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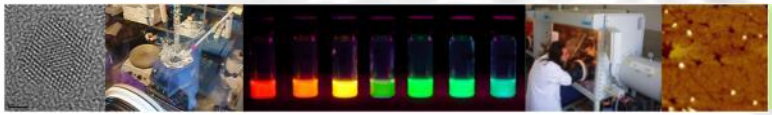
PHOTONICS RESEARCH GROUP

Navolchi Update
January 2014



Physics and Chemistry of Nanostructures Group

FCN

http://www.nano.UGent.be

Overview of activities

Outline

- (almost) Published results
- Ongoing work – light amplification by HgTe quantum dots

Published Results

Nanocrystal synthesis

- PbS/CdS dot-in-rods

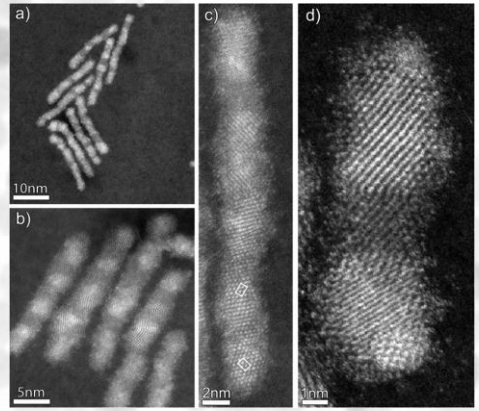
J|A|C|S
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
Communication
pubs.acs.org/JACS

Multiple Dot-in-Rod PbS/CdS Heterostructures with High Photoluminescence Quantum Yield in the Near-Infrared

Yolanda Justo,[†,‡] Bart Goris,[⊥] John Sundar Kamal,[†,‡] Pieter Geiregat,[†,‡,§] Sara Bals,[⊥] and Zeger Hens*[,†,‡]

[†]Physics and Chemistry of Nanostructures, [‡]Center for Nano and Biophotonics, and [§]Photonics Research Group, Ghent University, B-9000 Gent, Belgium

[⊥]EMAT, University of Antwerp, B-2020 Antwerp, Belgium



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

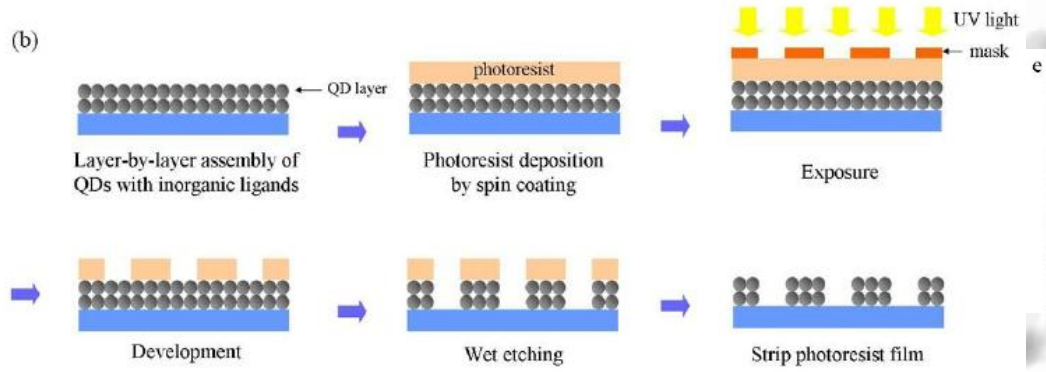
- HgTe QD synthesis
  - Study ongoing on size tuning by reaction kinetics in 1000-2000 nm range

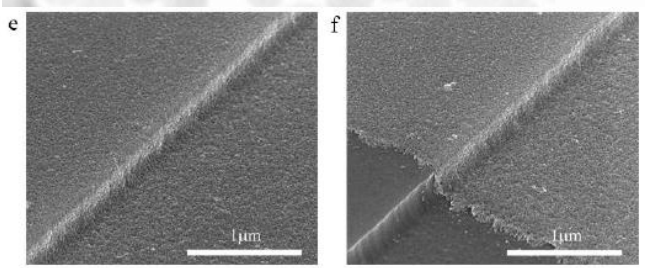
Published Results

Nanocrystal processing

Micropatterning of Layers of Colloidal Quantum Dots with Inorganic Ligands Using Selective Wet Etching

Chen Hu[1,2,3], Tangi Aubert[1,3], Yolanda Justo[1,3], Stijn Flamee[1,3], Marco Cirillo[1,3], Alban Gassenq[2,3], Oksana Drobchak[3,4], Filip Beunis[3,4], Günther Roelkens[2,3], Zeger Hens[1,3]





Chen et al., Nanotechnology, revised version submitted

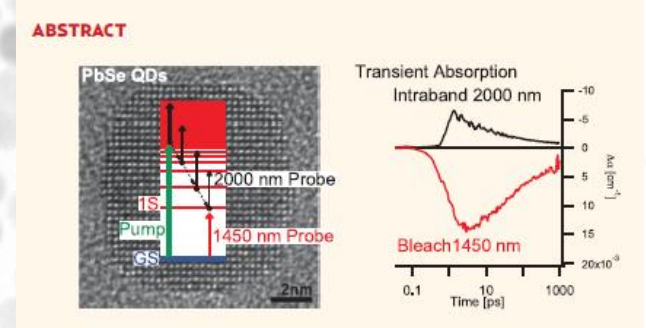
Published Results

Nanocrystal properties

ARTICLE

Broadband and Picosecond Intraband Absorption in Lead-Based Colloidal Quantum Dots

Bram De Geyter,[†,¶] Arjan J. Houtepen,[‡] Sergio Carrillo,[§] Pieter Geiregat,[†,¶] Yunan Gao,[‡,#] Sybren ten Cate,[‡] Juleon M. Schins,[‡] Dries Van Thourhout,[†,¶] Christophe Delerue,[§] Laurens D. A. Siebbeles,[‡] and Zeger Hens[∥,¶,*]



De Geyter et al., ACS Nano 2012, 6, 6067

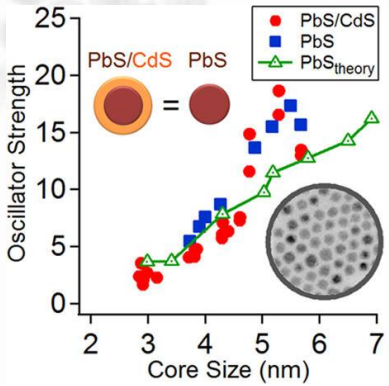
THE JOURNAL OF PHYSICAL CHEMISTRY C

Article

pubs.acs.org/JPCC

Optical Properties of PbS/CdS Core/Shell Quantum Dots

Yolanda Justo,*[,†,∥] Pieter Geiregat,[†,‡,∥] Karen Van Hoecke,[¶] Frank Vanhaecke,[¶] Celso De Mello Donega,[§] and Zeger Hens*[,†,∥]



Hens et al., J. Phys. Chem. C 2013, 117, 20171

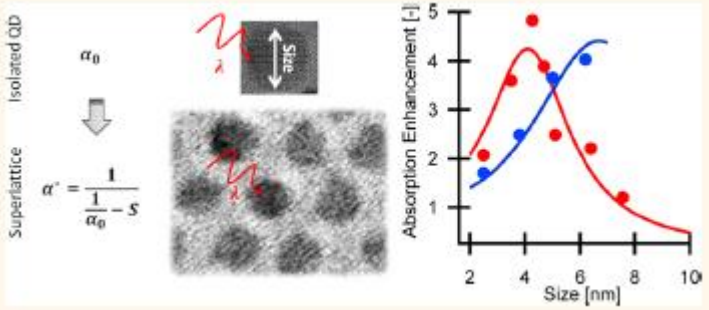
Published Results

Nanocrystal properties

Giant and Broad-Band Absorption Enhancement in Colloidal Quantum Dot Monolayers through Dipolar Coupling

Pieter Geiregat,[†,‡,§] Yolanda Justo,[†,§] Sofie Abe,[†,§] Stijn Flamee,[†,§] and Zeger Hens[†,§,*]

ARTICLE



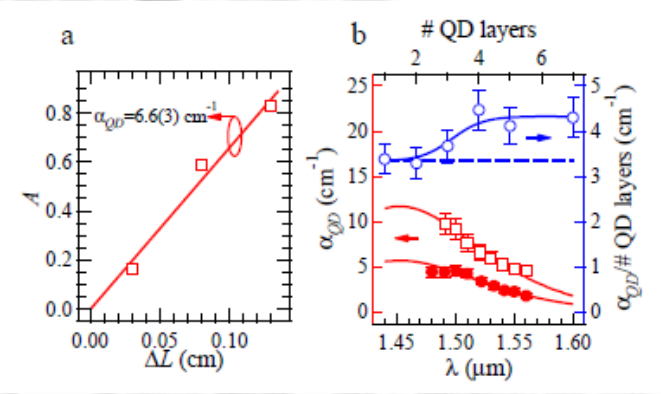
Geiregat et al., ACS Nano 2013, 7, 987

Published Results

Quantum-dot based devices

Light absorption in hybrid silicon-on-insulator/quantum dot waveguides

Abdoulghafar Omari,[1,2,3,*], Pieter Geiregat,[1,2,3], Dries Van Thourhout,[2,3] and Zeger Hens,[1,2]

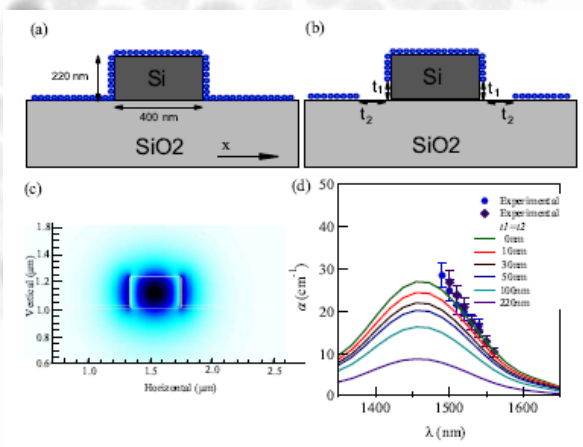


Omari et al., Opt. Exp. 2013, 21, 23272

JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, JULY/AUGUST 2014 1

Modeling the optical properties of low-cost colloidal quantum dot functionalized strip SOI waveguides

Abdoulghafar Omari, *Member, IEEE,* Weiqiang Xie, Pieter Geiregat, *Member, IEEE,* Dries Van Thourhout, *Member, IEEE,* and Zeger Hens

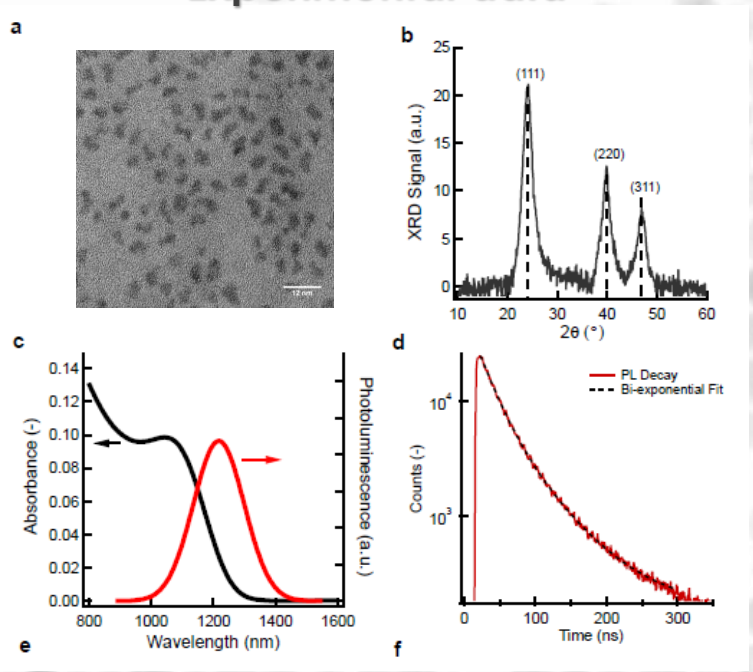


Omari et al., J. Sel. Top. Quant. Elec. 2014, accepted

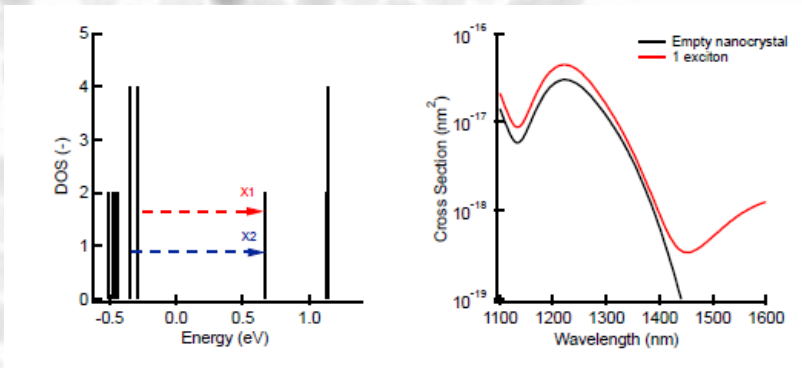
HgTe Quantum Dots

Properties

Experimental data



Theoretical Calculations

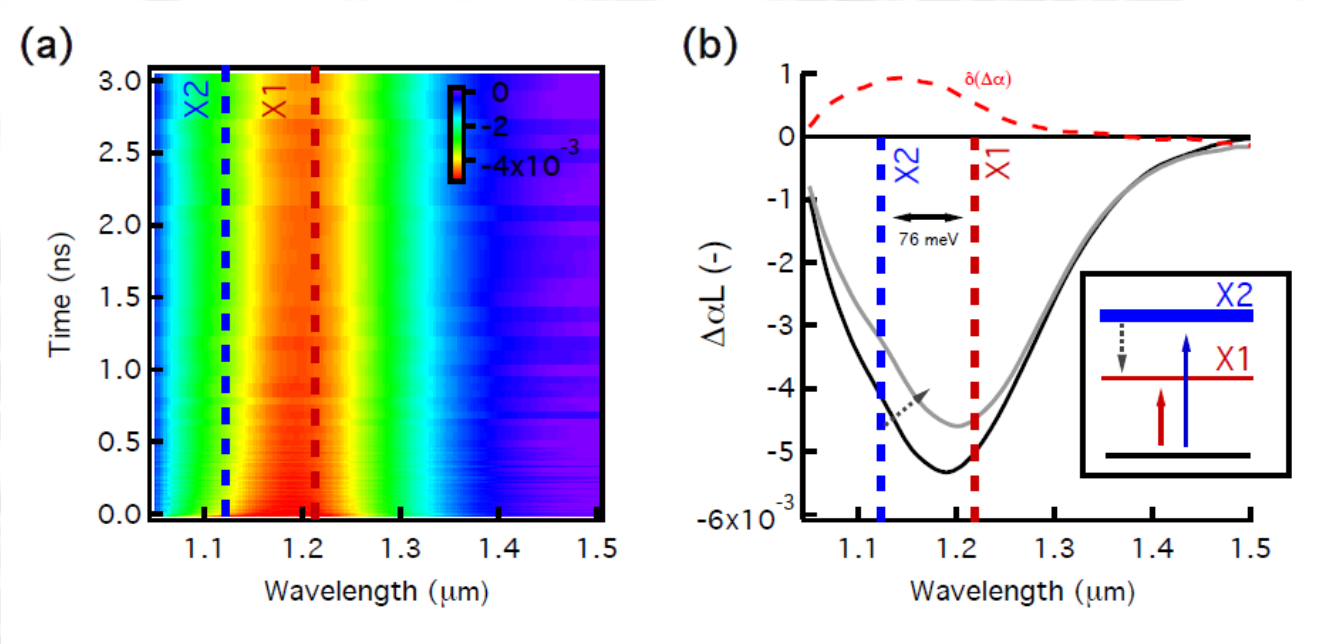


Energy levels

Absorption spectrum

HgTe Quantum Dots

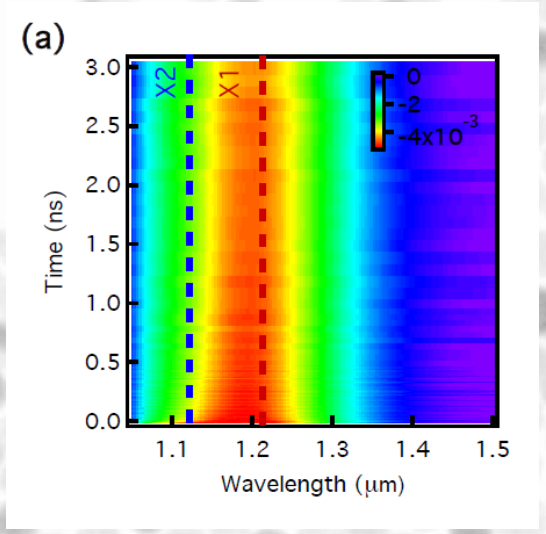
- Overview $\Delta\alpha$ hyperspectrum

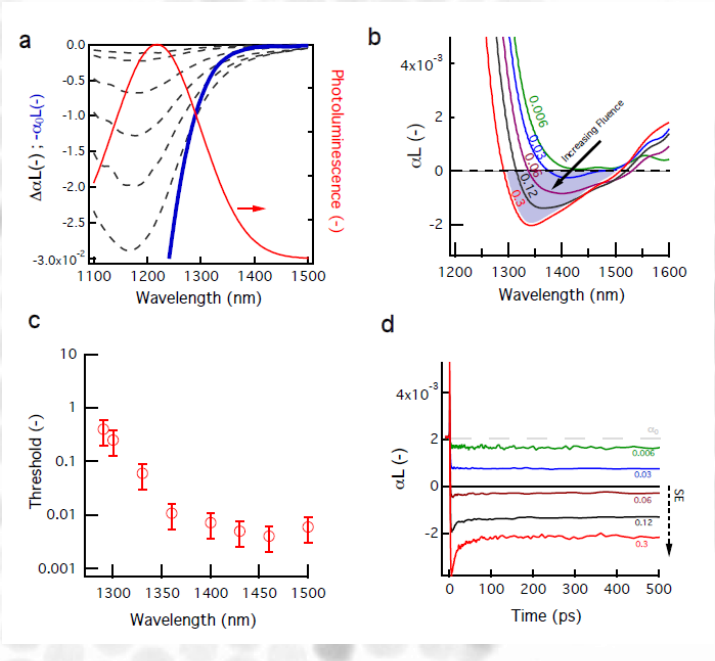


- Bleach of bandgap transition
- 500-1000 ps dynamics due to hole thermalization

HgTe Quantum Dots

- **Amplification – low fluence**

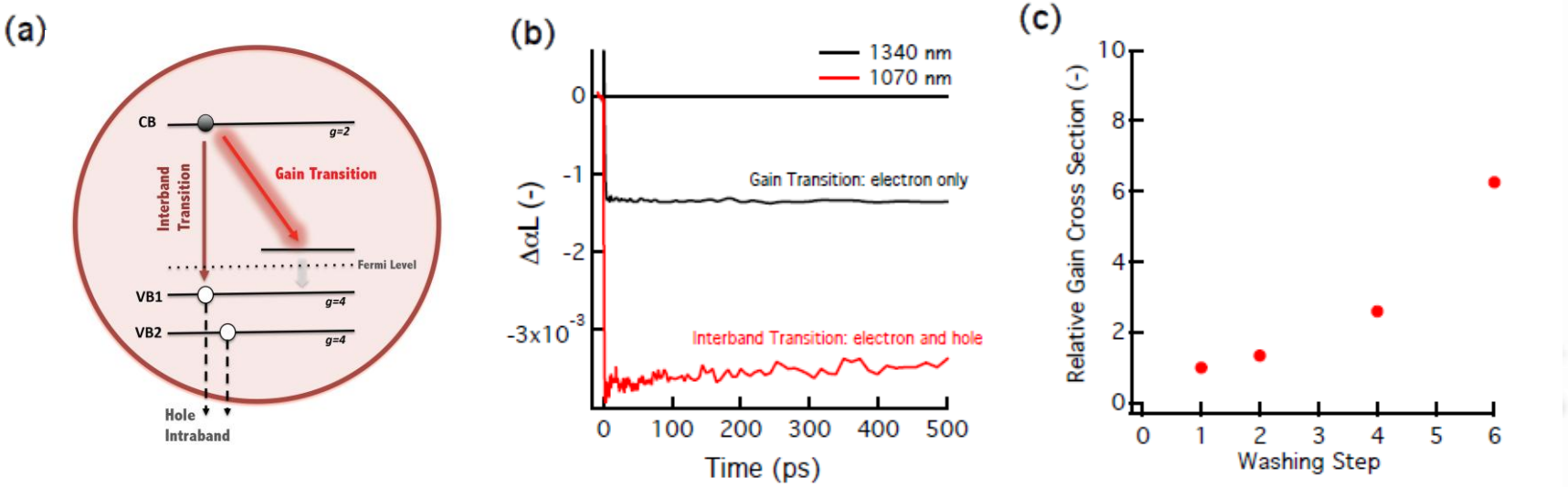




- **Gain feature develops at red side of bandgap for $\langle N \rangle < 0.01$**
- **Gain feature long-lived (not capped by Auger processes)**

HgTe Quantum Dots

On the origin of the optical gain in HgTe QDs

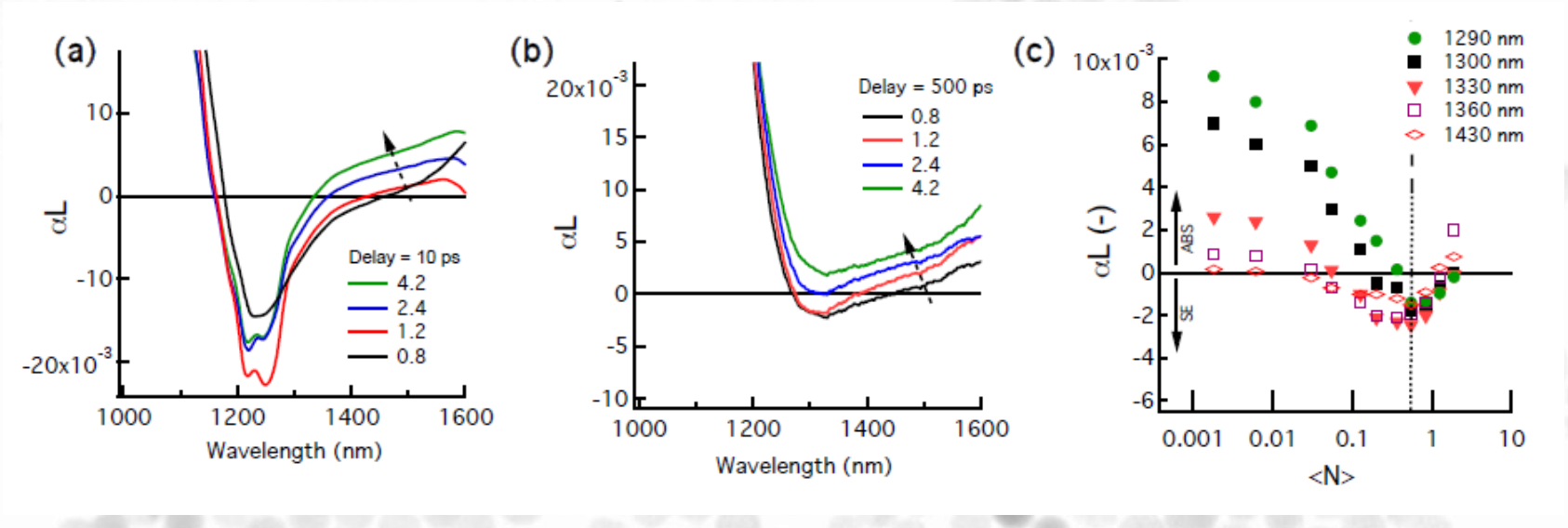


- Gain at long wavelength side of bandgap absorption
- No fingerprint of hole relaxation on gain dynamics
- Gain cross section increases with QD purification

Gain ~ transition from CB to empty surface state

HgTe Quantum Dots

Amplification high fluence



- Second gain band, capped by Auger recombination
- At long delay – only red side (trap related) persists
- With increasing fluence, amplification is lost (charged QDs?)

Outlook

- **Extend analysis to HgTe QD films**
  - **On dropcast films – gain signal is not preserved (trap absorption observed instead)**
  - **Dilution in polymer as the next step**