# GaAs single quantum dot embedded into AlGaAs nanowire.

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# Outline

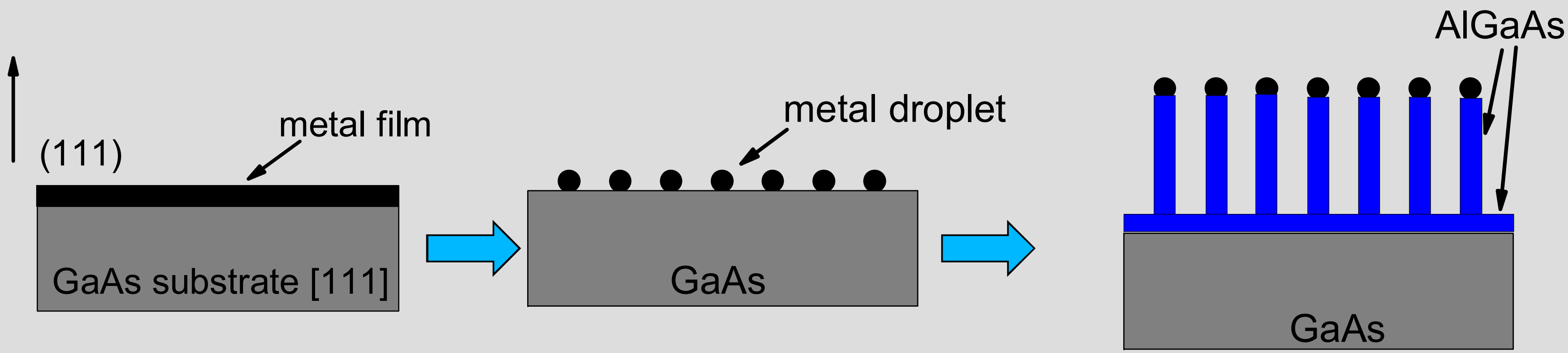
- Sample details
- Motivation
- Micro-PL on the single QD spectrocopy
  - Exciton and Exciton complexes in QD
  - PL polarization
  - Line broadening due to the spectral diffusion
  - Micro PLE data from the single QD
- Numerical simulation of the optical spectra. The role of the strain and piezoelectric effect.
- Time resolved PL spectra of the single QD.
- Conclusions

# Catalyst assisted MBE growth

Catalyst deposition

Droplet formation

MBE growth

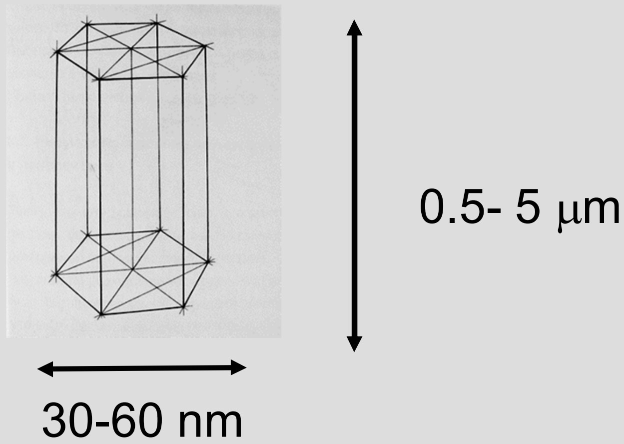



film thickness ~1nm
gold or gallium were used
as catalyst

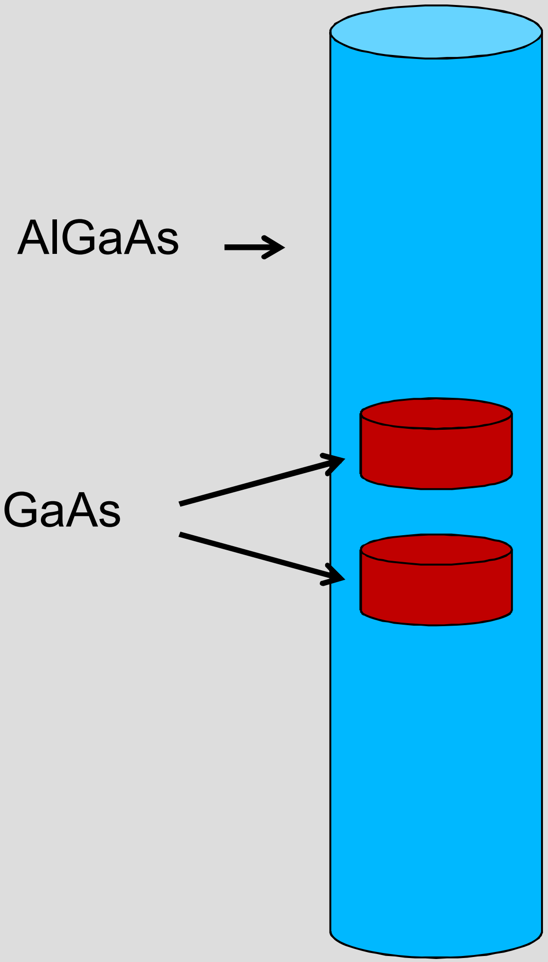
droplet size 30-60 nm

under the droplet the growth
rate is ten times faster

Finally under each droplet we obtain
the hexagonal prism with nanoscale
diameter and microscale height



# QD insertion

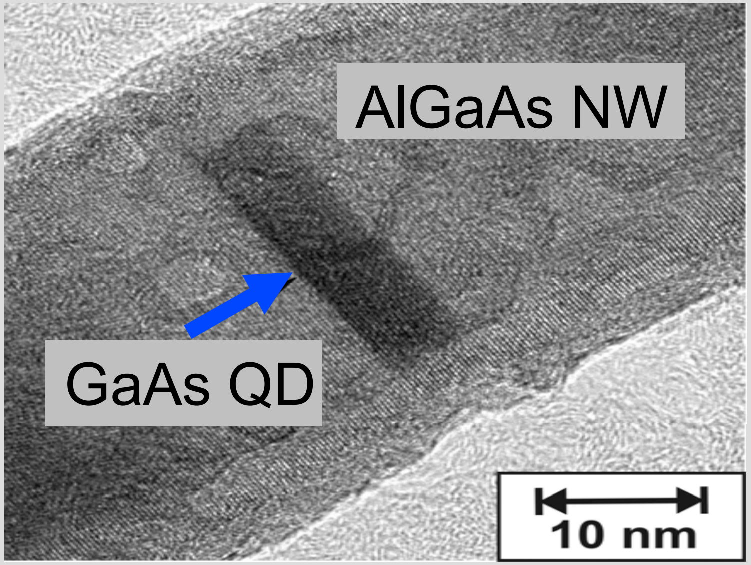


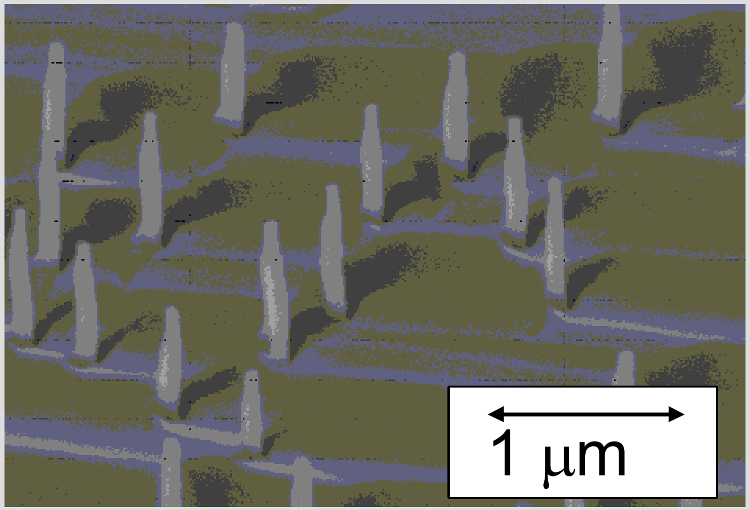

By closing the Al source for the short time we can produce pure GaAs layer within the nanowire.

This gives a way to insert the  single QD or the QD chain into the nanowire.

The QD shape is defined by the NW geometry and its height is controllable  with monolayer precision.

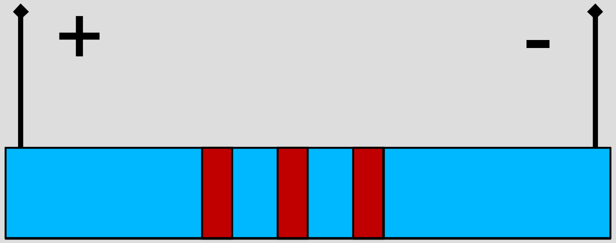
# TEM and SEM images




- QD height  5 nm and its diameter 20-30nm
- Sharp interfaces
- Wurzite crystal phase => strong piezoelectric effect

# Motivation




- QD with well controllable size and well defined shape
- The dots in nanowire can be contacted electrically
- Opportunity to produce the QD chain, which has a controllable overlap

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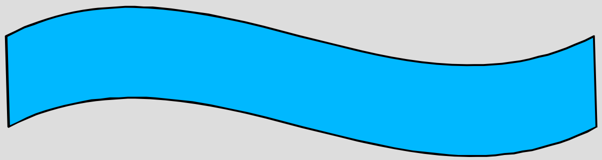
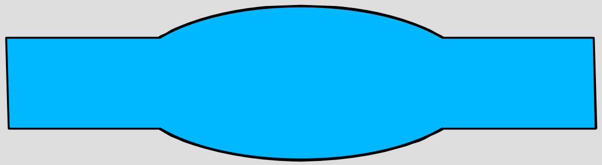
Specific vibration modes



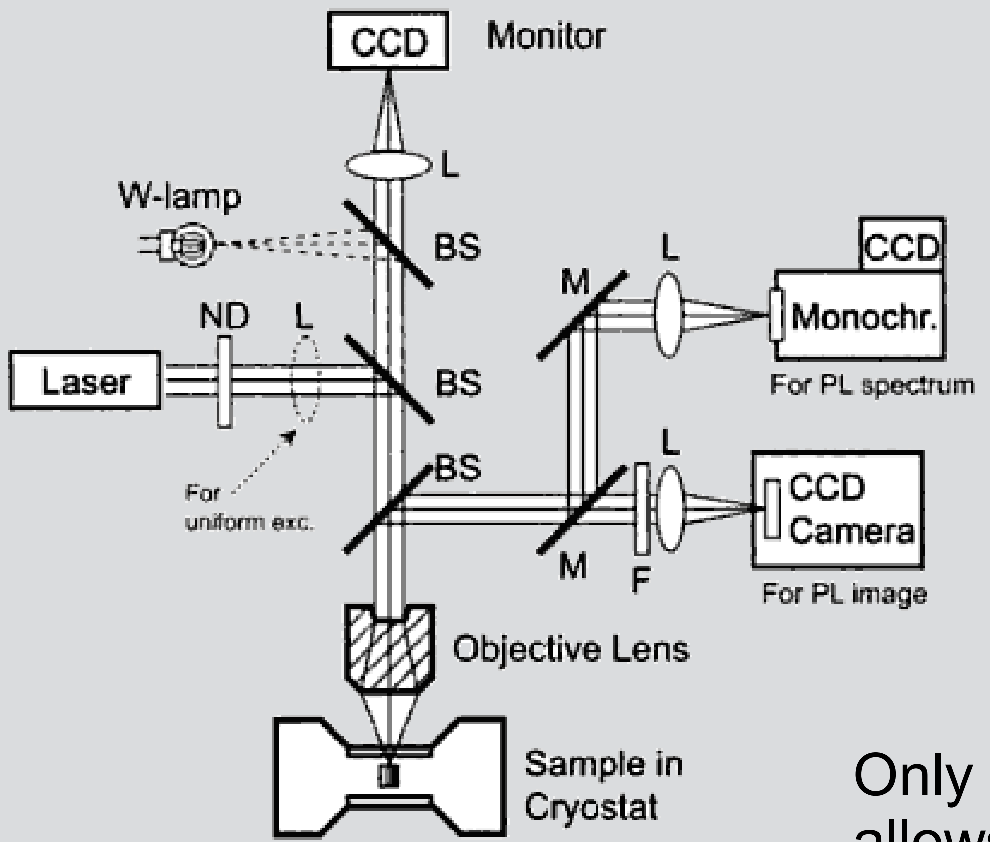


New field for the phonon spectroscopy

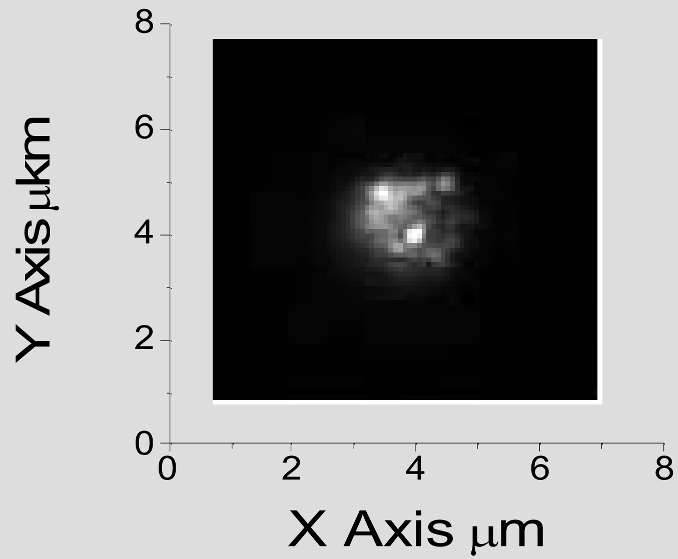
+ strong piezoelectric effect => high efficient acoustic transmitter and receiver in wide band

- Radio frequency – realized
- THz – probably realized
- 10-100 GHz – under consideration

# μ-PL measurements of the single QD



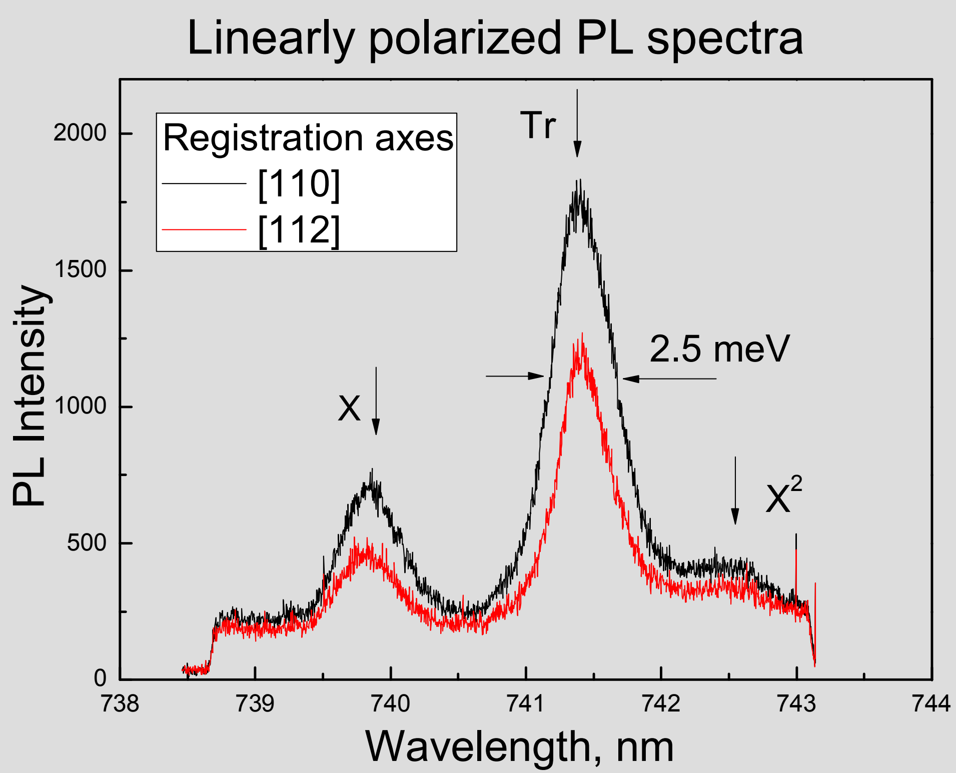

Spatially resolved μ-PL

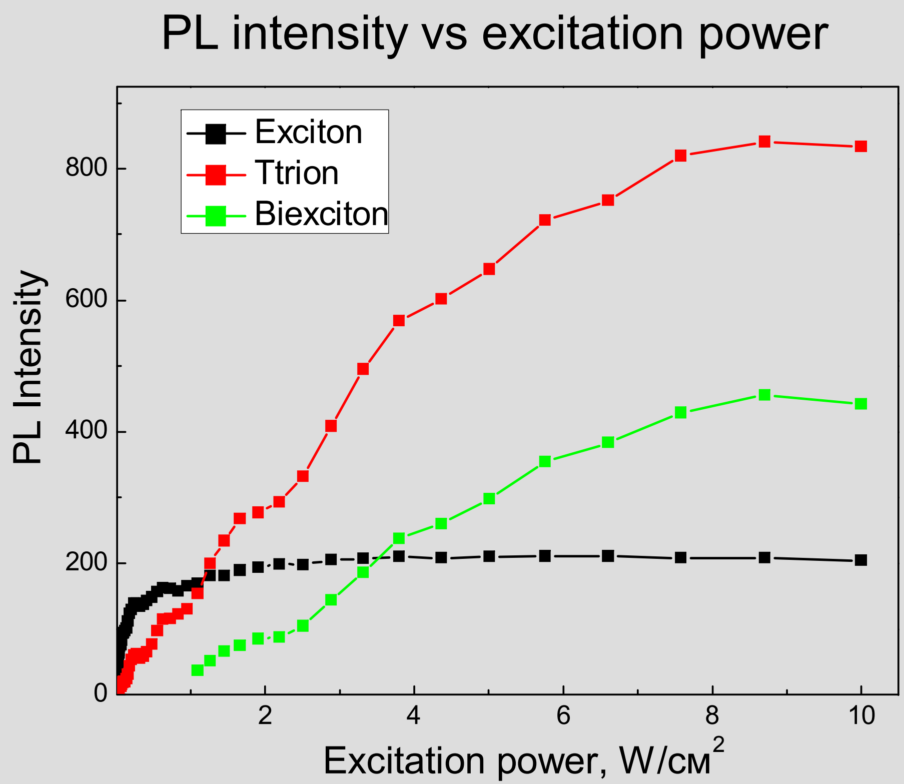



Only few NW catch the aperture that allows to operate with the single NW within ensemble.

Excitation and registration occurs along the wire. Normal geometry

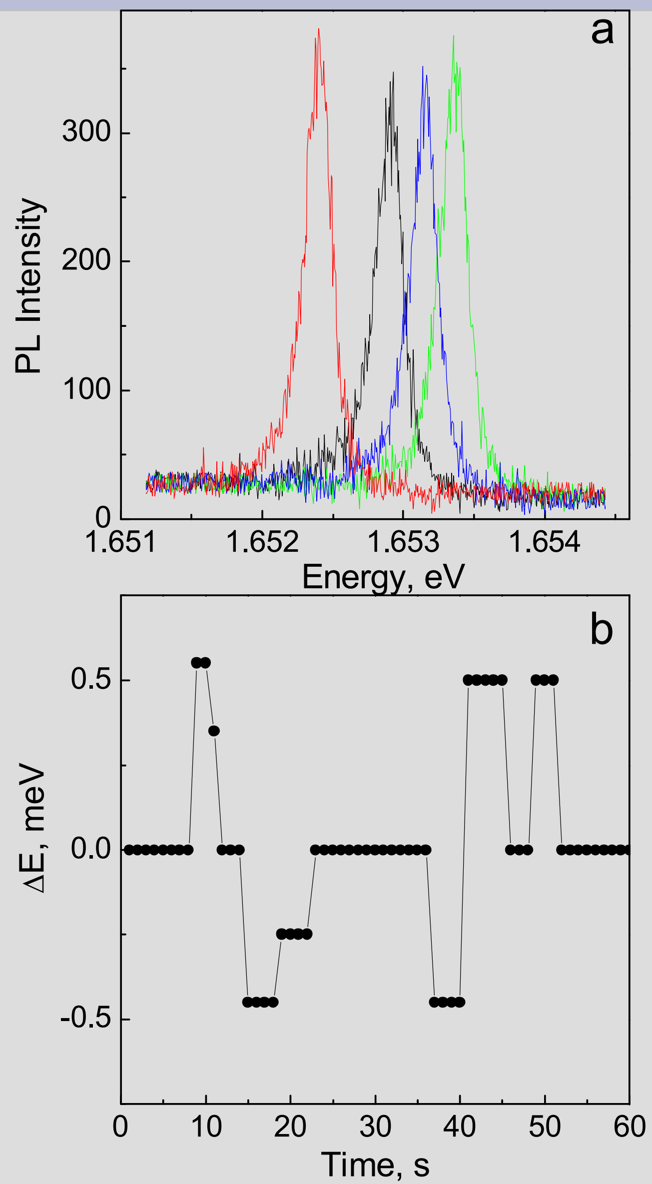
# PL spectra of the single QD in NW




- •Exciton, trion and biexciton are observed
- •PL spectra show a strong linear polarization
- •Line width is extremely large for the single QD

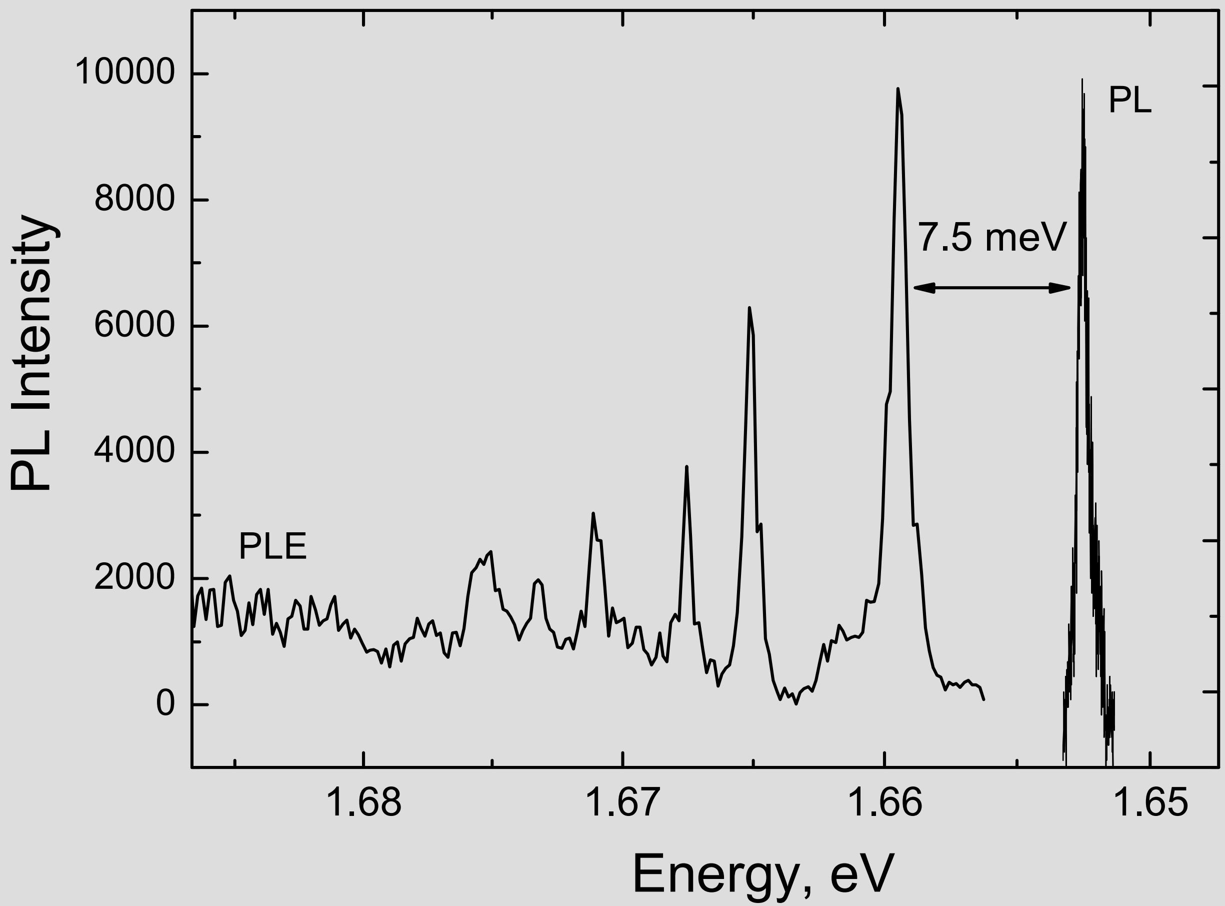
# Spectral diffusion




- At very low excitation power the line width decreases by the order of magnitude
- The line position changes for the discrete values.
- Jump rate increases by the increase of the power finally giving the broad line.

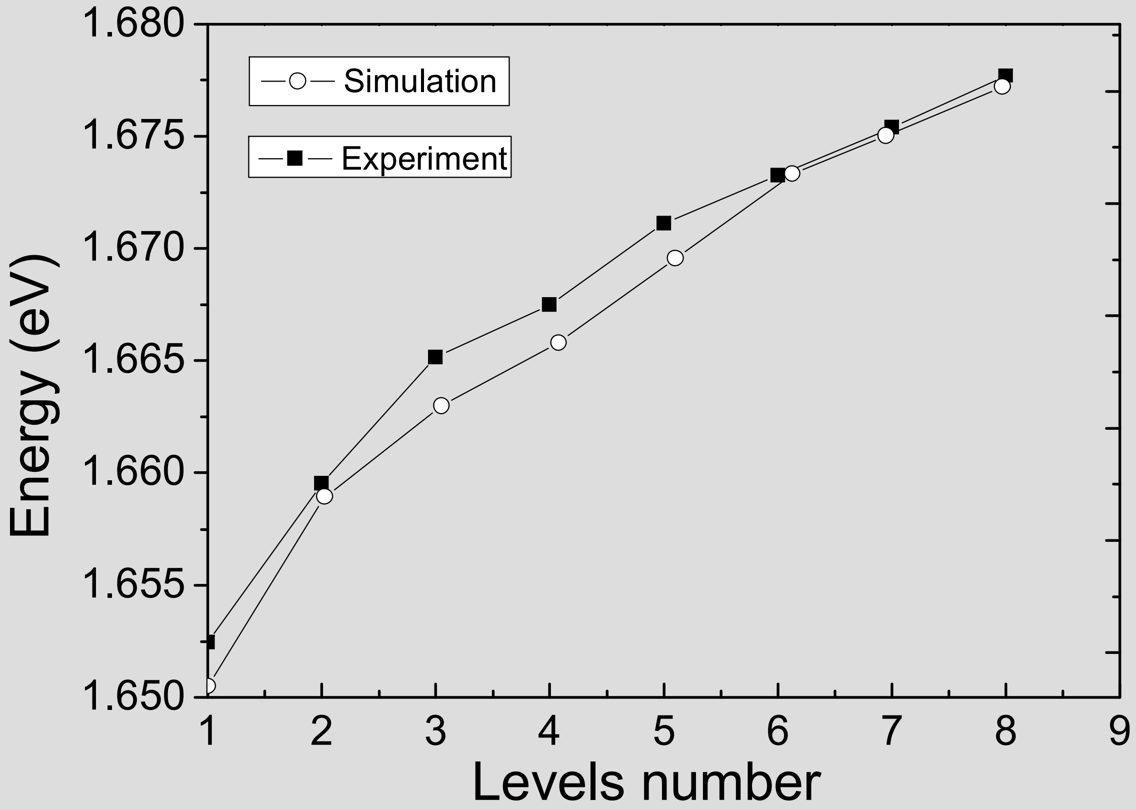
- The effect of the spectral diffusion can be explained by taking into account the possible charging of some deep states that can surround the QD.

# PLE spectra from the single QD in NW




PLE data allows us to obtain up to 7 excited states in the QD

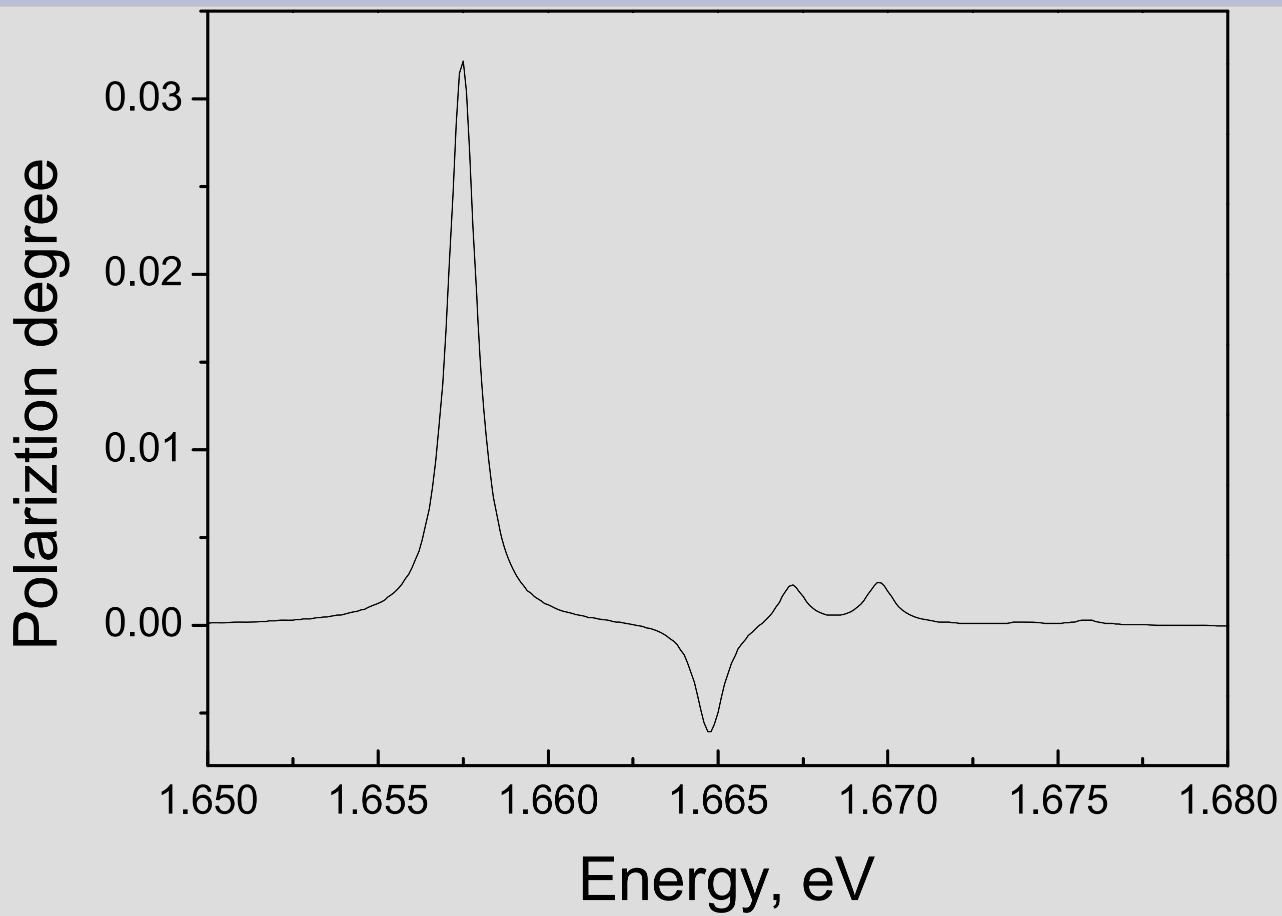
# Numerical calculation of the energy states Comparison with experiment data




- 8-band *kp* method is used
- QD height  and diameter were the only variable parameters. They were chosen to be 5  nm and 20 nm correspondently

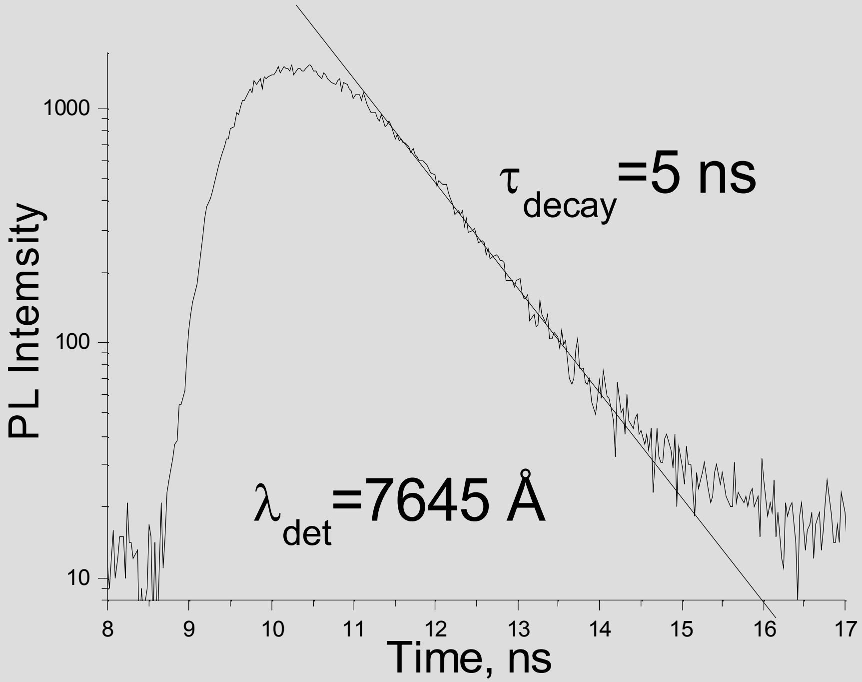
Good coincidence between experimental and simulated data allows us to assume the model adequacy

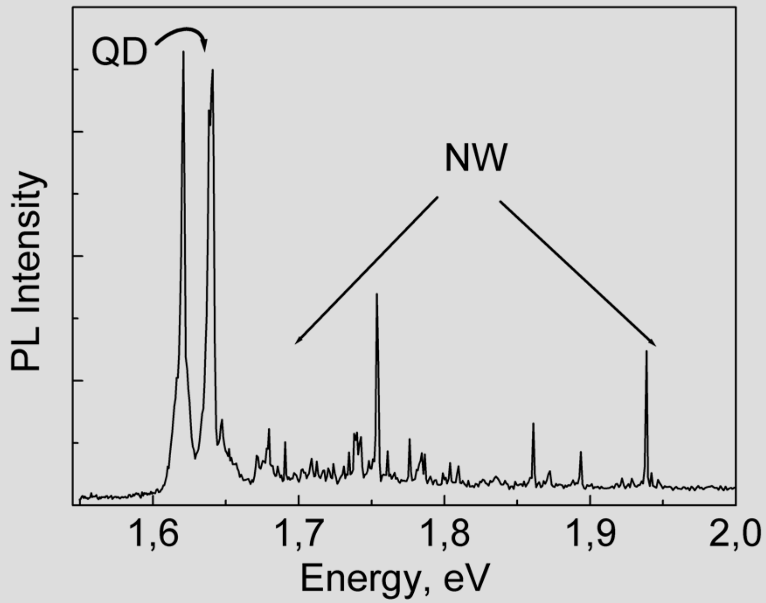
# Numerical simulation of the PL polarization




The model allows to consider the strain and electric filed. Both effects having minor influence on the state position  give the pronounced polarization ratio.  However its order of magnitude less then the observed one.

# Time resolved μ-PL




QD PL decay time 5 ns ------long capturing time

# Conclusions

- Photoluminescence spectra from the single QD/NW GaAs/AlGaAs structure have been measured.
- Optical transitions related to the exciton and exciton complexes are observed.
- The effect of the spectral diffusion is detected and explained.
- The strong PL polarization along symmetrical axes is found.
- Numerical simulation of the optical spectra is performed.
- The role of the strain and electric on the optical polarization is discussed.