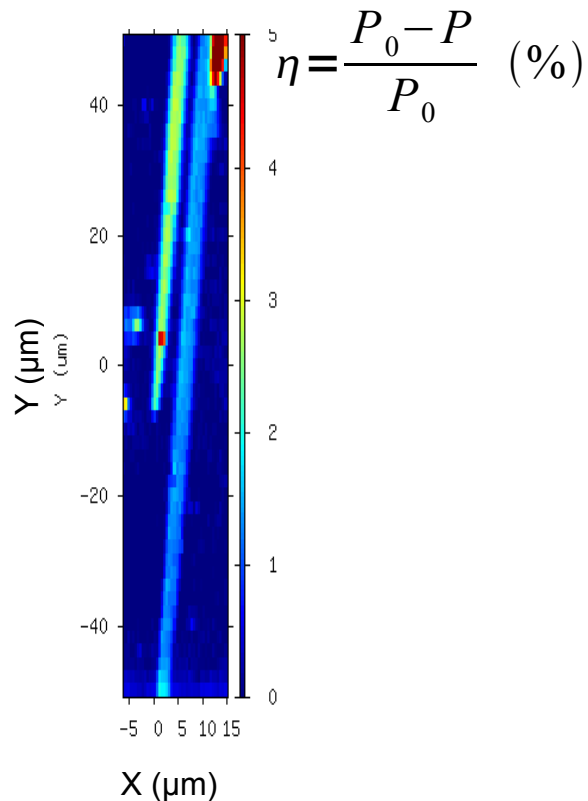
$$\eta = \frac{P_0 - P}{P_0} \quad (\%)$$



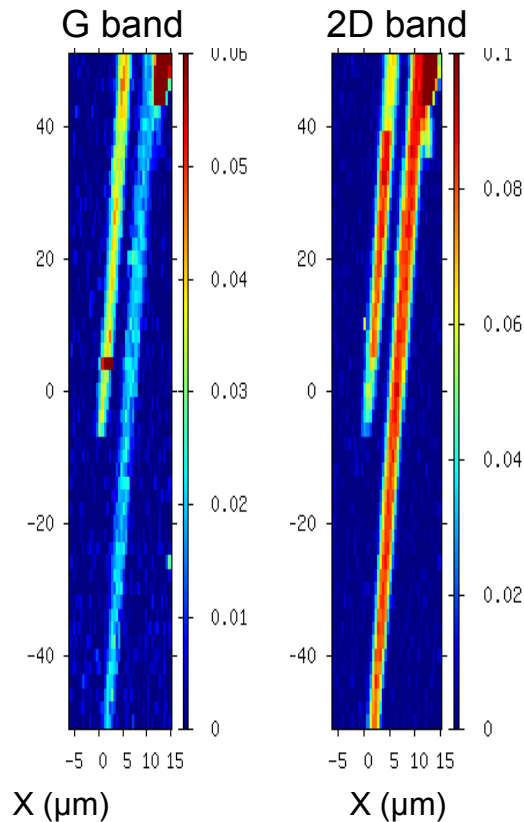
The left ribbon is a bernal bilayer
The right ribbon is a monolayer

Combined Transmission/Raman

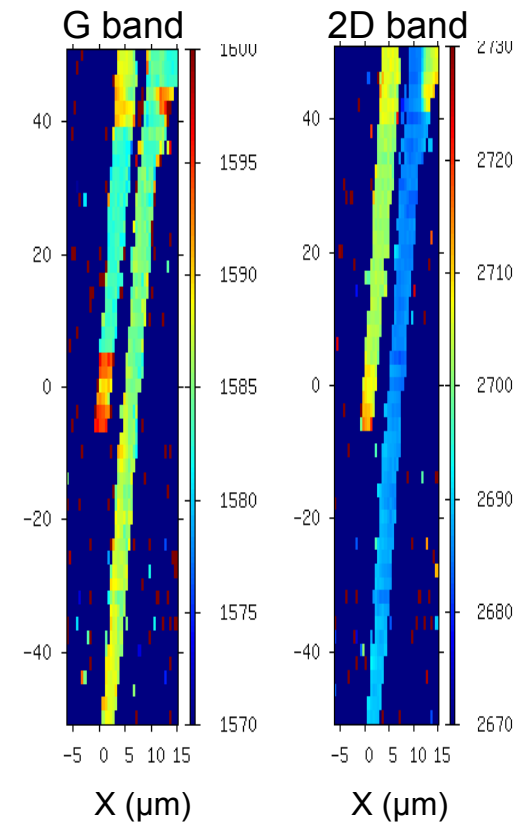
relative extinction coefficient



Raman Intensities



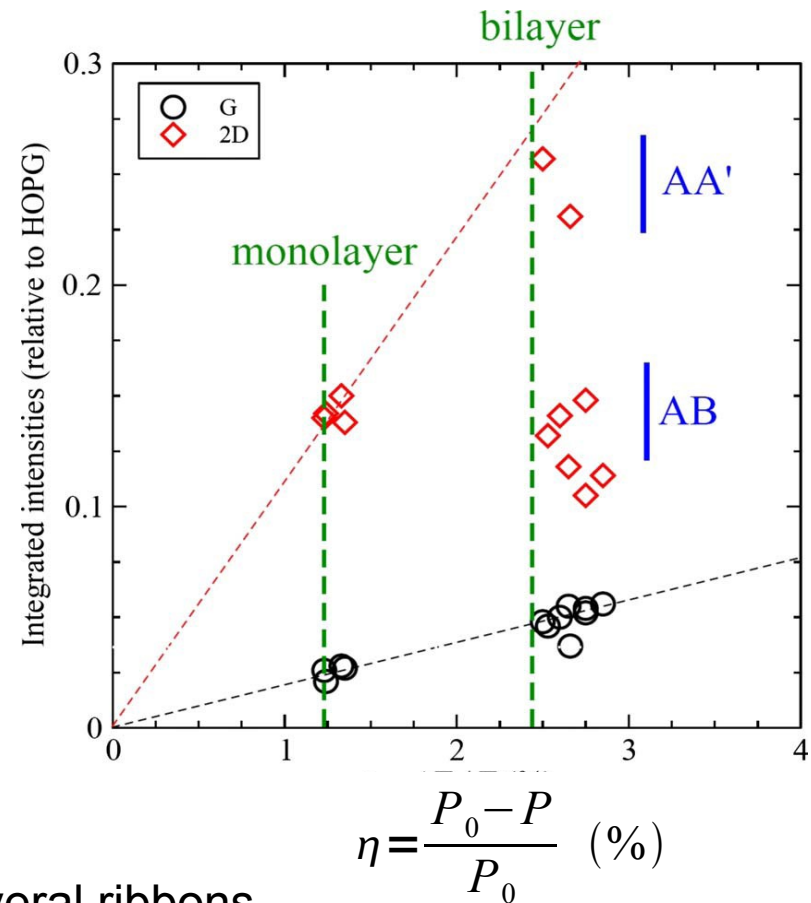
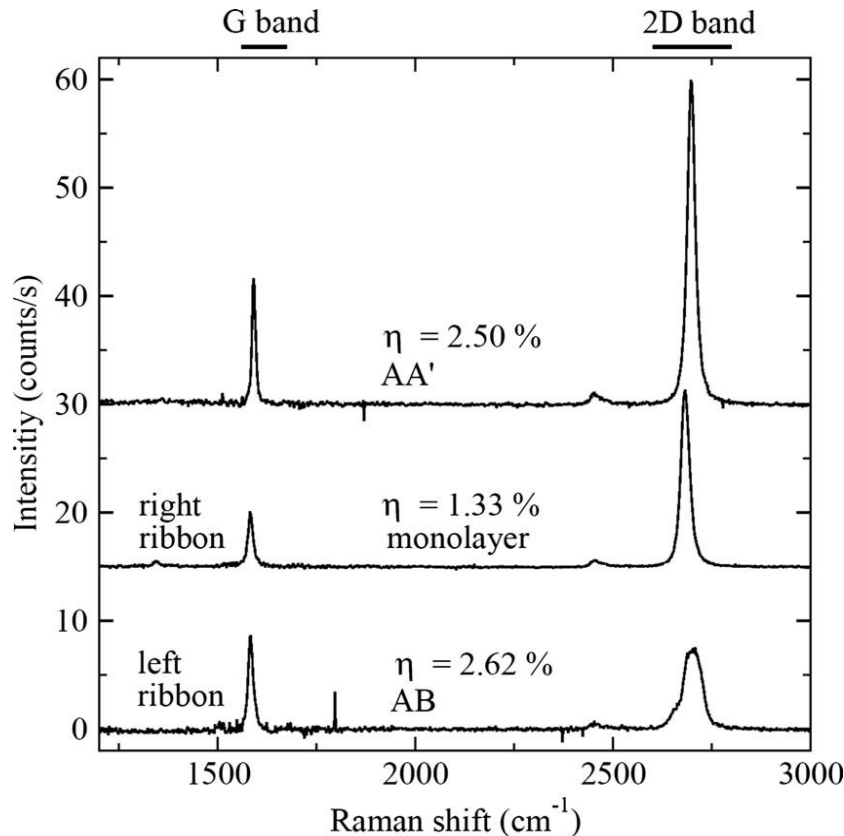
Raman shift (cm⁻¹)



N. Camara et al.,
Phys. Rev. B **80**, 125410 (2009)

ribbons strain relaxed and lightly P doped

Combined Transmission/Raman



Summary of the results measured on several ribbons
monolayer, bernal bilayer (AB) and misoriented bilayer (AA')

Summary

We developed a new experimental technique
combining transmission and raman spectroscopy
graphene thickness
stacking order
strain and doping level

Epitaxial growth of graphene on the C-face of SiC substrate yields
long isolated self organised graphene ribbons
100 μm x 5 μm
strain relaxed
neutral or lightly P doped

Acknowledgments

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CNR Catania

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