



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

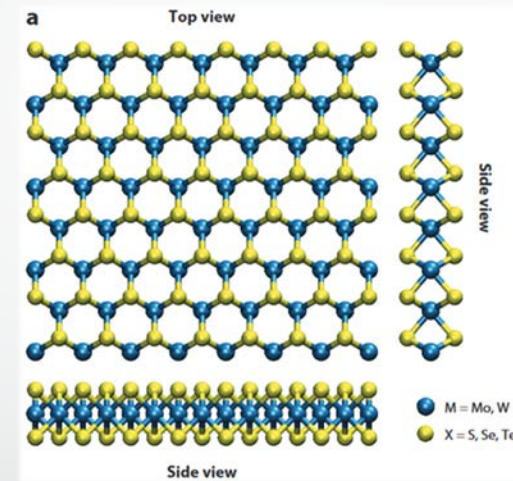
Structure

- MX_2 – M transition metal, X chalcogen
 - Examples: MoSe_2 , WSe_2 , WS_2 and MoS_2
- Bulk layered material → monolayers

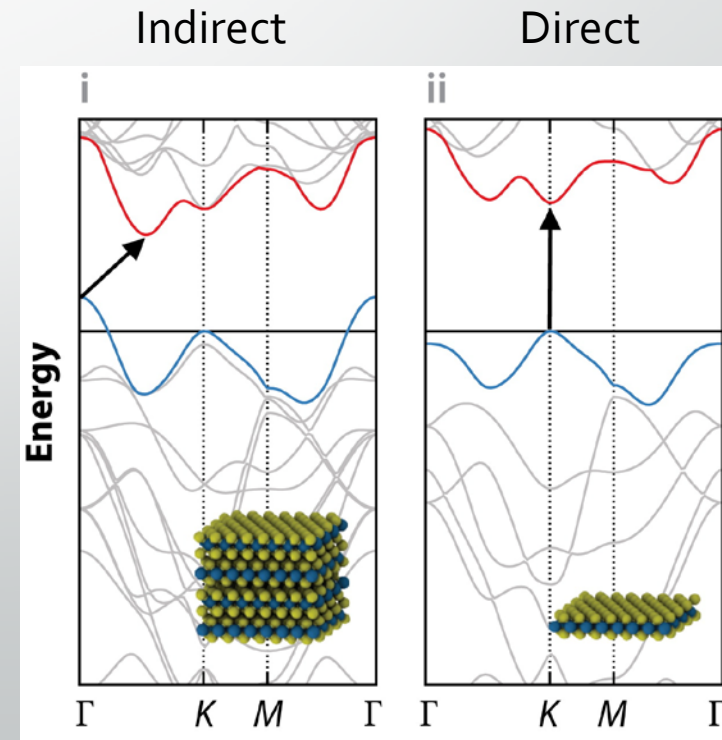
Properties

- 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

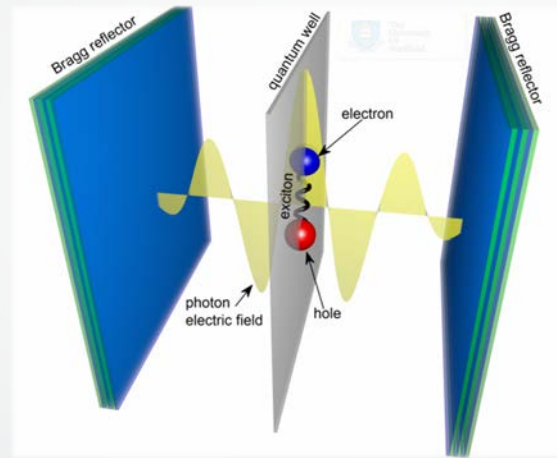


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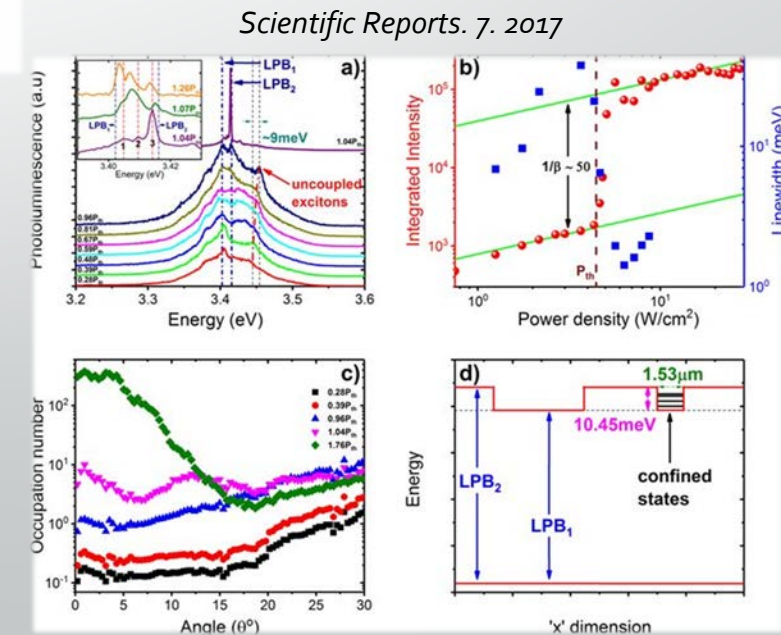


Light-matter Interaction: Polaritons

- 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 \sim four orders of magnitude lighter than an exciton
 - Easier to extend a phase coherent wave function despite crystal defects

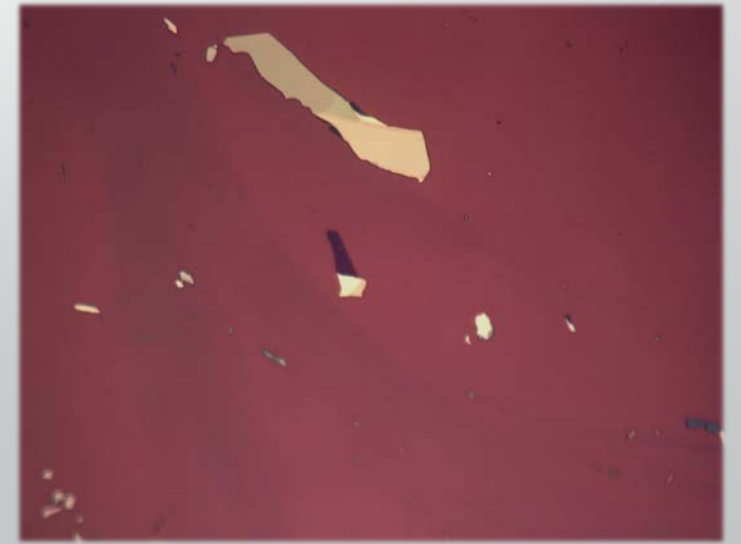
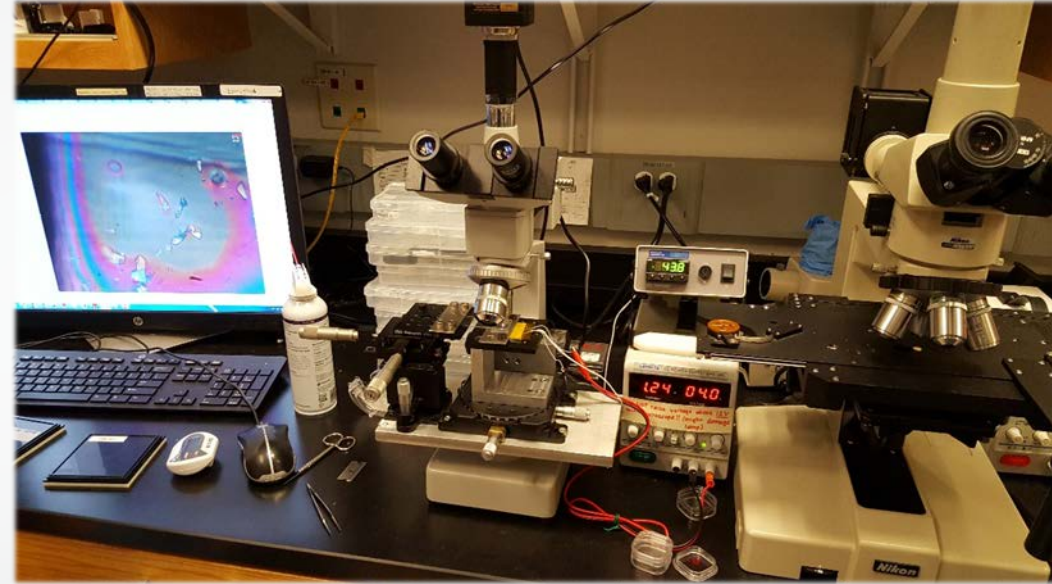


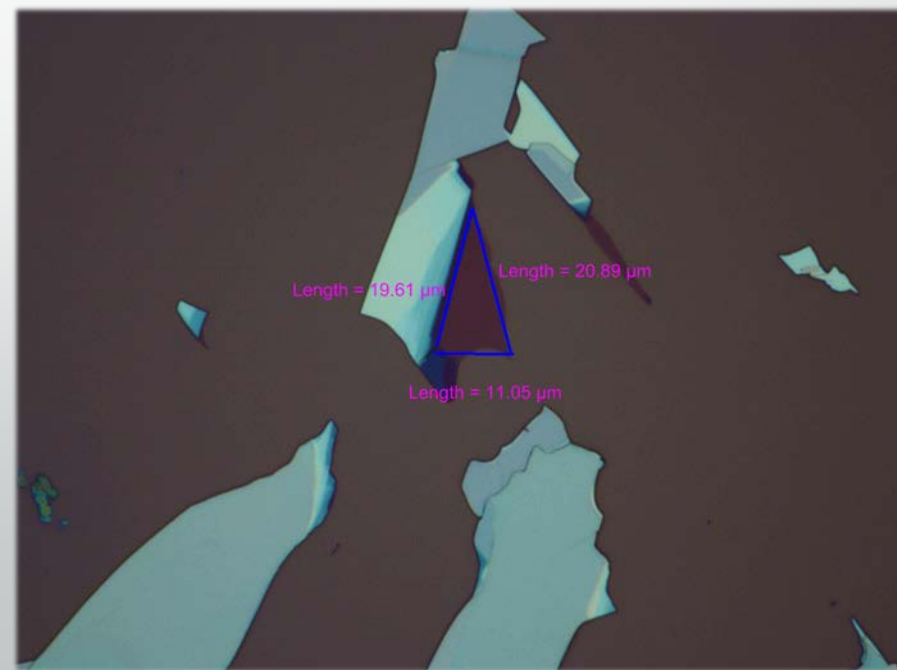
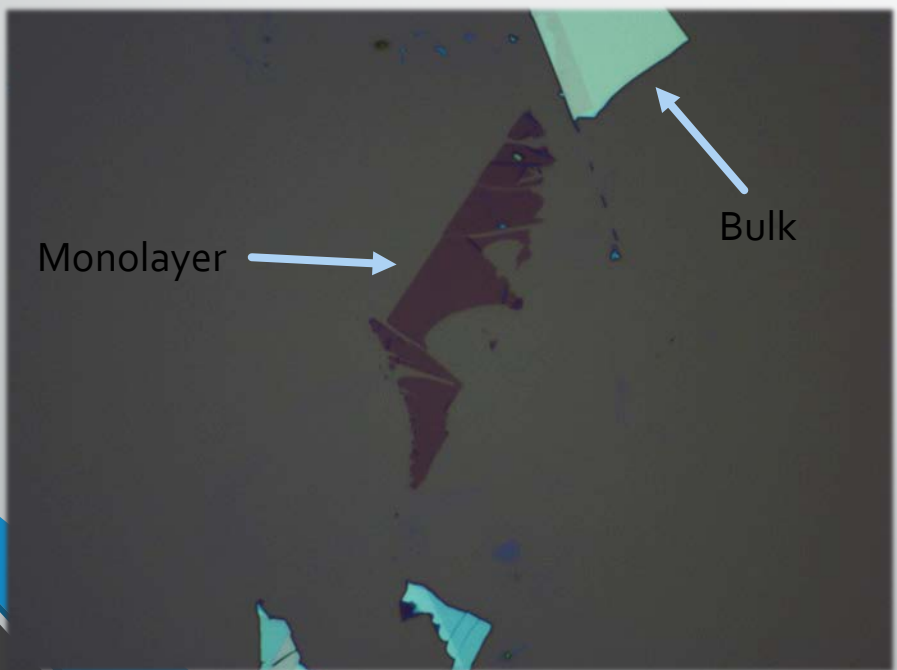
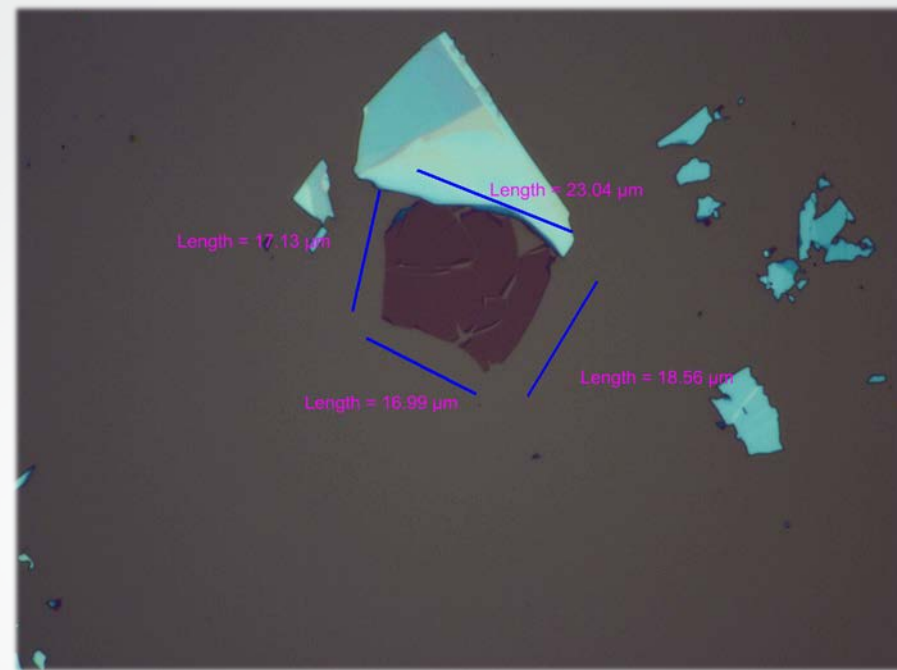
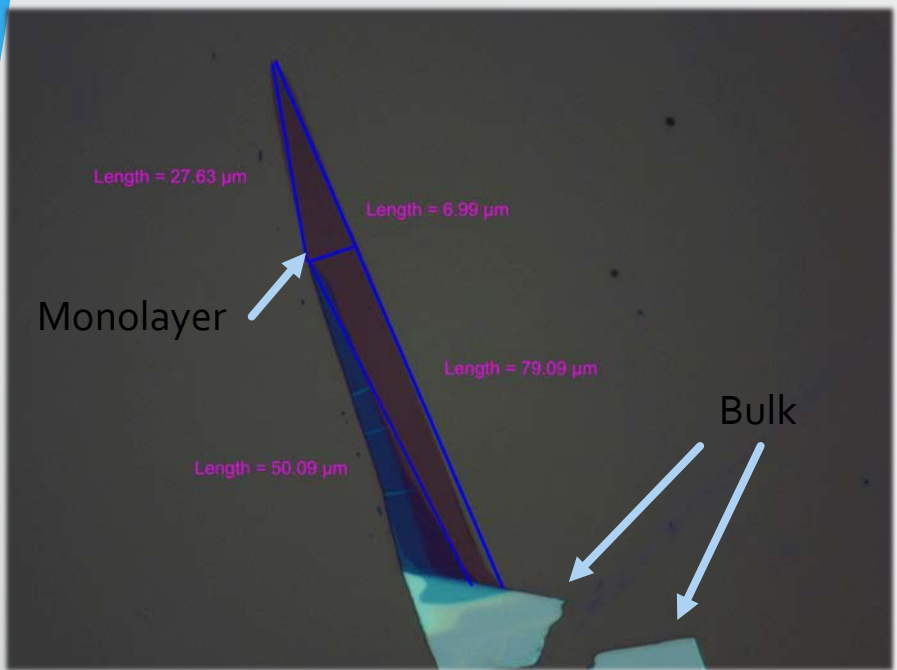
Low Dimensional Structures & Devices Group. University of Sheffield



Sample Fabrication

- Two methods
 - Chemical Vapor Deposition (CVD)
 - **Mechanical Exfoliation**
 - Nicknamed the “scotch tape” method

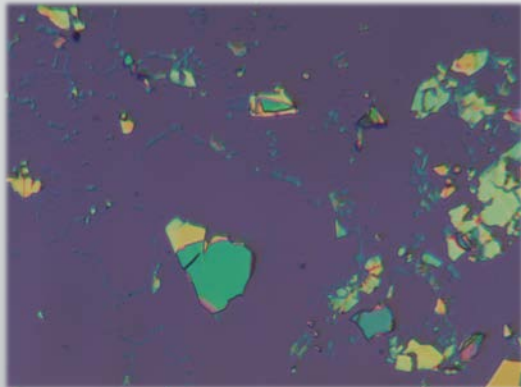




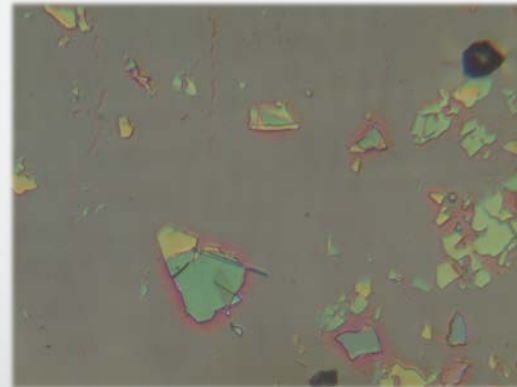
Sample Fabrication: Transfer Procedure

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

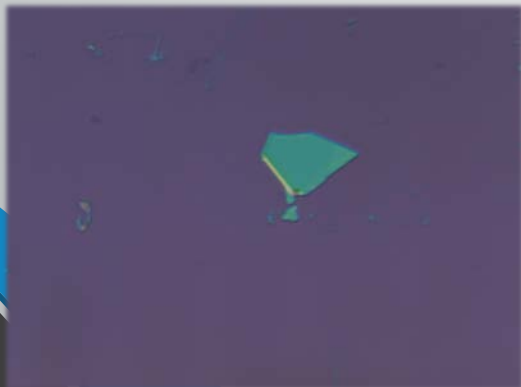
1. Top
hBN



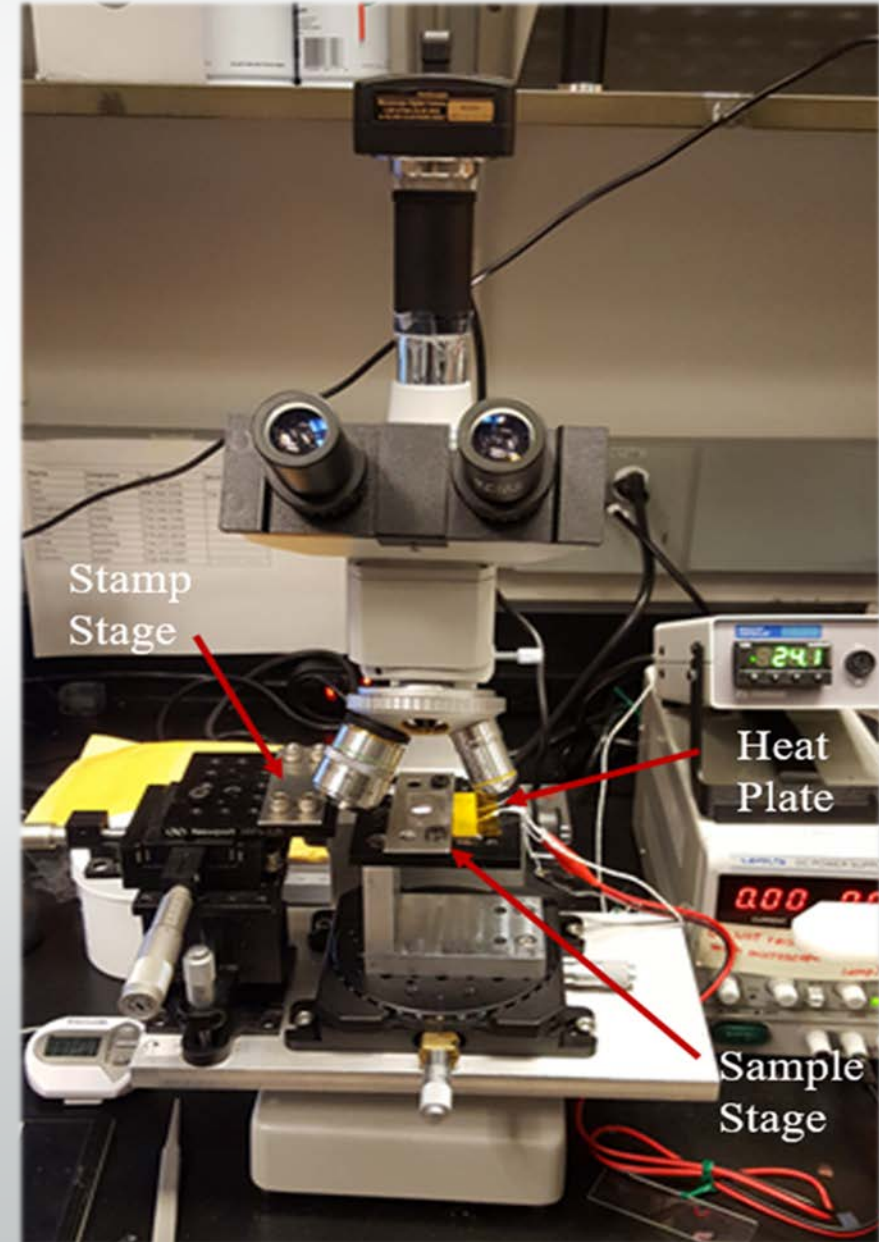
2. Top &
MoSe₂



3. Bottom
hBN



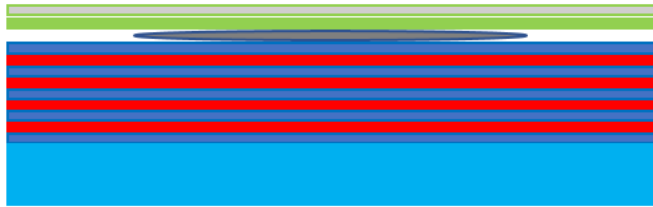
4. Final



Power Dependence Photoluminescence

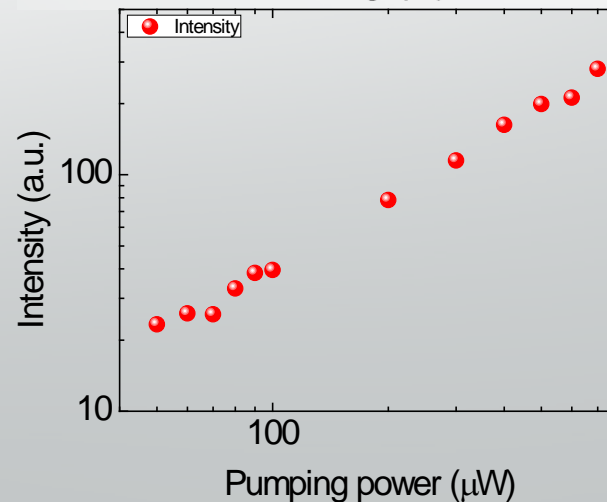
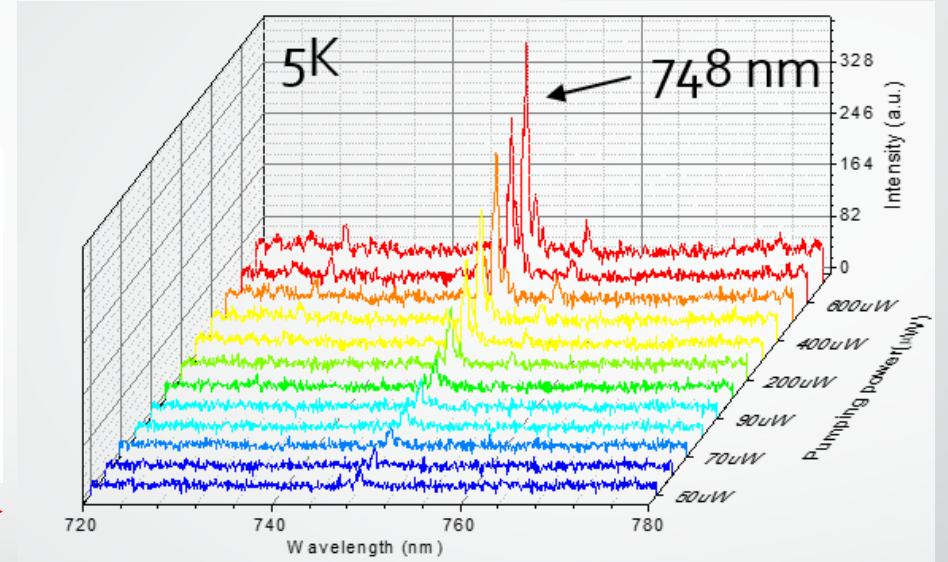
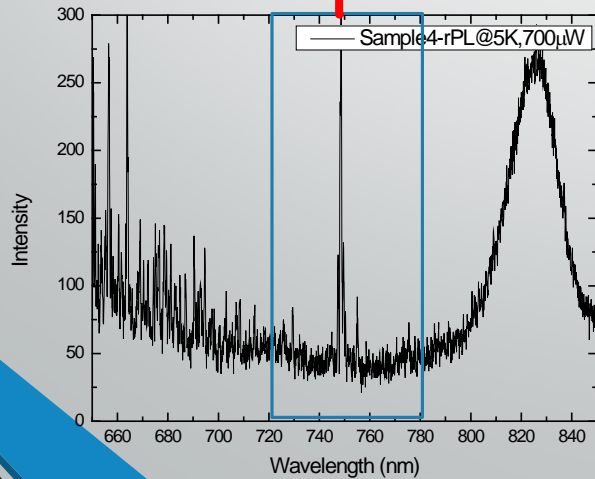
MoSe₂

Structure



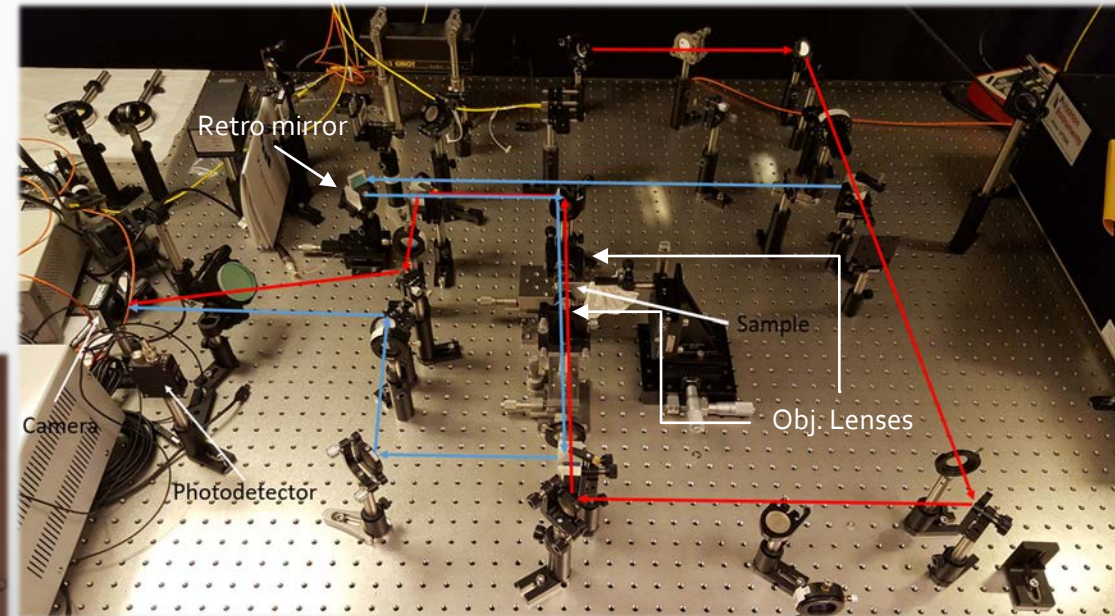
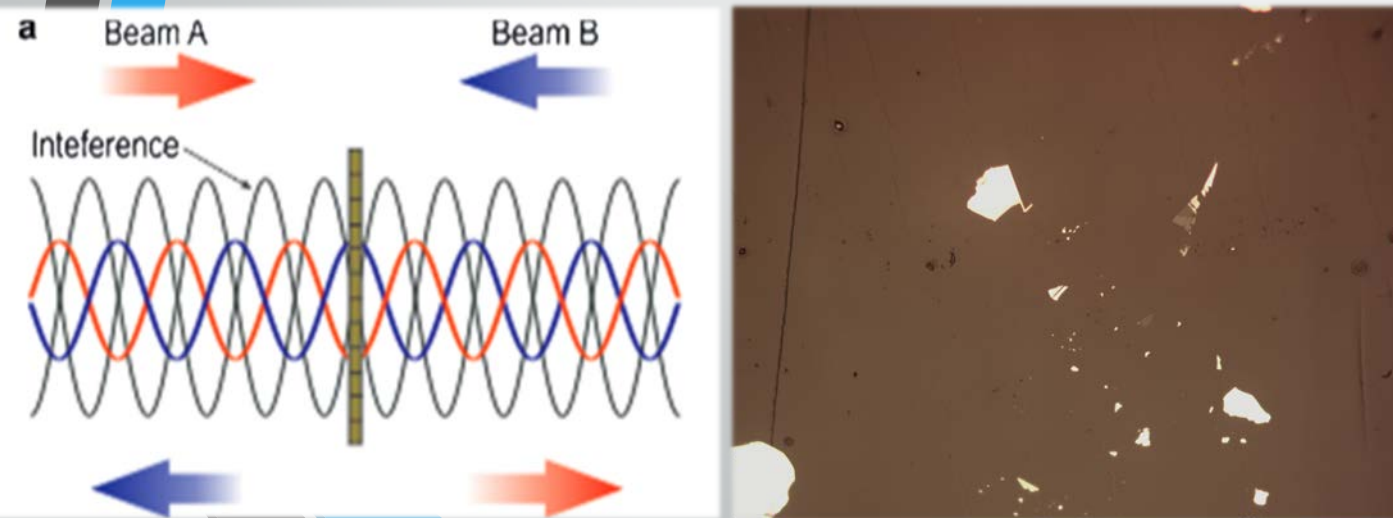
- Silver (100 nm)
- TPBi (108 nm)
- SiO₂ } 18.5 pairs
- TiO₂ }
- Double polished sapphire

Monolayer

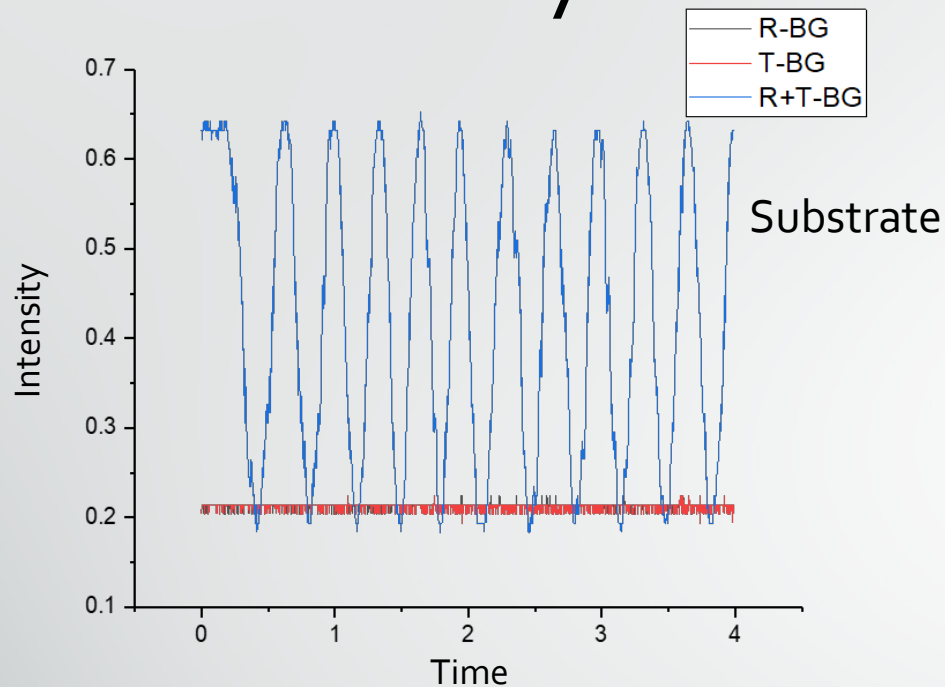


Light and Matter Interaction: Coherent Perfect Absorption (CPA)

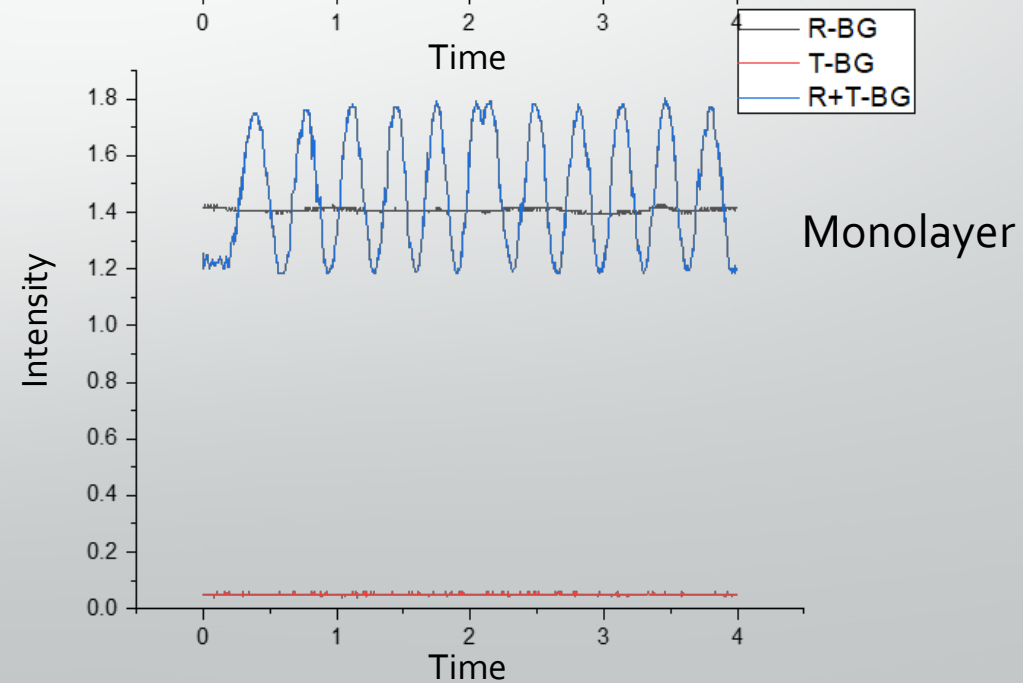
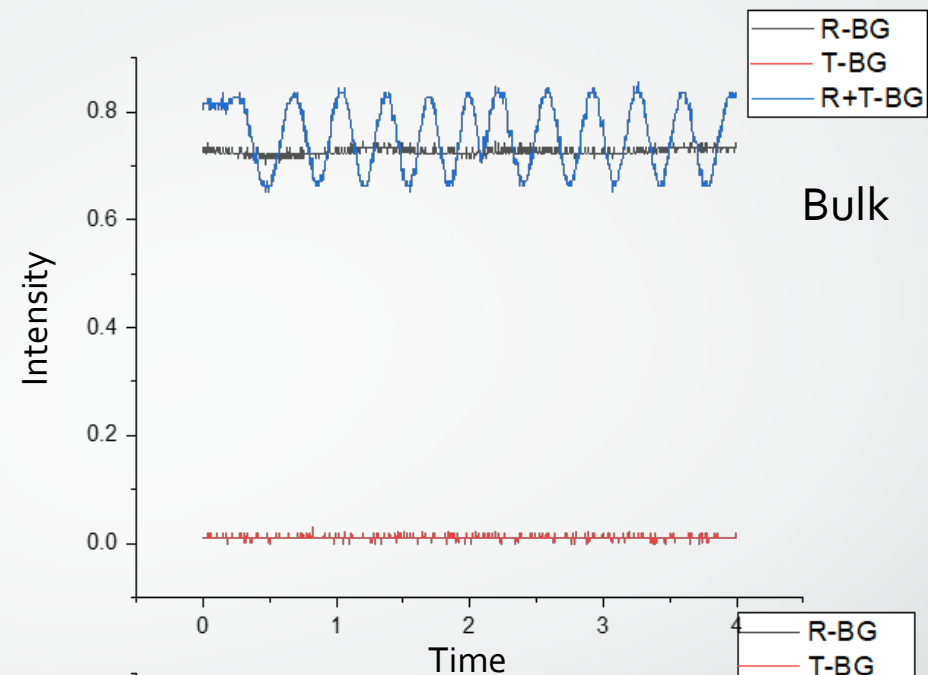
- Two counter propagating waves
- Destructive interference
 - Thin film located at antinode
- 100% absorption at antinode of standing wave



Preliminary Results



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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