Characterization and fabrication of monolayer graphene on h-BN semiconducting devices

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Since first isolated in 2004, graphene has established itself as a promising material in semi-conducting devices, exhibiting a host of unique properties regarding collective electron behavior.1 With respect to electronic applications, graphene’s massless charge carriers, referred to as Dirac fermions and exhibiting a relativistic-like energy dispersion, offer the potential to push semiconductor technology past the usage of silicon, whose mobility is far exceeded by that of graphene.2 However, because this high mobility is primarily observed only in isolated settings, one of the objectives for graphene researchers in electronics has been to create and perfect more-practical graphene field effect devices (FEDs). While retaining ultra-fast carrier mobility is difficult, mobility in graphene FEDs still exceeds that in traditional silicon devices.3 Since traditional FEDs are typically fabricated on silicon/silicon-dioxide wafers, recent discovery of hexagonal boron-nitride (h-BN), a material with only a 1.7% lattice mismatch with graphite, has increased hope of reaching isolated graphene level mobility.4 Motivated by this, we have used a methodology involving monolayer graphene preparation by mechanical exfoliation and transfer to h-BN via PMMA. Characteristic data has been taken at low-temperature using liquid He.

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Introduction

Objective: Characterize a monolayer graphene hexagonal boron-nitride device with high mobility at low-temperature

Method

1. Preparation of graphene by micro-mechanical exfoliation (Si surface), PVA/PMMA coating
2. Preparation of BN on SiO2
3. Transfer via floating PMMA
4. Removal of PMMA and addition of photo resist (LOR, V90)
5. Photolithography
6. Vapor deposition (Au, Sn) and liftoff (NMD-3)
7. Bonding (to chip carrier) and low-temperature preparation

Sample Properties

Mobility: 1.56×10^3 [cm^2/Vs]
Carrier density (n_e): 2.25×10^11 [cm^-2]

Dirac Point (~10 V), V_g step: 1 V

Summary

This was the lab's first experiment involving graphene on BN as opposed to just SiO2. We hope that the usage of BN, a flat, hydrophobic surface (no dangling bonds) high band gap insulator, will lead to devices with higher mobility than the traditional graphene-SiO2 device.

Characteristics

n_e = 1/e(dR_xy/dB)
μ = (L/W)(eν_eR_xx)⁻¹
B_c = h/e

Low-Temperature Properties

B_c = 0.017 [T]
L_0 = 493, L = 9 [μm], W = 6 [μm]
ν_e = 2.96 × 10^12 [cm^-2/s]
μ = 4.36 × 10^3 [cm^2/Vs]

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