Exciton and Exciton Dynamics in Transition Metal Dichalcogenide Monolayers

5th group, surface physics

Nov. 15th 2016

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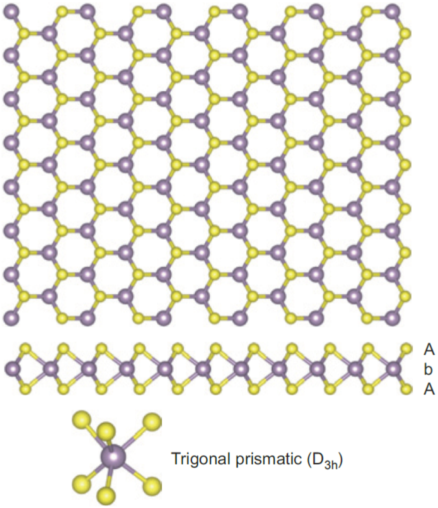
Background

Structure of Transition Metal Dichalcogenide(TMD)

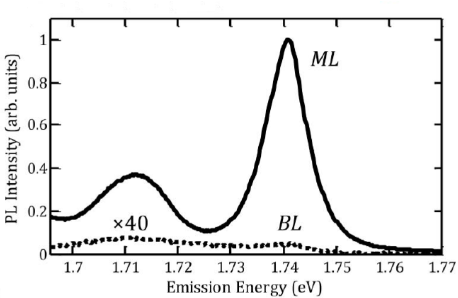


Background

Band Structure of TMD monolayer

From bulk to monolayer:

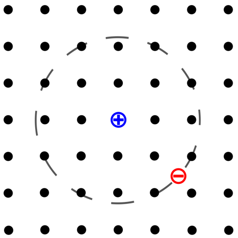
- indirect bangap to direct bangap
- increase in optical emission



Background

Brief Introduction to Exciton

Exciton:a bound state of an electron and a hole attracted to each other by the Coulomb force



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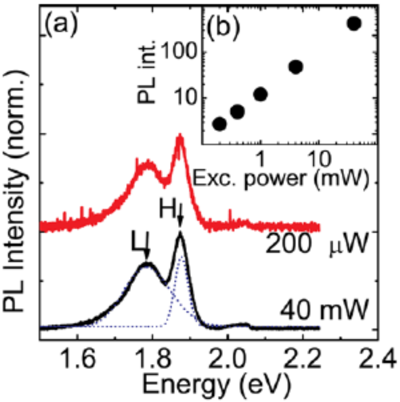
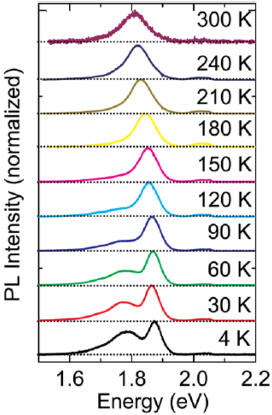
Exciton Dynamics in TMD monolayer

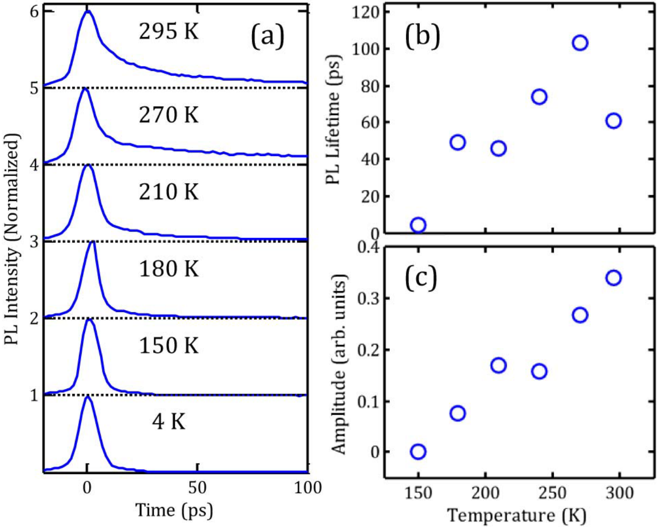
PL Study in Exciton Dynamics





Exciton Dynamics in TMD monolayer

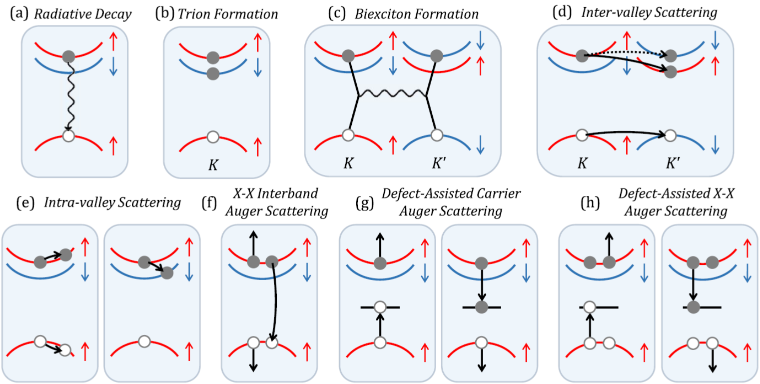
Time-resolved PL study



Exciton Dynamics in TMD monolayer

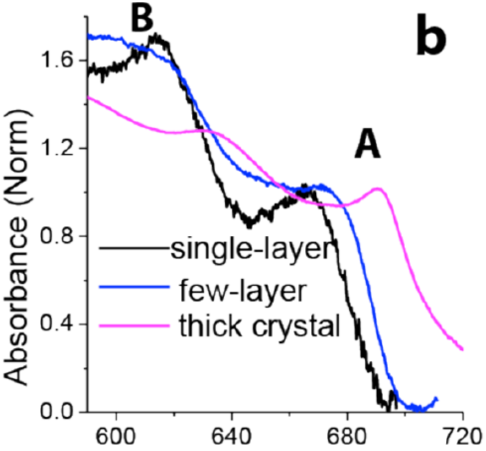
Challenges of PL Study

Radiative and non-radiative recombination processes in monolayer TMDs



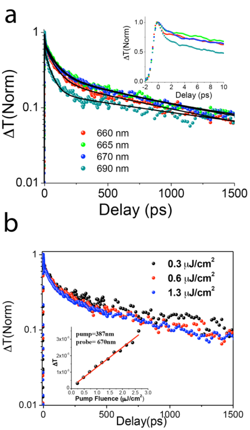
Exciton Dynamics in TMD monolayer

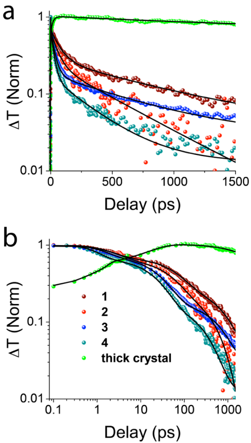
Ground State Absorbance Spectra



Exciton Dynamics in TMD monolayer

Transient Absorption Study in Exciton Dynamics





Exciton Dynamics in TMD monolayer

Transient Absorption Study in Exciton Dynamics

Triple exponential decay function:

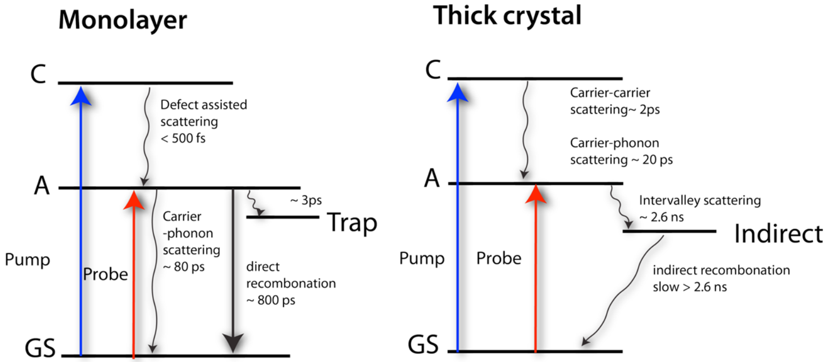
$$Ae^{-t/\tau_1} + Be^{-t/\tau_2} + Ce^{-t/\tau_3}$$

TABLE 1. Fitting Parameters for Decay Curves in Figure 4 Using a Gaussian Response Function Convoluted with the Three-Exponential Decays Function of $Ae^{-t/\tau_1} + Be^{-t/\tau_2} + Ce^{-t/\tau_3}$

	τ_1 (ps)	τ_2 (ps)	τ_3 (ps)
1 (suspended monolayer)	2.6 ± 0.1 (39%)	74 ± 3 (39%)	850 ± 48 (22%)
2 (supported monolayer)	3.3 ± 0.2 (40%)	55 ± 3 (38%)	469 ± 26 (22%)
3 (suspended few-layer)	2.1 ± 0.1 (40%)	34 ± 1 (47%)	708 ± 55 (13%)
4 (supported few-layer)	1.2 ± 0.1 (47%)	29 ± 2 (41%)	344 ± 28 (12%)
thick crystal	1.8 ± 0.6 (19%) (rise)	20 ± 2 (81%) (rise)	2626 ± 192 (100%) (decay)

Exciton Dynamics in TMD monolayer

Summary of the Exciton Dynamics



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Applications

Characteristics:

- direct bandgap
- sensitive to light
- brand spectral range
- high current on/off ratio
- ...

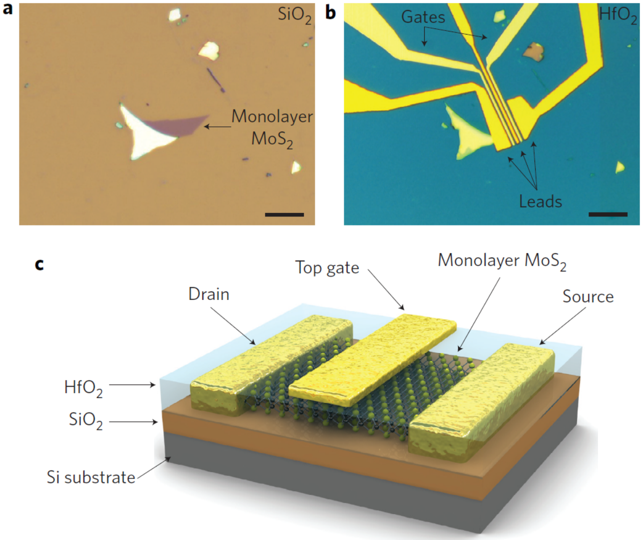
$\Rightarrow$

Applications:

- field effect transistor
- photon detector
- solar cell
- spintronic devices
- ...

Applications

Field Effect Transistor

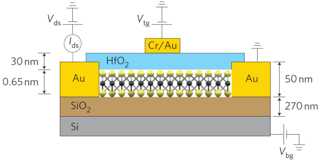


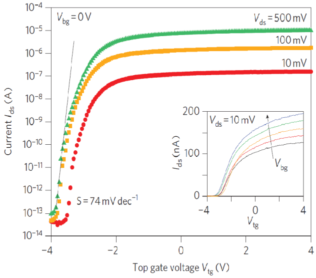
Applications

Field Effect Transistor

Advantages:

- small in size
- high sensitive to light(7.5mA/W)
- high current on/off ratio(10^8)
- high mobility($200 cm^2 V^{-1} s^{-1}$)
- ...





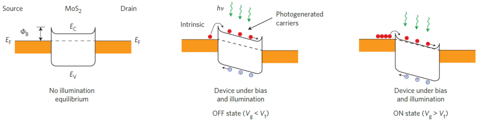
Applications

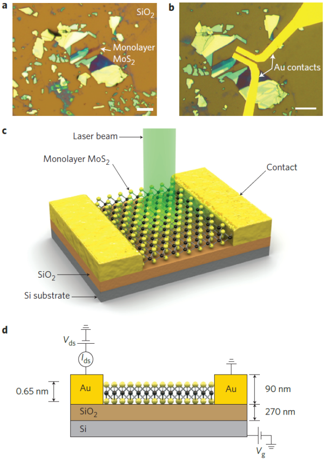
Photon Detector

How does it work:

- light-excitation of electrons
- bias

$\Rightarrow$ tunnelling through Schottky barriers

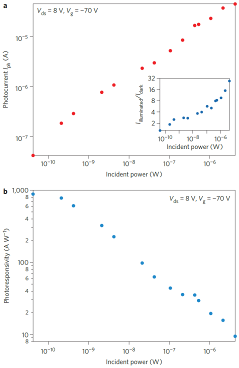




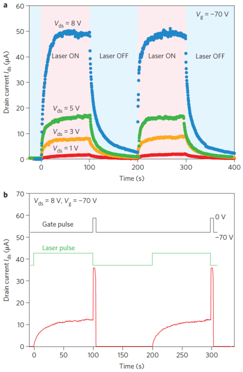
Applications

Advantages of TMD Monolayer Photon Detector

sensitive to light



quick response



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Summary

- Characteristics of TMD monolayer
  - direct bandgap
  - quantum confinement effect
- Exciton Dynamics in TMD monolayers
  - PL study
  - TAM study
- Applications
  - field effect transistor
  - photon detector
  - ...

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References I

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Thank You!