Fabricating van der Waals heterostructures

Outline

Introduction

Methods of fabricating new materials
- The transfer setup
- Transfer methods
- Rotational alignment
- Cleaning procedures

2D material heterostructures for quantum confinement
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2D material heterostructures for quantum confinement
Van der Waals materials

Crystal:
- Layered structure

Bonding:
- Strong in-plane covalent bonds
- Weak out-of-plane van der Waals bonds

Van der Waals materials span the entire spectrum of electronic properties

3D to 2D

Adhesive tape

Si/SiO₂

3D

cope (100X)

2L graphene

Graphite

20μm

van der Waals heterostructures

New platform for quantum dots

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2D material heterostructures for quantum confinement
The transfer setup

Optical microscope

Long working distance objectives

100X, 4.5mm W.D.  5X, 23.5mm W.D.  50X, 11mm W.D.
The transfer setup

Bottom Stage:

XYZθ motion

Heated stage
Top Stage:

XYZ motion
(10nm step size)
The transfer setup

Computer controlled
  • Programmed with LabVIEW

High resolution camera

Hands free
  • Possibility to be moved into a glovebox
Transfer methods

Various methods:
- PMMA/PVA\(^1\)
- Stamping\(^2\)
- Pick-up\(^2\)

Polymers:
- PMMA
- PVA
- PPC
- PDMS

Rotational alignment
Cleaning procedures

Polymer residues

2nd layer
1st layer
Si/SiO₂

Bubbles and wrinkles

2nd layer
1st layer
Si/SiO₂
Cleaning procedures - thermal annealing
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2D material heterostructures for quantum confinement
Quantum confinement in 2D materials - graphene
Quantum confinement in 2D materials – MoS$_2$

Quantum confinement
Quantum confinement

$V_{BG} = 60 \text{ (V)}$

$V_{BG} = 42 \text{ (V)}$
Summary

Introduction – 2D materials

Methods to assemble custom, new, ultrathin crystals

2D material heterostructures for quantum confinement
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Collaborators:
- Cleanroom facilities (uOttawa)
- Raman spectroscopy
  Center for Advanced Materials Research
- National Research Council (NRC)