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SPATIALLY-RESOLVED PHOTOLUMINESCENCE MAPPING OF SINGLE CdS NANOSHEETS

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Motivation

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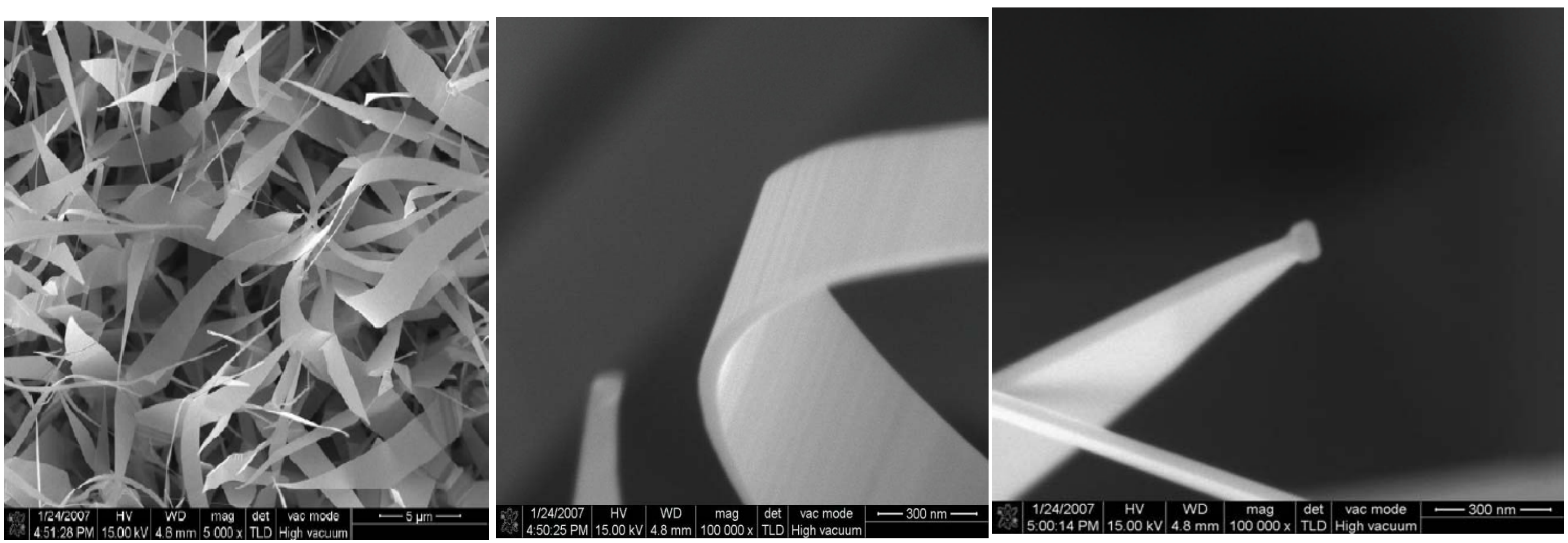
- Semiconductor nanowires and nanosheets exhibit new material properties that are of interest to both basic and applied scientists

- We are interested in exploring using single CdS nanosheets to make a sensitive biosensor for biomolecules and pathogens.

CdS Nanosheet Samples

- Grown by pulsed laser deposition using vapor-phase transport method (800°C; 20min)
- Individual nanosheets were ~50 *nm* thick; ~ 4 *um* wide and 30-100 *um* long
- Surfaces were curved & smooth with uniform thickness.



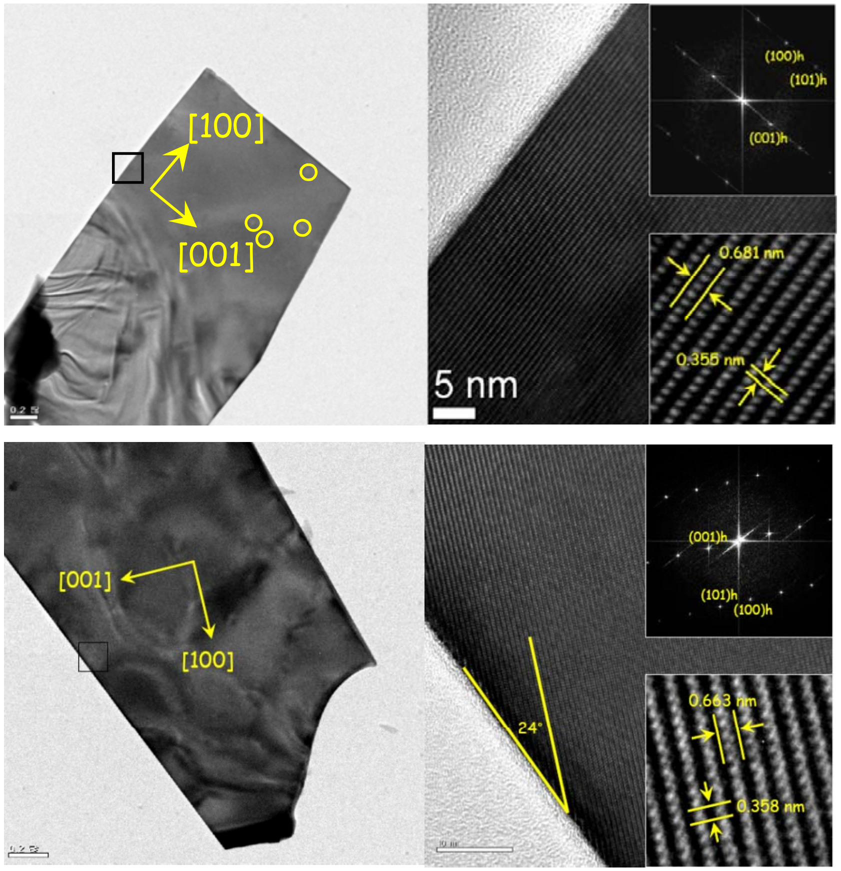
SEM images of ensemble and single nanosheets

CdS Nanosheet Samples

•HRTEM images show variation in the orientation of the c-axis

•Wurtzite structures exhibit maximum PL emmision perpendicular to C axis.

•Want non-destructive way to measure the orientation of the C axis in these samples.



Experimental Setup

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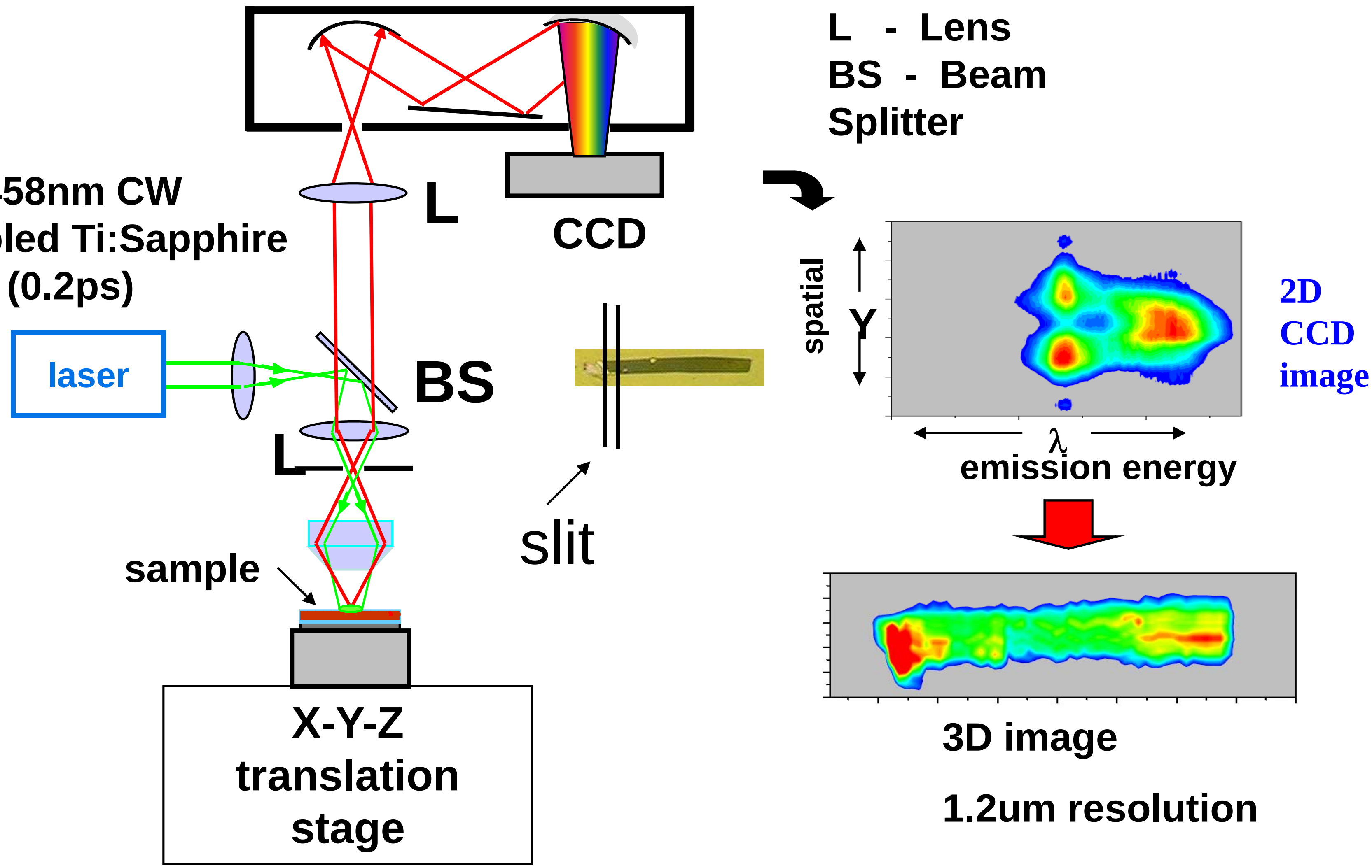
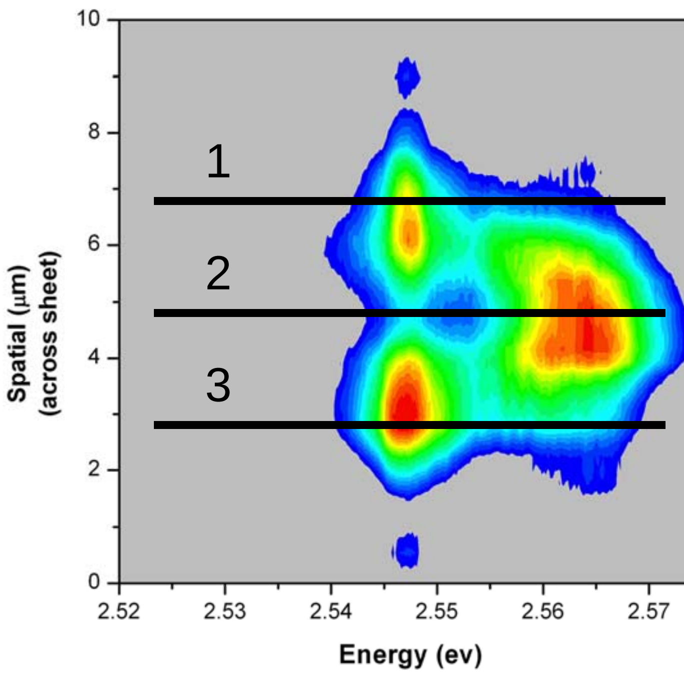
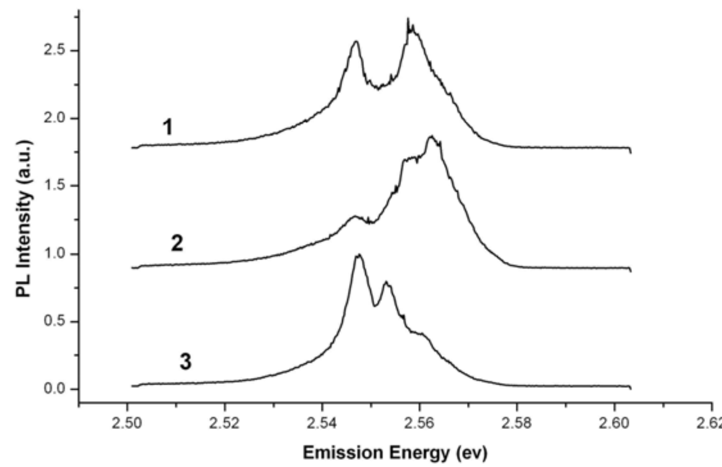
- Ar+ 458nm CW
- Doubled Ti:Sapphire 432nm (0.2ps)



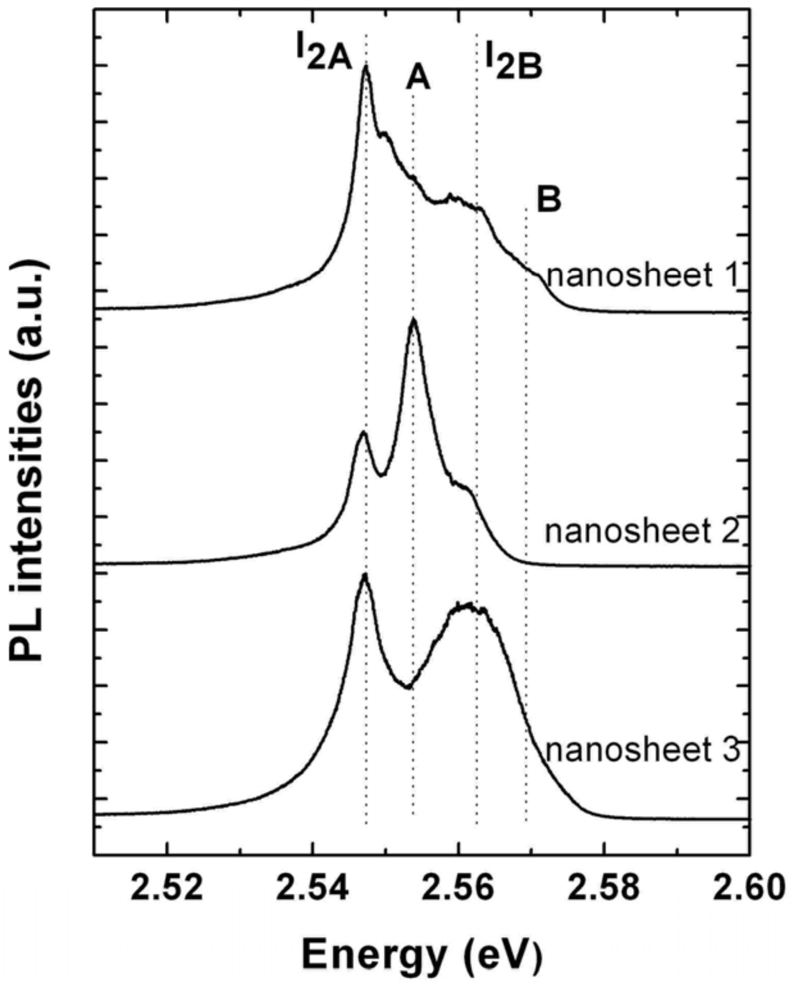
Experimental Setup





Low Temperature PL

- **PL spectra from several nanosheets show *A- and B- like exciton states***
- **Strong PL intensity indicating *high quantum efficiency***



PL Polarization

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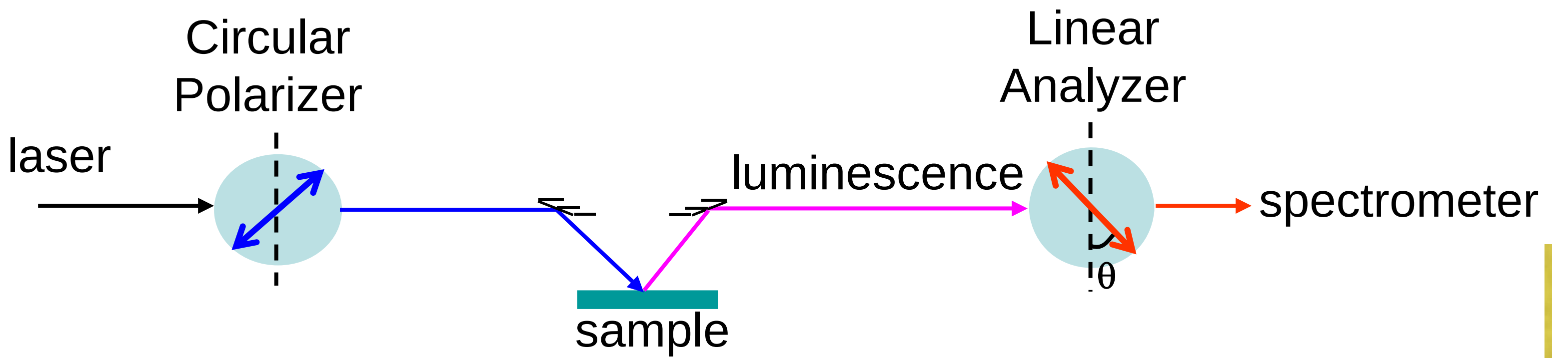
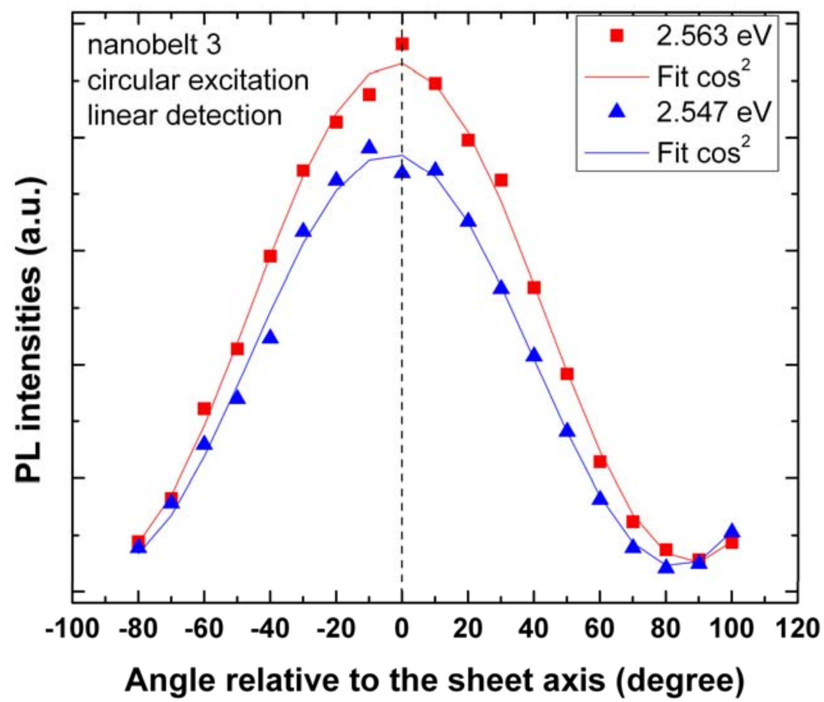
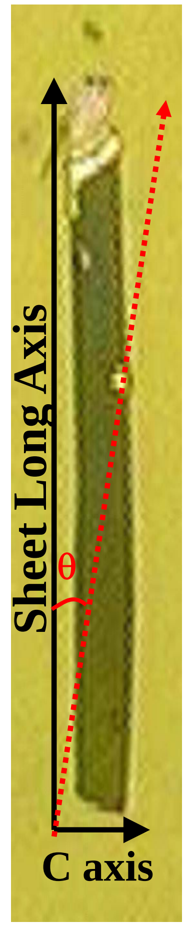


- ➢**PL emissions of A- and B-like excitons are *strongly polarized perpendicular to the c-axis***

- ➢**Consistent with HRTEM**





Low Temp PL Imaging

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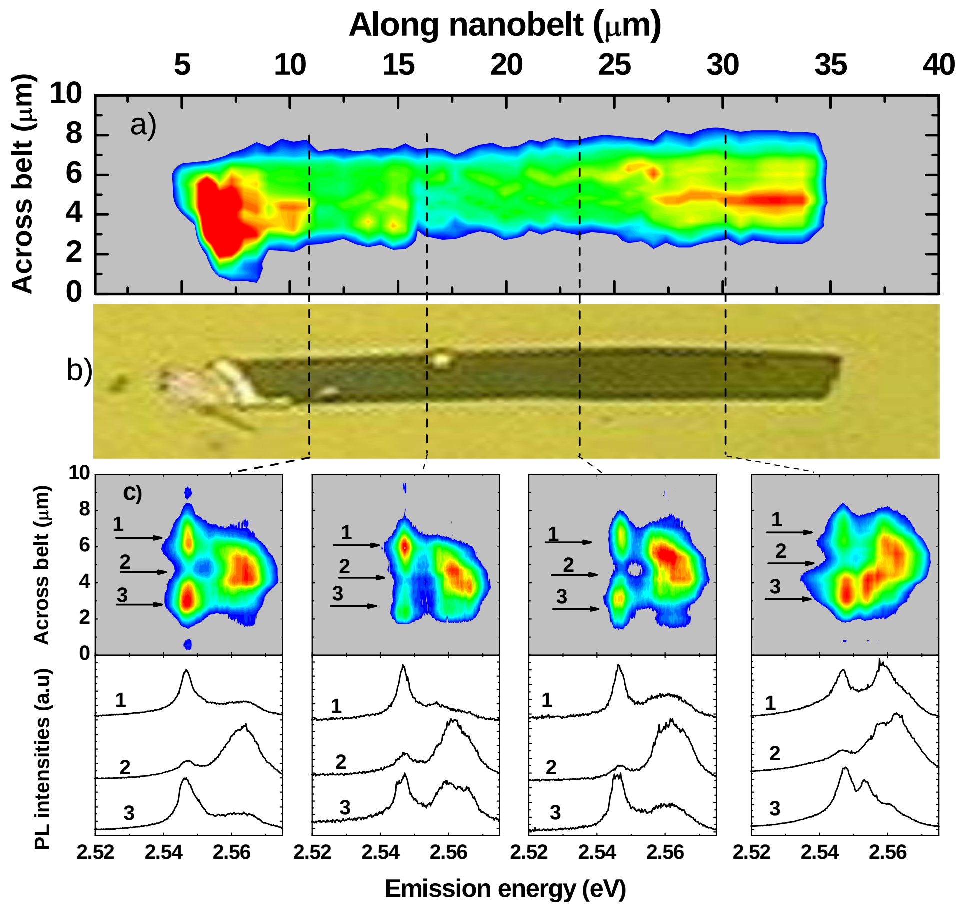

PL spectrum exhibits high variability both along and across the sheet.

Low Temp PL Imaging

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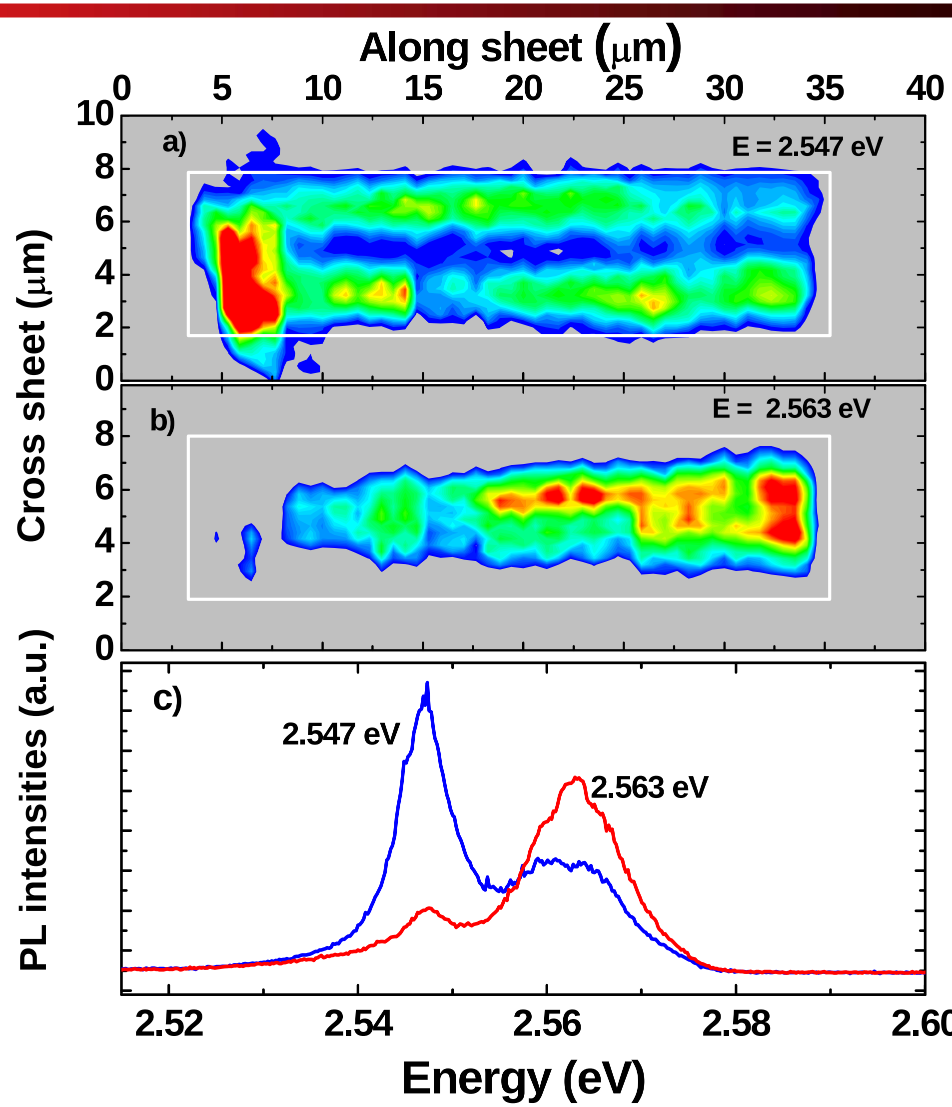
- *A- and B-like exciton emissions are spatially separated:* **lower energy excitons stronger at the edges while higher energy excitons dominate at the center**

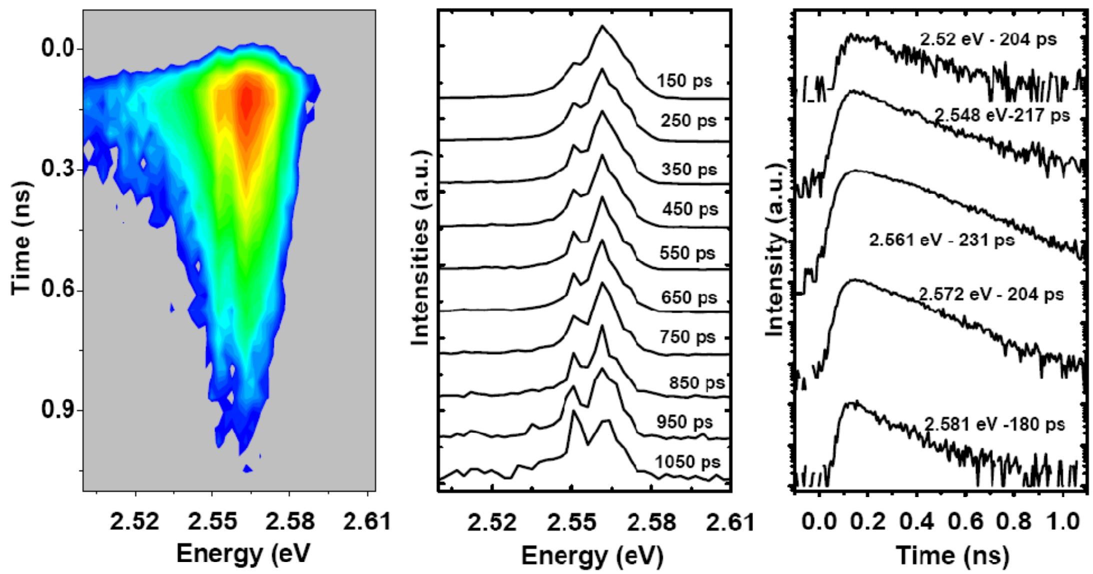
- **may suggest a spatial distribution of stress in the nanosheet**



Time-Resolved PL Imaging

- PL emission at energies 2.547 eV and 2.563 eV (I_2A and I_2B) are the most intense.

- Exhibit time-decays with lifetimes of ~200 ps: shorter than in bulk CdS (~1 ns) but longer than in CdS nanowires (< 50ps)



(Appl. Phys. Lett., 89 053119 (2006))

Photocurrent

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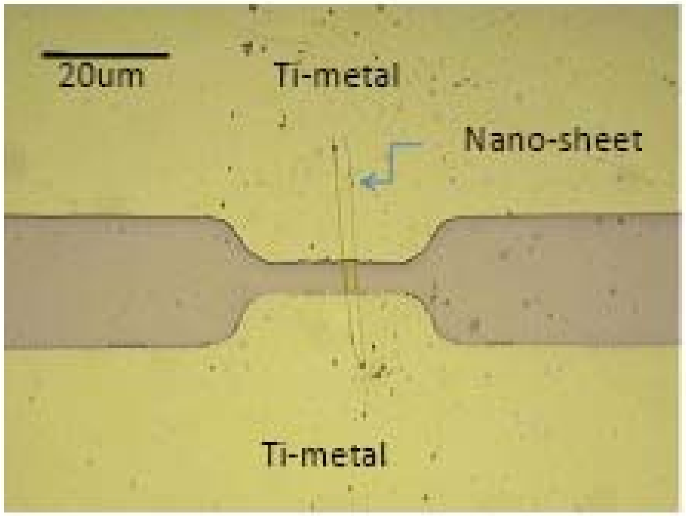
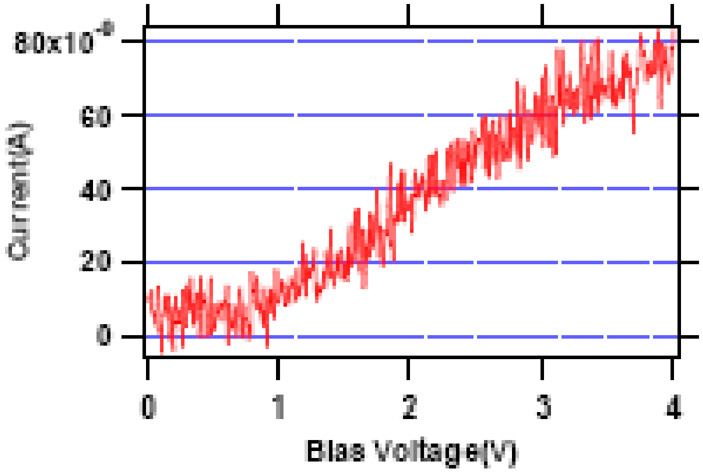
- CdS Nanosheets bridging a gap in Titanium contact pads

- Initial measurements show a photo-induced current response to a voltage bias.

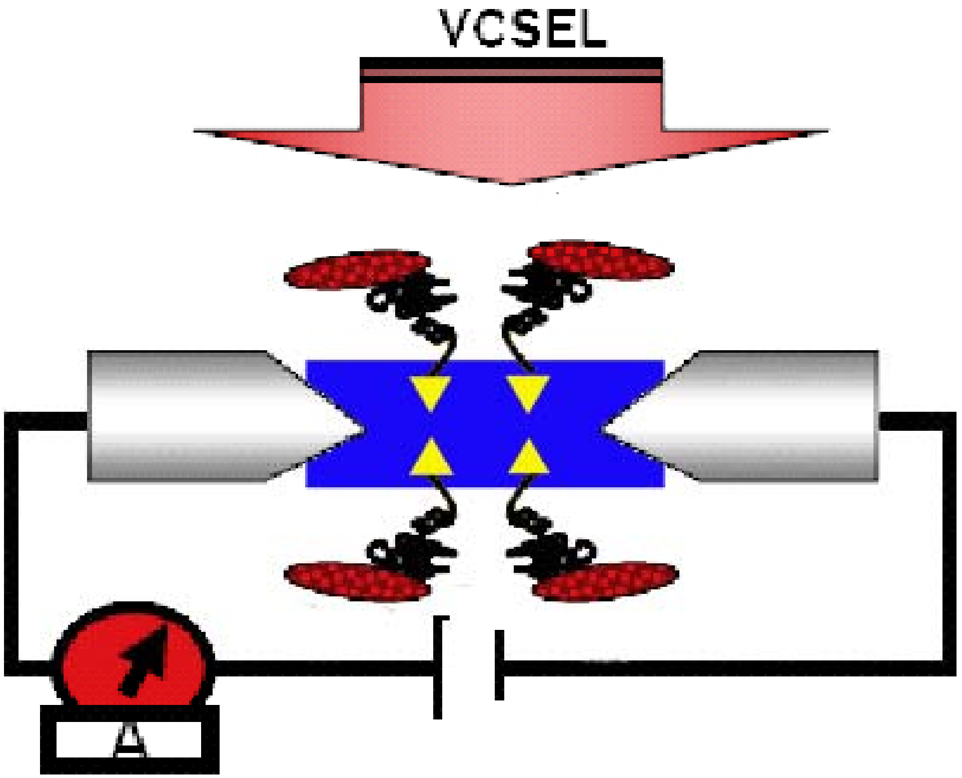




Biosensor Development

- We will use the CdS nanosheets to make device where the photocurrent responds to the presence of a pathogen.

- The next step will be to functionalize the nanosheet with antibodies sensitized to particular biomolecules or bacteria.



Conclusions

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- **Strongly polarized PL emission perpendicular to the c-axis -> agrees with HRTEM**
- **High quantum efficiency -> potential applications for nanosheet-based biosensor**
- **Spatial dependence of emission energies -> possible strain distribution in the nanosheets**
- **Exciton decay-time ~200 ps: shorter than in bulk CdS, but much longer than in nanowires**