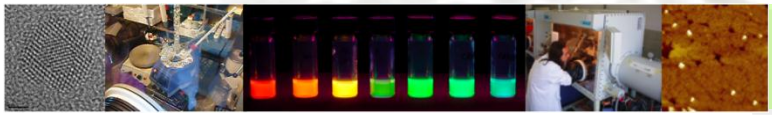
UNIVERSITEIT GENT

Physics and chemistry of nanostructures

Progress Navolchi project

March 12th, 2012

Prof. Zeger Hens
Ghent University
Belgium



Physics and Chemistry of Nanostructures Group

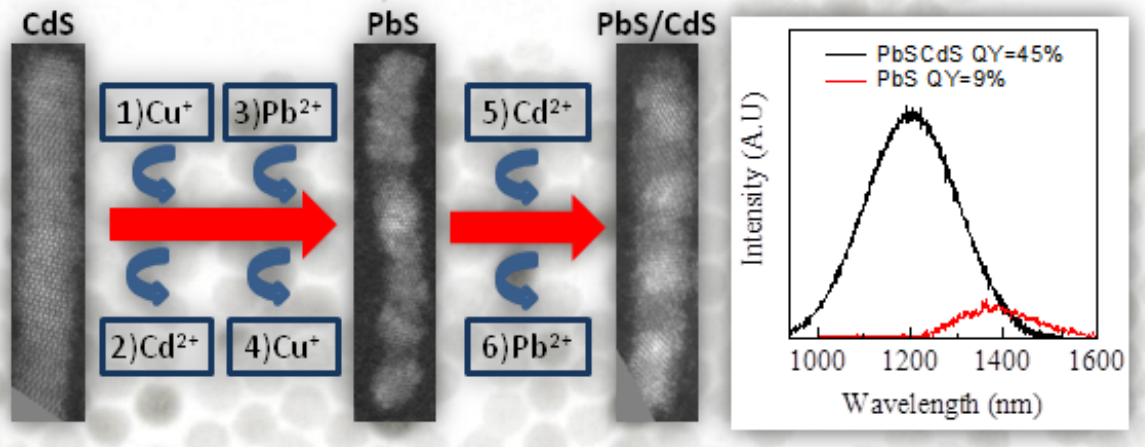
FCN

http://www.nano.UGent.be

Outline

- Materials
  - PbX/CdX heterostructures
- Processing
- Properties
  - Absorption enhancement in QD monolayers
  - Intraband absorption with PbX QDs
  - Pump-probe measurements -> amplification
- Devices
  - Absorbance of functionalized waveguides
- Planning of future work

PbS/CdS multiplie dot-in-rods

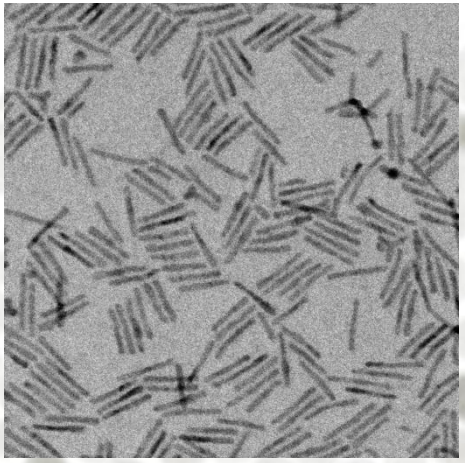


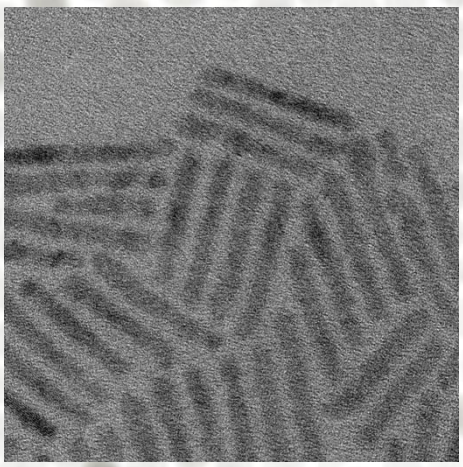
- Successive cation exchange steps transform original CdS rod into a PbS/CdS multiple dot-in-rod
- Passivation by CdS enhances PLQY to 45-55%

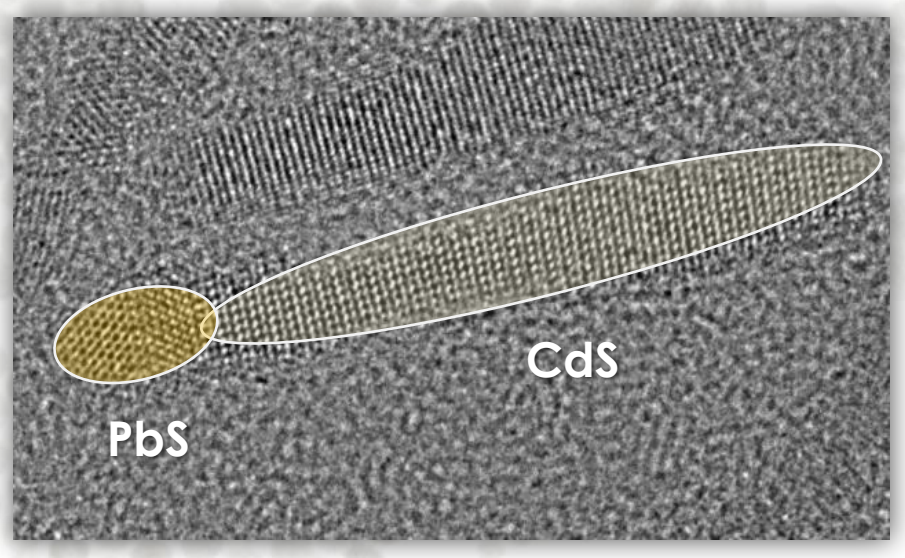
Justo *et al.*, *J. Am. Chem. Soc.* 2012, *134*, 5484–5487

PbS/CdS dot-in-rods

PbS/CdS dot-in-rods

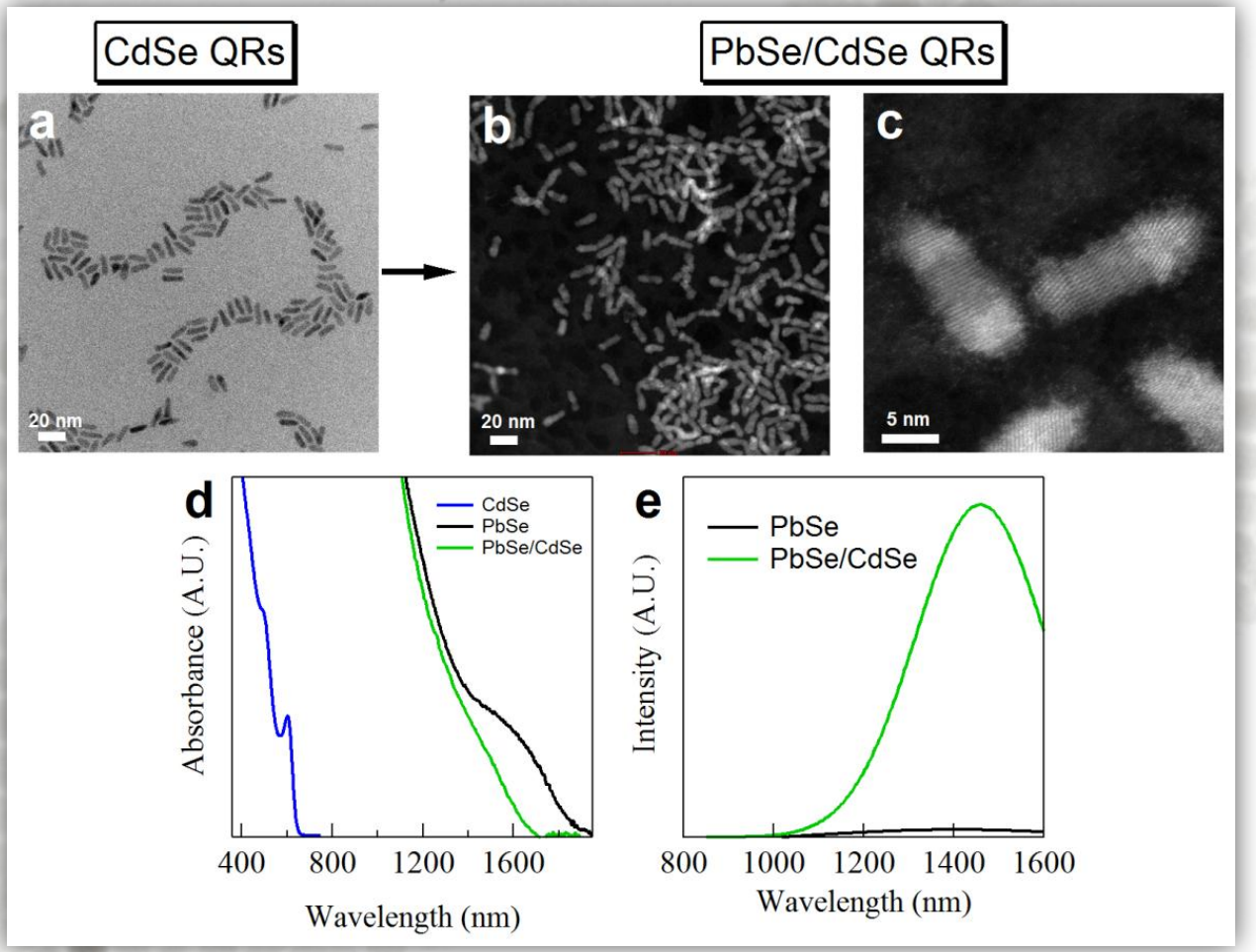




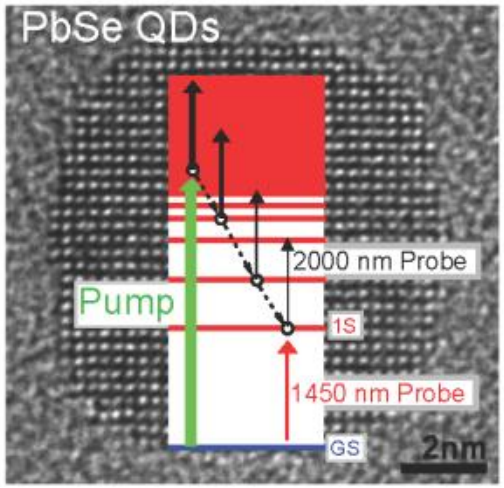


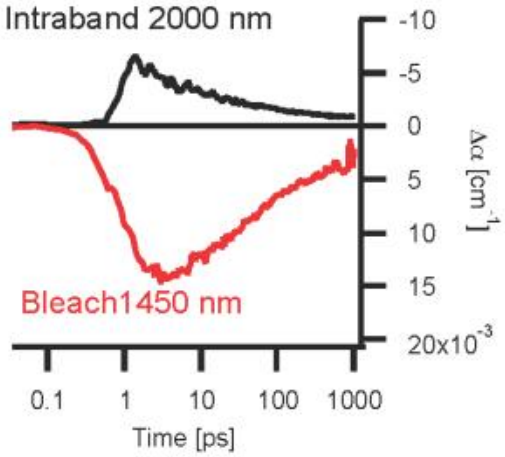
PbSe/CdSe rods

Similar synthesis as PbS/CdS dot-in-rods



Intraband absorption



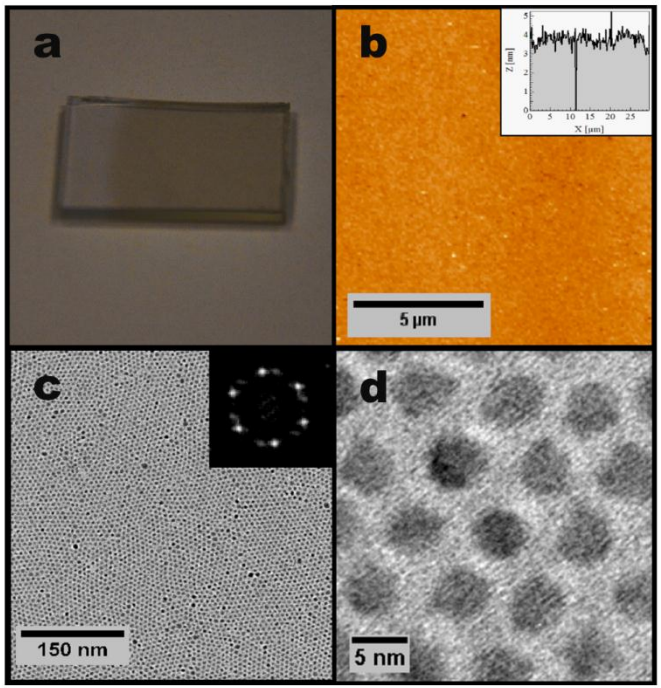


- **Potential for switching**
- **Setback for gain (raises threshold)**

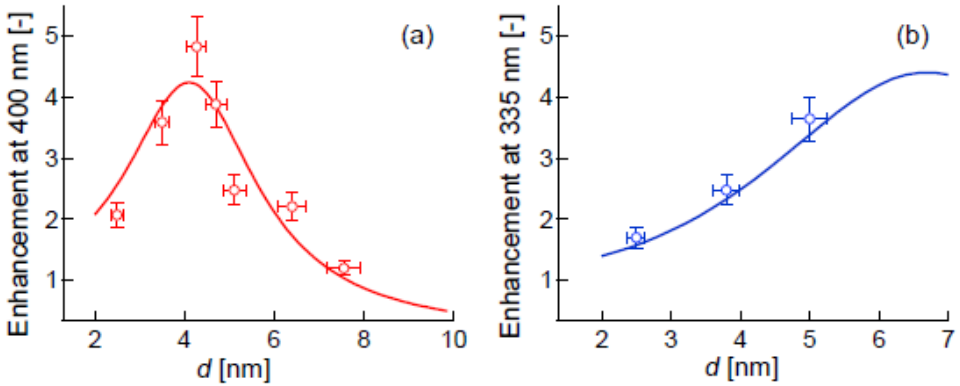
De Geyter et al., accepted by *ACS Nano*

Absorption enhancement

Measurement of absorption cross section of QDs in close packed monolayer



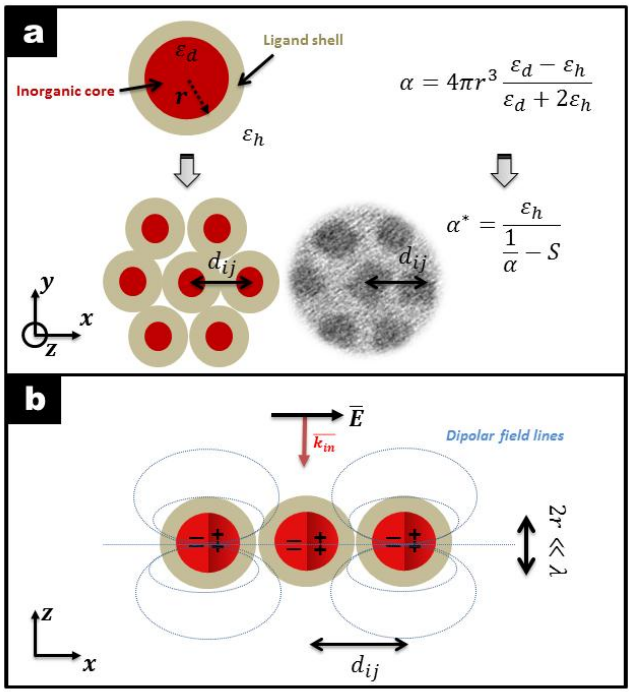
$$E = \frac{\sigma_{film}}{\sigma_{sol}}$$



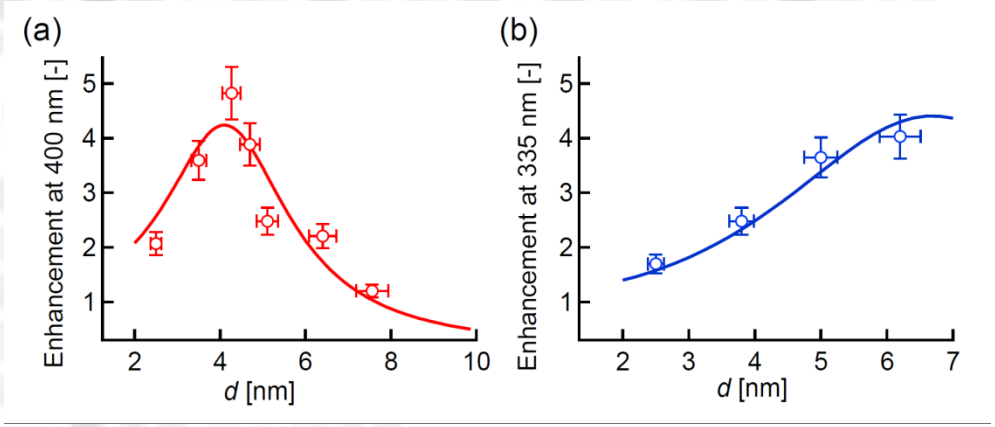
Geiregat et al., resubmitted to *ACS Nano*

Absorption enhancement

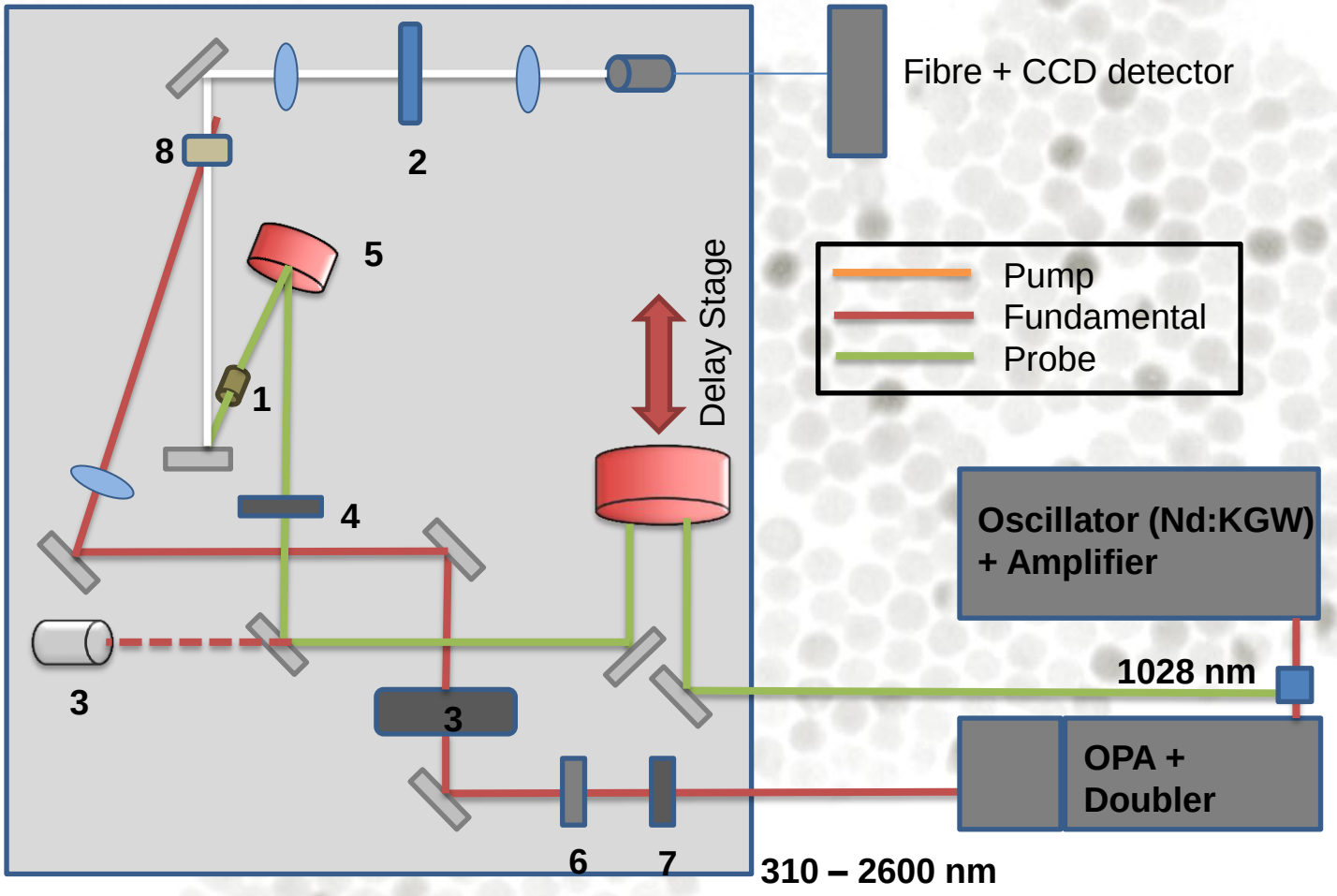
Measurement of absorption cross section of QDs in close packed monolayer

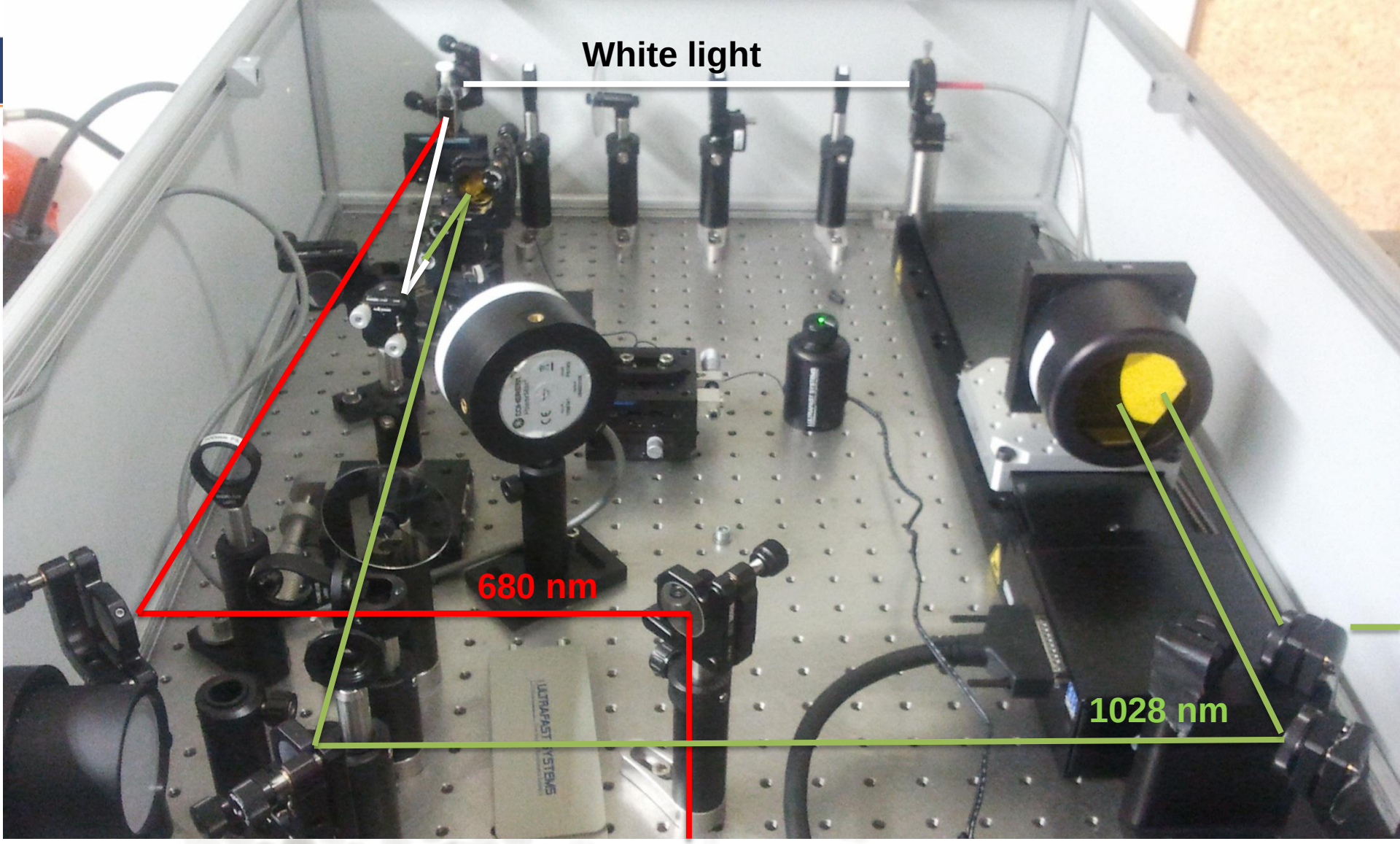


$$E = \frac{\sigma_{film}}{\sigma_{sol}}$$



Geiregat et al., under review at *ACS Nano*

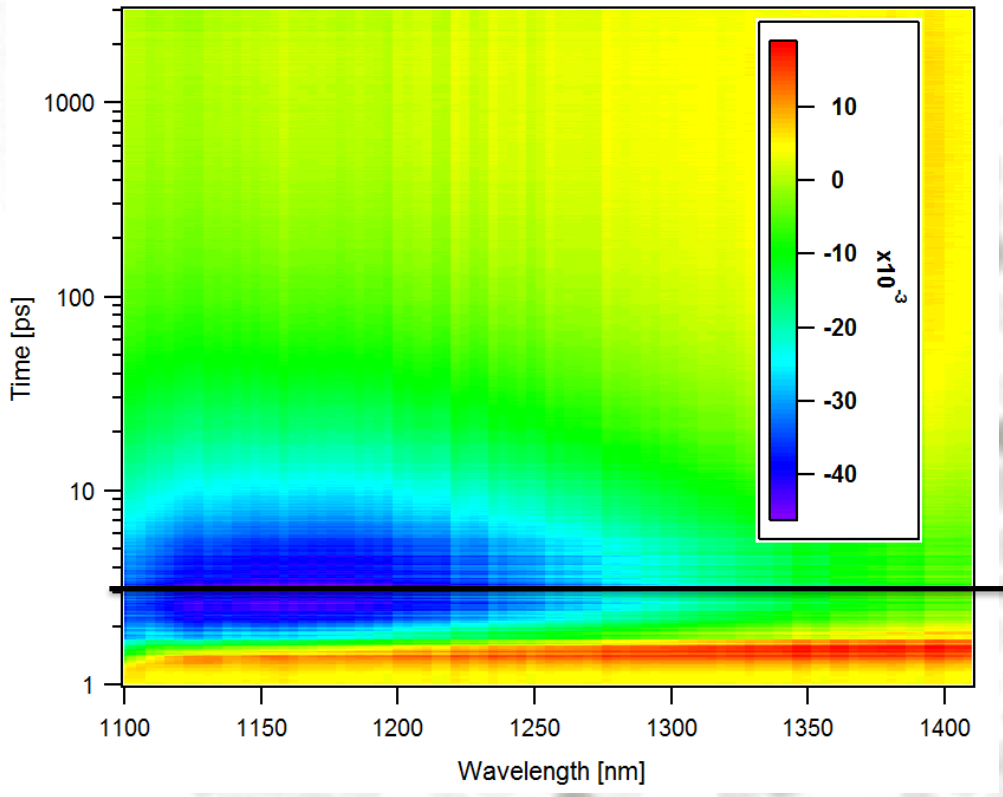

Fibre + CCD detector
8
2
5
1
4
3
3
6
7
Delay Stage
Pump
Fundamental
Probe
Oscillator (Nd:KGW)
+ Amplifier
1028 nm
OPA +
Doubler
310 – 2600 nm

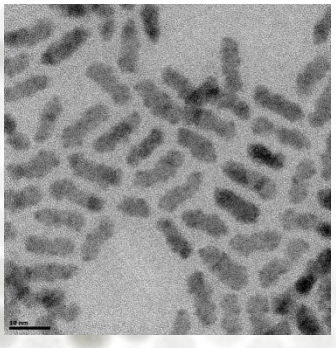


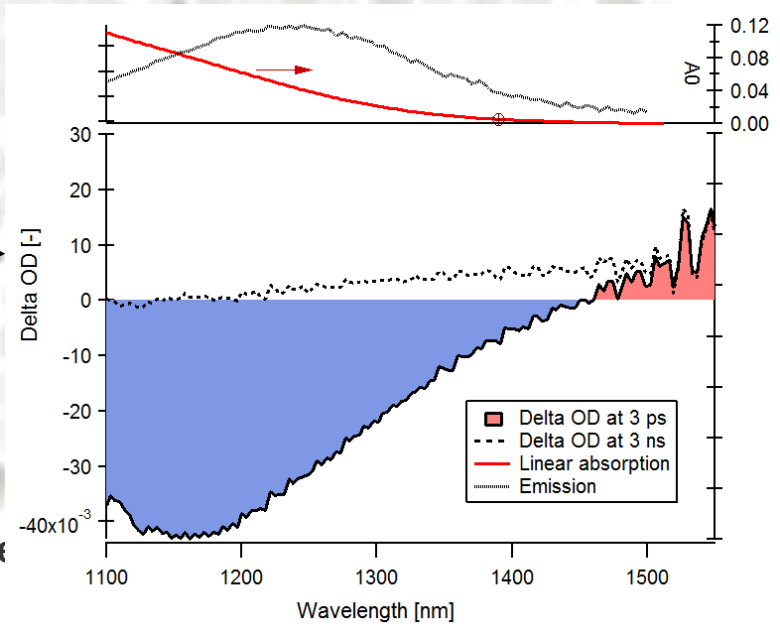
White light (up to 1600 nm) is created in sapphire crystal through 1028 nm pumping (fundamental of laser oscillator Nd:KGW).

PbS rods 4 x 12.8 nm

Analysis around Band Gap



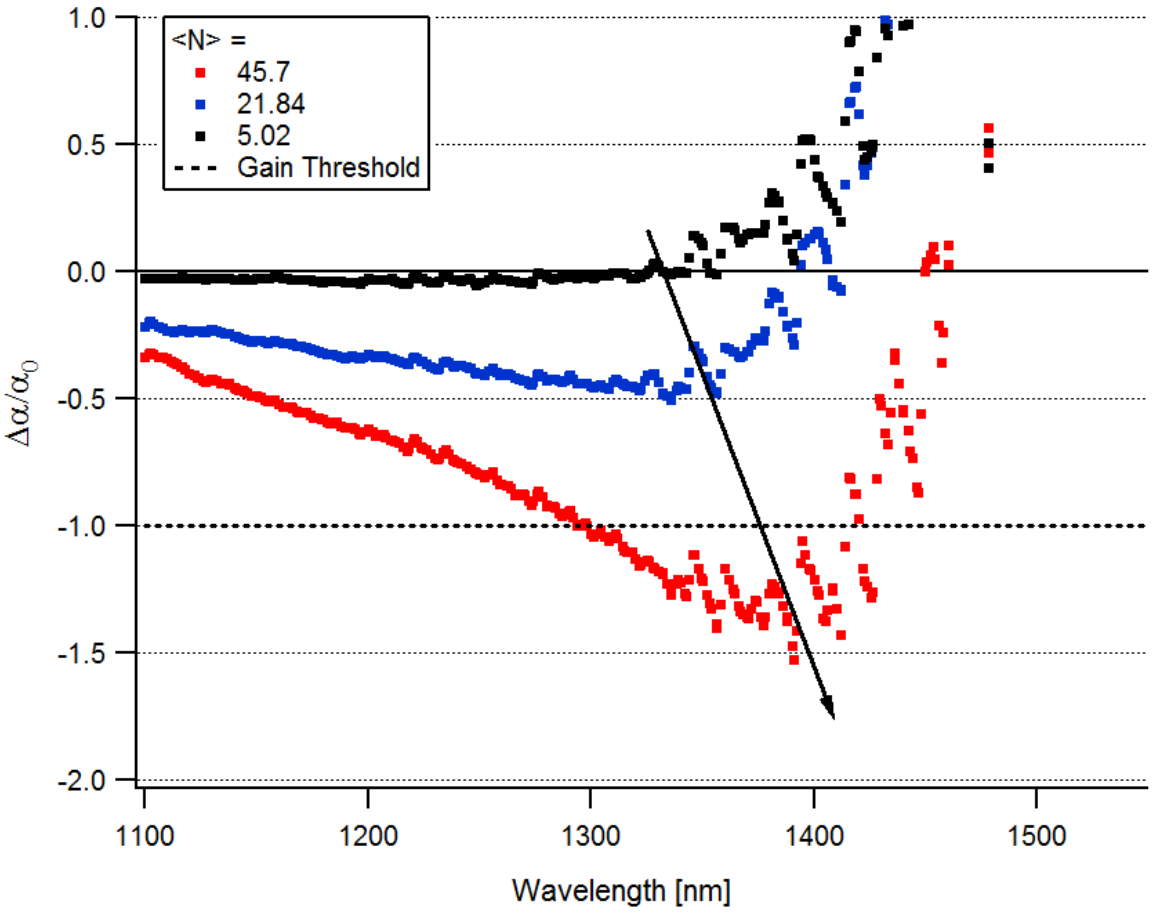




White light TA spectrum (now reliable up to 1600):

- Bleach band
- PA band

Pump dependent spectra



Bleach maximum redshifts due to increased multi-exciton shifts

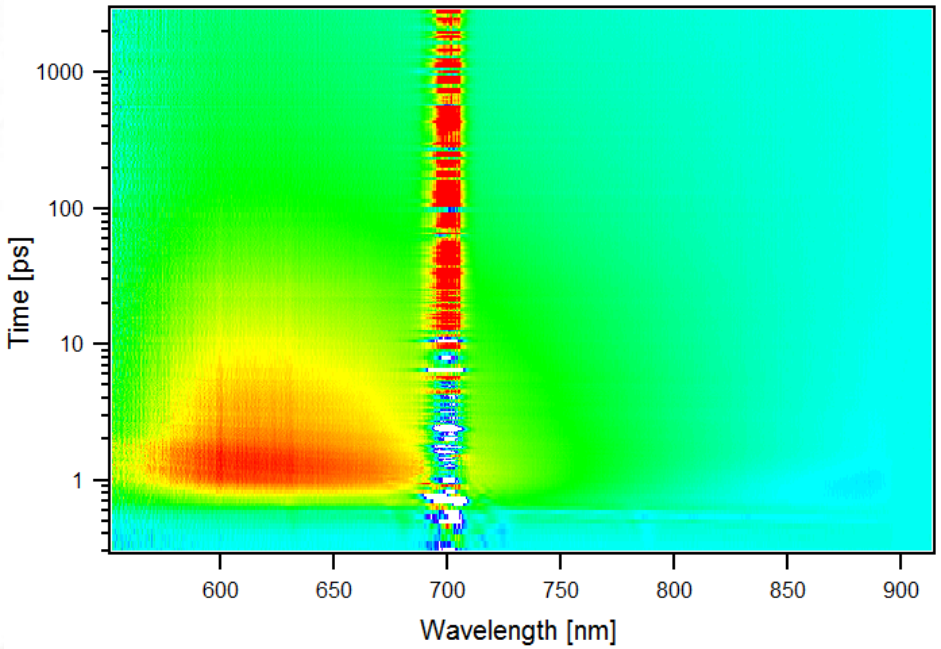
At gain transition (ca. 1400 nm) you evolve from an absorbing transition at low fluence to a full bleach at high fluence.

How ?

Competition between PA and gain buildup with different dependence on carrier density?

PbS rods 4 x 12.8 nm

Analysis in the visible

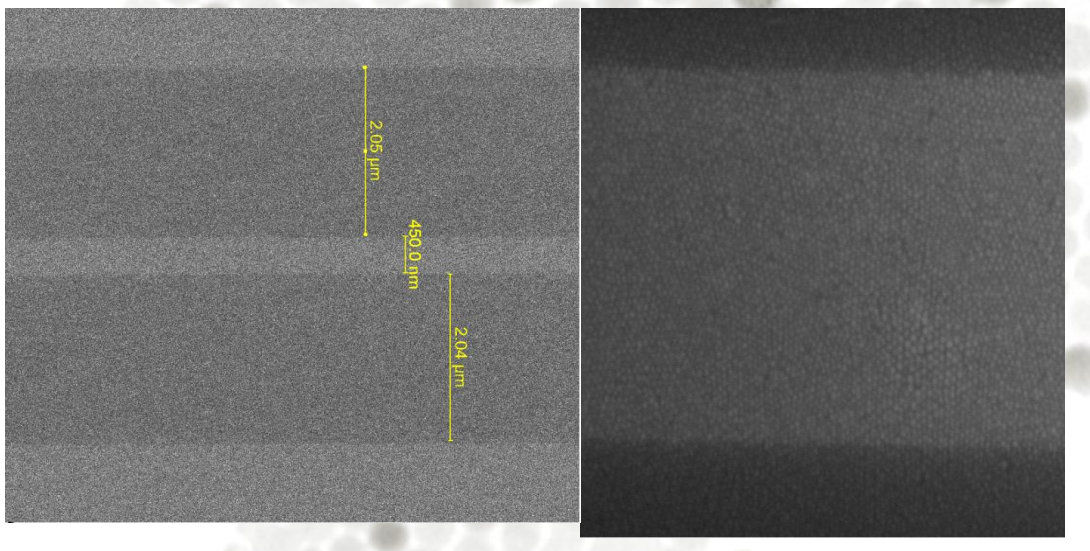


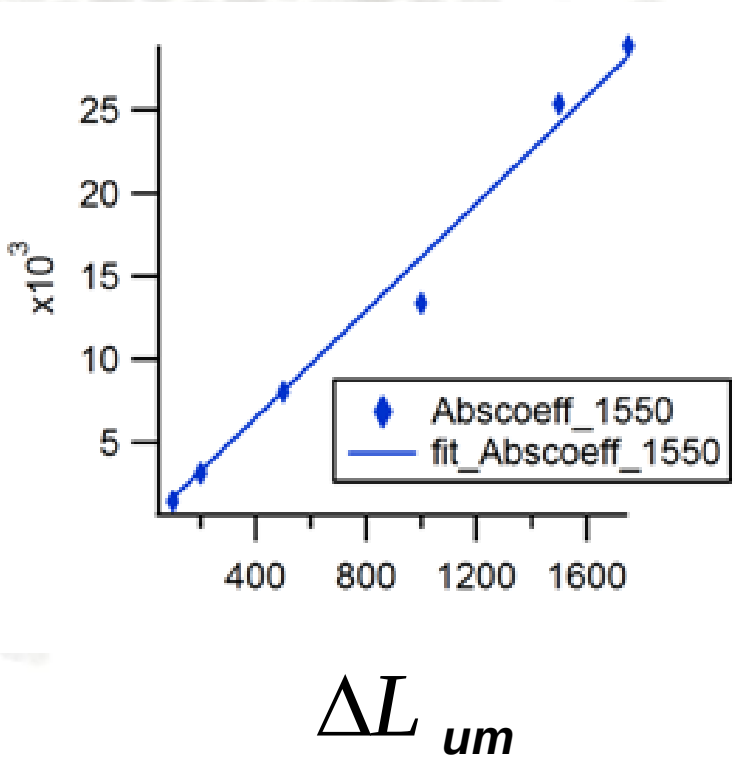
- Pronounced PA absorbance also for supra bandgap light
- Measurements also done on PbS dots – analysis ongoing

QD functionalized waveguides

Absorbance of QD functionalized waveguide

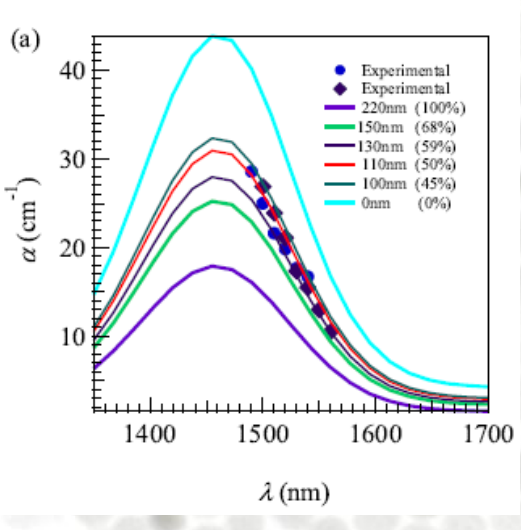
$$loss, wg, L = \alpha \Delta L = \frac{\Delta P, dB}{10 \log(e)}$$

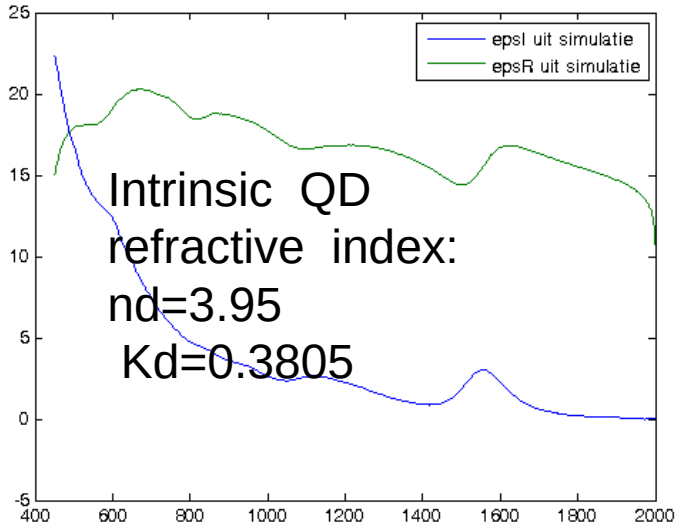




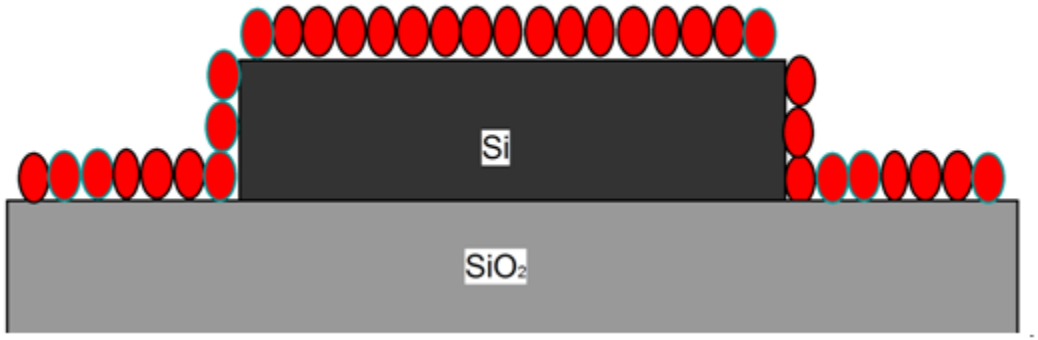
QD functionalized waveguides

Non-planarized



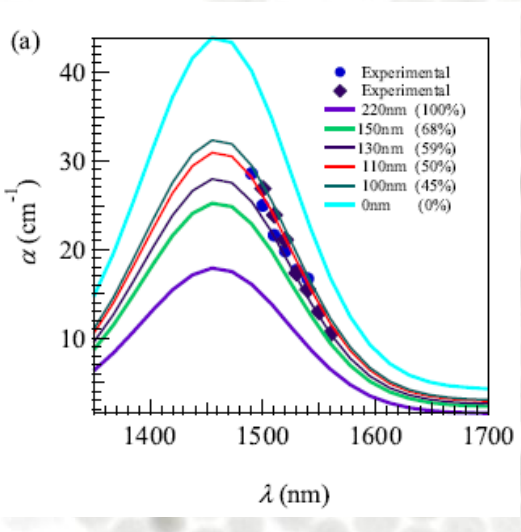


Intrinsic QD refractive index:
nd=3.95
Kd=0.3805

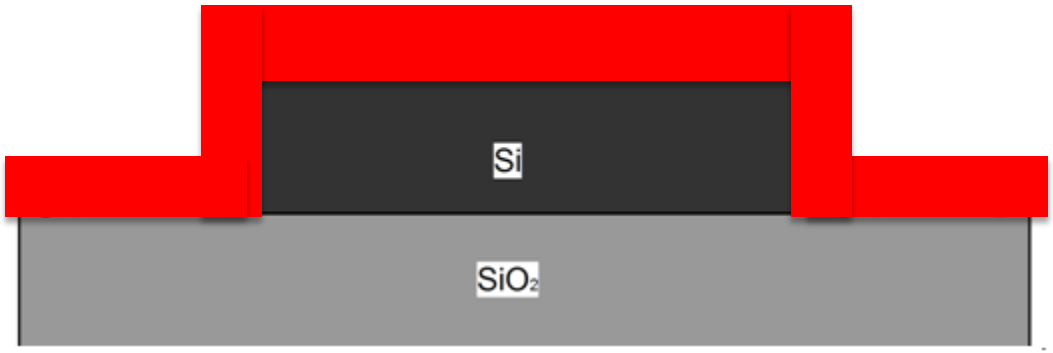


QD functionalized waveguides

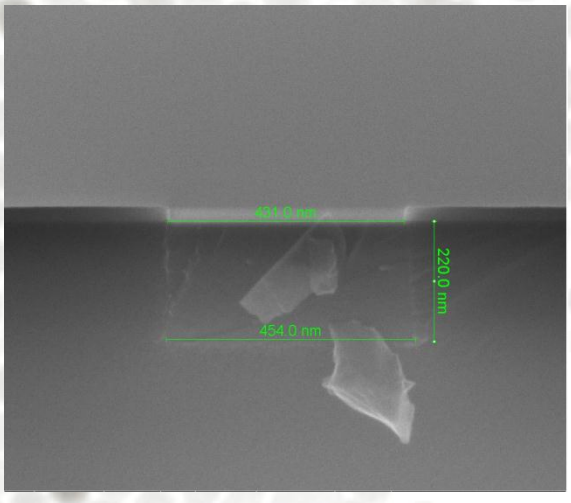
Non-planarized

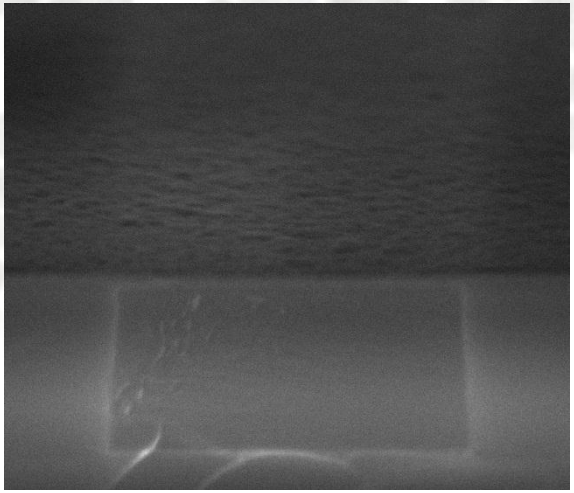


Effective medium refractive refractive index (MG):
n=1.876
K=0.034

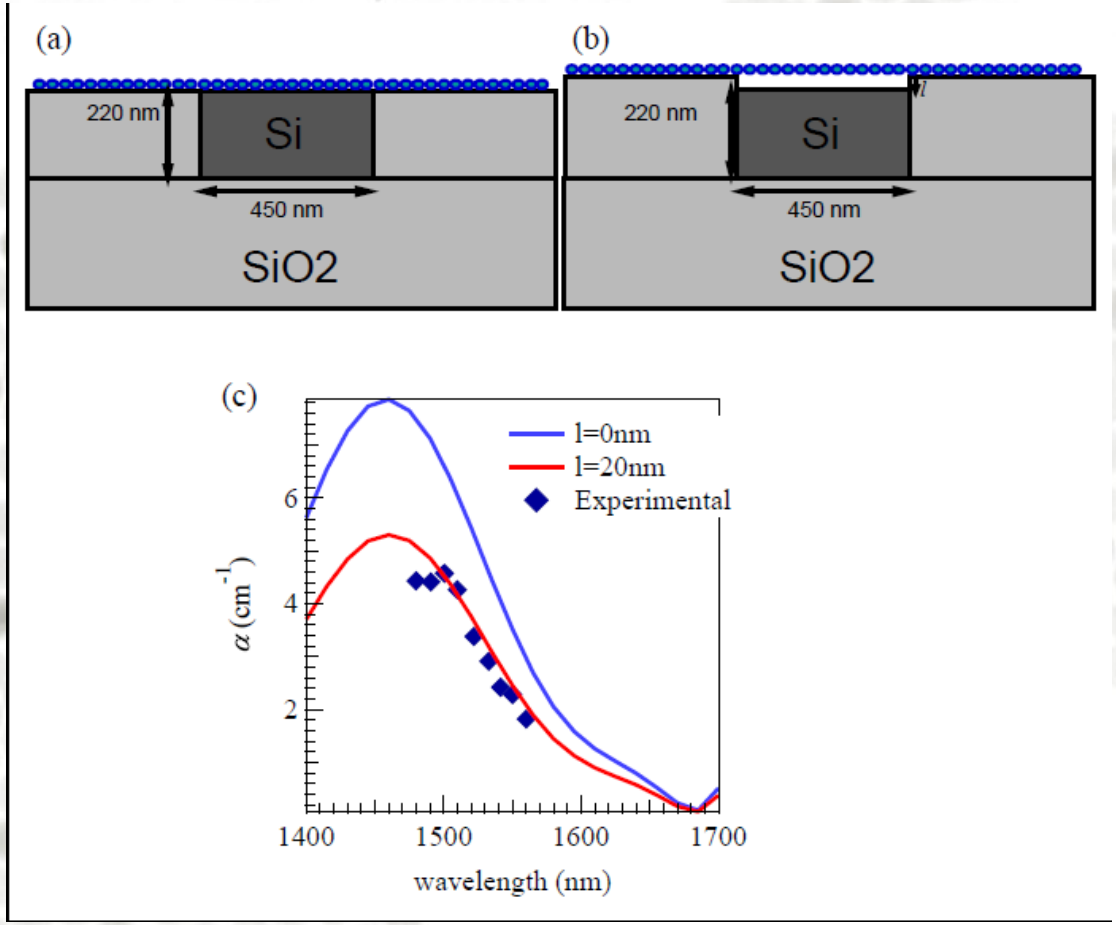


QD functionalized waveguides





QD functionalized waveguides



Future work

- **Materials syntesis**
  - **HR-TEM analysis of PbSe/CdSe QDs**
- **Continuation of Transient Absorption spectroscopy**
  - **Benchmarking relative to PbS and PbS/CdS QDs**
  - **Analysis of PbS/CdS and PbSe/CdSe dot(s)-in-rod**
- **Sample exchange with Valencia**
  - **Discussion on report needed**