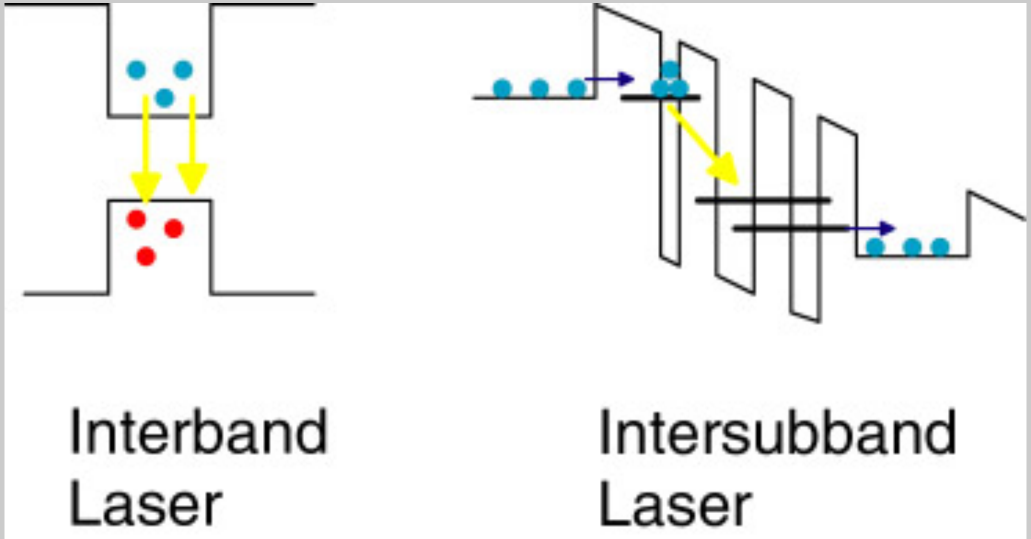
Intersubband laser



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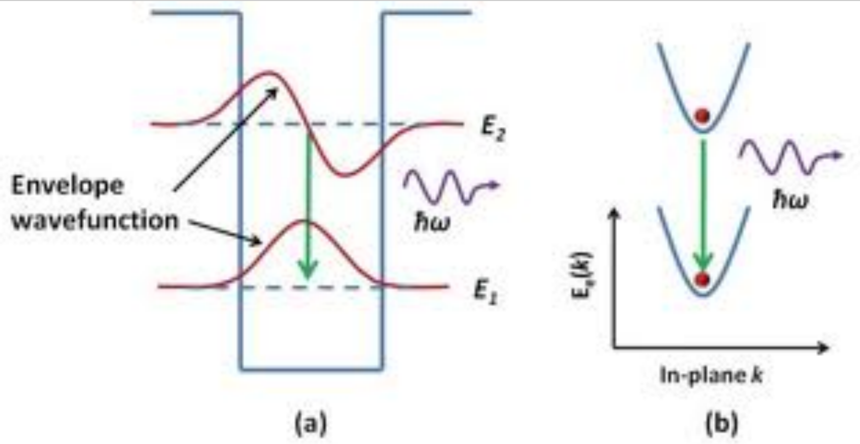
Intersubband laser

Long wavelength

Maybe silicon can be used



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Intersubband laser application

Molecules absorb in the infrared, which is precisely where intersubband lasers emit.

Detect low concentration of molecules in air.

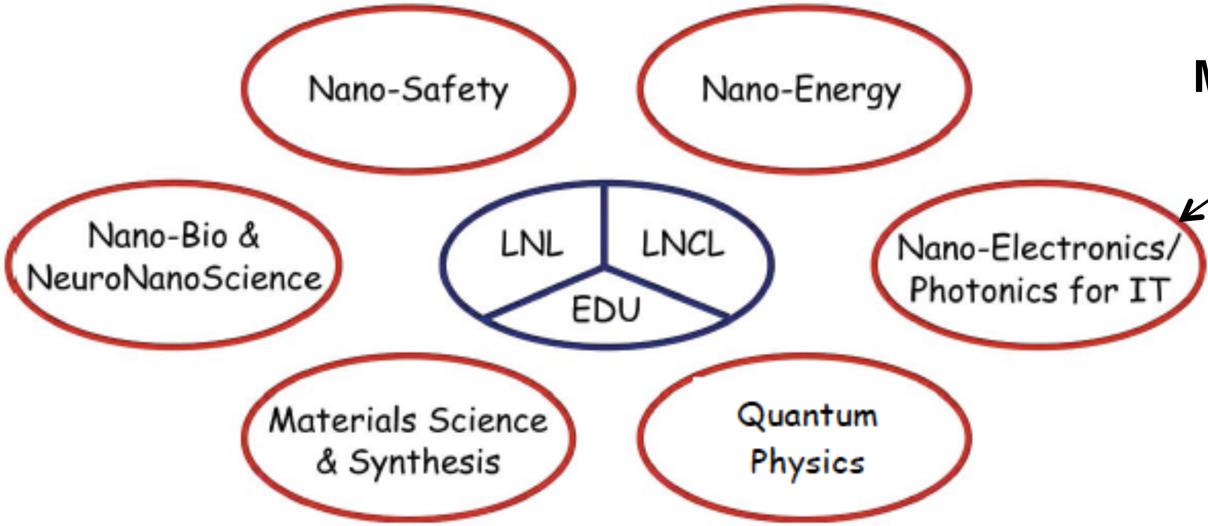
For example in medicine, detect lung cancer (and many other diseases) via breath.

Analyze smog, ...

nanometer Consortium Lund

Director: Heiner Linke,
Founder: Lars Samuelson, Co-director: Sara Linse

Since 1 January 2010:
The Nanometer Structure Consortium at Lund University (nmC@LU),
a Strategic Research Area funded by the Swedish Government
(in the area of Nanoscience and Nanotechnology)



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Nicklas Anttu

Resource areas:

LNL	Lund Nano Lab
LNCL	Lund Characterization Labs
EDU	Nanoscience Education

Resources

Fabrication of nanowires using several machines

Structural characterisation:
transmission elecron microscopy, X-ray diffraction

Electrical characterisation, also in magnetic field.

Optical characterisation, photoluminescence,
photoconductivity, ...

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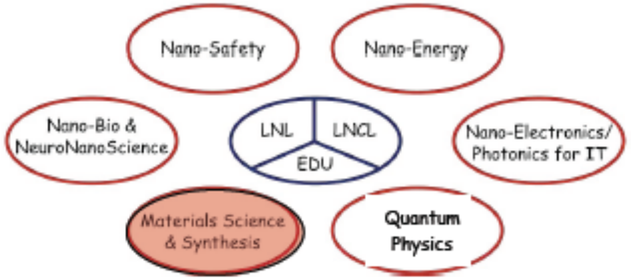
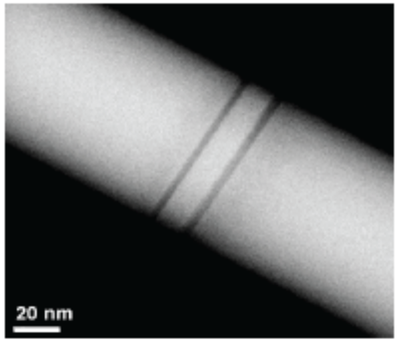
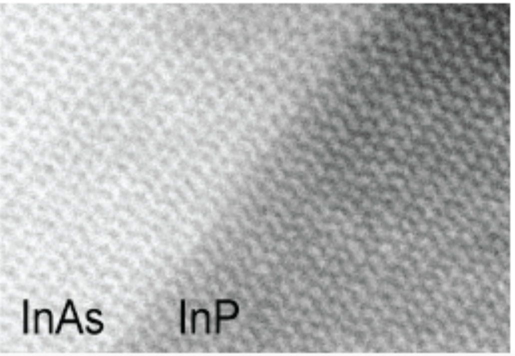
possibilities

Materials science & synthesis

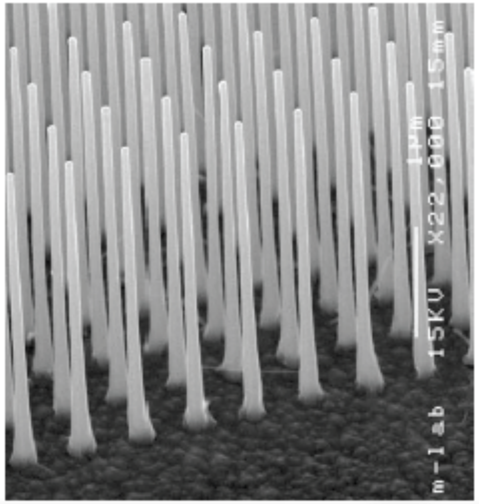


Heterostructures with atomically sharp interfaces

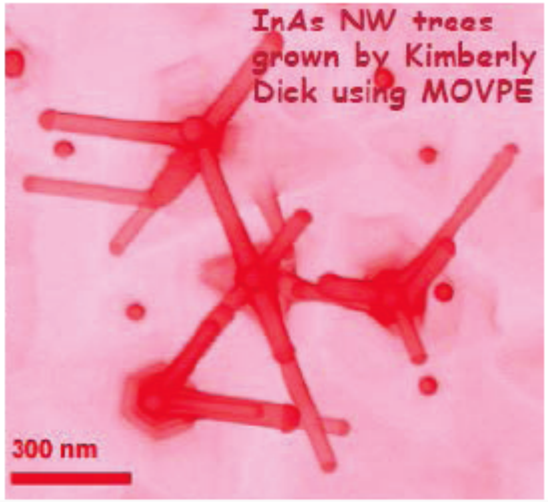




Accurate positioning: metal seed positioning by electron-beam lithography



Branched nanowire "trees"



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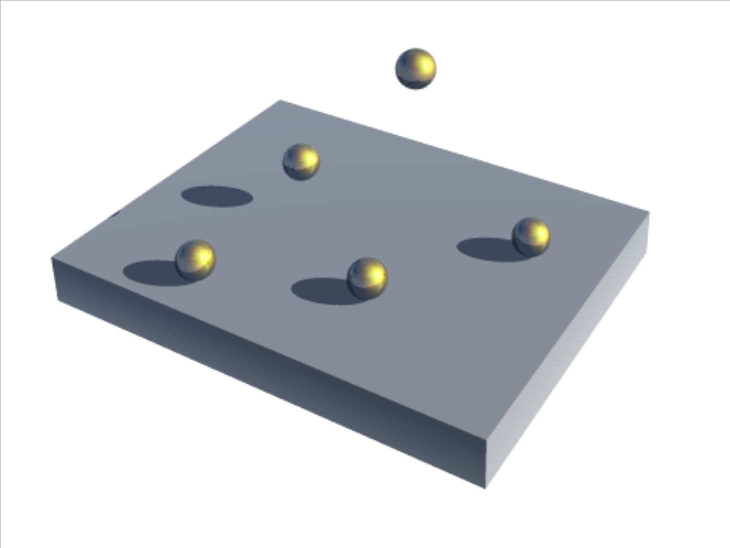
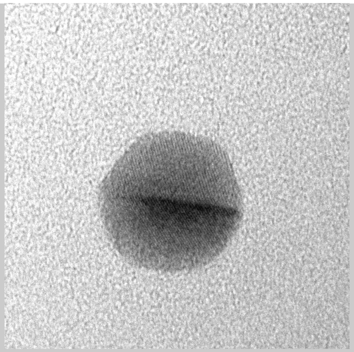
Seeding nanowire growth





• Nm-sized metal particles (Au)

- Aerosols
- Colloids
- Lithography

• Crystalline substrate (InAs)

- (111)B orientation

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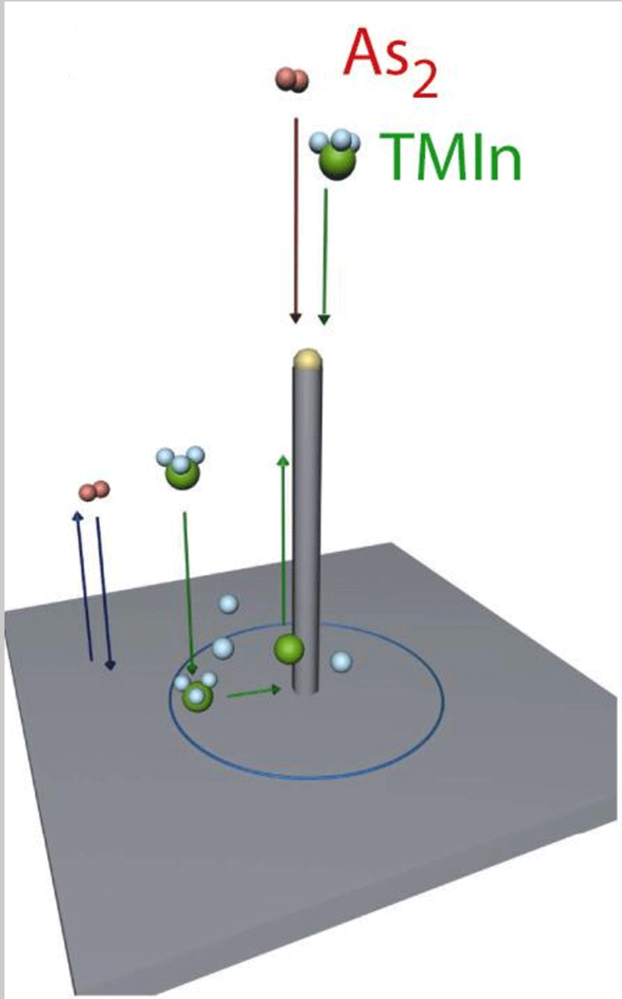
Metal-Organic Vapor Phase Epitaxy



MOCVD:
- **Low pressure**
- **Low growth rates**

Growth:
- **Au catalyze nanowire growth**
- **$D_{wire} \approx D_{Au}$**

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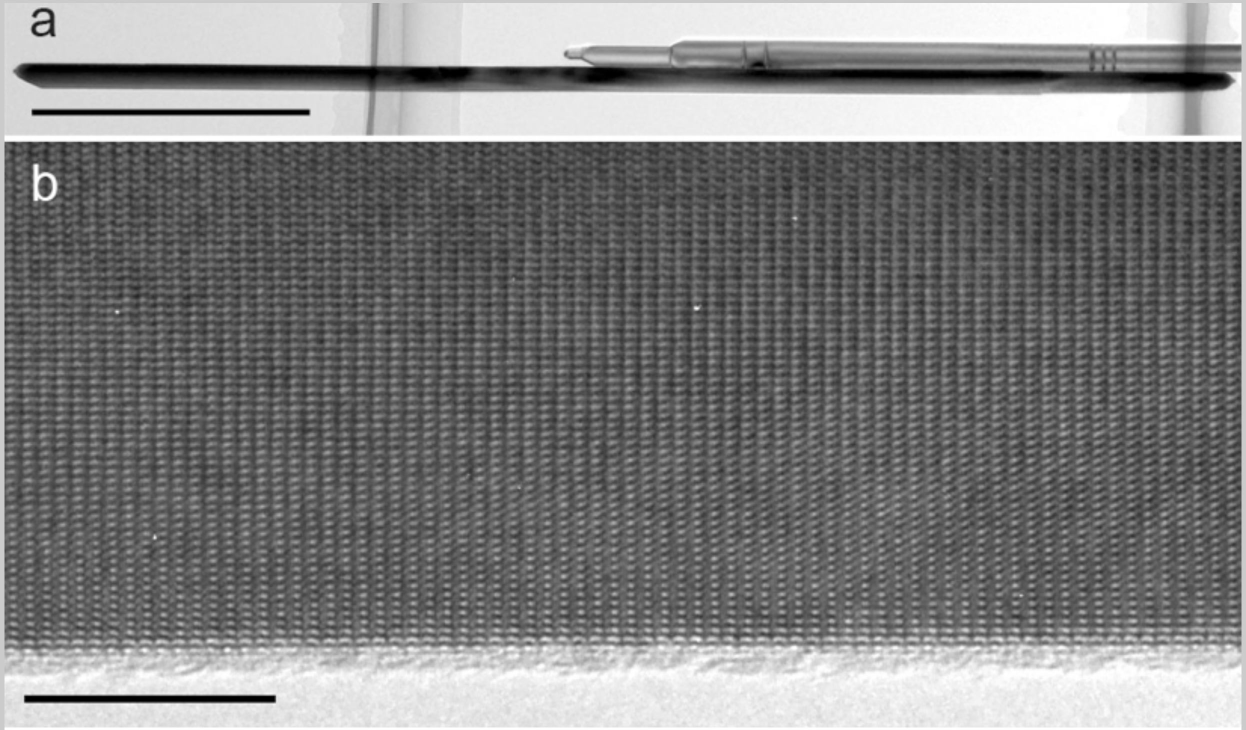
TEM results (wurtzite)



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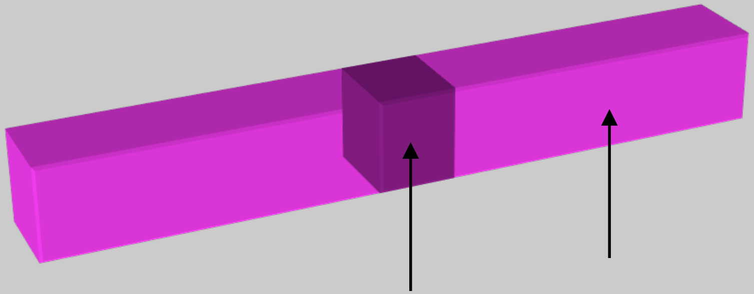
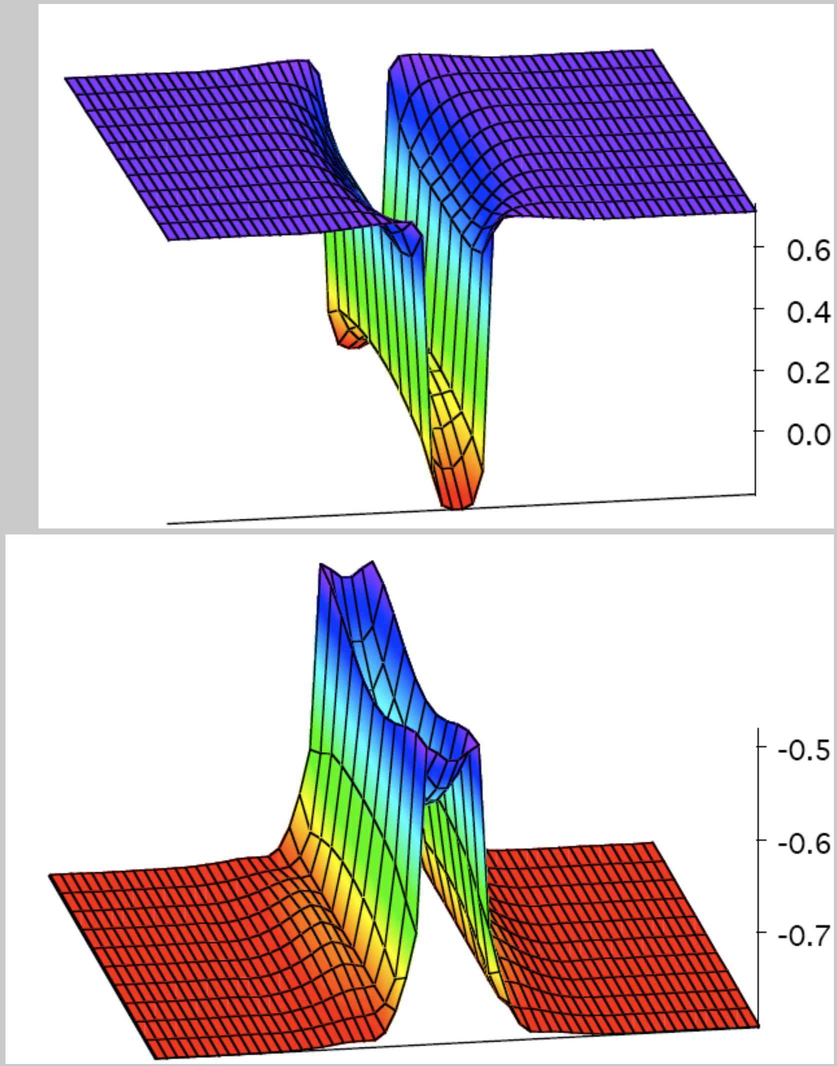
Segmented wires

Conduction band





Valence band

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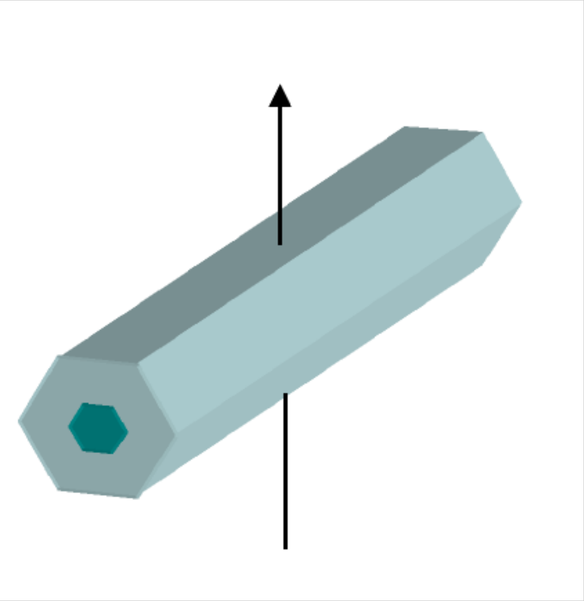
Core-shell



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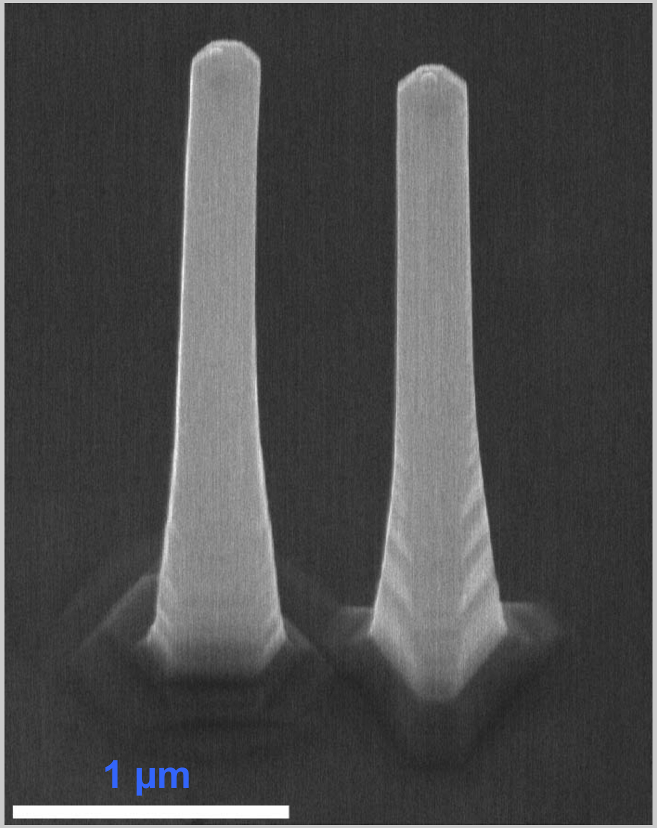
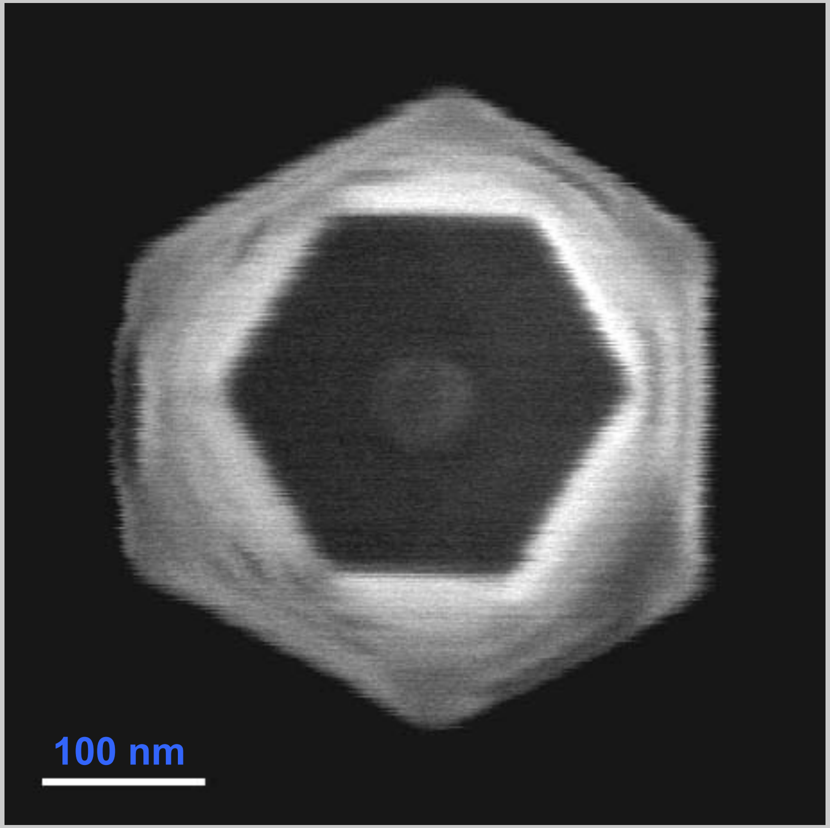
Core-shell wires

45 ° angle



topview



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Single photon source

using quantum dots

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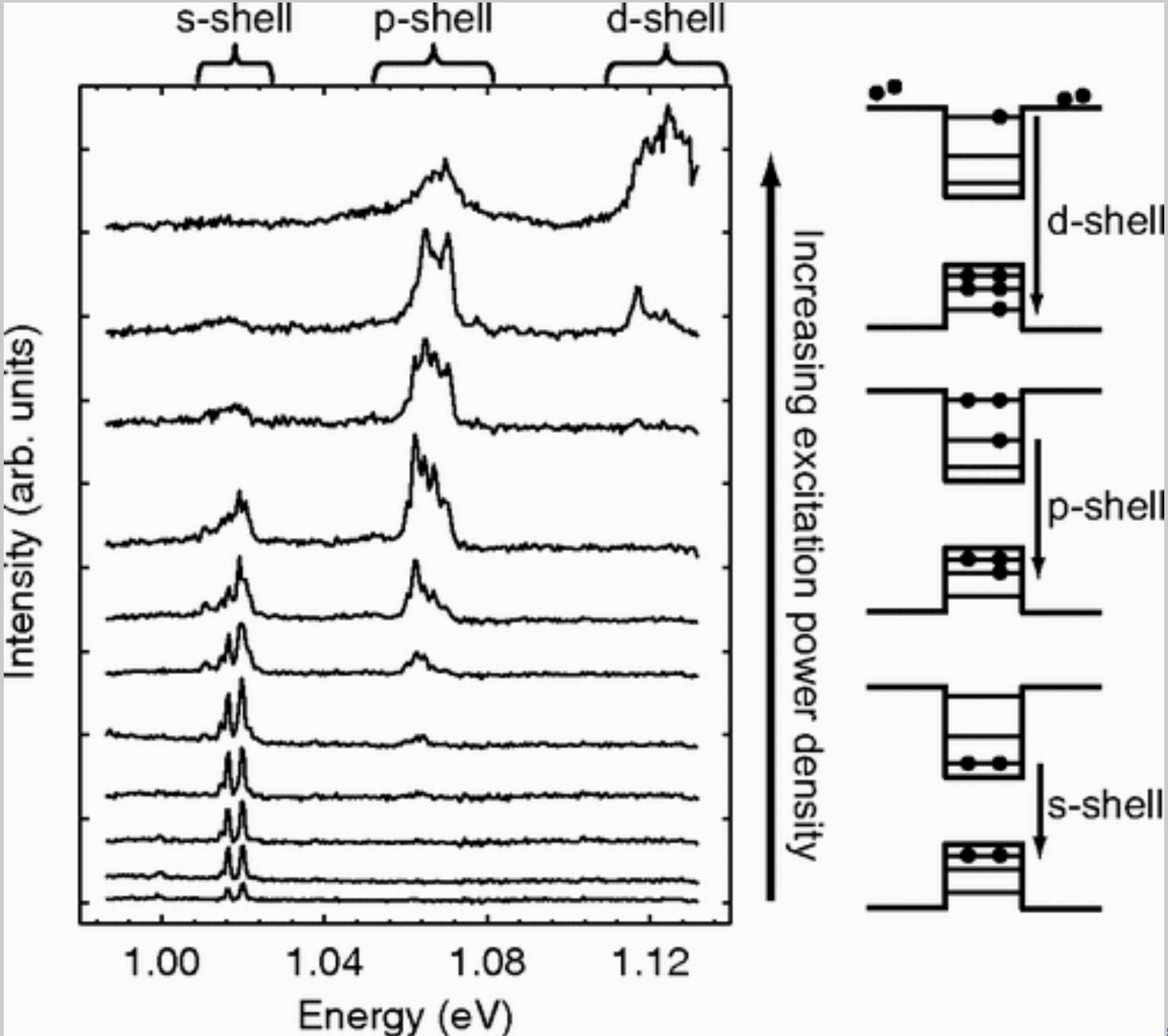
Increasing filling



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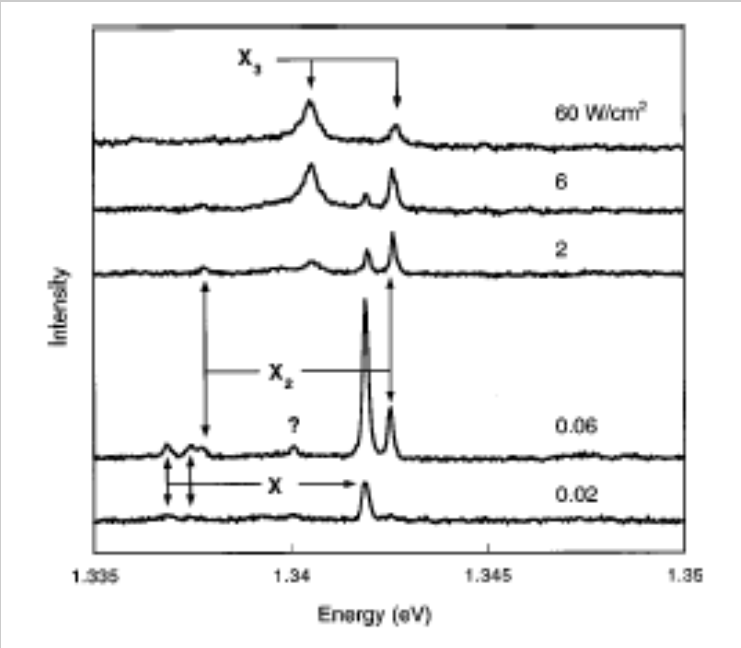
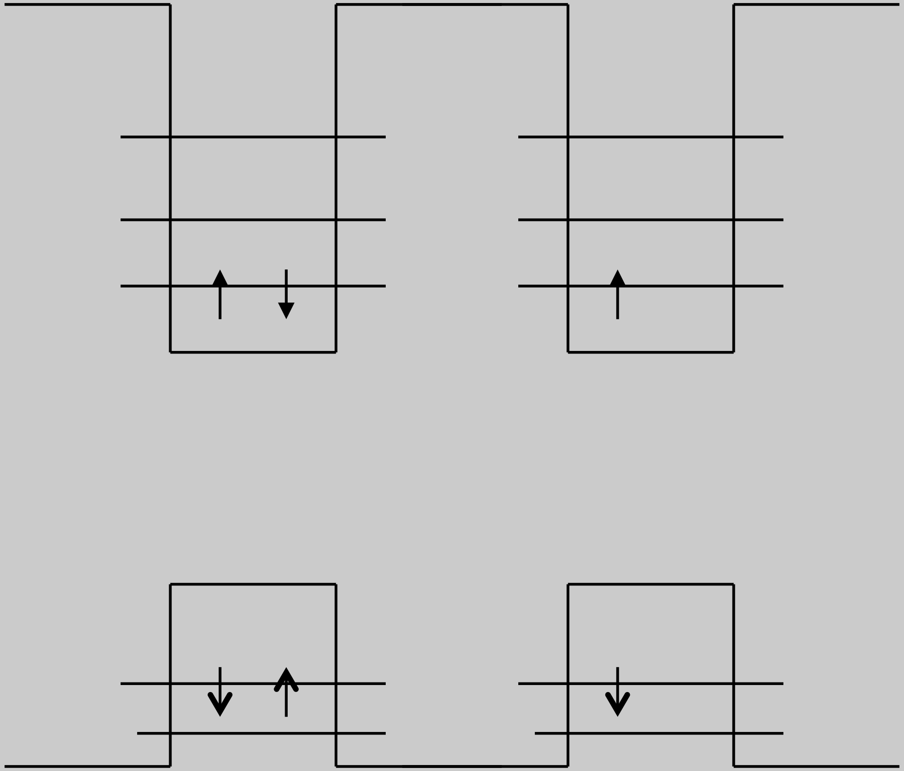
Detailed look





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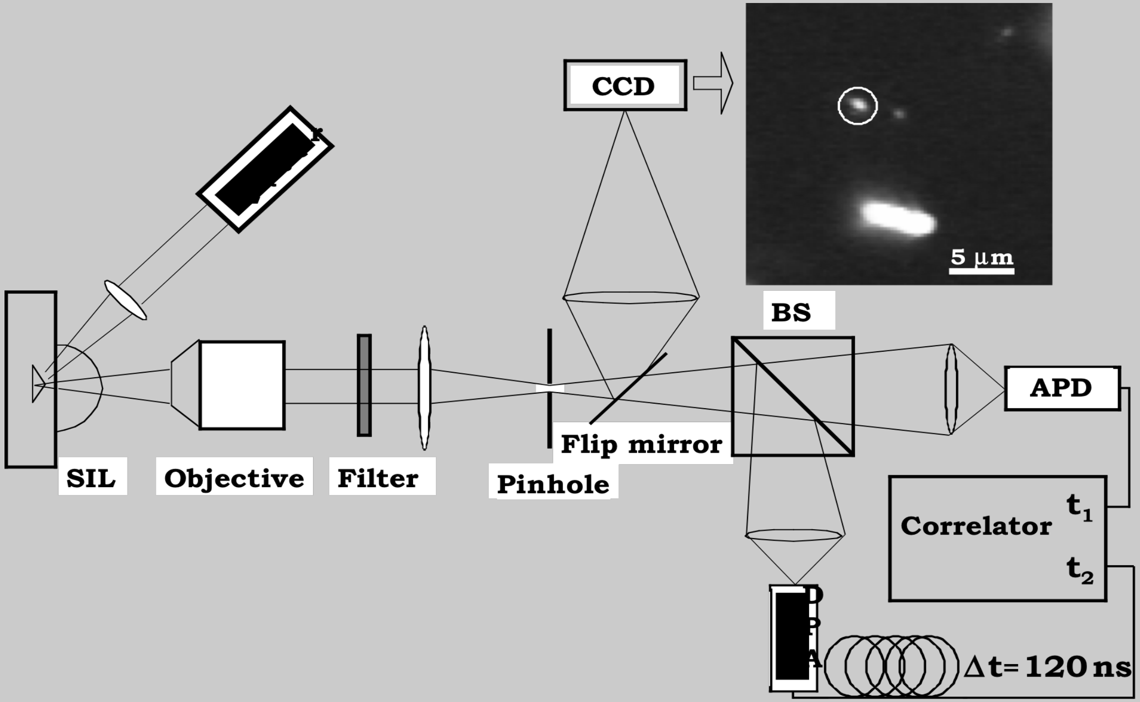
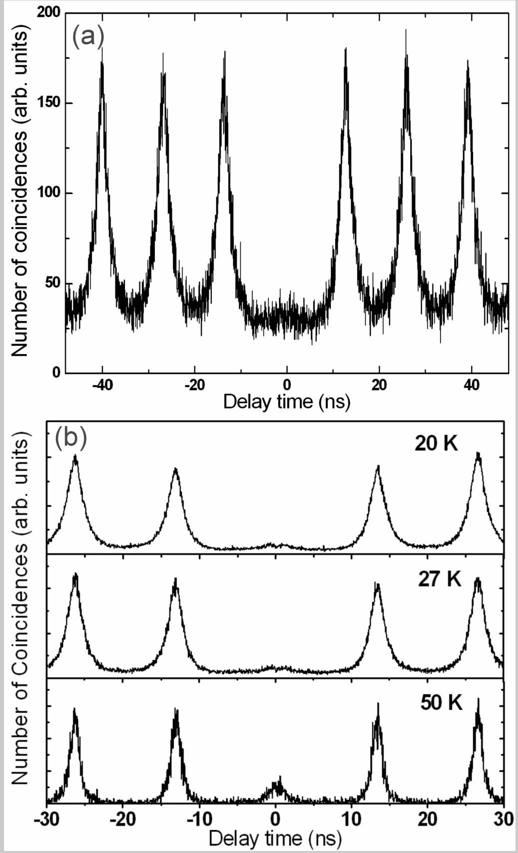
Single photons





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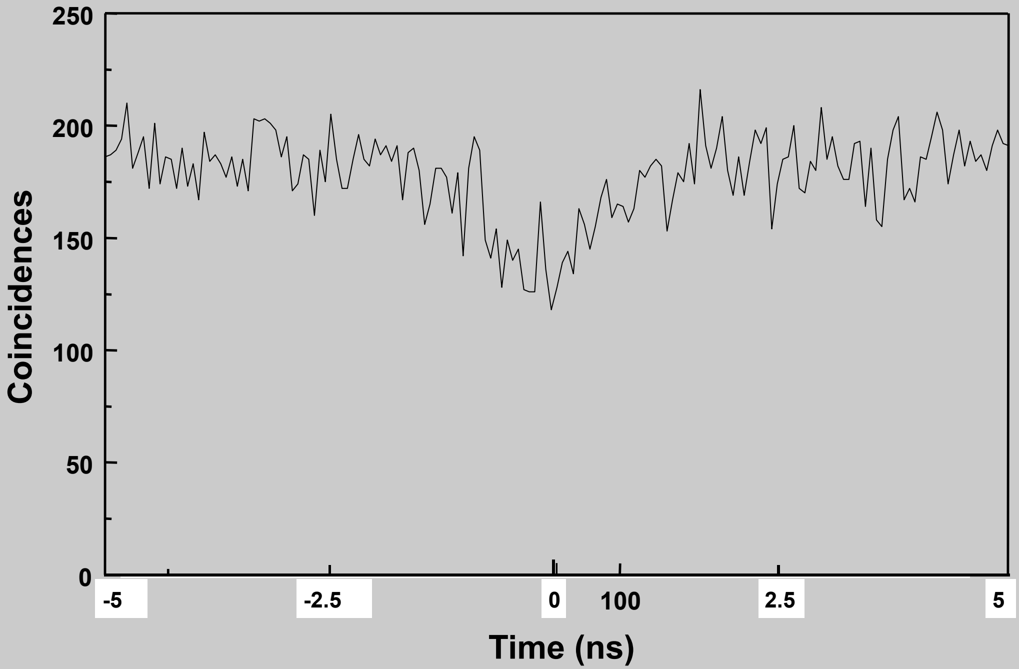
Single photons

Under continuous excitation



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Photon upconversion

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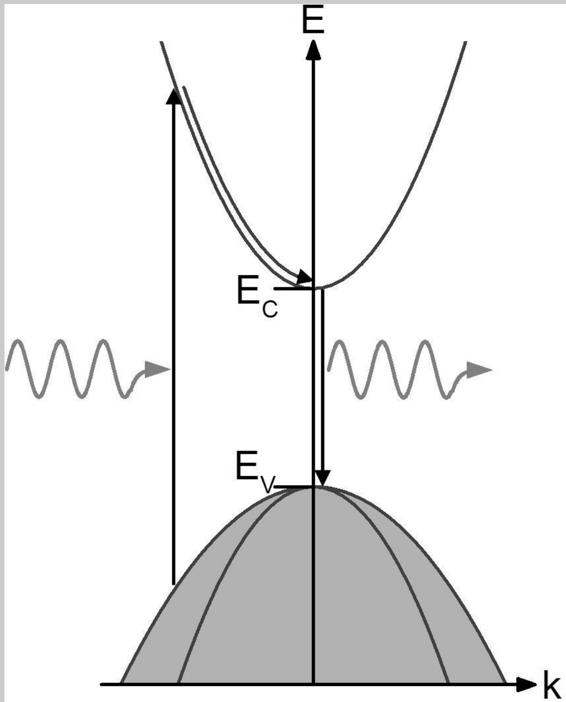
Photoluminescence

Excite



Conduction band

Detect

Valence band

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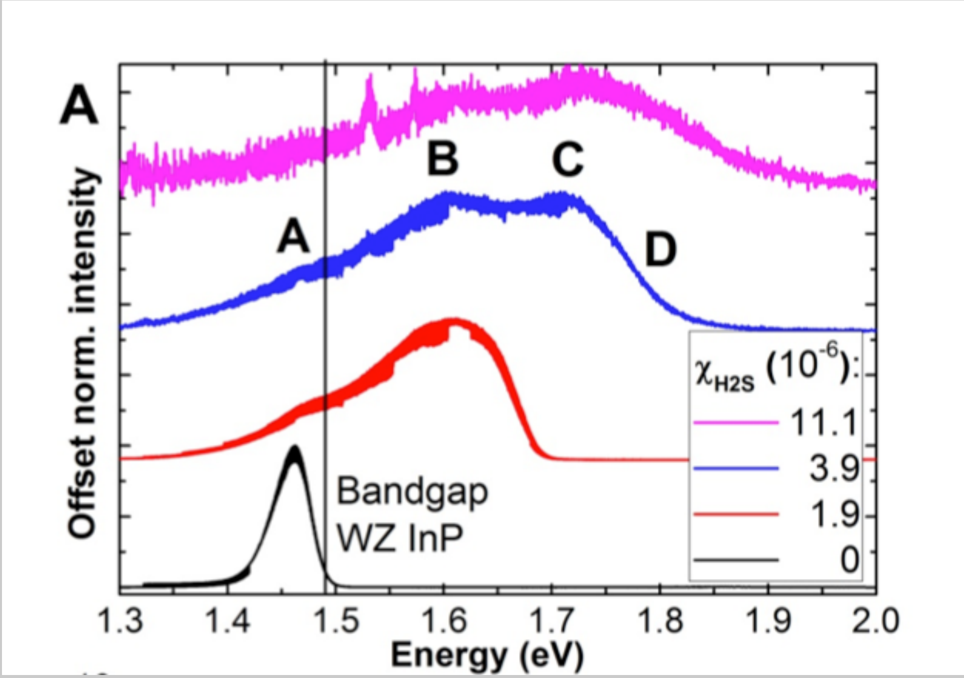
Doping dependent Photoluminescence
Single n-type InP wire

Increasing doping shifts the PL

Burstein-Moss effect

Increasing doping



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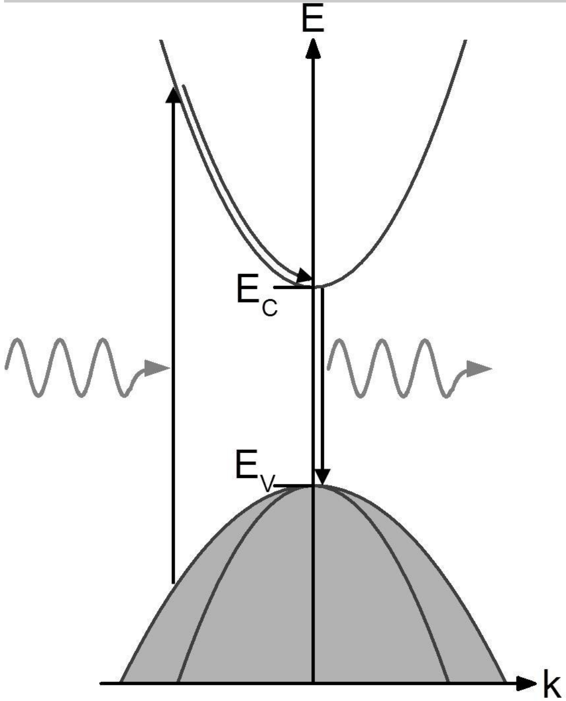
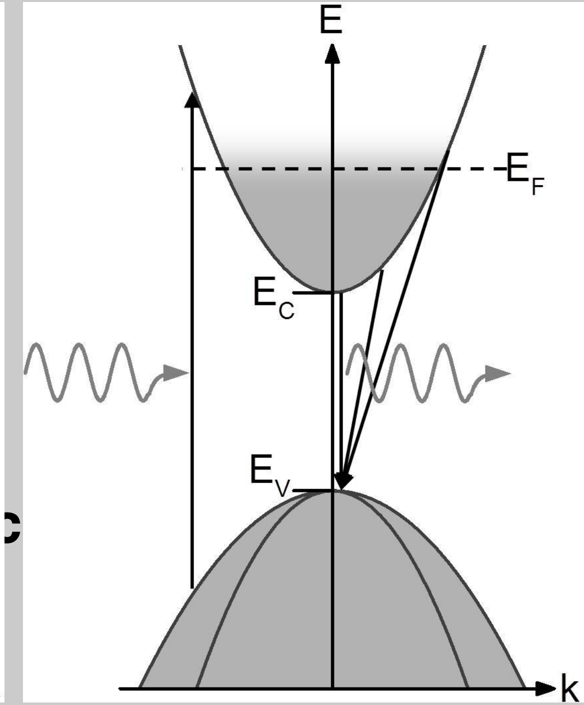
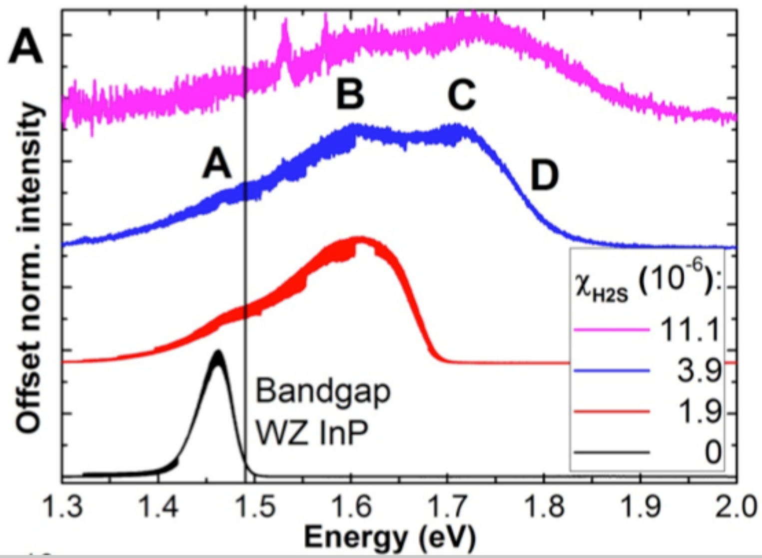
Burstein-Moss effect

No doping / **High doping**







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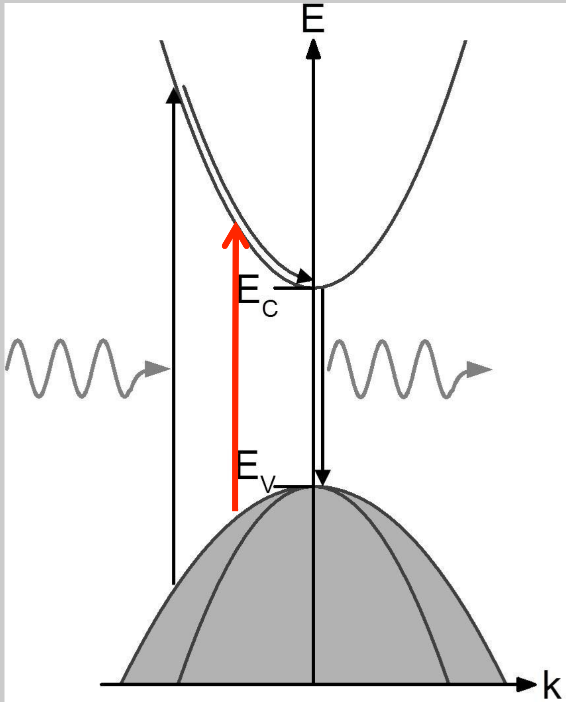
Photoluminescence excitation spectroscopy

Change excitation
energy using a tunable laser

Almost like absorption



Detect

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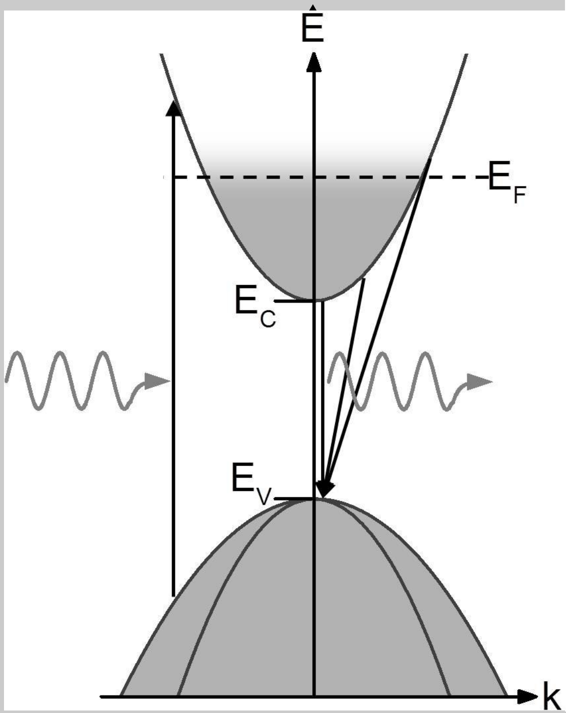
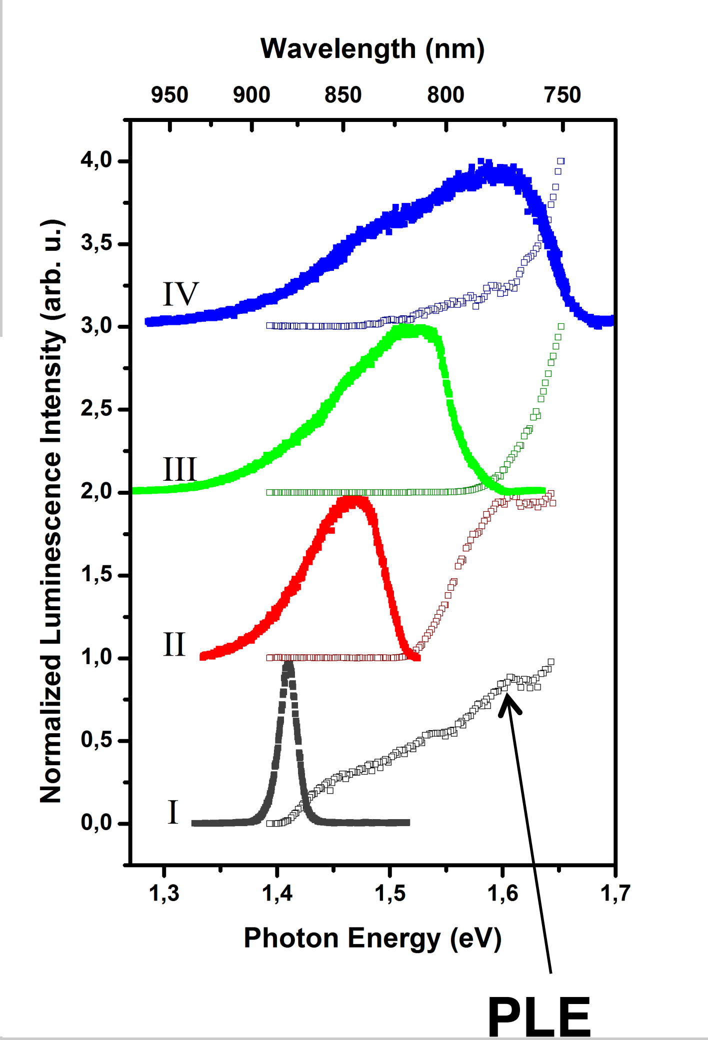
Doping dependent Photoluminescence Excitation Spectroscopy (PLE)

Change excitation energy.
Monitor luminescence

The absorption edge shifts.

No absorption into the electron gas according to text books.





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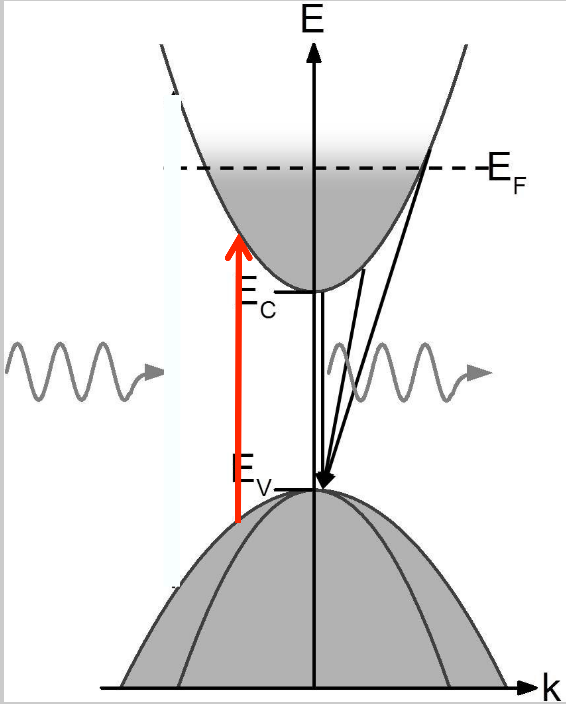
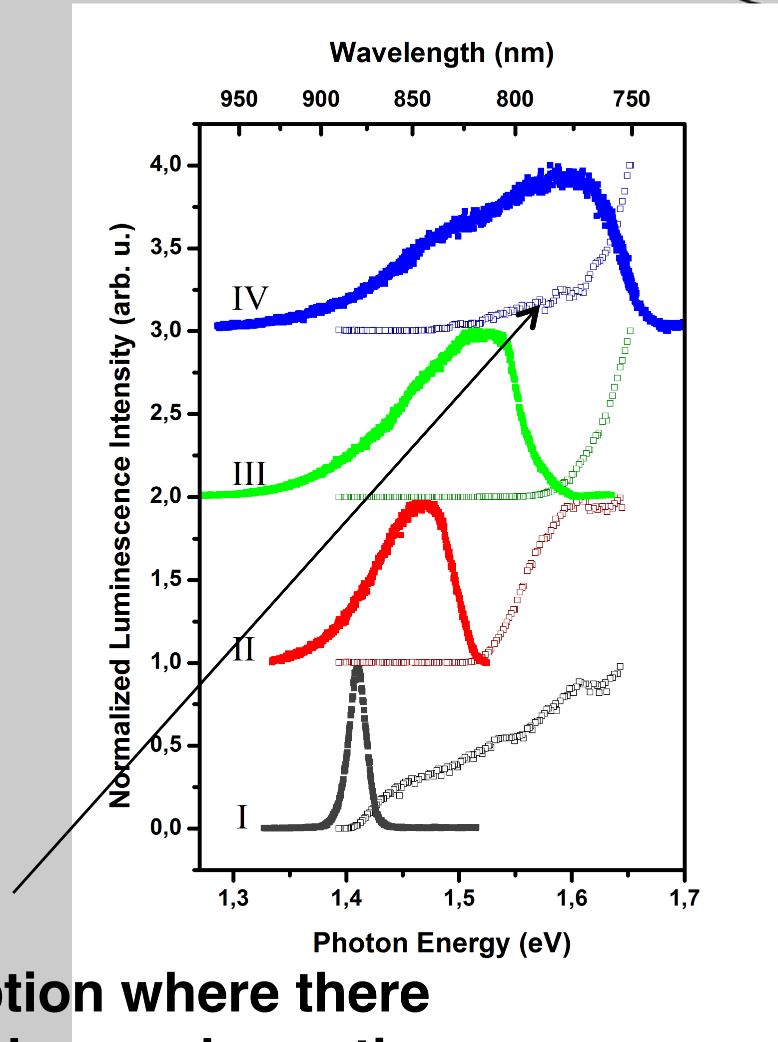
A closer look





Absorption where there should be no absorption

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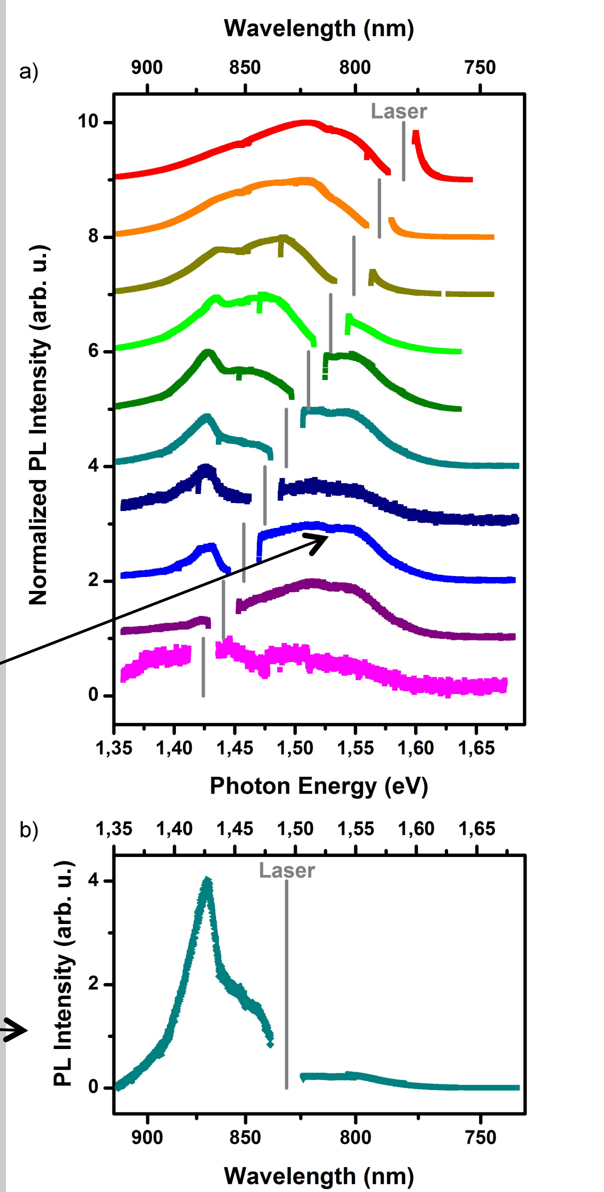
Excite into the electron gas

Photoluminescence below
and above the exciting laser energy

Photon upconversion !

Without adjustment of gain



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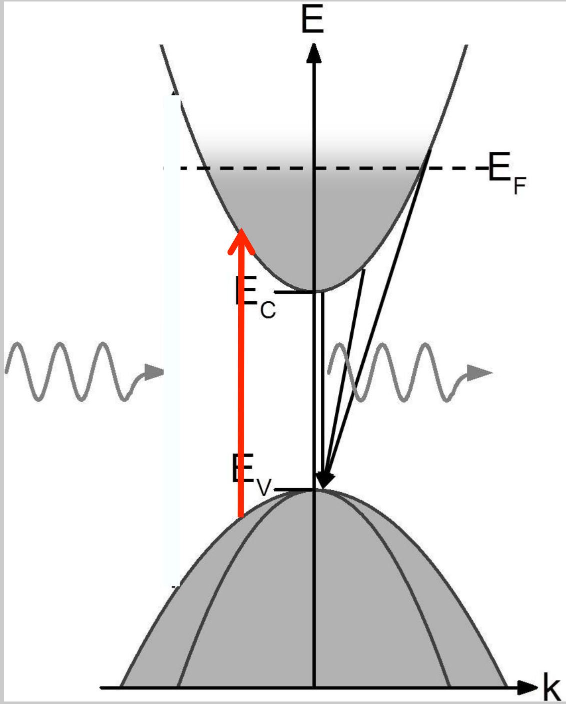
Rough explanation.



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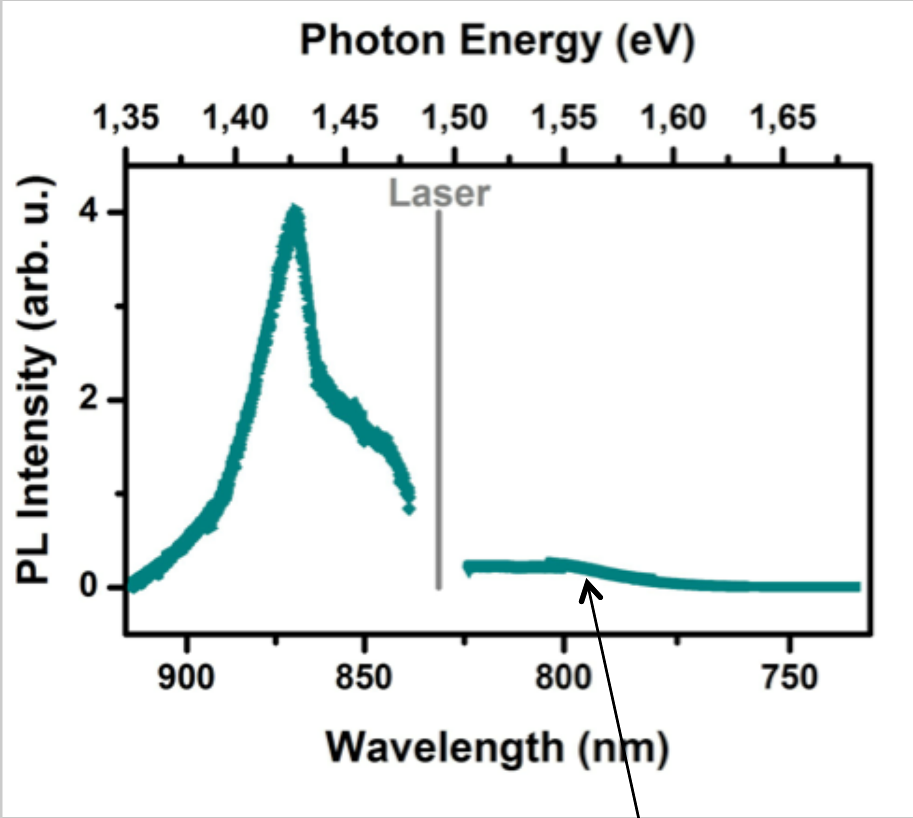
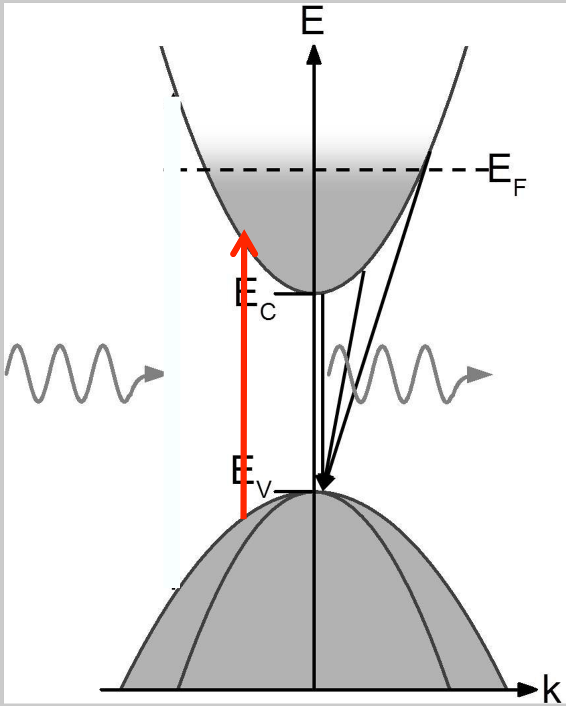
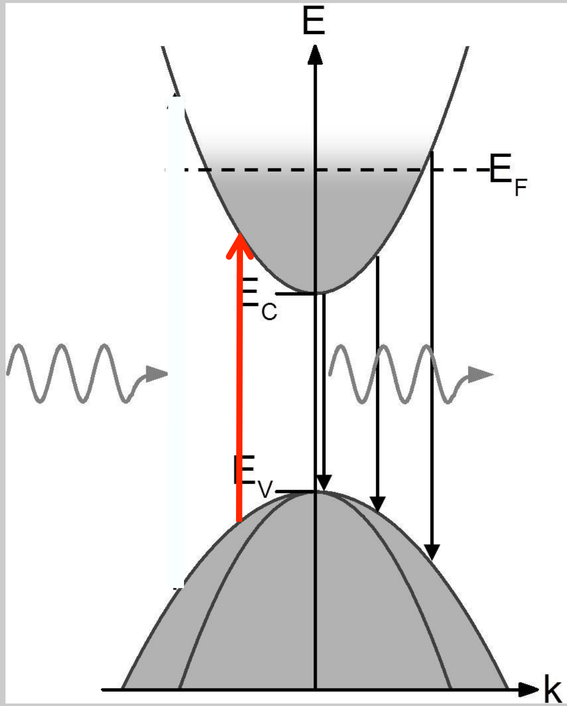
A puzzle



Why is this so weak?

A puzzle





It cannot be like this, because then the upconversion and downconversion peaks should have similar intensity.

It must be more like this. I. e. recombination must be as fast as the hole relaxation.

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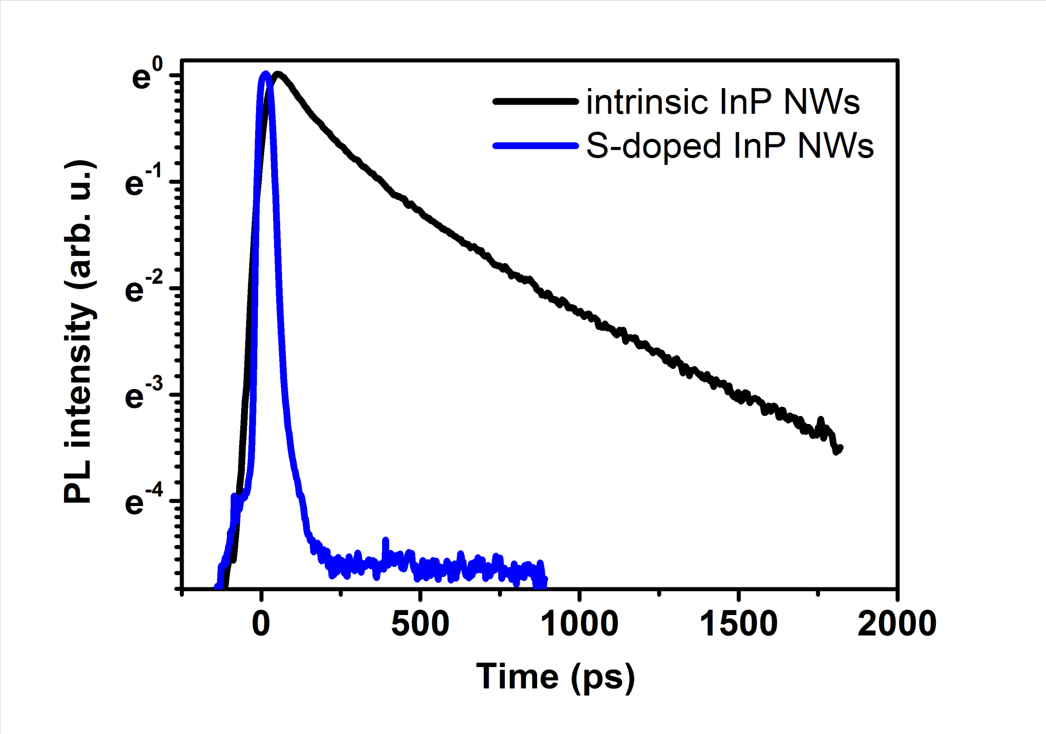
Test

Time-resolved photoluminescence



Highly doped samples have a very fast recombination time (10 ps)
Undoped samples have a recombination time of 200 ps.

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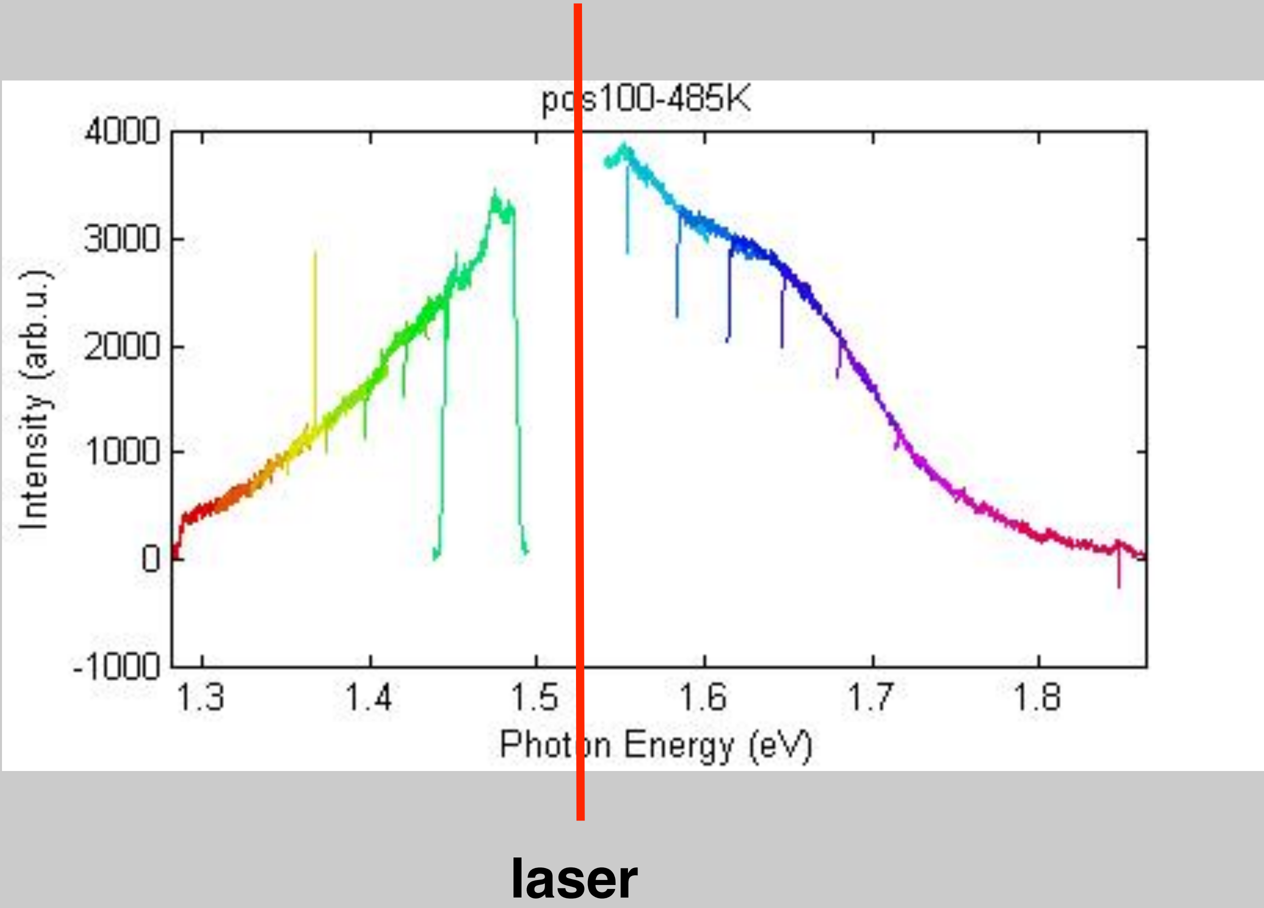
Room temperature



Equal intensity above and below laser line!

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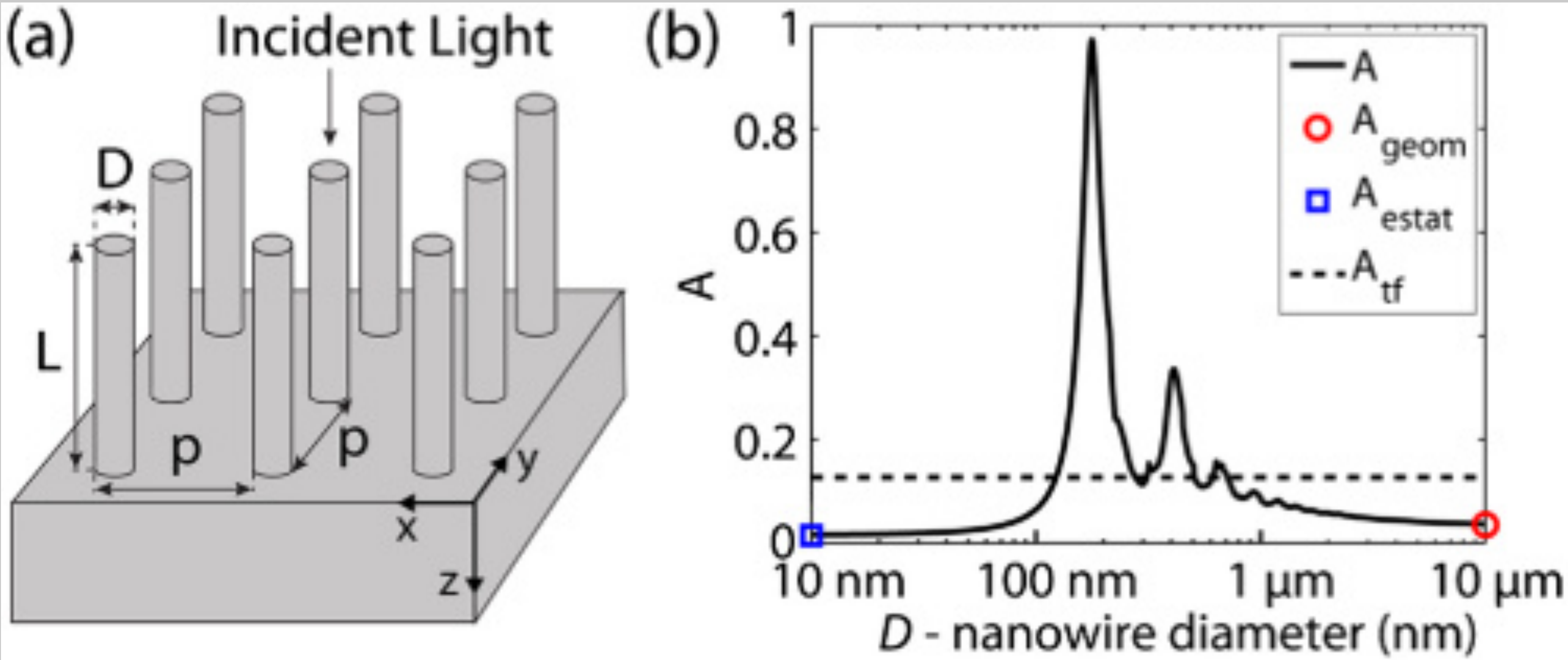
Classical optics, incoupling



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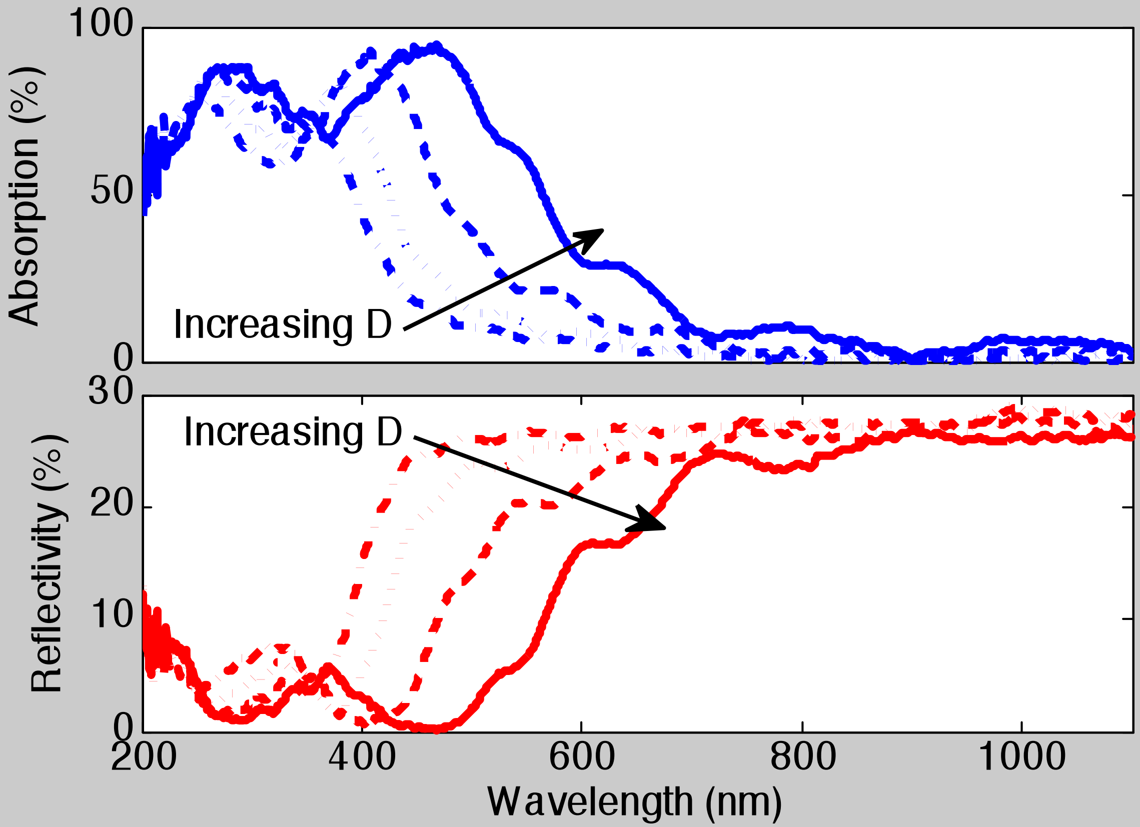
Classical optics, incoupling



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