Optimization of Hexagonal Boron Nitride for 2D Electronics

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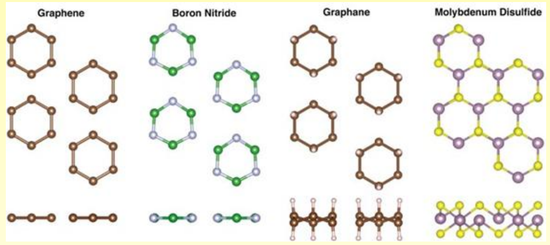
Abstract

The 2D insulator hexagonal boron nitride (hBN) has been highly researched for its exceptional thermal conductivity, high tensile strength, and isostructural characteristics with graphene. However, the optimal parameters for its synthesis by chemical vapor deposition (CVD) have never been fully understood. This study investigated the relationship between precursor temperature and the growth of hBN for further synthesis. Raman spectroscopy and scanning electronic microscopy (SEM) were used to quantify the size, percent coverage, and number of layers of hBN. This research represents significant progress to optimize the precursor temperature for high-quality, large-scale hexagonal boron nitride for potential 2D nanoelectronics and other 2D nanodevices.



[1]

Introduction

- hBN has profound and distinct properties:
  1. One-atom thickness
  2. Exceptional thermal conductivity
  3. High in-plane mechanical strength
  4. High chemical stability[2]
  5. High tensile strength (Young's modulus equivalent to diamond)
  6. Low dielectric constant (2-4)[3]
  7. Strong electrical insulation (band gap - 5.97eV)

- **Applications**:
  1. Prospective transparent and flexible electronics[4]
  2. Nanotransistors (heterostructures with graphene)

- These create a need for production of large-scale, high-quality hBN films

- **Promising method**: Chemical vapor deposition (CVD)

- The optimal parameters and fundamental growth mechanisms have not been extensively studied
- Here, we report the effects of controlling precursor temperature in CVD to study its impact on the growth of hBN

Results

Sample	BNCu59	BNCu47	BNCu46	BNCu44
T_0 (^oC)	75	80	85	90
Percent coverage	10-20 Monolayer	60-80 Monolayer	100 Monolayer (bilayer)	100 Multilayer

Figure 1 Table of precursor temperature vs. percent coverage of hBN

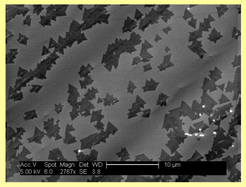


Figure 2 SEM image of hBN domains with T_o at 75^oC

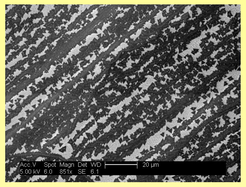


Figure 3 SEM image of hBN domains with T_o at 80^oC

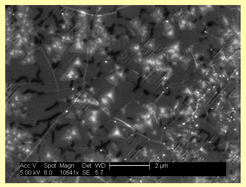


Figure 4 SEM image of hBN domains with T_o at 85^oC

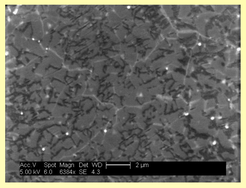


Figure 5 SEM image of hBN domains with T_o at 90^oC

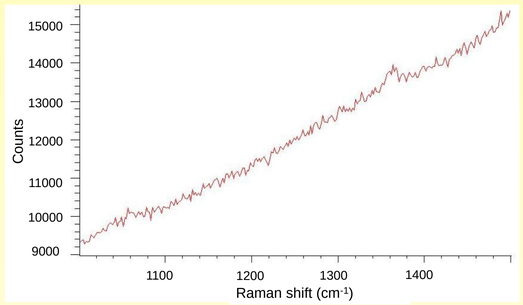
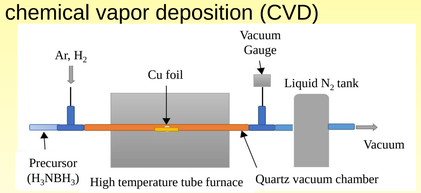


Figure 5 Raman spectrum of bilayer BN with peak at ~1366 cm^{-1}

Methods

1. Pretreatment
   - Copper foil
   - Ammonia borane (H_3BNH_3)
2. Anneal
   - High-temperature furnace
   - Low pressure chemical vapor deposition (CVD)
3. Growth
   - Parameters



Conclusions

Trend observed from the graphs and data collected:

- Increasing T_o can effectively increase:
  - the nucleation density
  - the percent coverage on Cu
  - the number of layers of hBN grown

References

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