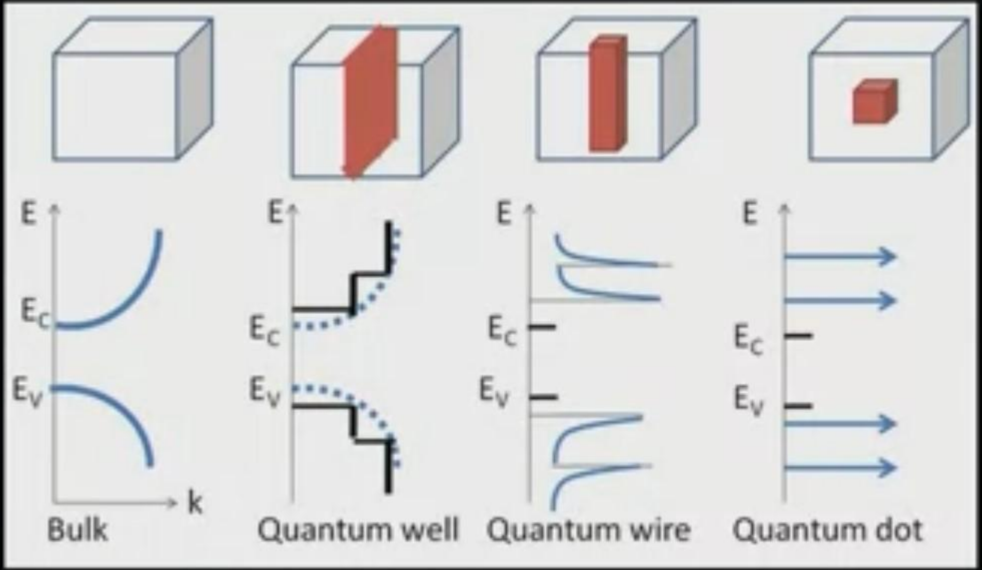
Quantum confinement

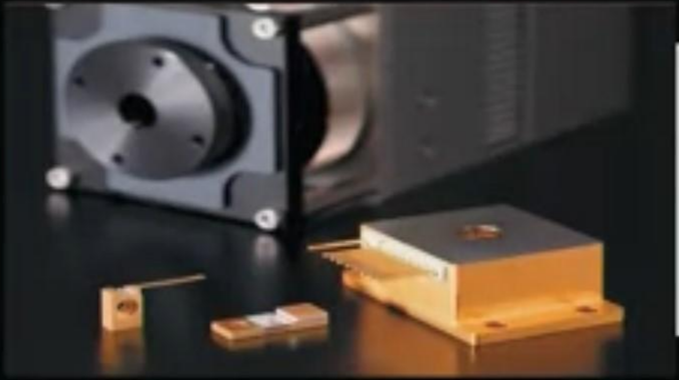


https://www.intechopen.com/books/solar-cells-new-approaches-and-reviews/quantum-dots-solar-cells

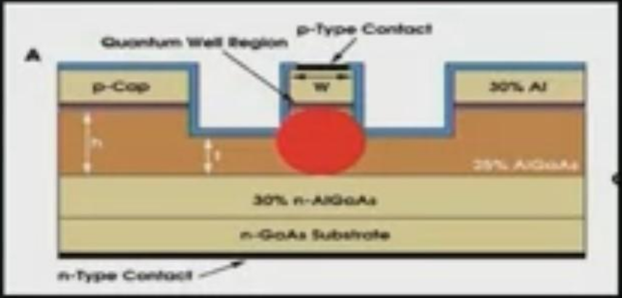
enhanced performance from your optical devices

Quantum effects and lasers

Quantum cascade laser [1]



Quantum well laser [2]



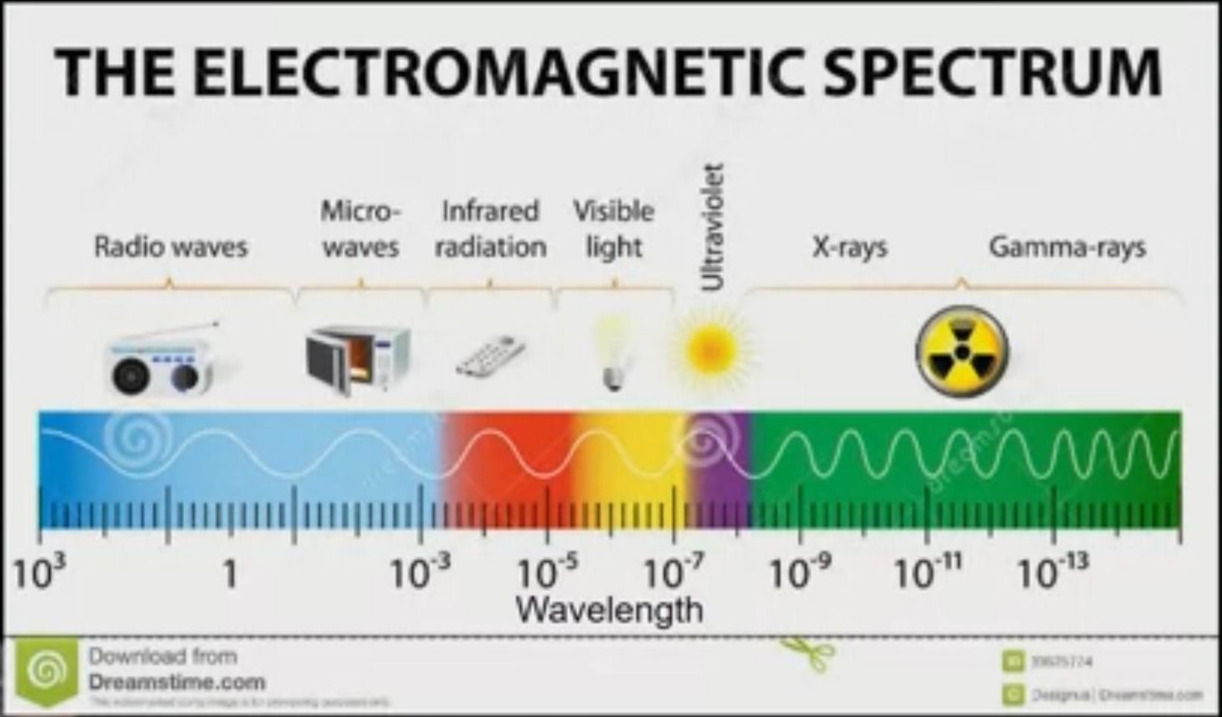
[1] https://www.google.com/search?q=quantum+cascade+laser&source=lnms&tbm=isch&sa=X&ved=0ahUKEwje-ZSh_IDWAhUi7IMKHUx-Ad8Q_AUIDCgD&biw=1264&bih=734#imgrc=smIKu2nydmGmSM:&spf=1504165248807

[2] P. W. Juodawlkis et al, "High-Power, Low-Noise 1.5-µm Slab-Coupled Optical Waveguide (SCOW) Emitters: Physics, Devices, and Applications," IEEE J. of Sel. Top. in Quant. Electron. 17, 1698-1714 (2011).

just see an example from a publication from 2011,

1:02 / 1:57

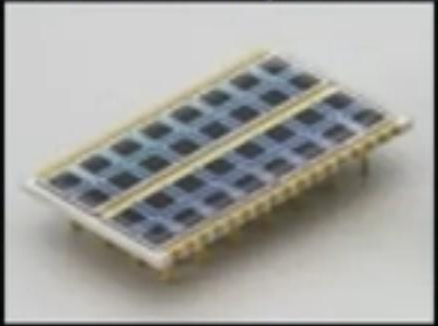
Electromagnetic spectrum



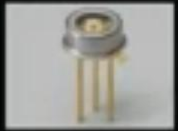
you're essentially going doing optical detection to electrical,

Detectors

Silicon avalanche photodiode



PIN photodiode



http://www.hamamatsu.com/us/en/product/category/3100/4003/index.html

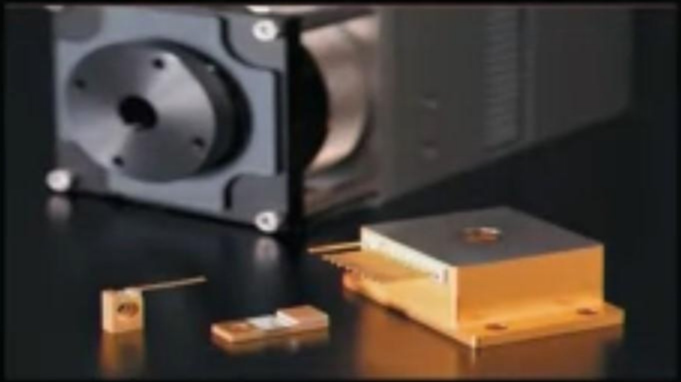
Questions to answer

- How do different detectors work?
- What are pros/cons?
- State of the art?

also a PIN photo diode and answer questions of how do these detectors work?

1:47 / 1:57

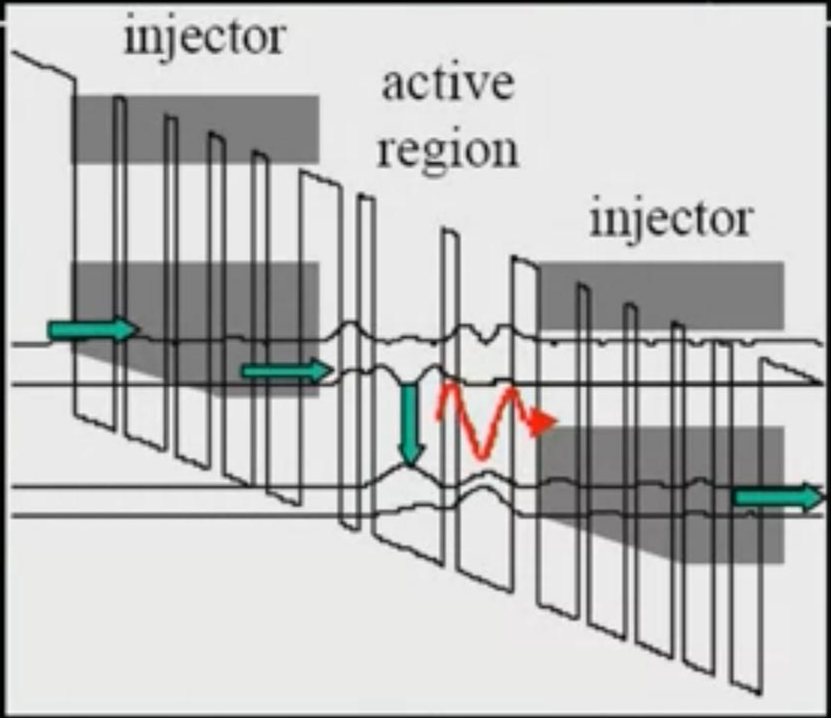
Quantum Cascade Laser



https://www.google.com/search?q=quantum+cascade+laser&source=lnms&tbm=isch&sa=X&ved=0ahUKEwje-ZSh_IDWAhUi7IMKHUx-Ad8Q_AUIDCgD&biw=1264&bih=734#imgrc=smIKu2nydmGmSM:&spf=1504165248807

revolutionized the market for mid and long wavelength infrared lasers.

Quantum Cascade Laser

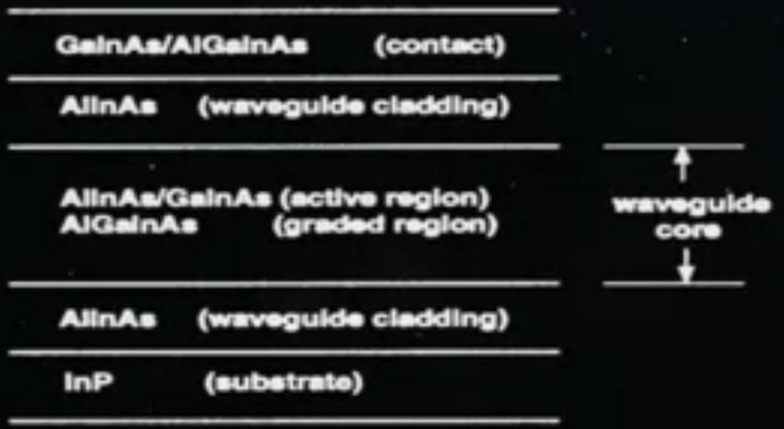


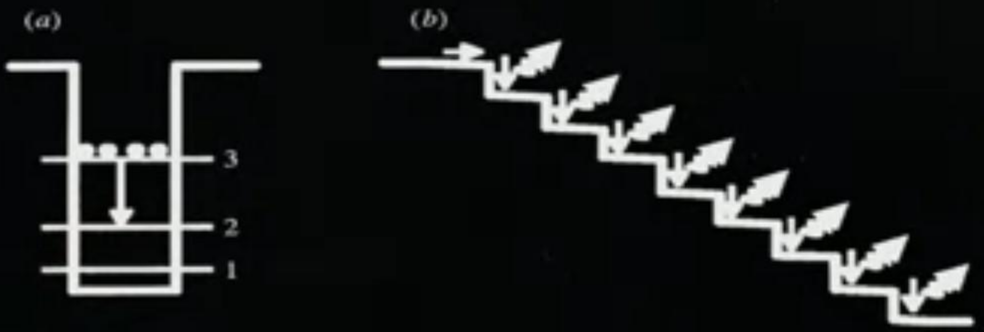
http://cqd.eecs.northwestern.edu/research/qcl.php

based on a series of hundreds of semiconductor laser layers.

0:31 / 1:25

Quantum Cascade Laser

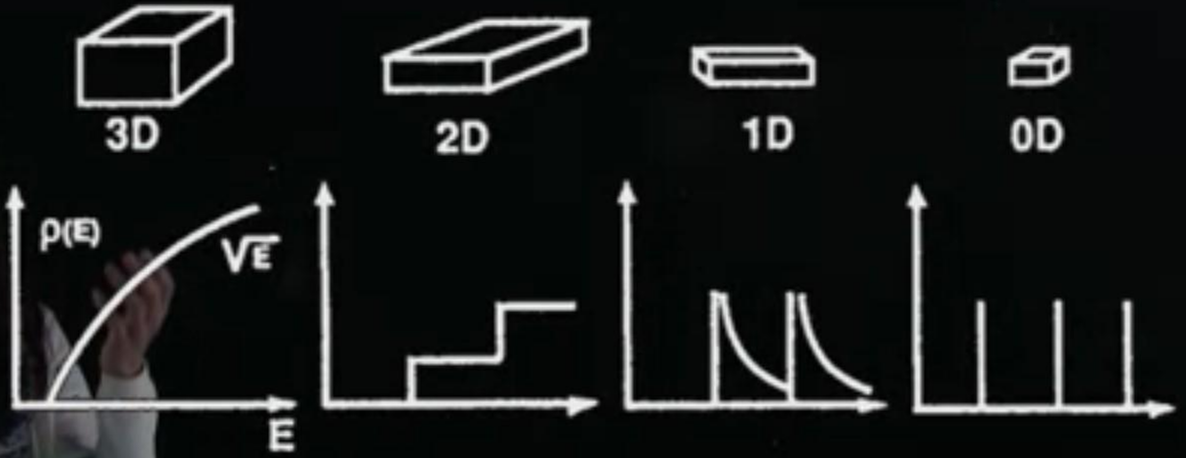




That's in essence what's happening with the quantum cascade laser.

0:44 / 1:25

DOS in Low-Dimensional Structures

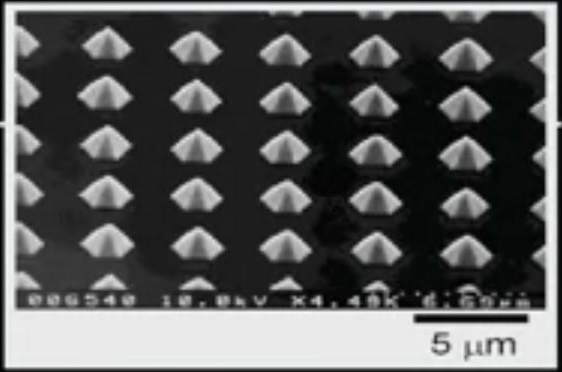


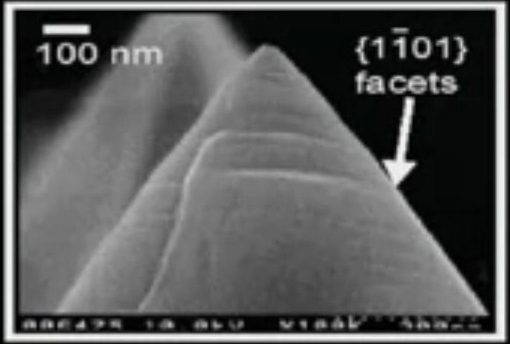
https://www.researchgate.net/figure/241880293_fig1_Figure-11-Schematic-of-low-dimensional-semiconductor-structures-and-the-corresponding

what happens when I have three-dimensions?

0:55 / 1:25

Nitride Quantum Dot Laser

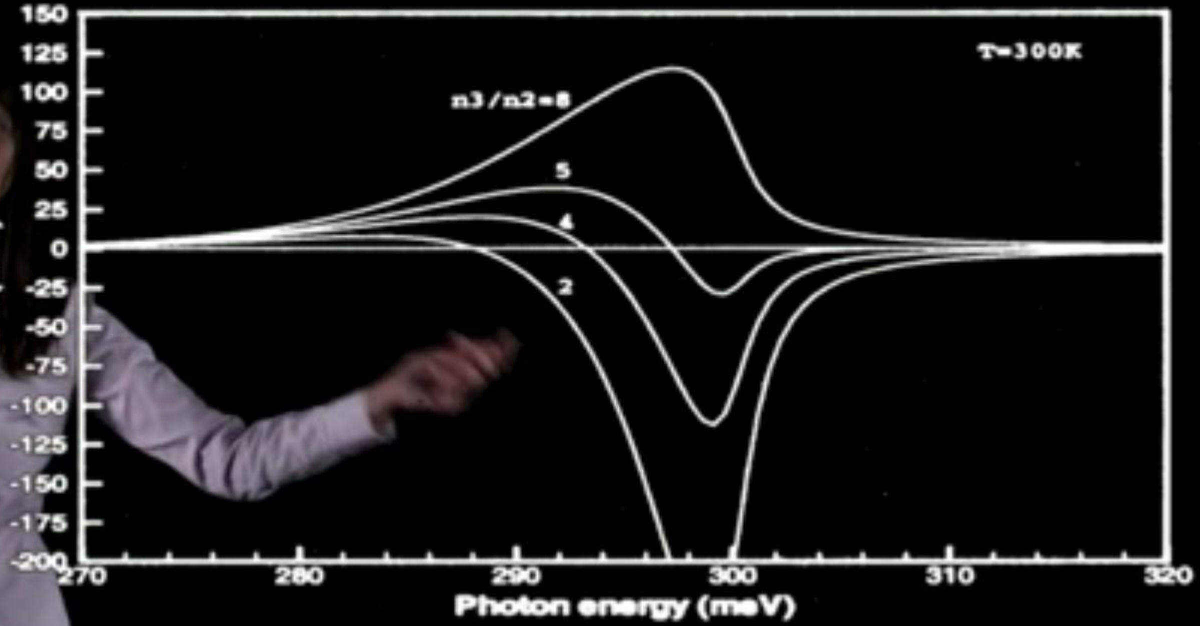




Tachibana, Someya, Ishida, and Arakawa, Fabrication of GaN quantum dots by metalorganic chemical vapor selective deposition, J. Crystal Growth, 237-239, 1312 (2002).

This is an example of a nitride quantum dot laser

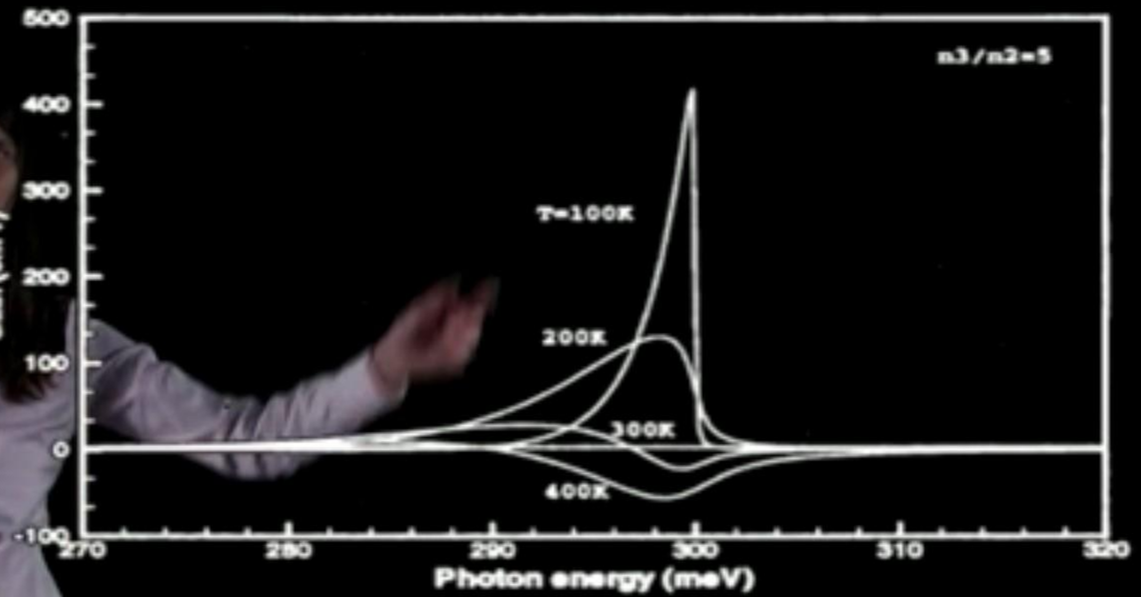
Quantum Cascade Laser



and you can see when you get to about five,

5:39 / 7:07

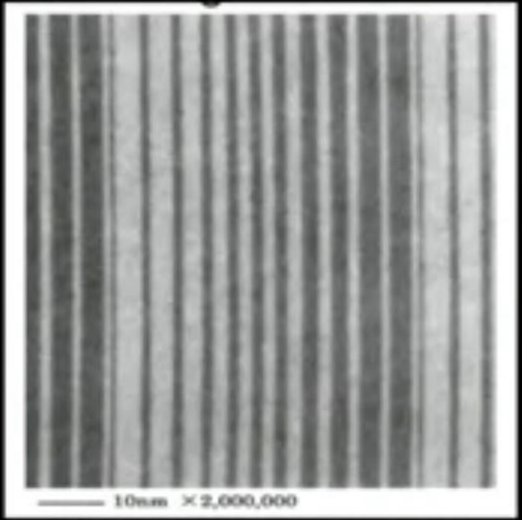
Quantum Cascade Laser



You can see that here so you can see what happens to the gain as I started
100K,

6:00 / 7:07

Quantum Cascade Laser



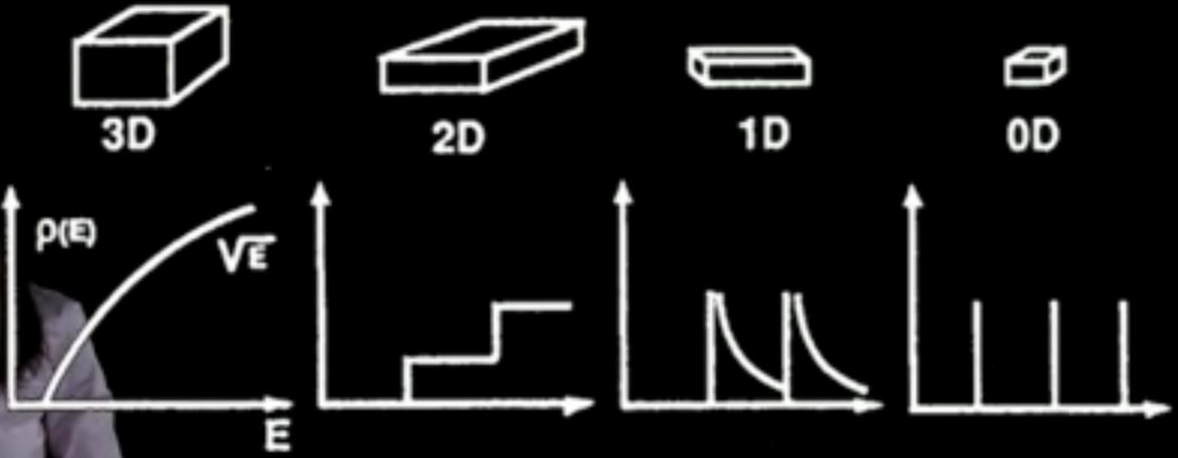
you the different layers in a typical Quantum Cascade Laser.

7:00 / 7:07

DOS in Low-Dimensional Structures

1D
$g(E) \propto \frac{1}{\sqrt{E}}$

0D
$g(E) \propto \delta$



https://www.researchgate.net/figure/241880293_fig1_Figure-11-Schematic-of-low-dimensional-semiconductor-structures-and-the-corresponding

the lever we have on the device
performance is that it modifies the gain.

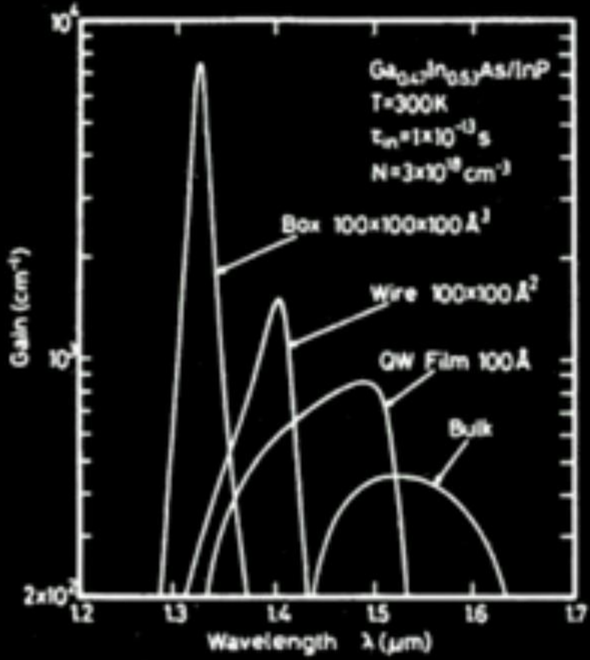
DOS in Low-Dimensional Structures

1D

$$g(E) \propto \frac{1}{\sqrt{E}}$$

0D

$$g(E) \propto \delta$$



Arai and Maruyama, GaInAsP/InP quantum wire lasers, IEEE Sel. Top. In Quant. Electron. 15, 731 (2009)

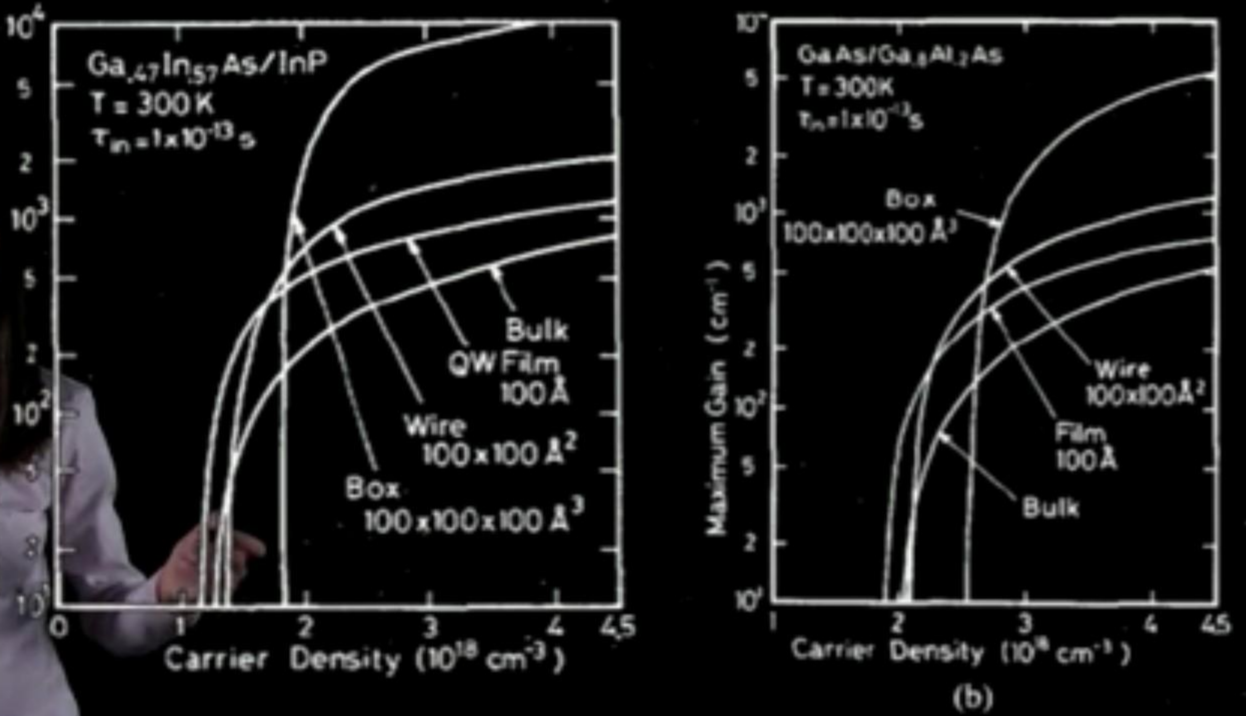
So here you're looking at gallium
indium arsenide indium phosphide.

2:01 / 3:14

DOS in Low-Dimensional Structures

1D
$g(E) \propto \frac{1}{\sqrt{E}}$

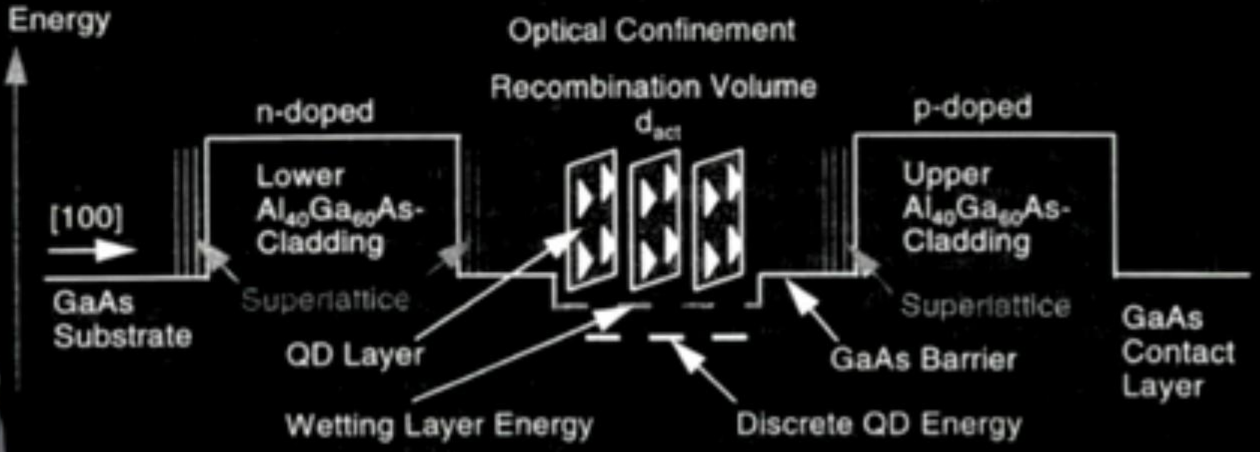
0D
$g(E) \propto \delta$



Asada, Miyamoto, and Suematsu, Gain and the threshold of three-dimensional quantum-box lasers, IEEE J. Quant. Electron. 22, 1915 (1986)

And so here, you can see what happens
with the bulk structure, it's actually

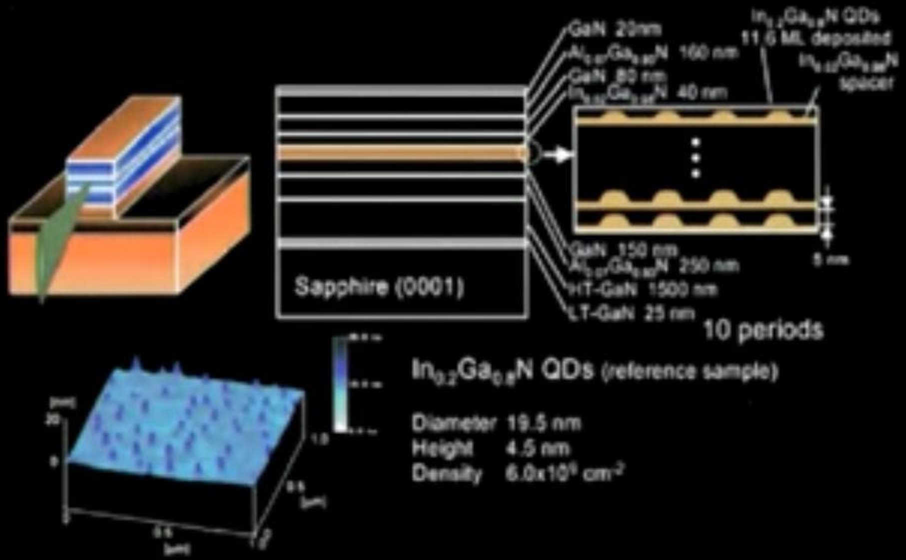
Self-Organized Quantum Dots



Bimberg et al, Physica E 3, 129 (1998)

So, here you're looking at an aluminum gallium arsenide based quantum dot system and so

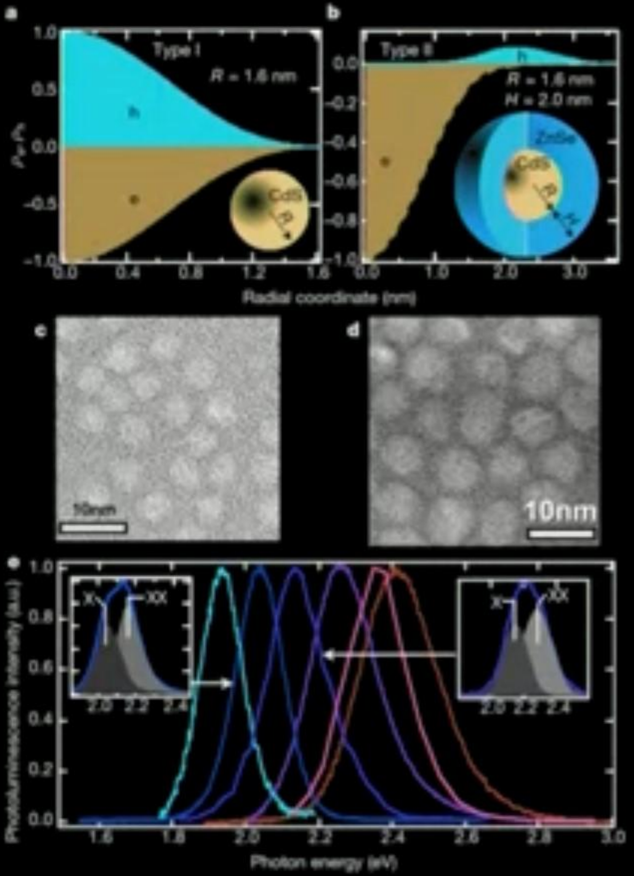
Nitride Quantum Dot Laser



Tachibana, Someya, Ishida, and Arakawa, Fabrication of GaN quantum dots by metalorganic chemical vapor selective deposition, J. Crystal Growth, 237-239, 1312 (2002).

we've got a wave guide defined by this ridge to confine the light.

Colloidal QD

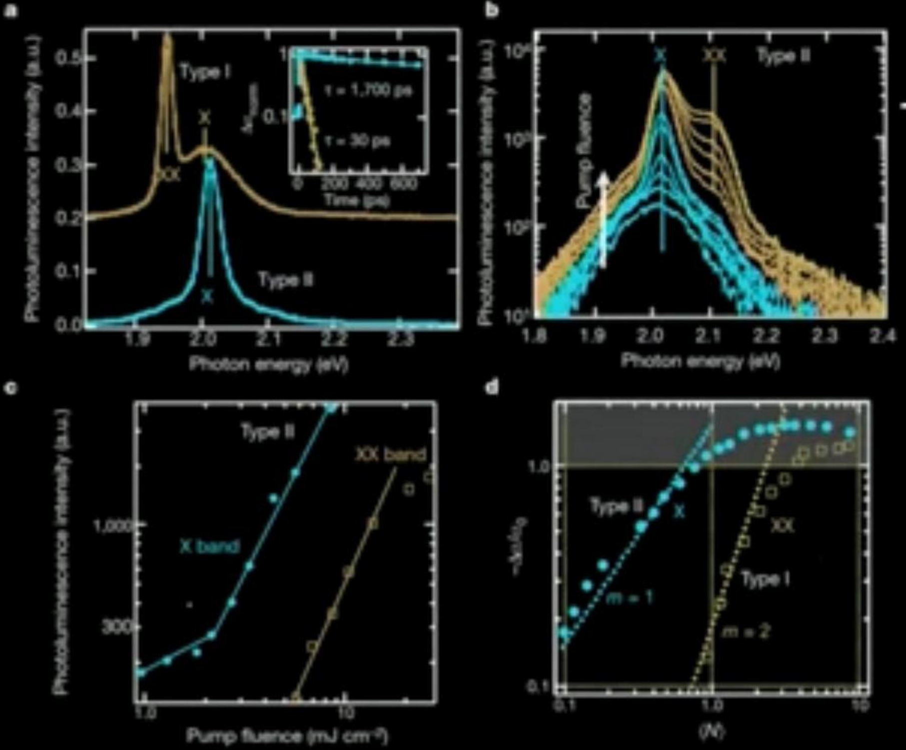


Klimov, Ivanov, Nanda, Achermann, Bezel, McGuire and Piryatinski, Single-exciton optical gain, semiconductor nanocrystals, Nature 447, 441 (2007)

nanoscale crystal and particles that are surrounded by

5:09 / 5:50

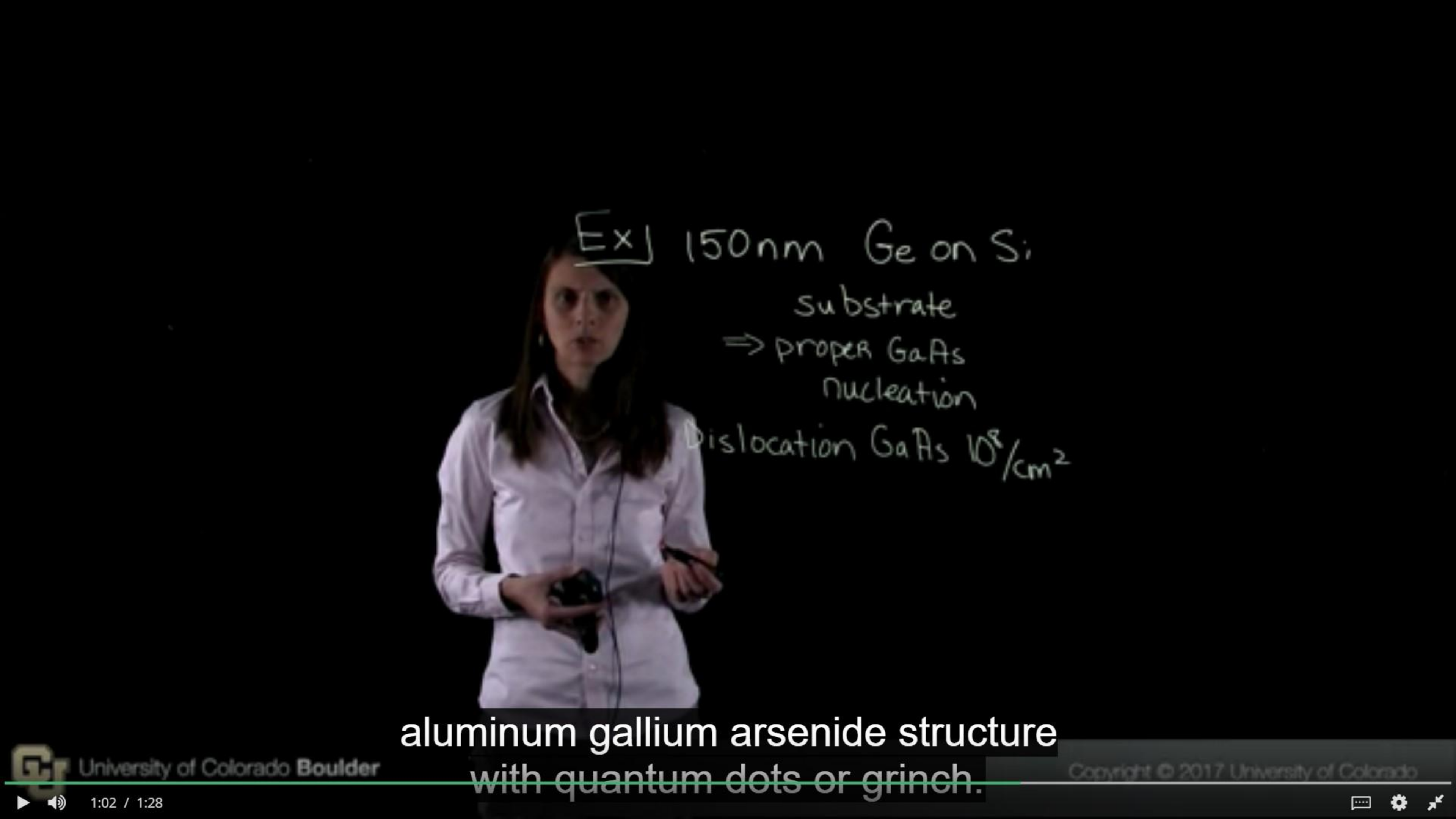
Colloidal QD



Klimov, Ivanov, Nanda, Achermann, Bezel, McGuire and Piryatinski, Single-exciton optical gain semiconductor nanocrystals, Nature **447**, 441 (2007)

the system showing you that depending on the type quantum dot that we use,

5:32 / 5:50


Ex 150nm Ge on Si
substrate
⇒ proper GaAs
nucleation
Dislocation GaAs $10^8/cm^2$
aluminum gallium arsenide structure
with quantum dots or grinch.
University of Colorado Boulder
Copyright © 2017 University of Colorado
1:02 / 1:28

References

The books below provide a nice introduction to the covered material, but are completely optional and are listed here in the case that you desire additional resources.

G. P. Agrawal, Semiconductor Lasers, Van Nostrand Reinhold, 1993.

L. A. Coldren S. W. Corzine, and M. L. Maasanovic, Diode Lasers and Photonic Integrated Circuits, Wiley 1995.