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

SiC surface reconstruction (step bunching)
Graphene grows on larger terraces

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

graphene / SiC
no optical contrast

exfoliated graphene / SiO₂ / Si

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Transmission of graphene

Free standing, in air (n=1)

Graphene optical conductivity
\[ \sigma = \frac{\pi e^2}{2 h} \]

R+T+A=1

\[ T = \frac{4n}{1 + n + \frac{\sigma}{\varepsilon_0 c}} \]


The absorptance A is proportionnal to the number of graphene sheets

Raman spectroscopy of graphene

![Graphene Raman spectrum](image)

- G band
- 2D band

Intensity (counts/s)

Raman shift (cm\(^{-1}\))

Graphene monolayer
Raman spectroscopy of graphene

2D band depends on the thickness and the stacking


misoriented bi-layer same as monolayer except for intensity
Combined Transmission/Raman

Theory: 
\[ \eta_{th} = 1.23\% \text{ monolayer} / \text{ SiC} \]
\[ \eta_{th} = 2.44\% \text{ bilayer} / \text{ SiC} \]
Combined Transmission/Raman

\[ \eta = \frac{P_0 - P}{P_0} \times 100 \%
\]

The left ribbon is a bernal bilayer

The right ribbon is a monolayer

![Graph showing Raman spectra with G band and 2D band, indicating the percentage of intensity changes between the left and right ribbons.](image-url)
Combined Transmission/Raman

relative extinction coefficient

\[ \eta = \frac{P_0 - P}{P_0} \, (\%) \]

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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')

\[ \eta = \frac{P_0 - P}{P_0} \times 100 \% \]
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-organized graphene ribbons:
- 100 µm x 5 µm
- strain relaxed
- neutral or lightly P doped
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