SPATIALLY-RESOLVED PHOTOLUMINESCENCE MAPPING OF SINGLE CdS NANOSHEETS

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Motivation

- 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 μm wide and 30-100 μm 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 emission perpendicular to C axis.

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

- **L** - Lens
- **BS** - Beam Splitter

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

- Laser
- Sample
- Slit

- **X-Y-Z translation stage**

- 2D CCD image
- 3D image
  - Emission energy
  - Spatial
  - 1.2um resolution
Experimental Setup

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[Diagram showing energy distribution and spatial distribution with graphs indicating PL intensity across different energies.]
Low Temperature PL

- PL spectra from several nanosheets show \textit{A- and B-like exciton states}

- Strong PL intensity indicating \textit{high quantum efficiency}
PL emissions of A- and B-like excitons are strongly polarized perpendicular to the c-axis.

Consistent with HRTEM
PL spectrum exhibits high variability both along and across the sheet.
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.
PL emission at energies 2.547 eV and 2.563 eV (I₂A and I₂B) 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 (< 50 ps)

Photocurrent

- 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

- 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 $\sim200$ ps: shorter than in bulk CdS, but much longer than in nanowires