Synthesis and Clean Transfer of Atomically Thin Materials

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Introduction

Atomically Thin Materials

- Graphene is commonly grown using chemical vapor deposition and transferred using a polymethyl methacrylate support layer

Motivation

Primary Goals

1. Grow a uniform monolayer of graphene
2. Transfer clean, pristine graphene from growth substrate to target substrate

Common Growth Issues:

1. Graphene adlayers
2. Discontinuity
3. Intrinsic defects (I_D/I_G > 0.05)

Common Transfer Issues:

- PMMA often leaves residue
- PMMA transfer requires skill
- Wet etching method is expensive and limits scalability

Graphene Growth

Growth via Chemical Vapor Deposition

- Goal: grow a uniform monolayer of graphene
- Variables: gas volume, pressure, temperature, time, pre-treatment
- Possible methods: 2 Step Growth

Graphene Transfer

Transfer via PMMA

- Goal: provide adequate support to prevent graphene defects and achieve clean transfer
- Possible alternatives: Polyvinyl Alcohol - Rosin/PMMA Double Layer

Results: 2 Step CVD Growth

- Grow at 100:1 H_2:CH_4 ratio for 30 minutes
- 100:2 H_2:CH_4 ratio for 30 minutes
- Continuous graphene layer
- Minimal defects

Results: Liquid Copper Growth

- Problem: 2 step CVD growth still produces multilayer graphene
- Solution: Grow a continuous layer of graphene on solid copper
- Raise the temperature of the CVD reactor above the melting point of copper for 3 minutes
- Treatment on liquid copper reduces multilayer graphene regions

Conclusion

Implications of Results

- 2 step CVD growth is successful
- Liquid copper growth shows promise in decreasing areas of multilayer graphene
- Short term: Rosin is better than PMMA for the clean, defect free transfer of graphene
- Long term: PVA integration with roll-to-roll manufacturing

Future Work

- Proton transport and diffusion studies using new graphene
- Electrochemical bubbling with rosin support mechanism
- Apply transfer methods to few layer graphene and hBN

References


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