X-Ray Diffraction of Buffer Layer Graphene on SiC

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Why Graphene?

- 2-D material: Carbon
  - All atoms are surface atoms
- High carrier mobility
  - Up to 60,000 cm$^2$/Vs
- Potential material for post-silicon integrated circuits
3 Methods of Graphene production

- Mechanical Exfoliation
  - Scotch Tape method
  - Inexpensive, poor quality
- Chemical Vapor Deposition
  - Gaseous carbon deposits on metal substrate
  - Inexpensive, difficult to manipulate
- Epitaxial growth on SiC
  - Expensive, but best quality
Buffer layer samples grown by heating SiC to 1400°C in controlled vacuum

Sublimation of Si from SiC

Carbon left behind, restructures into graphene on cooling
Buffer Layer

Graphene

Buffer layer

SiC

Si-face

C-face

Image credit: T. Maassen. 2013
Buffer Layer

Band gap observed in Buffer Layer Graphene

Image credit: M. Nevius 2015
Objectives

- Accurate measurement of Buffer Layer Lattice constants and structure
- Overall goal is a more accurate model of surface reconstruction and shape
- A model of surface structure can be used to better understand properties of the material!
Problems – Surface Physics is Hard!

- Surface reconstructions
- Completely different structures
- SiC surface reconstruction
Double-Slit

Used to make measurement of extremely small repetitive structures
X-Ray Diffraction

Bragg’s Law: \[ n\lambda = 2d \sin \theta \]

High Energy, high resolution
Diffraction of a 2-D structure
Diffraction pattern of epitaxial Graphene (LEED image)
XRD at Soleil synchrotron

"Schéma de principe du synchrotron" by EPSIM 3D/JF Santarelli, Synchrotron Soleil
XRD performed on samples in April 2015

What I did:
- AutoCAD “map” of SiC & Buffer Layer Graphene diffraction pattern
- Data analysis and curve fitting of XRD data
Results

Buffer Layer Graphene Peak

3 important parameters:
- Position
- Height
- Width (FWHM)
Results

Buffer Layer SiC Reconstruction Peaks

Intensity (counts/sec)

k

$5/6_{\text{SiC}}$

$(0,1)_{\text{SiC}}$

$7/6_{\text{SiC}}$
Results

(0,1)_{SiC}
Improving the surface model:
- SiC interface reconstruction layer has a strained lattice constant, and that strain oscillates with some periodicity
- Buffer layer Graphene is commensurate with SiC structure every 6\(^{th}\) atom
Further questions

- More XRD data from more points can refine model
- Does the buffer layer graphene lattice constant also oscillate?
- When you put monolayer on top of buffer layer, how does that change the surface?
1. Formal Lesson plan on fitting a curve to a set of data
2. More AutoCAD uses and applications
3. Optics and Diffraction content
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