Electron Spin Resonance of Graphite and Graphene

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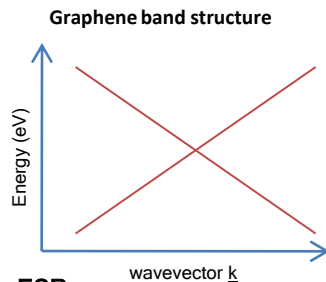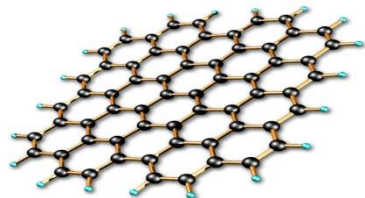[2]Department of Nanomaterial Science, Chiba University, Chiba, Japan

Introduction

Gaphene-
- ❖Zero effective mass of electrons due band structure
  - ➤ Causes high electron mobility (100 times that of silicon at room temp)
- ❖Small spin-orbit coupling of carbon atoms
 - ➤Highly desirable in spintronic devices

Graphene band structure

Energy (eV) vs wavevector k

ESR-
- ❖Used to explore spin properties of electrons in graphite and graphene
- ❖Will determine g-factor using this method

Methods and Sample Prep

- ❖Sample subjected to constant 9.2 GHz microwave frequency v
- ❖DC magnetic field B_0 scans over sample
- ❖When B_0 satisfies $\hbar v = g\mu_B B_0$ electrons absorb microwave photon energy
- ❖Lock-in amplifier separates signal from noise
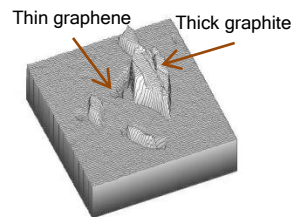- ❖Produces absorption peaks as function of magnetic field strength

B=0   B≠0

microwave

Optical Microscope 100X magnification
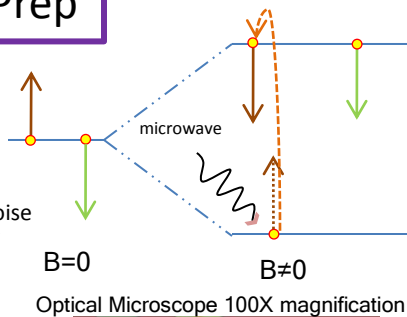
graphene

- ❖Used kish and HOPG graphite
- ❖Prepared sample using exfoliation and scraping techniques
- ❖Light pink areas in right photo are graphene
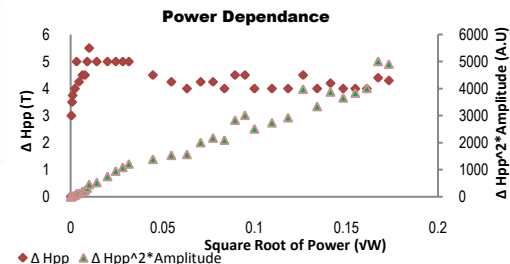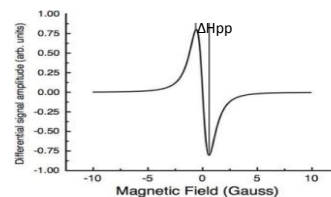- ❖Glue and green areas are graphite

Results

Graphene

- ❖Field based ESR insufficiently sensitive to detect the microwave absorption of graphene
  - ➤Size of sample produced by exfoliation is to small
  - ➤Interference from surrounding graphite dwarfed the graphene absorption

Thin graphene   Thick graphite

Graphite Power Dependence-

ΔHpp

Differential signal amplitude (arb. units) vs Magnetic Field (Gauss)

Power Dependance

Δ Hpp (T) and Δ Hpp^2*Amplitude (A.U) vs Square Root of Power (√W)

◆ Δ Hpp   ▲ Hpp^2*Amplitude

T_1	2.35×10^{-12} s
T_2	8.6×10^{-9} s
g-factor	2.0034

Conclusion

- ❖Detected graphite absorption spectrum
- ❖Derived graphite g-factor
- ❖Calculated T_1 and T_2 relaxation times

- ❖Will implement low temperature aspect to power dependant testing
- ❖Must use resistive techniques in order to determine graphene g-factor

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