Imaging and optical properties of single core-shell GaAs-AlGaAs nanowires

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Motivation

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- **we study electronic structure and optical properties of single core-shell GaAs-AlGaAs nanowires**

  bare GaAs nanowires: low quantum efficiency due to nonradiative surface recombination

- **core-shell GaAs-AlGaAs nanowires have much higher quantum efficiency**

Sample growth

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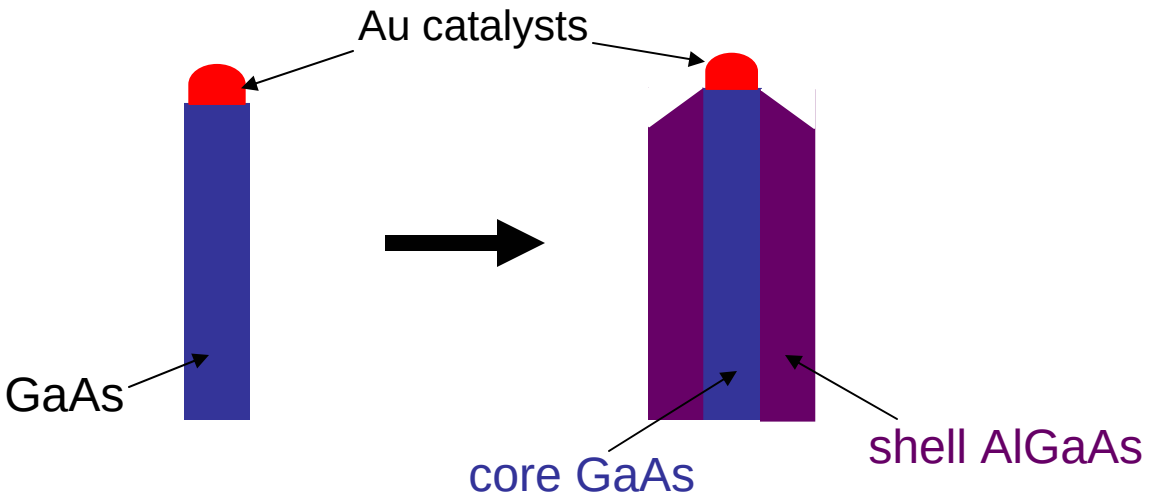
Grown by Vapor-Liquid-Solid technique

core:

450°C

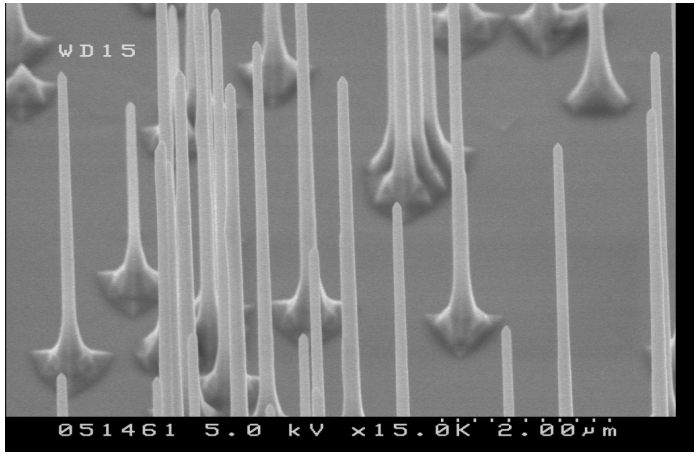
C.J. Barrelet et al, J. Am. Chem. Soc. 125, 11498 (2003)

shell:



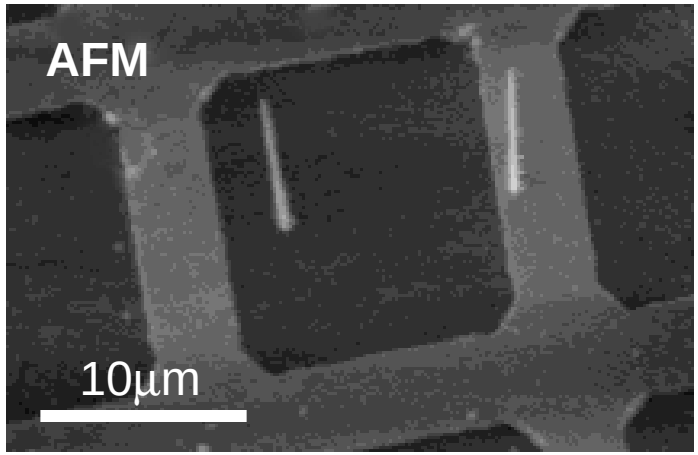
630°C

Single nanowire studies



Field-Emission Scanning Electron Microscope (FESEM) image

nanowires were removed from the growth substrate into solution and deposited onto a silicon substrate



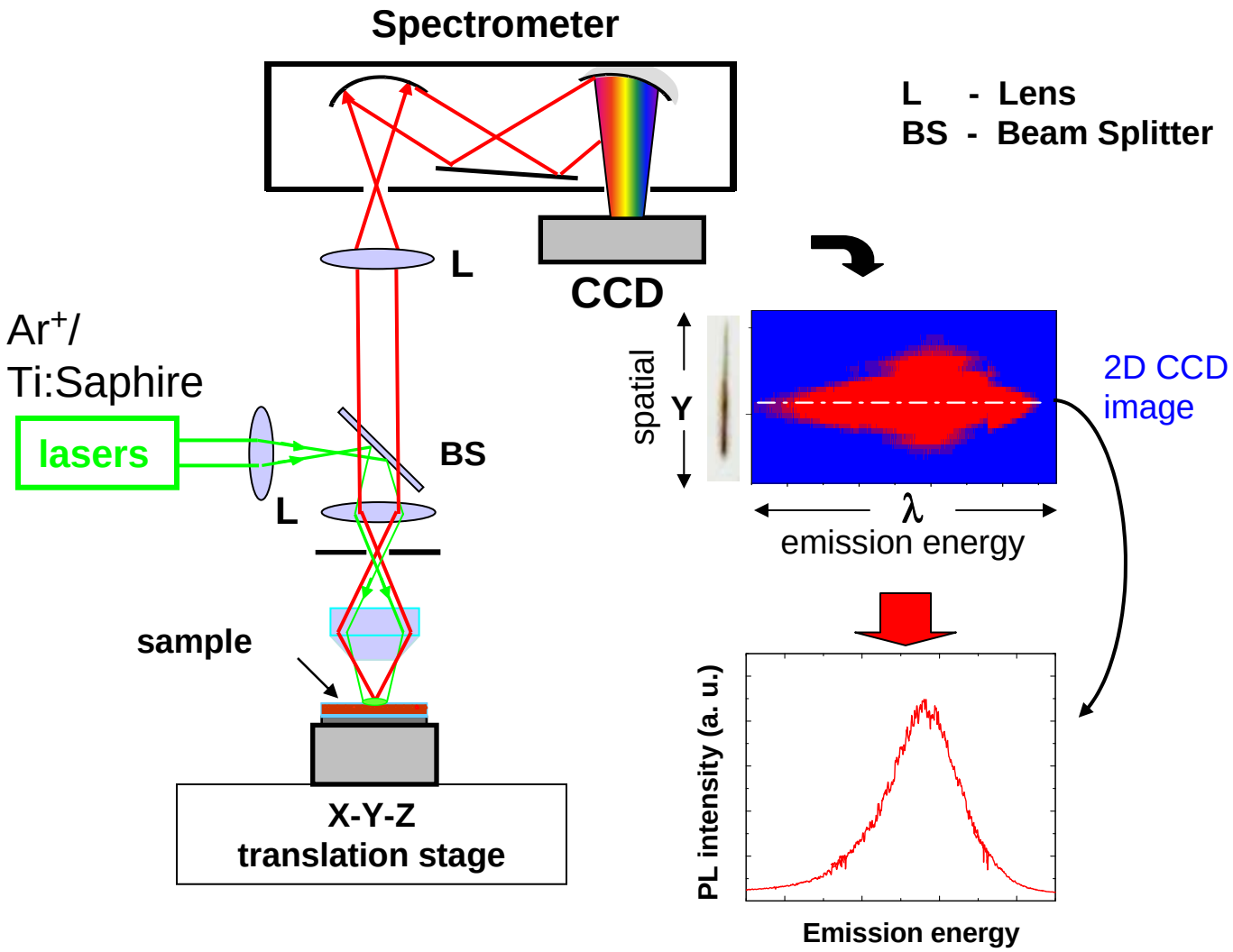
a single nanowire:

~80nm in diameter, ~5-8 µm long

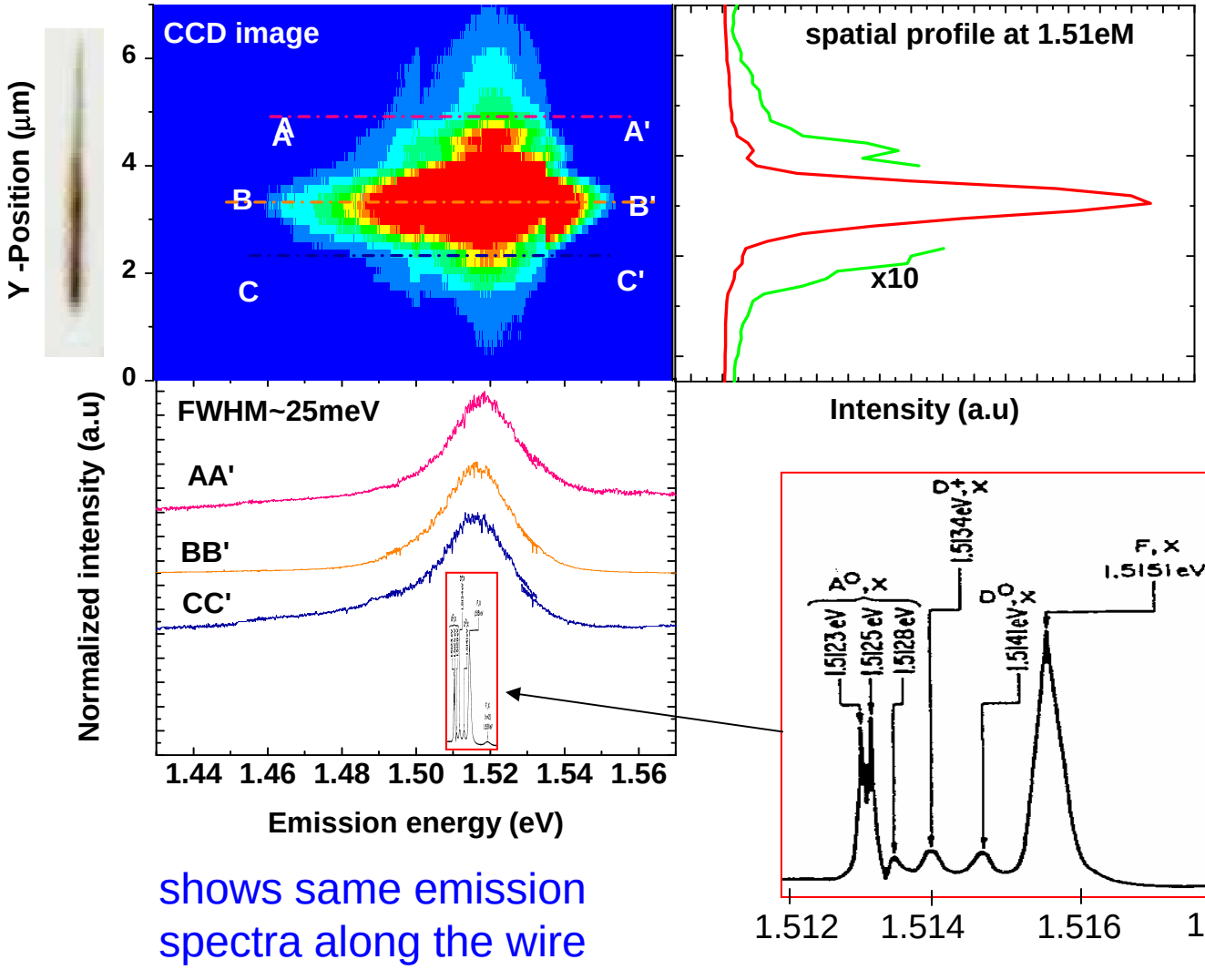
wire's diameter > Bohr exciton diameter

=> expect no quantum confinement

Experimental setup



Low-T PL imaging



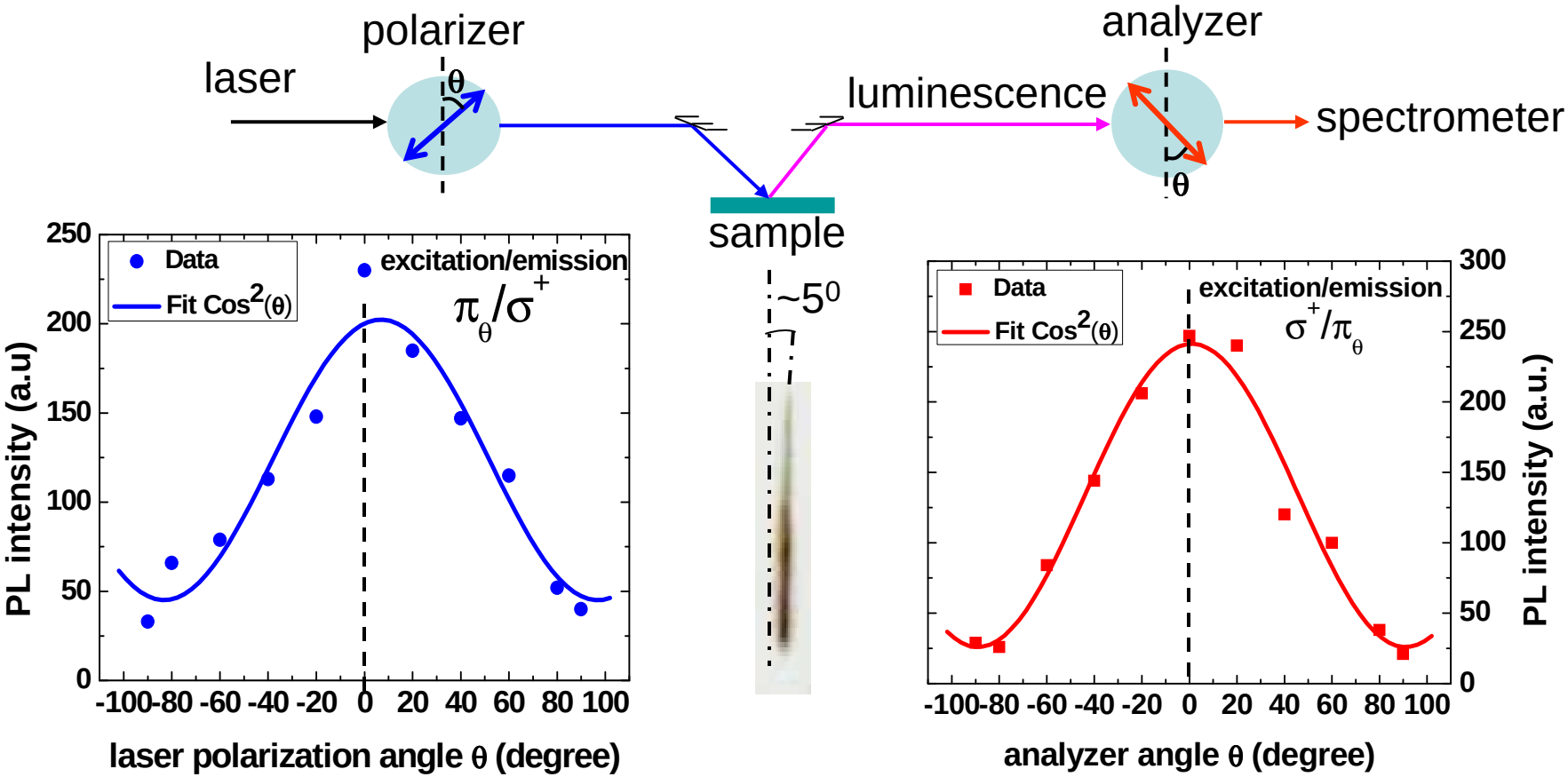
2D CCD image (spatial vs. emission) shows PL emission along the wire.

shows same emission spectra along the wire

undoped MBE-grown GaAs epilayer (PL at 5K)

(Heiblum et al. J. Vac. Sci. Tech. B2 233 (1984))

Polarization studies

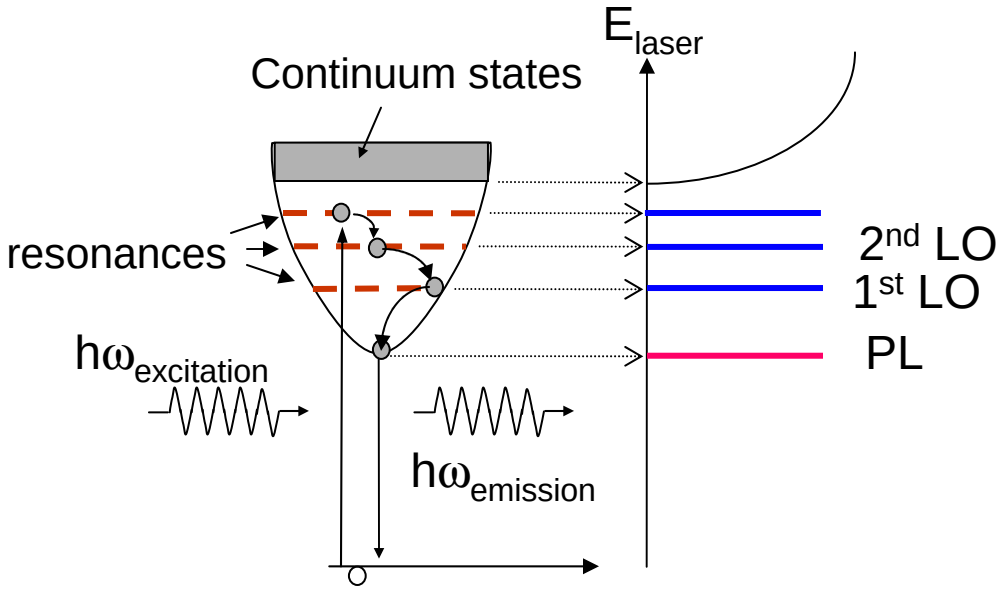


polarizer = π_θ ; analyzer = σ^+

polarizer = σ^+ ; analyzer = π_θ

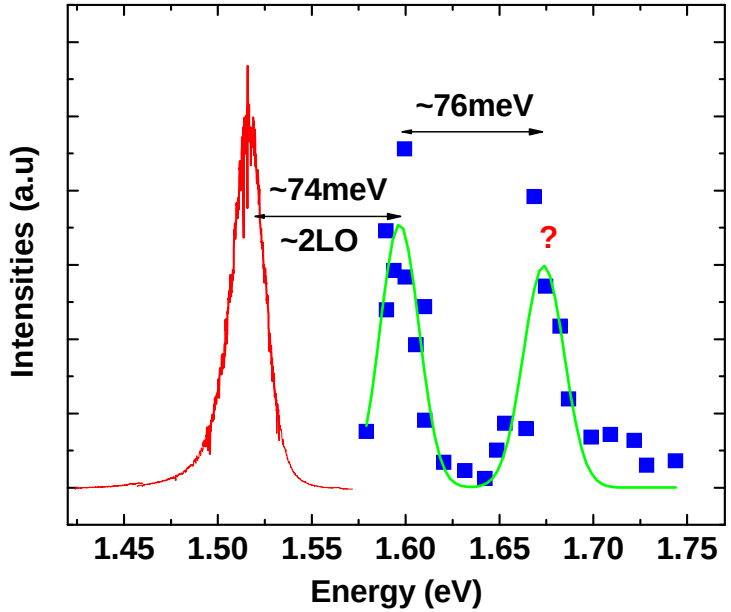
PL emission is *strongly polarized* parallel to the wire, and is *strongly enhanced* when the laser excitation is polarized parallel to the wire

Resonant excitation



tune excitation energy, E_{Laser}, record PL intensity

resonances at ~74meV and 150 meV above free exciton energy



Conclusions

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- **core-shell GaAs-AlGaAs nanowires display strong PL emission (non-radiative surface recombination is suppressed)**
- **PL emission is *strongly enhanced* when the laser excitation is polarized parallel to the wire, and is *strongly polarized* parallel to the wire**
- **striking excitation resonances at ~74 meV and ~150 meV above the PL emission line**
  - **74 meV: 2LO resonance - phonon-assisted absorption (GaAs)**
  - **150 meV: LO resonance of GaAs (higher order) or AlGaAs**

Dove Prism (DP) can be used to rotate image of a nanowire