UNIVERSITEIT GENT

imec

PHOTONICS RESEARCH GROUP

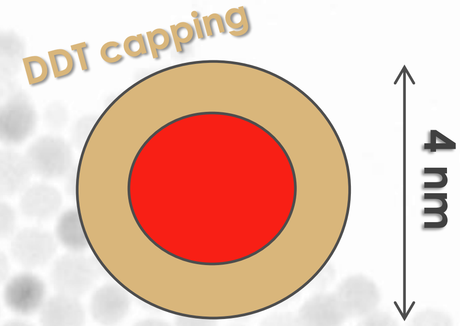
Navolchi Update
September 2013

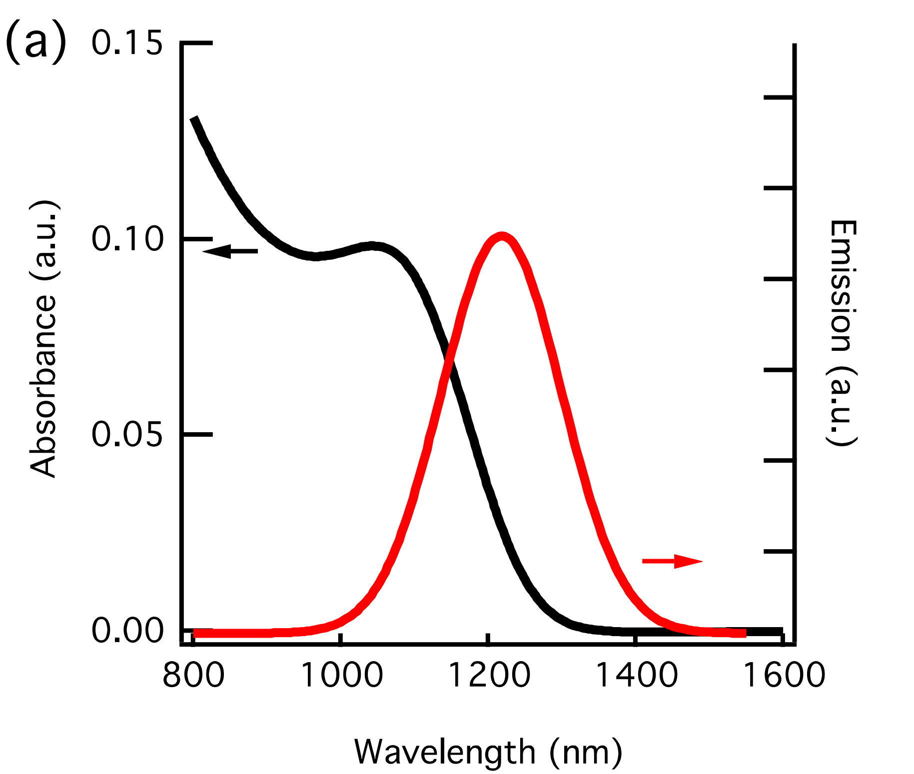
Pieter Geiregat (PCN, PRG)

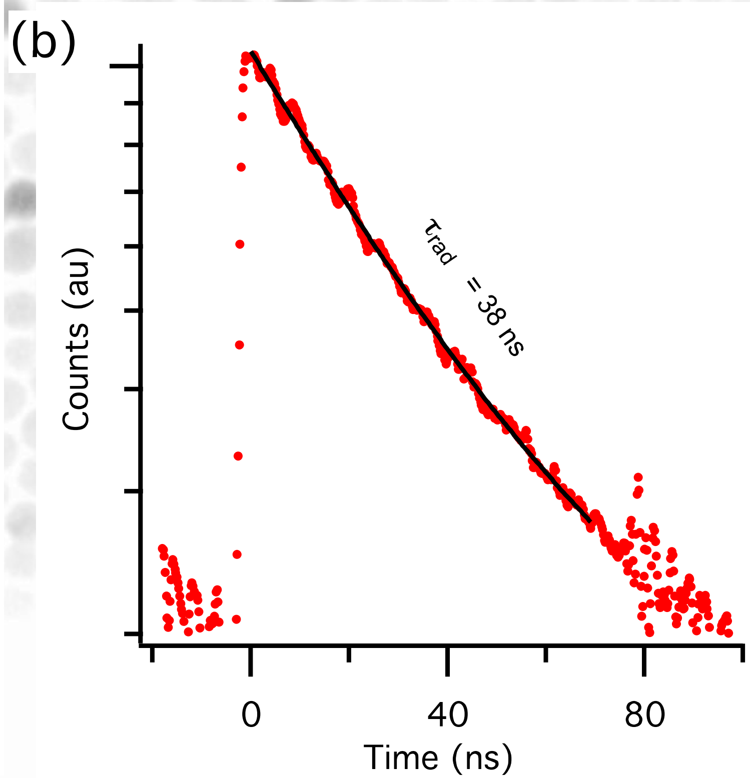
HgTe linear properties

Absorption and emission in the **near-infrared**
Radiative lifetime: **30-40 ns** , single X decay

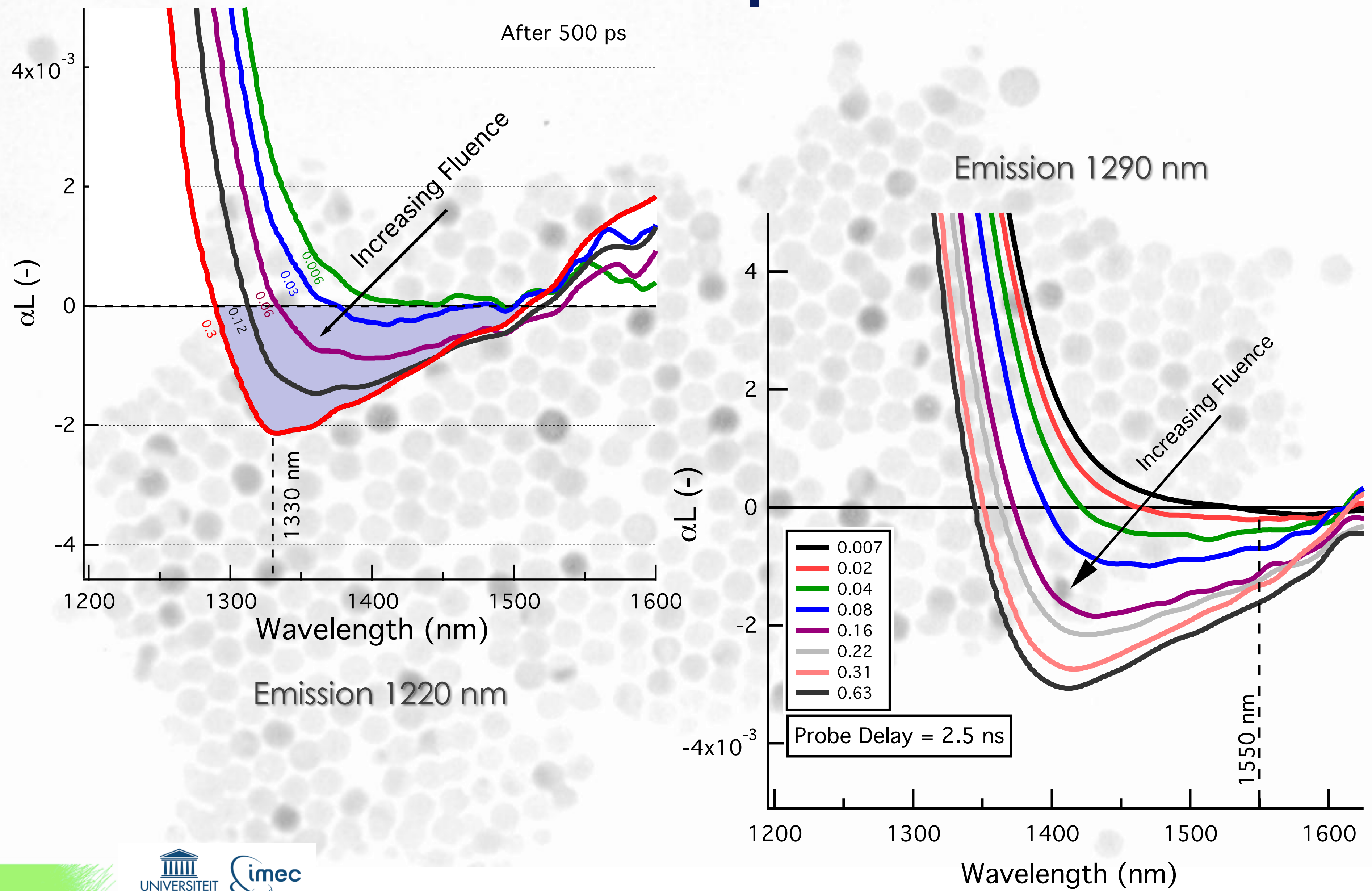
Large Stokes shift (up to 100 meV)





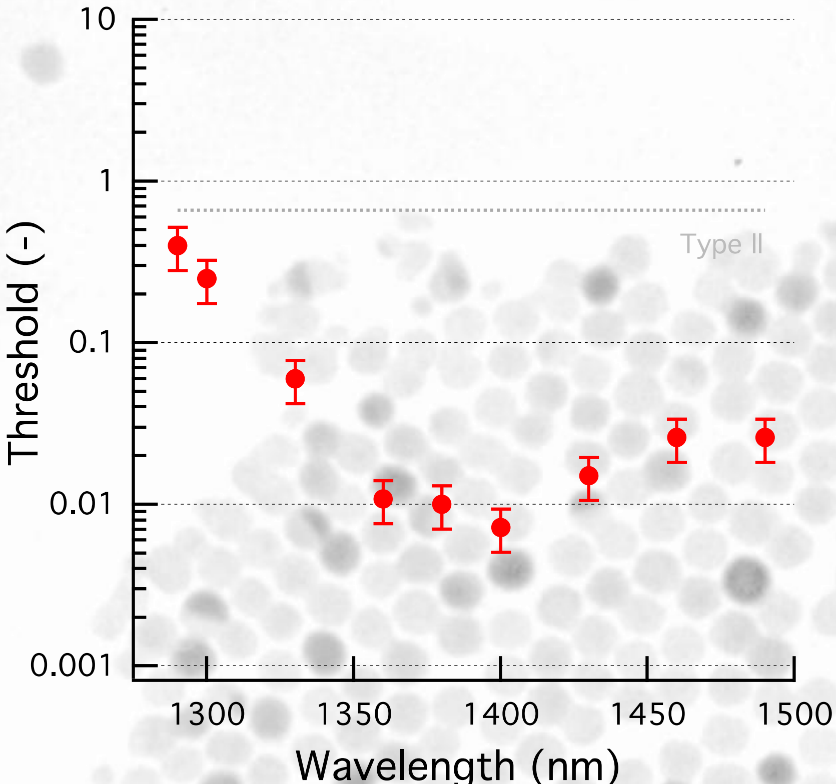


Non-linear absorption



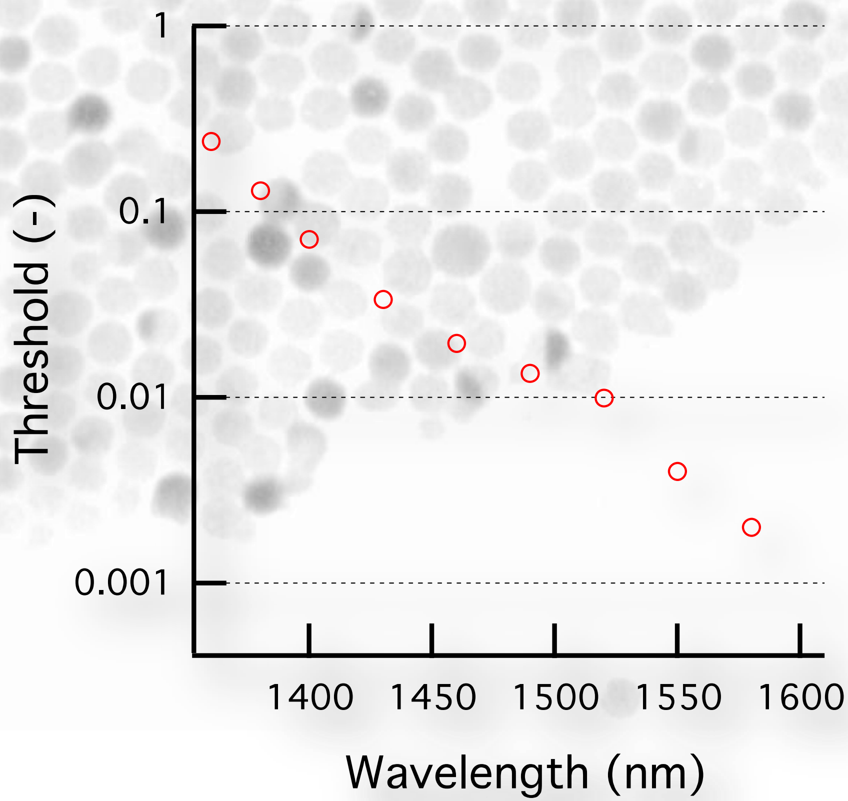
UNIVERSITEIT GENT
imec
PHOTONICS RESEARCH GROUP

Thresholdless amplification



"The threshold is far below the single X level and orders of magnitude smaller than the best values obtained so far (<N> = 2/3)"

"Real threshold is 0, but photo-induced absorption and spectral broadening limits us to 0.01"

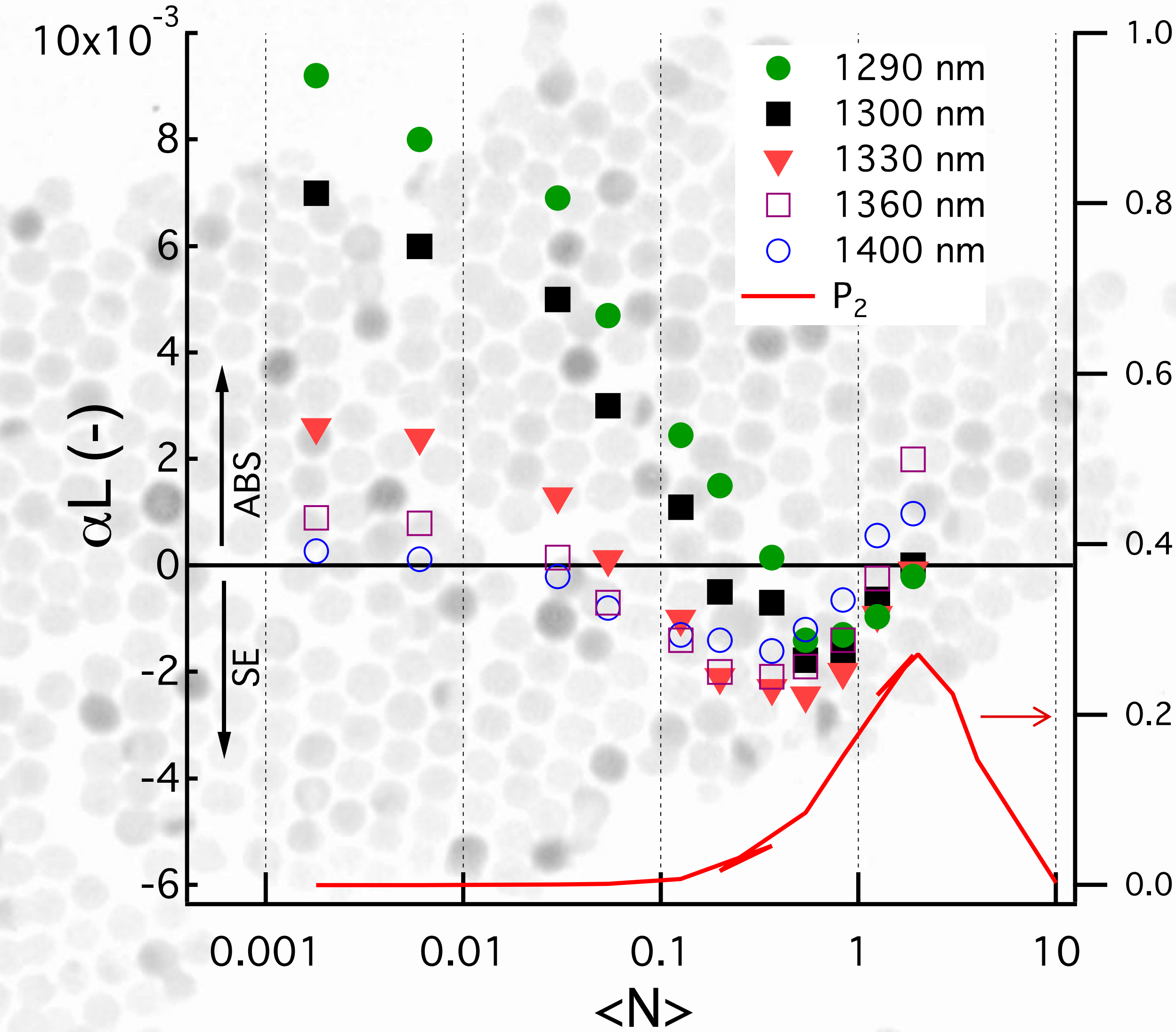


Fluence dependence

Stimulated emission dominates when increasing the fluence

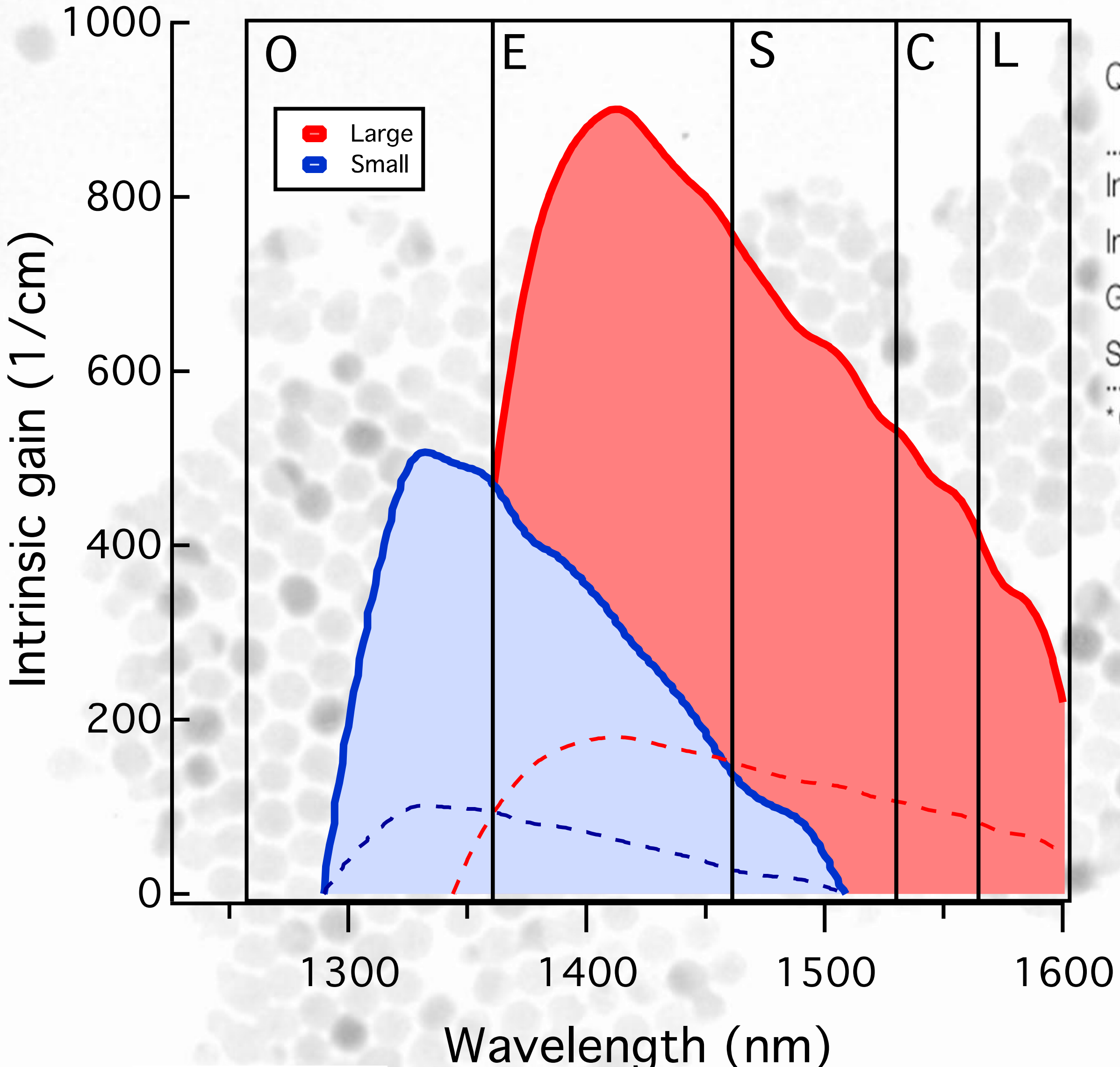
At high fluence, Auger ionization creates hot carriers

Hot carriers give rise to increase of PA



UNIVERSITEIT GENT
imec
PHOTONICS RESEARCH GROUP

Intrinsic gain: covering OESCL



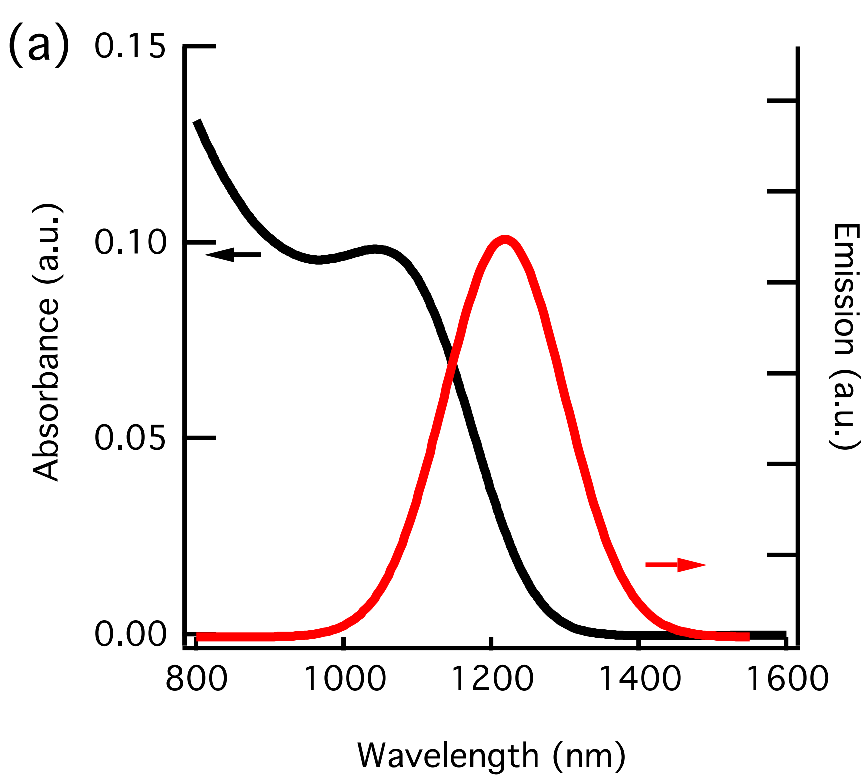
Quantum dot material	Net model gain (cm^{-1})
InAs single layer quantum dot	8.2
InAs 7 stacks quantum dot	70–85
GaAs single layer quantum dot	13*
Si nanocrystals	100

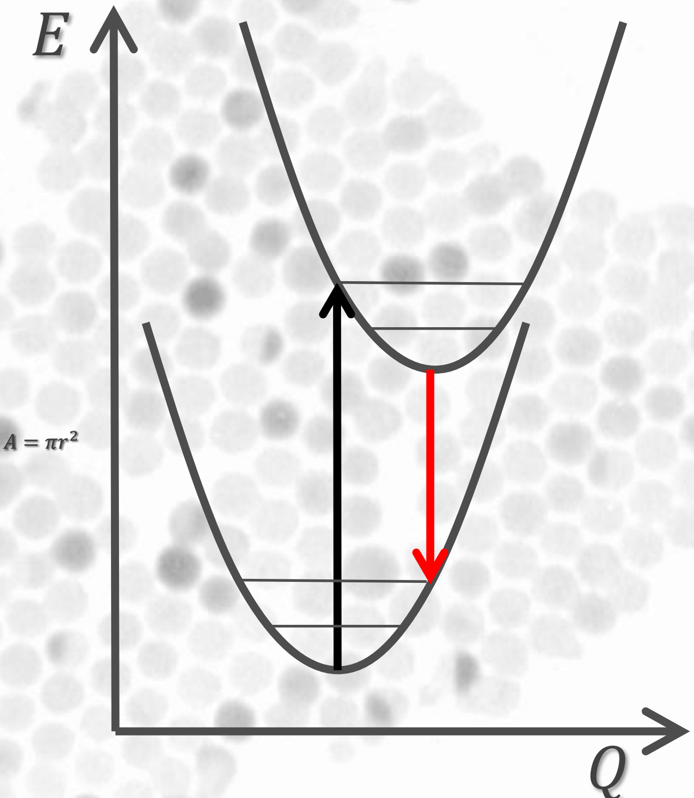
* Calculated approximately.

Gain comparable to best epitaxial systems !

But much more broadband and cheaper materials !

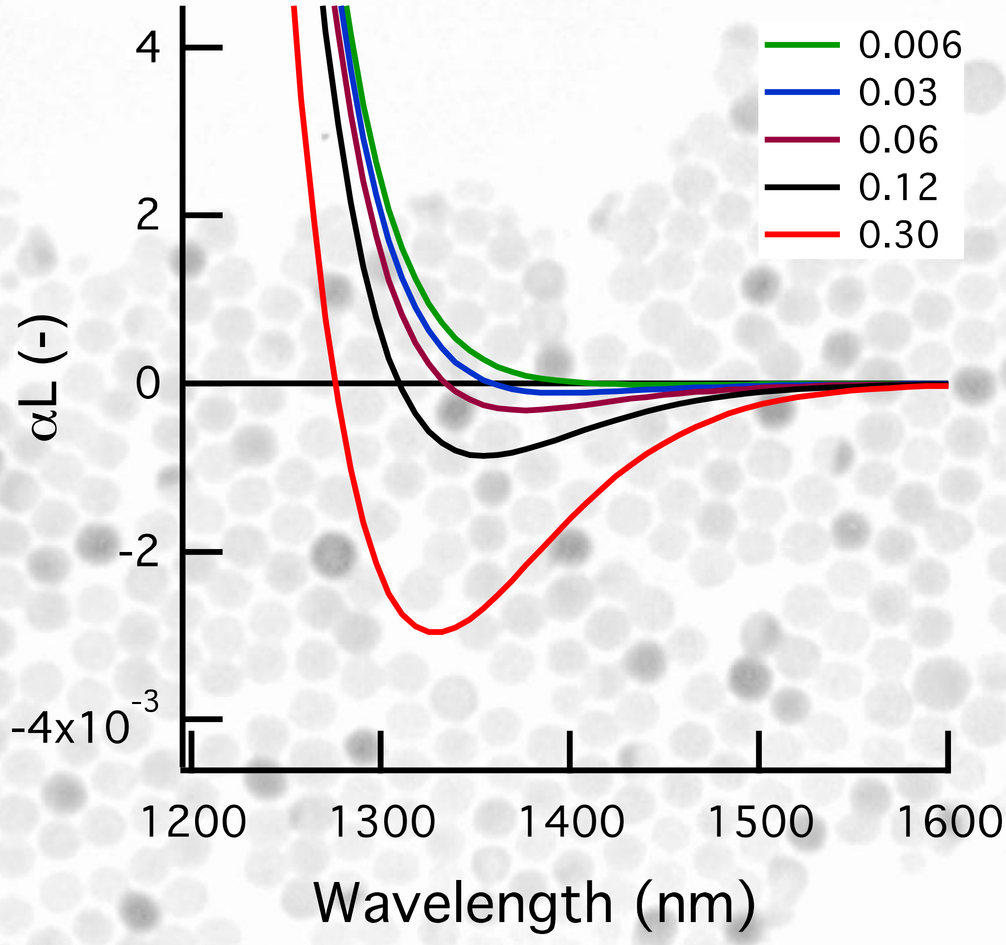
Gain Mechanism





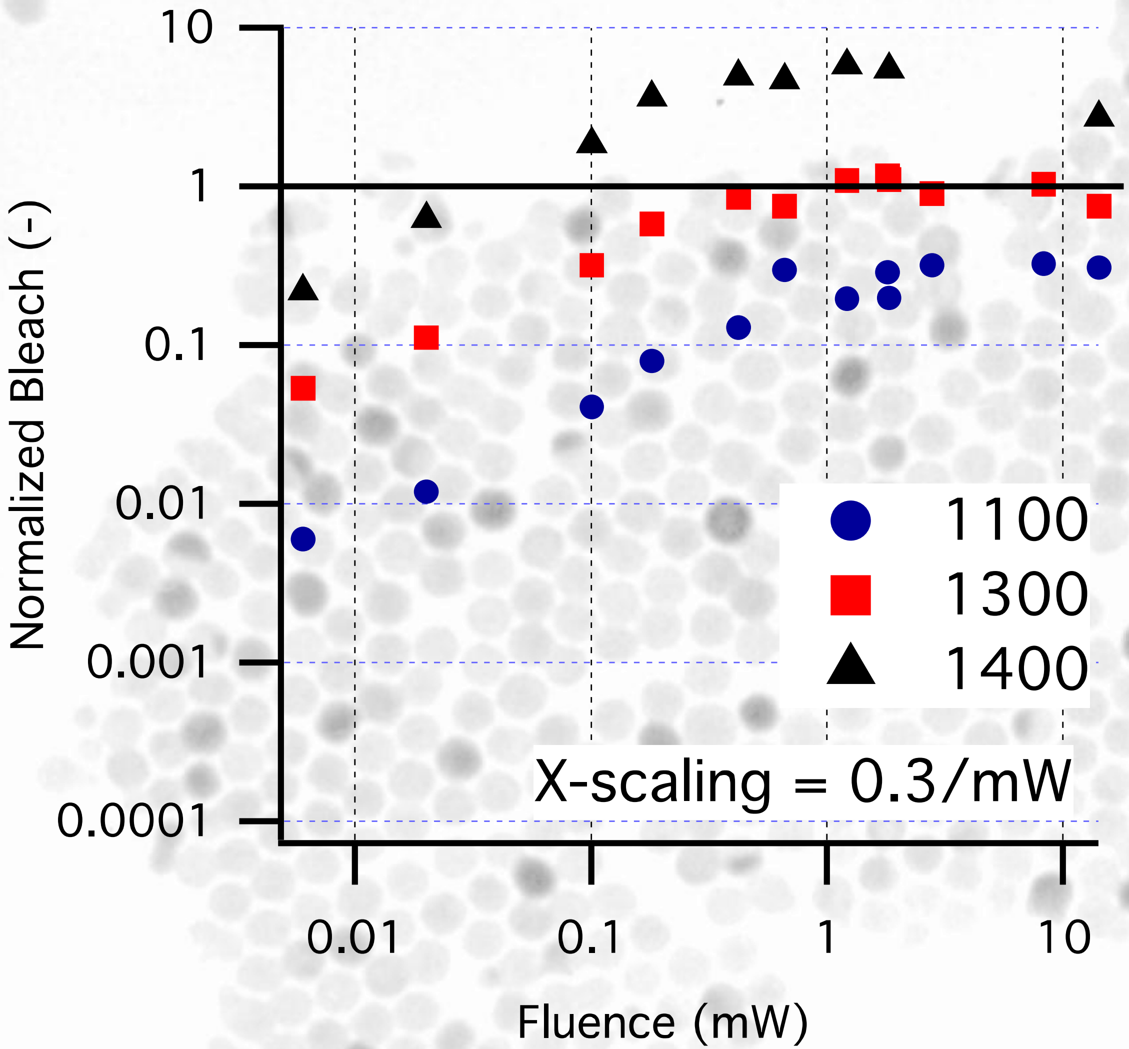
$$\alpha(\lambda) = \left(N_0 + \frac{3}{8}N_1\right)\alpha_0(\lambda) - \frac{1}{8}N_1\alpha_0(\lambda - \lambda_{em})$$

Gain Mechanism



$$\alpha(\lambda) = \left(N_0 + \frac{3}{8}N_1\right)\alpha_0(\lambda) - \frac{1}{8}N_1\alpha_0(\lambda - \lambda_{em})$$

Normalized spectra



$$\frac{-\Delta a}{a_0} > 1$$

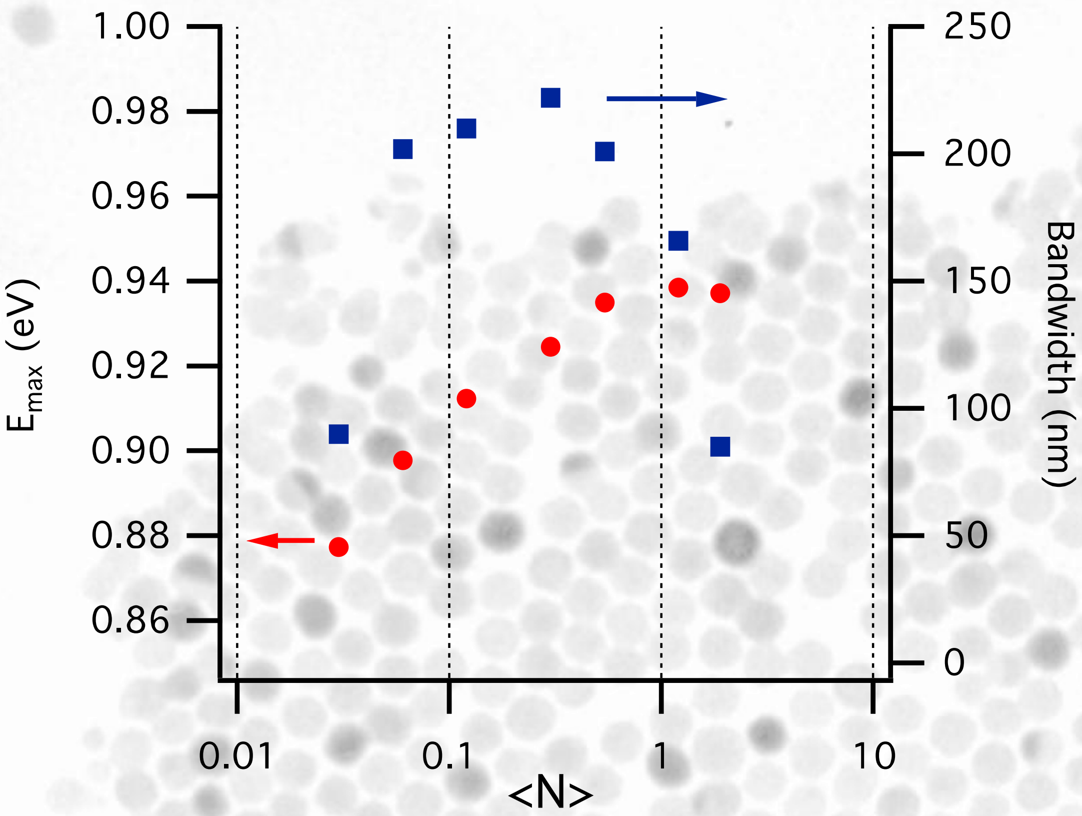
Transparency reached at sub-X level !

Normalized bleach > 1, indicative of red-shifted emission/gain band

⇩

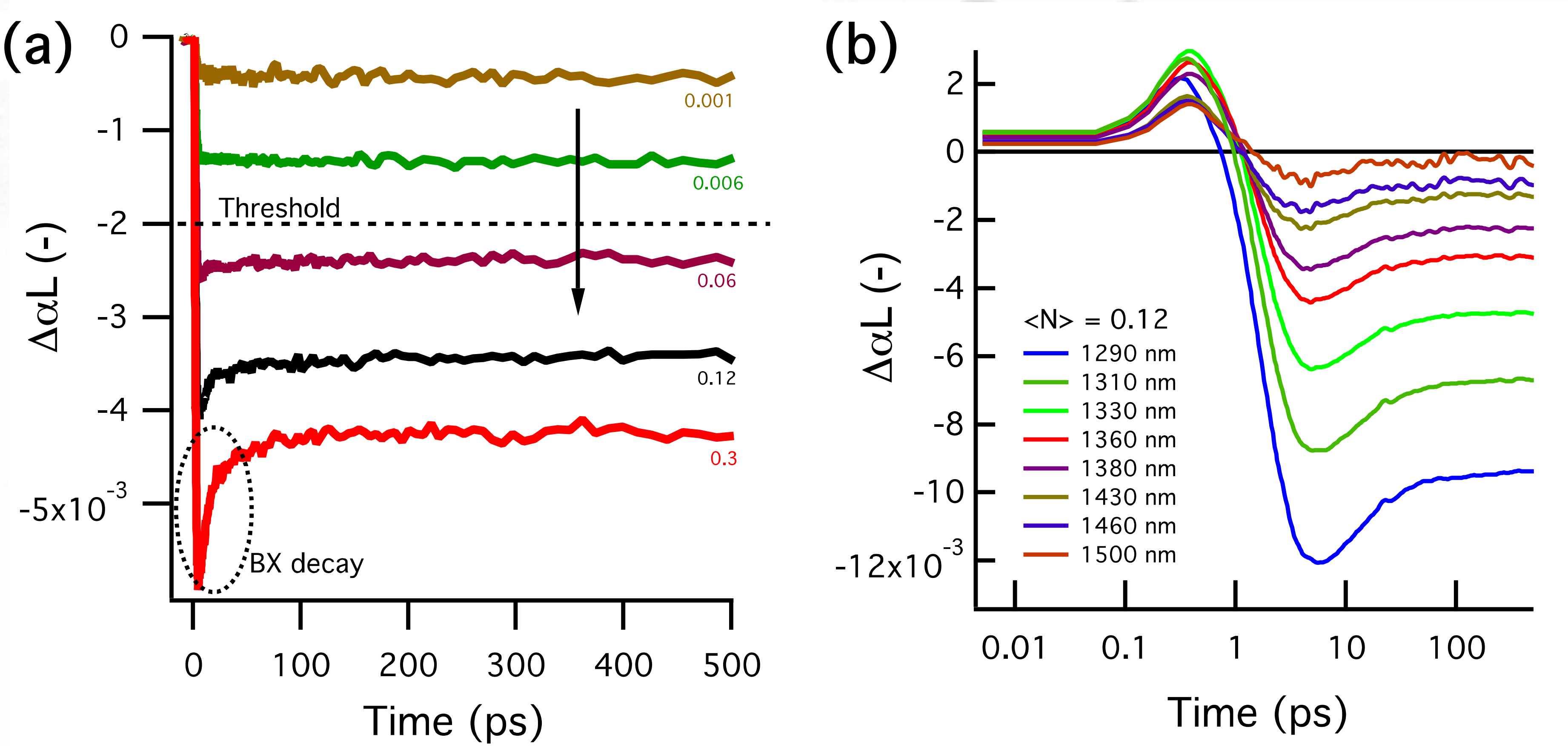
Gain comes from different 2-level system than absorption !

Gain maximum and bandwidth



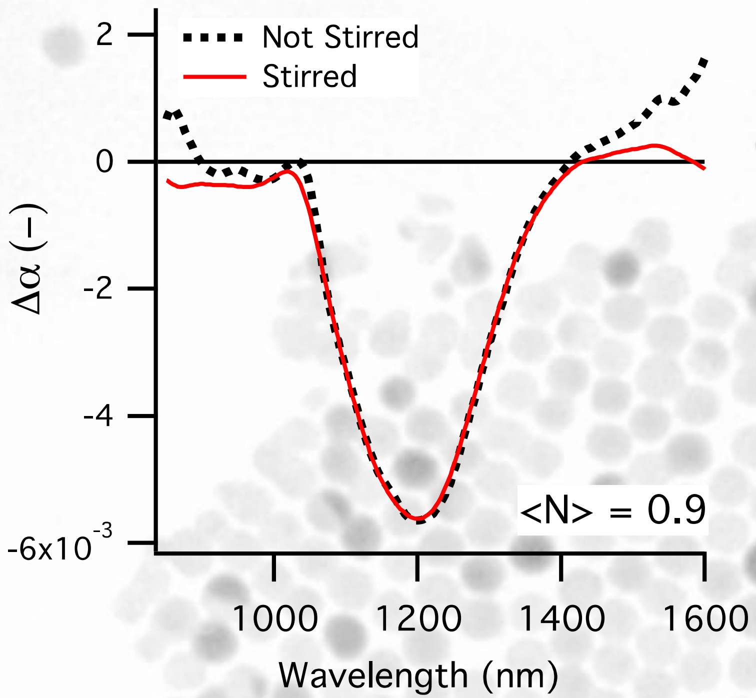
UNIVERSITEIT GENT
imec
PHOTONICS RESEARCH GROUP

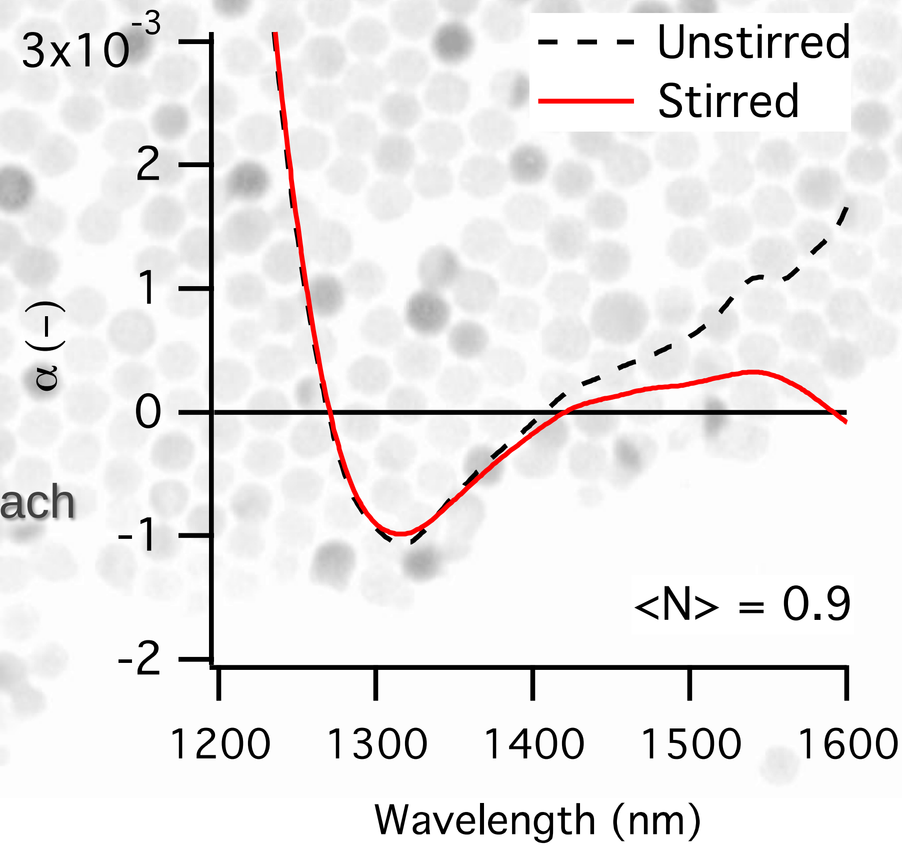
Kinetics



Bleach lives for >3 ns ! ⇨ **Gain is due to single excitons !**

To stir or not to stir …





Stirring has no influence on bleach but reduces PA background !

HgTe, really that great ?

Lowest gain threshold ever reported for colloidal NC, in essence thresholdless.

Long gain lifetime (up to radiative lifetime of 40 ns)

Low threshold/Long Gain lifetime = 5 orders of magnitude lower threshold then current NIR colloidal materials

(PbS, PbSe, …)

And :

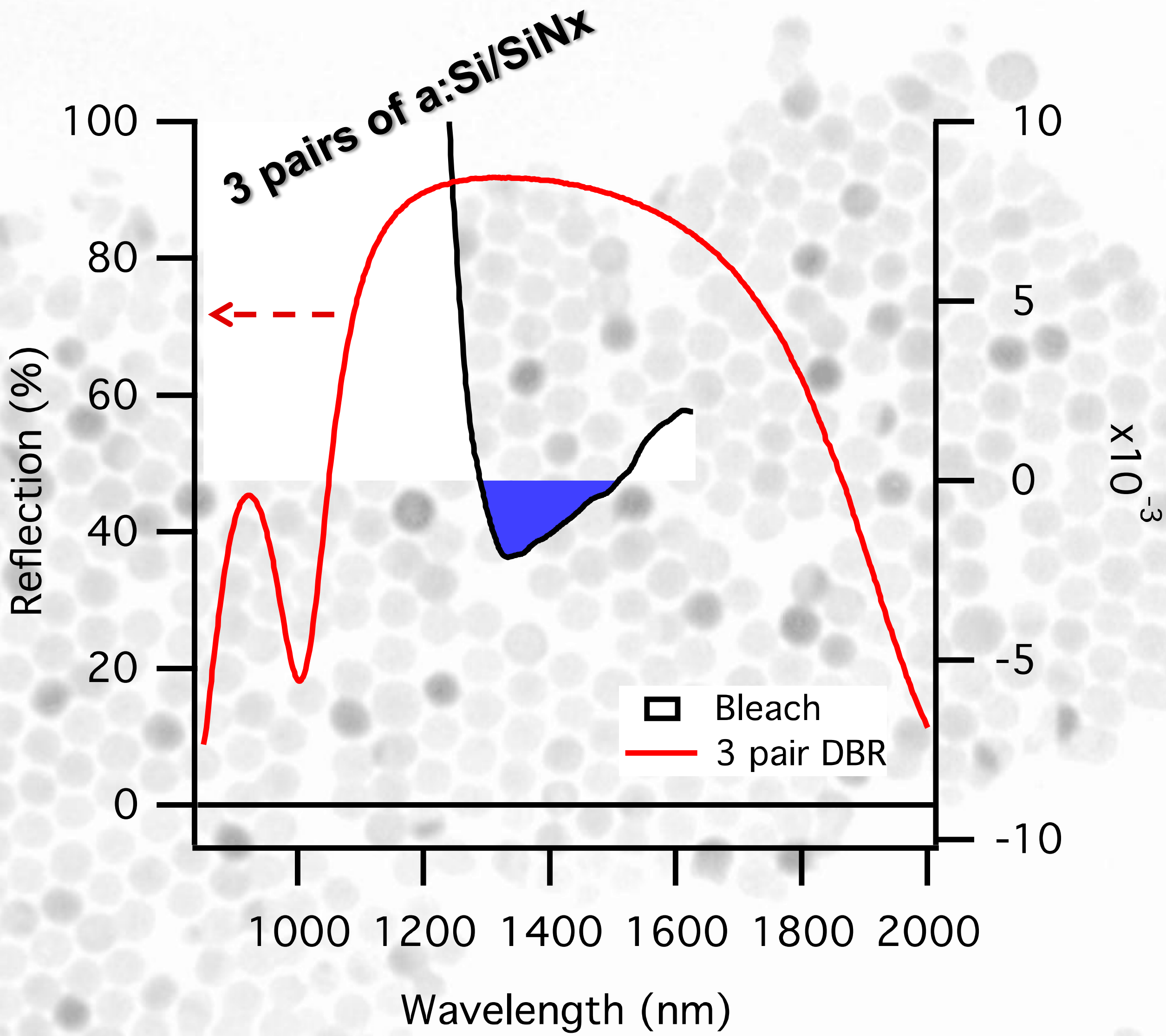
Gain is broadband (>200 nm) and achieved throughout the entire OESCL band

Easy wet chemical synthesis, no vacuum techniques needed

To conclude

- Inorganic dye, stable under long laser exposure
- Stable under ambient, not air-sensitive
- Easy synthesis (1 minute) at low T (60° C)
- Gain over the entire OESCL band

DBR fabrication – a:Si/SiNx



Acknowledgements

UNIVERSITEIT GENT

imec

PHOTONICS RESEARCH GROUP

FCN

nb-photonics

Center for Nano- and Biophotonics
Ghent University

TU Delft

Technische Universiteit Delft