GaAs band gap engineering by colloidal PbS quantum dots

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Motivation

- Work in 2009 showed that PbS quantum dots (QDs) notably alter the emission of GaAs
- Tailored photonic applications?
- Ullrich et al., J. Appl. Phys. **108**, 013525 (2010)

Presentation's outline

Essentially, two points will be covered:

a) Optical properties of colloidal PbS QDs on GaAs

b) Absorption edge engineering of GaAs with PbS QDs

Sample preparation

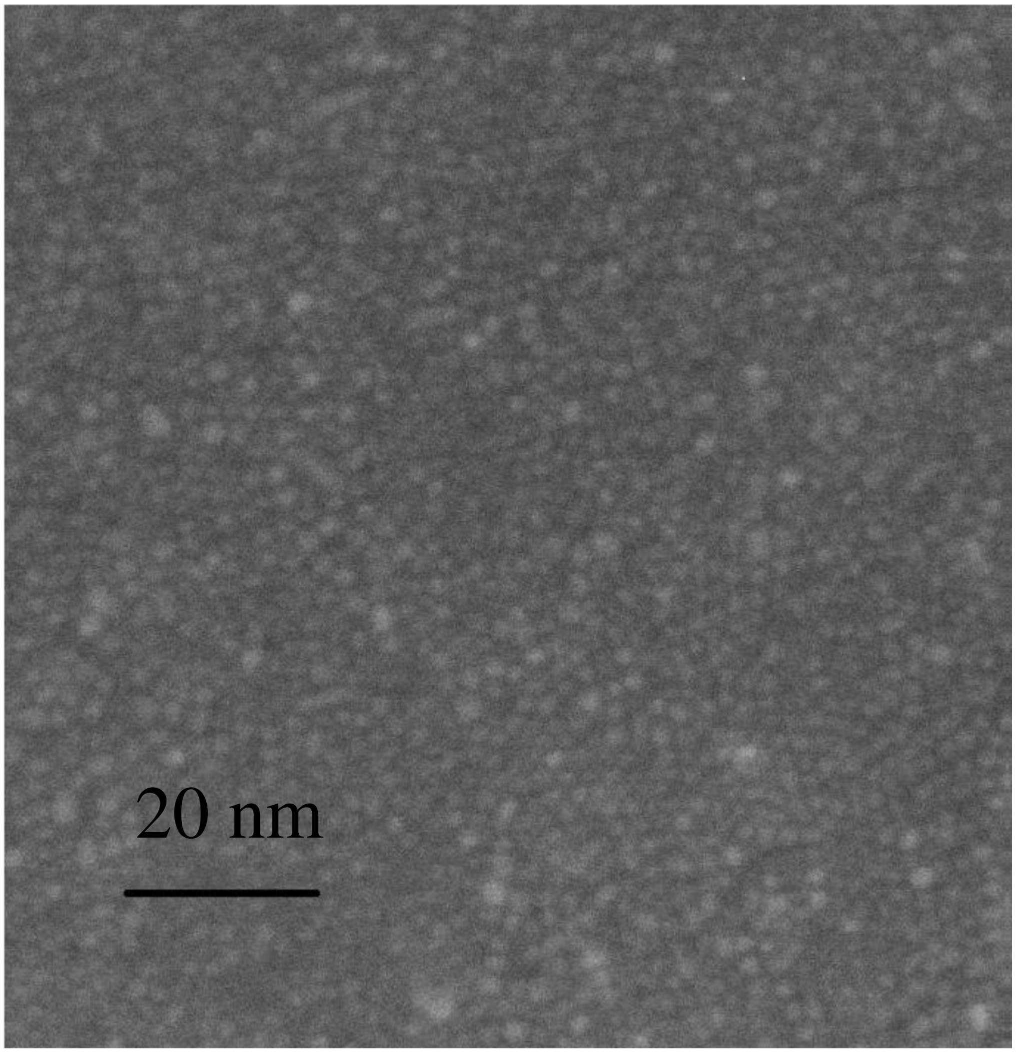
Oleic acid capped PbS QDs are dispersed on GaAs either by a supercritical CO_2 method*) or by spin coating.

*)Wang et al., Mat. Chem. Phys. **141**, 195 (2013).

Why PbS, why GaAs?

- PbS possesses a large Bohr radius (~20 nm). Emission covers the attractive range for optical fibers
- GaAs is "fast" and meanwhile a main player in optoelectronics

SEM image of a typical sample

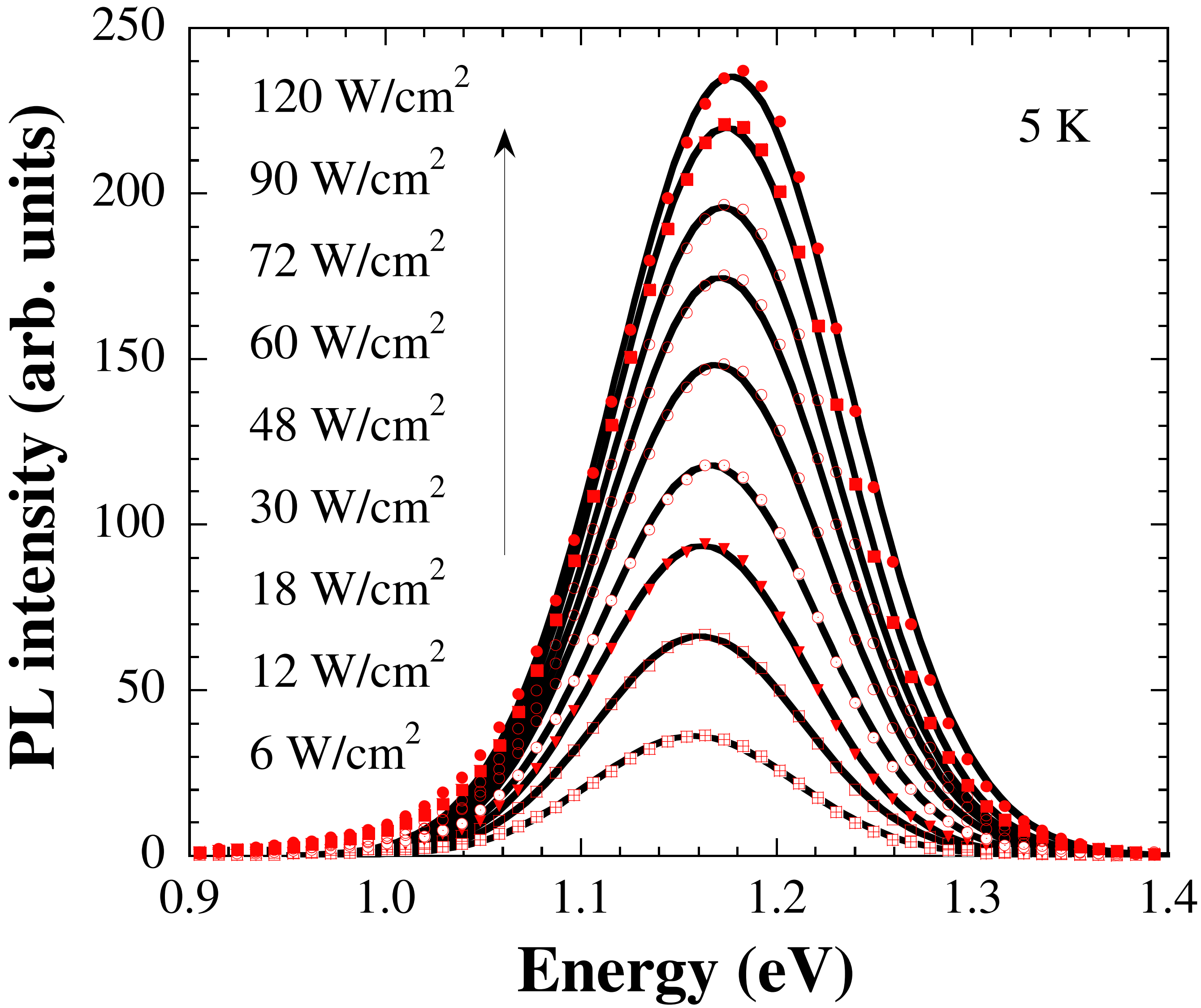


Particle size:
2.0±0.4 nm

We are dealing with a *size-hybrid*

- Sample can be considered – to a certain extend – as free standing (regularly arranged) energy confinement potentials with similarities to superlattices.
- Indeed, electronic states of the QDs are coupled via tunneling.

Photoluminescence



Experimental setup

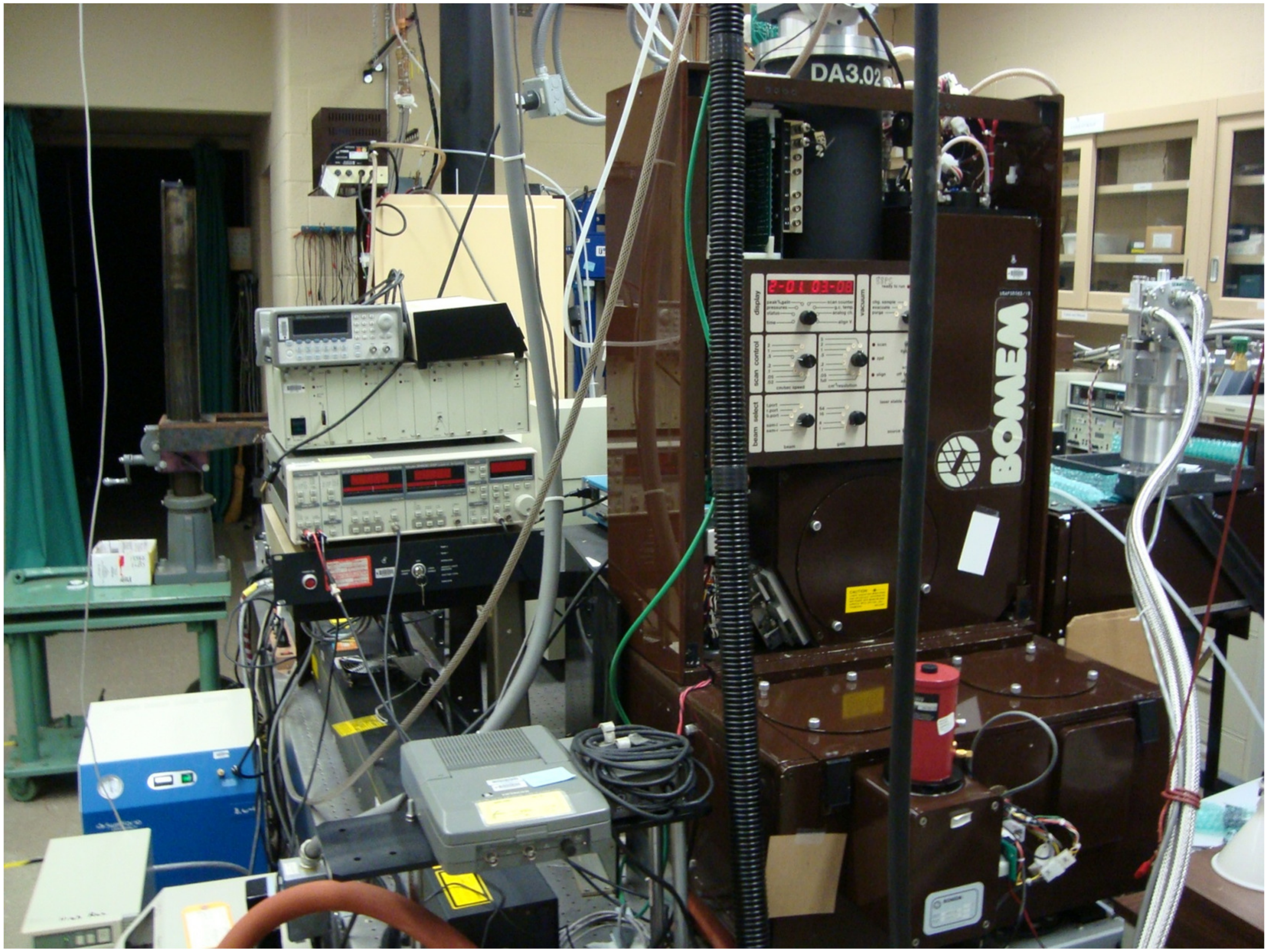
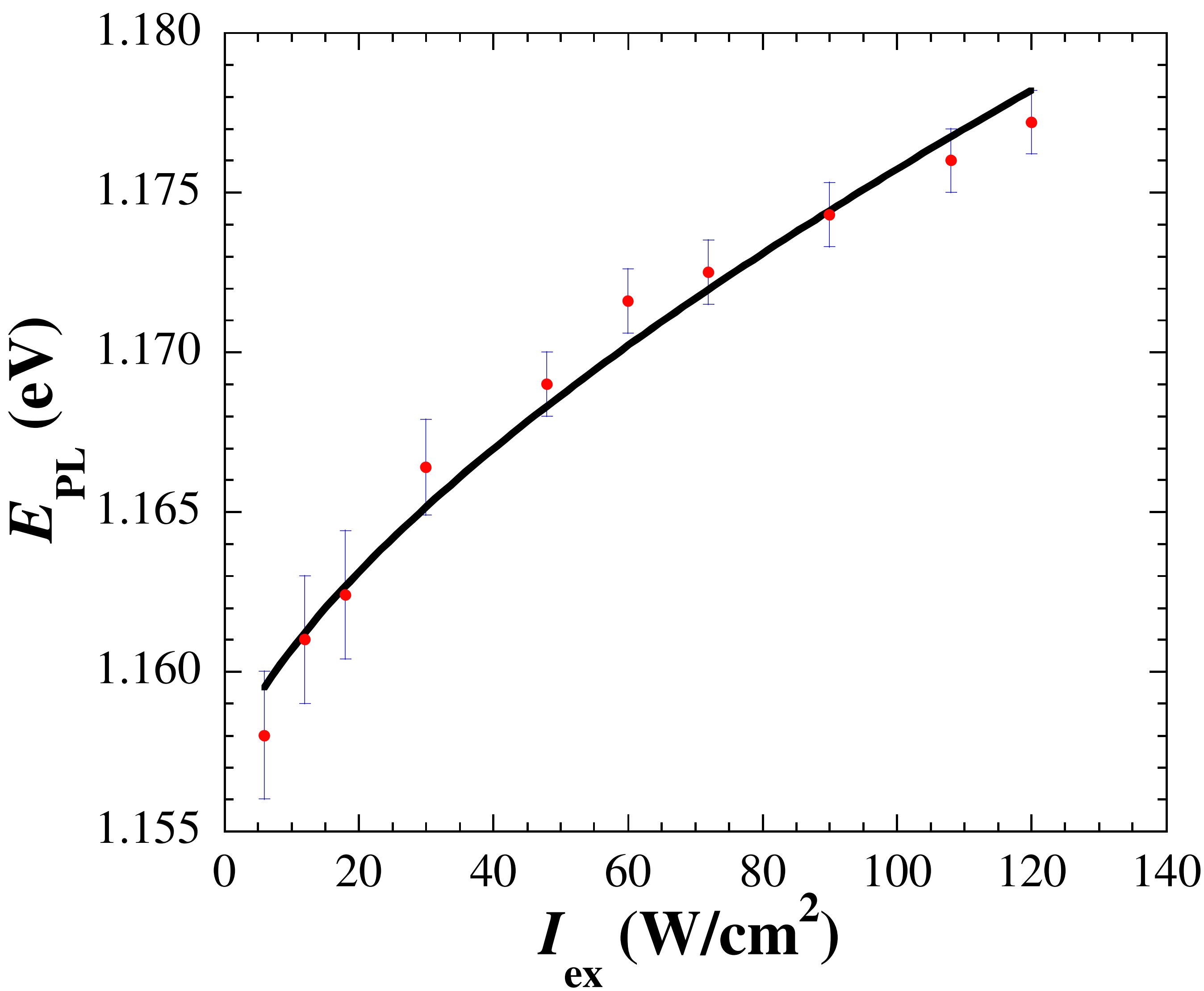


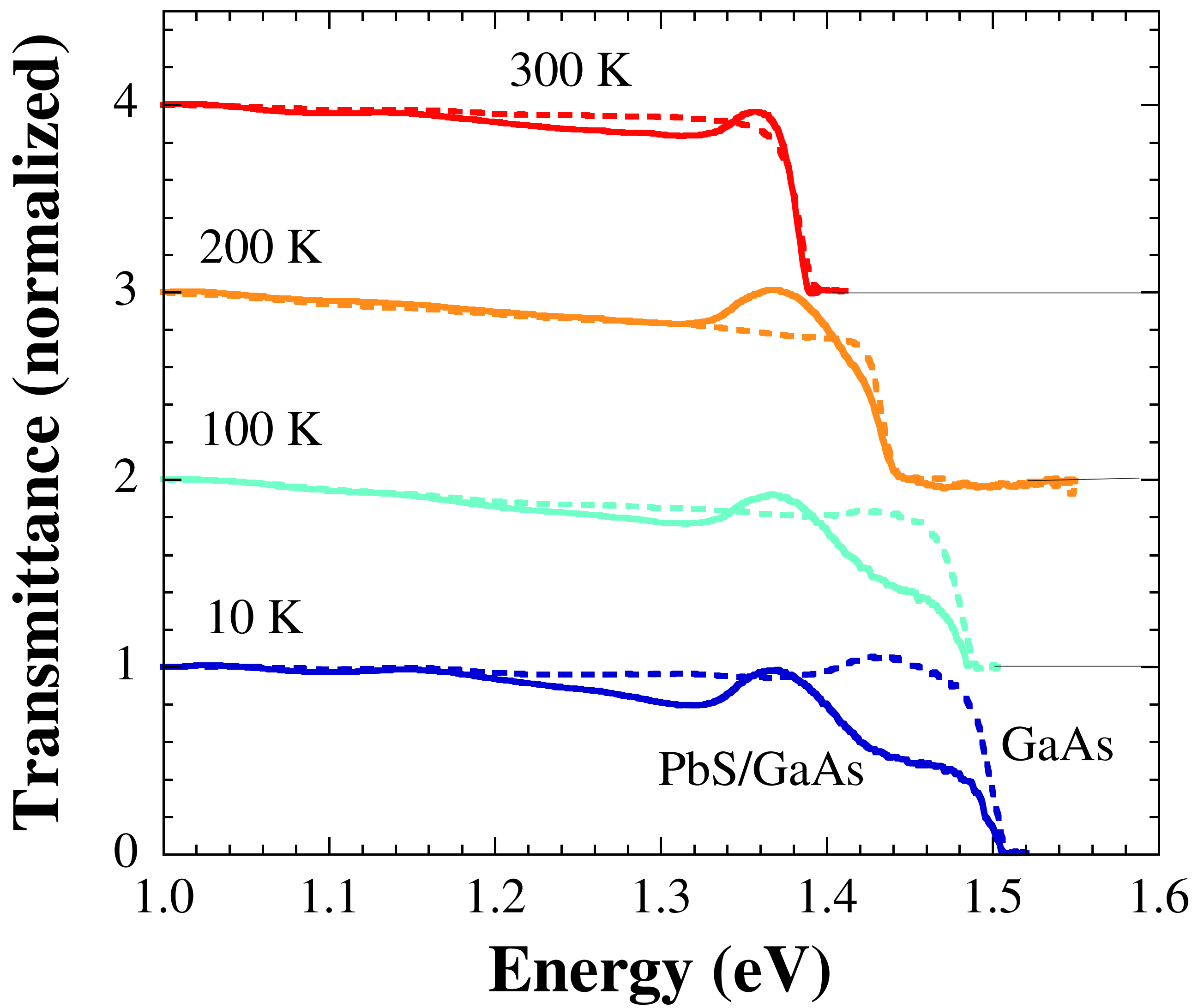
Photo-doping



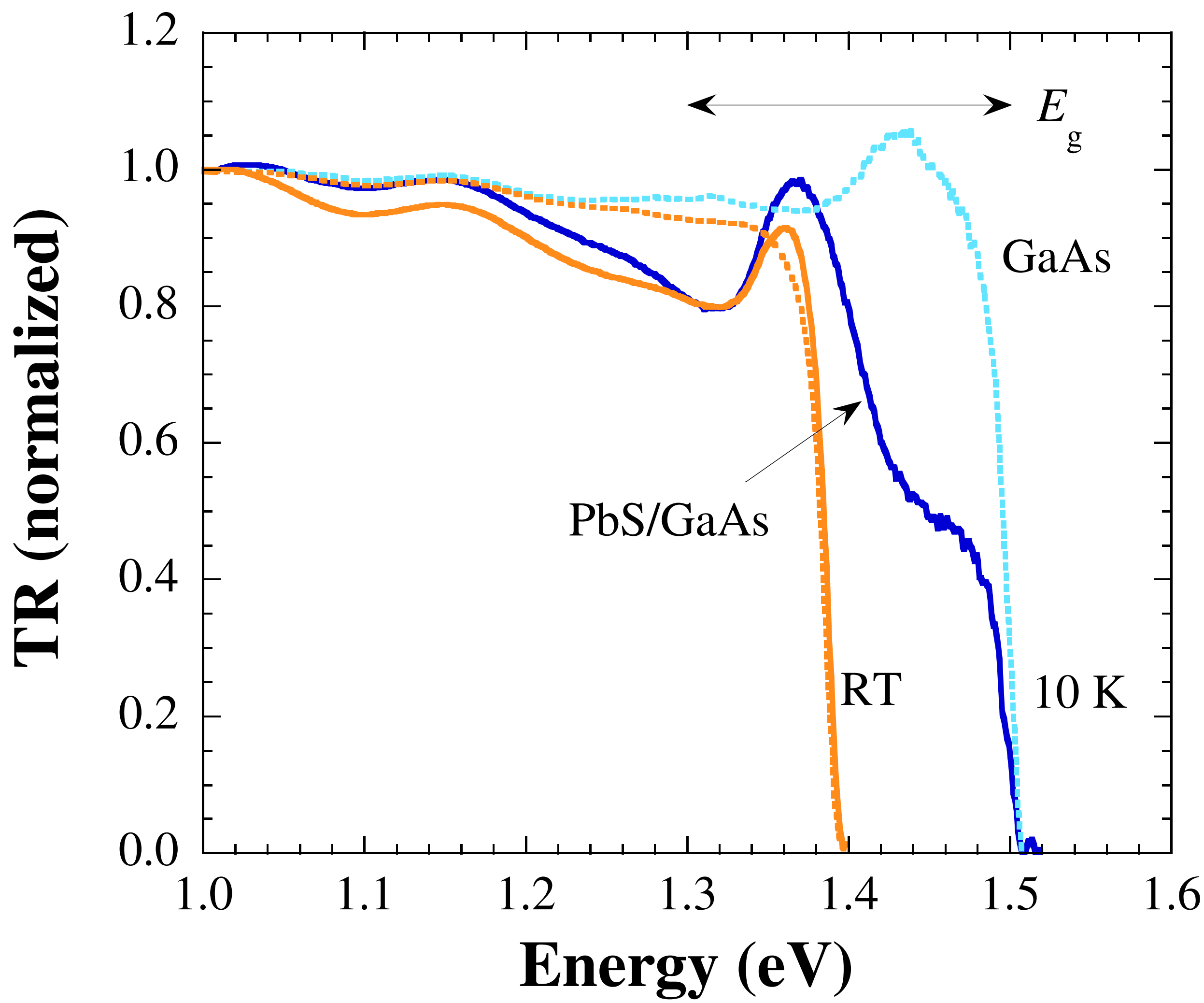
Burstein-Moss effect

- Doping by excited charge carriers increases the QD band gap
- Generation of at least one electron-hole pair per QD
- Reversible band gap alteration proportional to $I_{ex}^{2/3}$
- Ullrich et al., J. Appl. Phys. **115**, 233503 (2014)

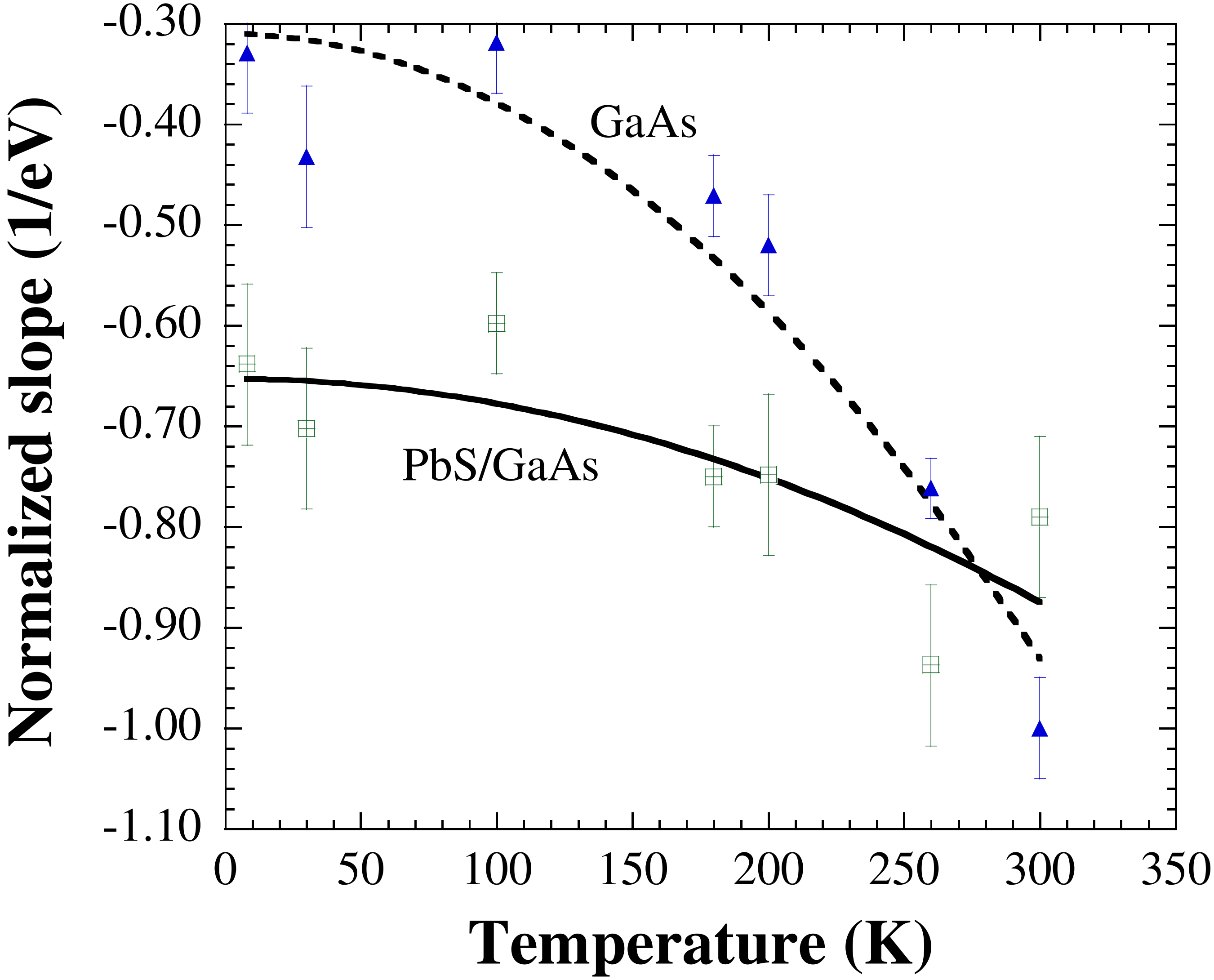
Transmittance



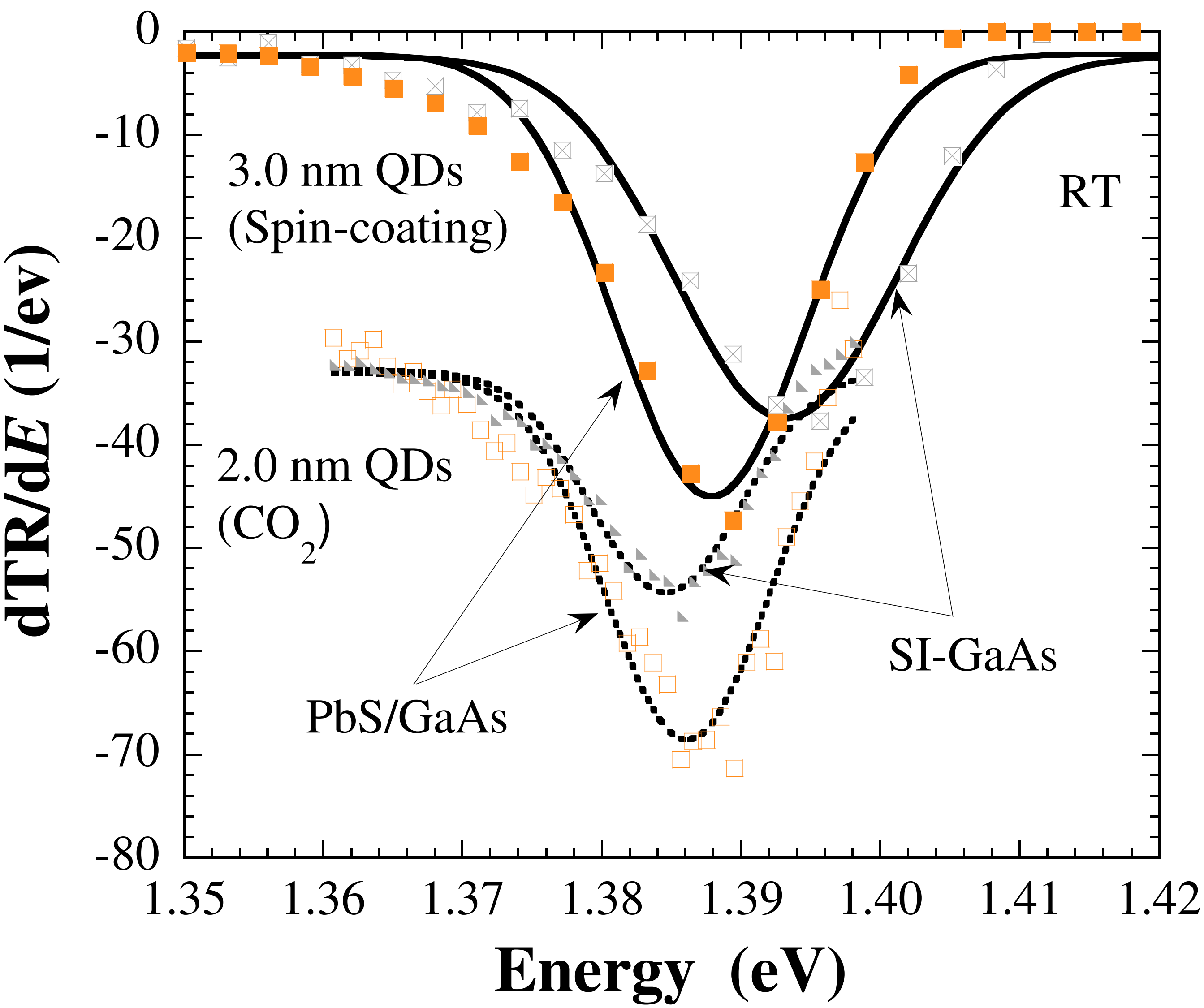
Absorption edge manipulation



Slope of the edge



Band gap shift



?Reasons?

- Charge transfer (Urbach tail alteration)
- Superposition of absorption spectra
- Interfacial impurities
- Vibronic mode manipulation
- Influence of preparation method and doping of the substrate (currently ongoing studies)
- Change of reflectance

Conclusion and future

- QDs alter the optical properties of the host
- Concentration on the emission properties for technological applications (emission from the interface?)
- Possible influence of the QD size on the optical properties of the host
- Formation of opto-electronically active junctions

Thank you!

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