Light and Matter Interaction in TMDC Systems

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Outline

• Two-dimensional Transition Metal Dichalcogenides (TMDCs)
• Light Matter Interaction: Polaritons
• Sample Fabrication & Transfer Process
• Light Matter Interaction: Coherent Perfect Absorption (CPA)
• Moving Forward
2D Transition Metal Dichalcogenides

Structure

- $MX_2$ – M transition metal, X chalcogen
  - Examples: MoSe$_2$, WSe$_2$, WS$_2$ and MoS$_2$
- Bulk layered material → monolayers

Properties

- 0.6-0.7 nm thick
- Bulk Layer → Indirect gap
- Monolayer → direct band gap
- Exciton binding energy up to 500 meV
  - Good for room temperature experiments
- High oscillator strength

Light-matter Interaction: Polaritons

• Polariton: a quasiparticle of light and matter
  • Strong coupling between a photon and an exciton

• Experimental advantages for BEC in solids at higher temperatures
  • Effective mass ~ four orders of magnitude lighter than an exciton
  • Easier to extend a phase coherent wave function despite crystal defects
Sample Fabrication

• Two methods
  • Chemical Vapor Deposition (CVD)
  • Mechanical Exfoliation
    • Nicknamed the “scotch tape” method
Sample Fabrication: Transfer Procedure

- Transferring (or stacking) of monolayers from one substrate to another, or onto a DBR

1. Top hBN
2. Top & MoSe$_2$
3. Bottom hBN
4. Final
Power Dependence Photoluminescence

MoSe$_2$

Structure

- Silver (100 nm)
- TPBi (108 nm)
- SiO$_2$ - 18.5 pairs
- TiO$_2$
- Double polished sapphire

Monolayer
Light and Matter Interaction: Coherent Perfect Absorption (CPA)

- Two counter propagating waves
- Destructive interference
  - Thin film located at antinode
- 100% absorption at antinode of standing wave
Preliminary Results

Substrate

Bulk

Monolayer

R-BG = Reflection – Background
T-BG = Transmission – Background
R+T-BG = Reflection + Transmission - Background
Moving Forward

• Complete CPA experiment
• Continue CPA with different materials
• Explore new exfoliation methods
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