IUPAP Commission 17

Quantum Electronics

Working Group on Nanoscience

Richart E. Slusher
Szeged, Hungary

September 2006

Commission Conferences

IQEC (International Quantum Electronics Conference)

- Moscow, Russia 2002
- Tokyo, Japan, 2005

International Symposium "Modern Problems of Laser Physics"

- Novosibirsk, Russia 2004

Session Titles at IQEC 2005

- Quantum Nanostructures, Optics, and Applications
  - A. Forchel, Wuerzburg University

    "Strongly Coupled Single **Quantum Dot**-Microcavity System“
  - D. Awschalom, University of California, Santa Barbara

    "Optoelectronic Control of Electron and Nuclear Spins in Semiconductor **Nanostructures**"

- Cold Atoms, Cold Molecules, Collective Quantum Phenomena and Atom Optics
  - Similar to C15

- New Trends in Chemistry, Biology and Other Fields
  - D. Miller, Stanford University

    "**Nanoresonators** and **Nanophotonics**“
  - S. Fainman, Univ. California, San Diego,

    "Ultra Short Surface Plasmon Polaritons in Photonic Crystal Structures"

Session Titles at IQEC 2005

- Photonic Nanostructures and Devices
  - Y. H. Lee, KAIST
    "Photonic Crystal **Nanolasers** by Optical and Electrical Pump“
  - M. Notomi, NTT Basic Research Laboratories,
    "Nonlinear Switching by Photonic-Crystal **Nanocavities** for All-Optical Digital Processing"
- Near-field Optics and Applications
  - Y. Inoue, Graduate School of Frontier Biosciences
    "Tip-Enhanced Near-Field Raman Spectroscopy for Molecular **Nano-Imaging**“
- THz Emission and Spectroscopy
  - T. Norris, Michigan University
    "**Nanoacoustics**: Propagation and Imaging with THz Coherent Phonons“
  - S. Komiyama, University of Tokyo
    "Photon Counting THz Imaging with **Quantum-Dot** Detectors"

Session Titles at IQEC 2005

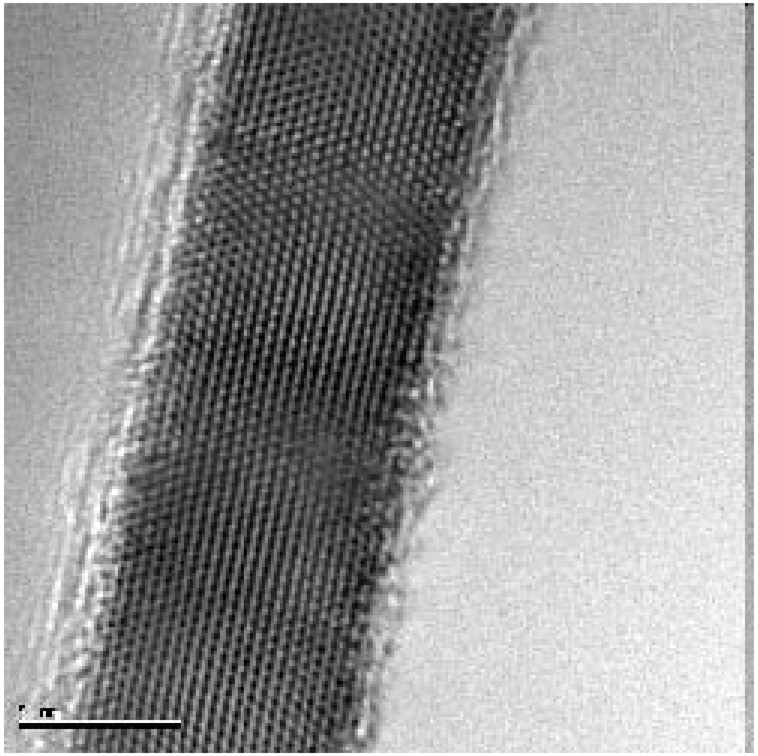
- Nonlinear Optics and Materials
  - H. Kamada, NTT Basic Research Laboratories
  "Coherent Nonlinear Effects in a Single **Quantum Dot**“

- Single Photon Emission and Entanglement States for Quantum Information
  - J. Vuckovic, Stanford University
    "Single Photon Source Based on a **Quantum Dot** in Photonic Crystal“

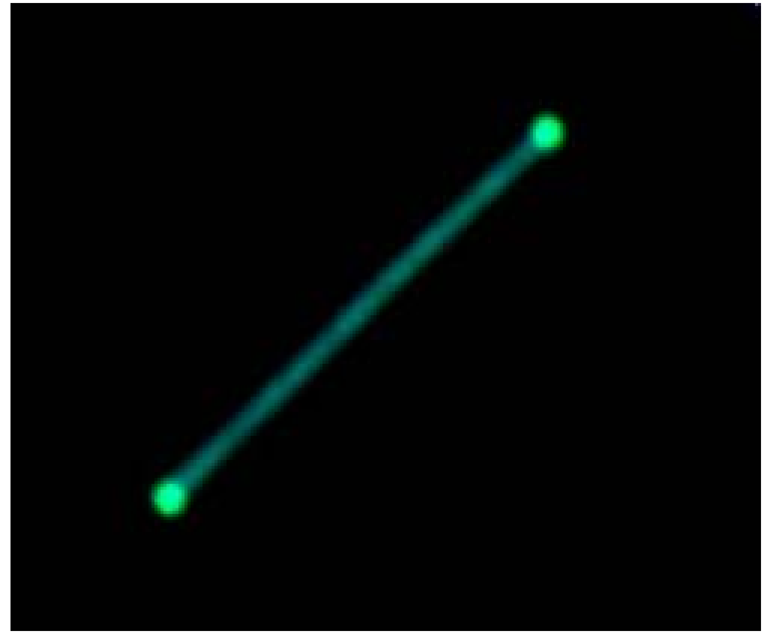
- Dynamics of Photoinduced Phase Transition
  - M. Rini, Lawrence Berkeley National Laboratory
  "On Photo-Induced Phase Transitions in Strongly Correlated **Nanosystems**”

- Plenary Speaker
  - Prof. Zhores Alferov
    Director, The Ioffe Institute, Russia
    2000 Nobel Laureate in Physics
    "Past, Present and Future of Semiconductor Lasers and Related **Nanophotonic** Devices"

Harvard
Prof. Charles Lieber's Group

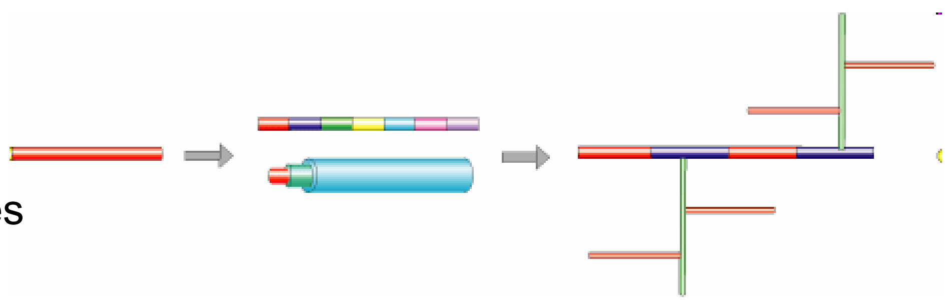


A transmission electron microscope (TEM) image of a Cadmium Sulfide nanowire.

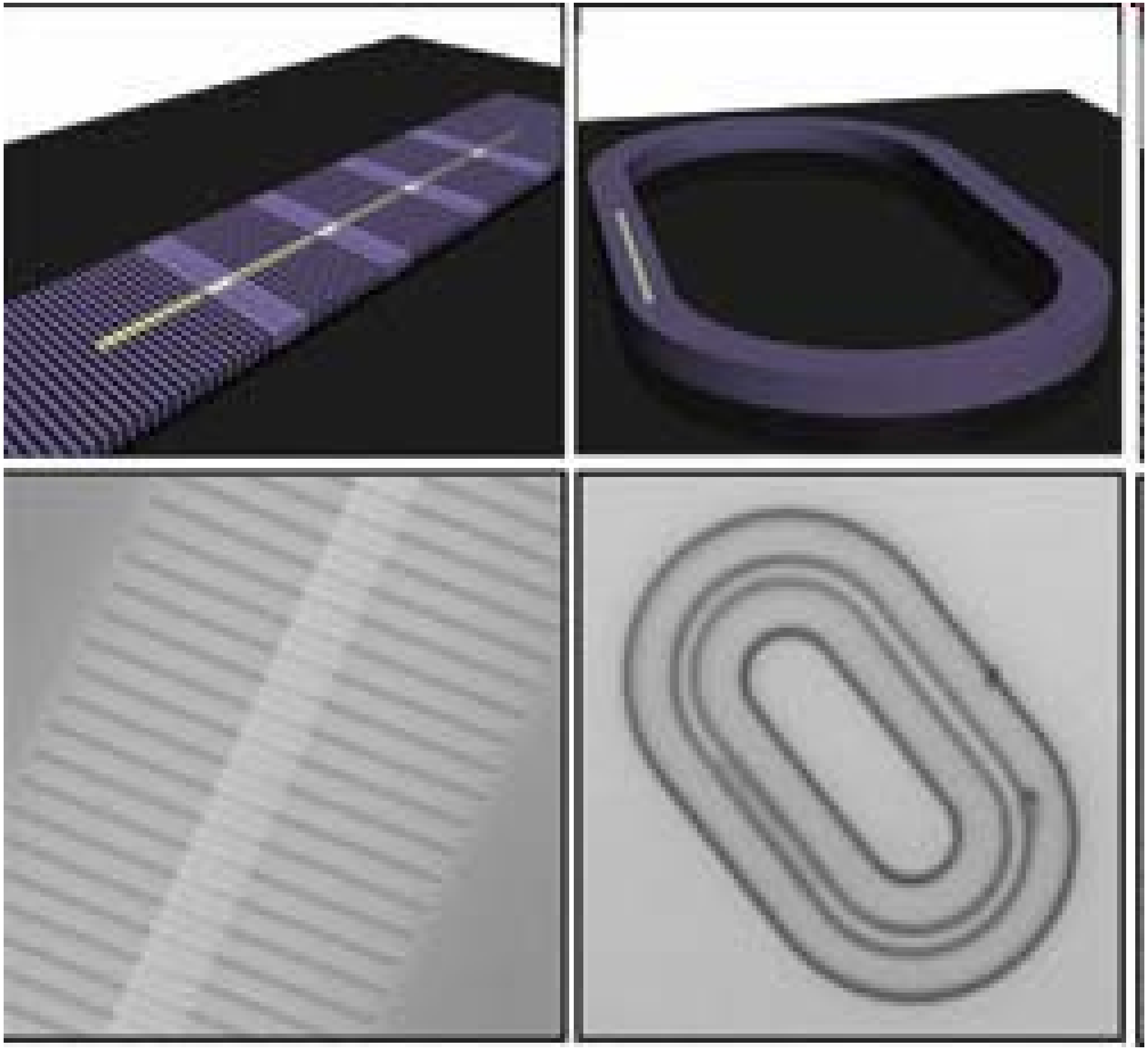


A photoluminescence image of a Cadmium Sulfide nanowire.

Future directions:
Radial and segmented nanowire sructures



Nanowire Devices

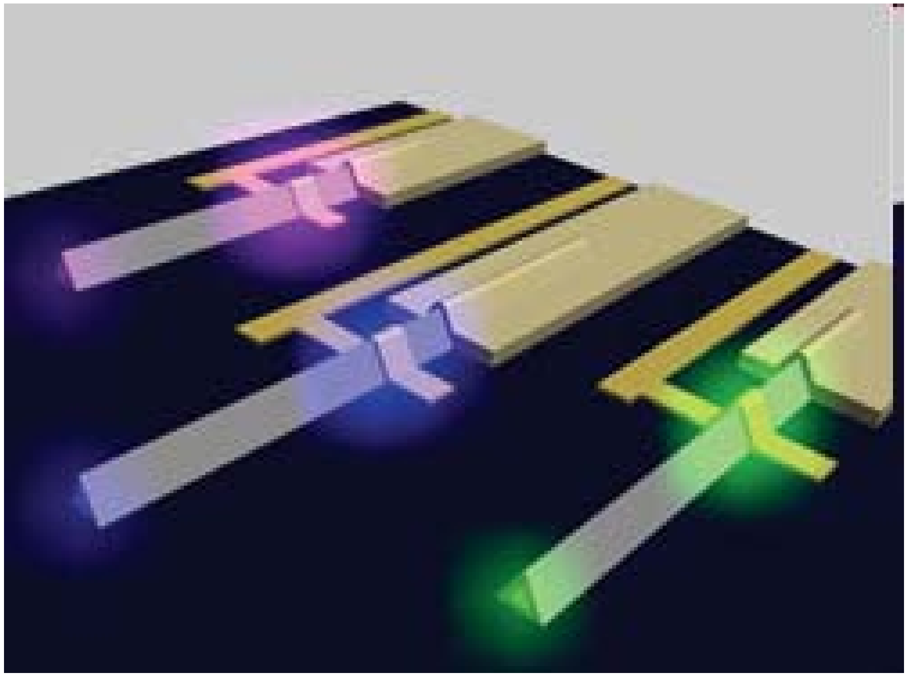


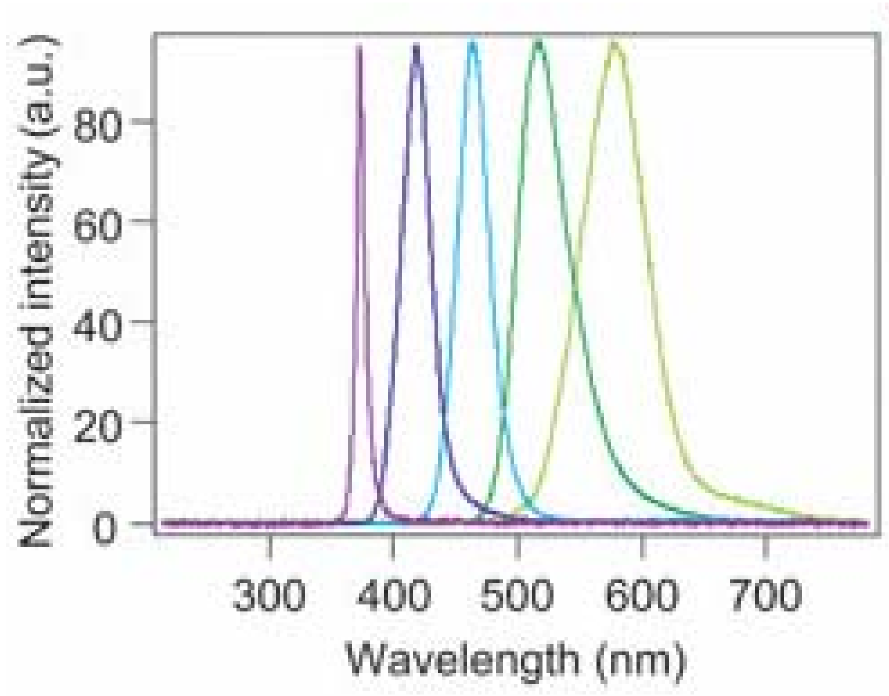
Schematics:
nanowire photonic crystal
with
four engineered defects (left)
nanowire racetrack
microresonator (right).

Scanning electron
microscope micrograph
of the nanowire
photonic crystal (left)
and optical micrograph
of the nanowire
racetrack
microresonator (right).

C. Lieber group

New materials for nanophotonics

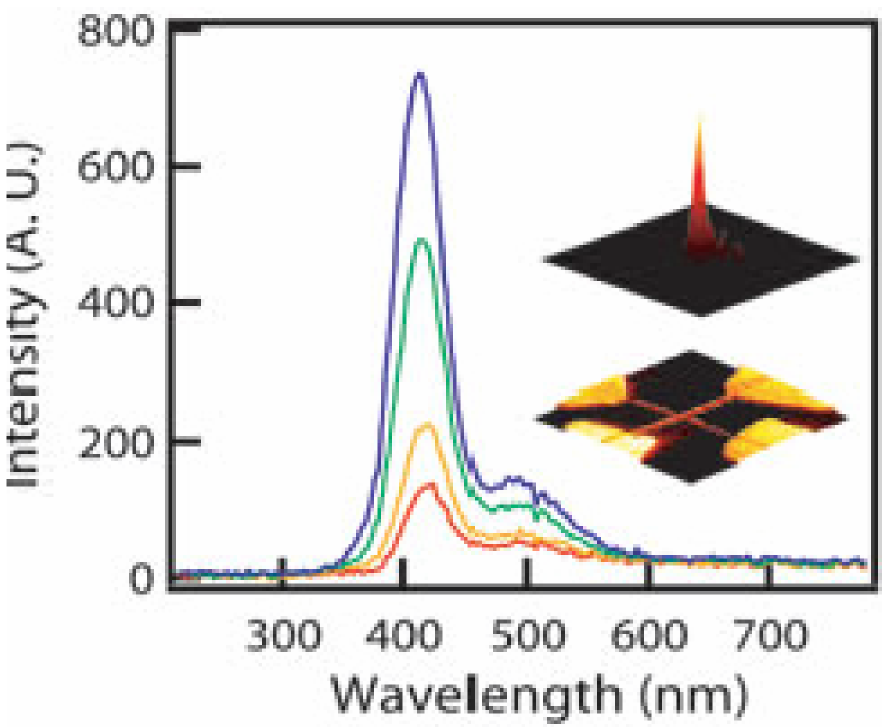


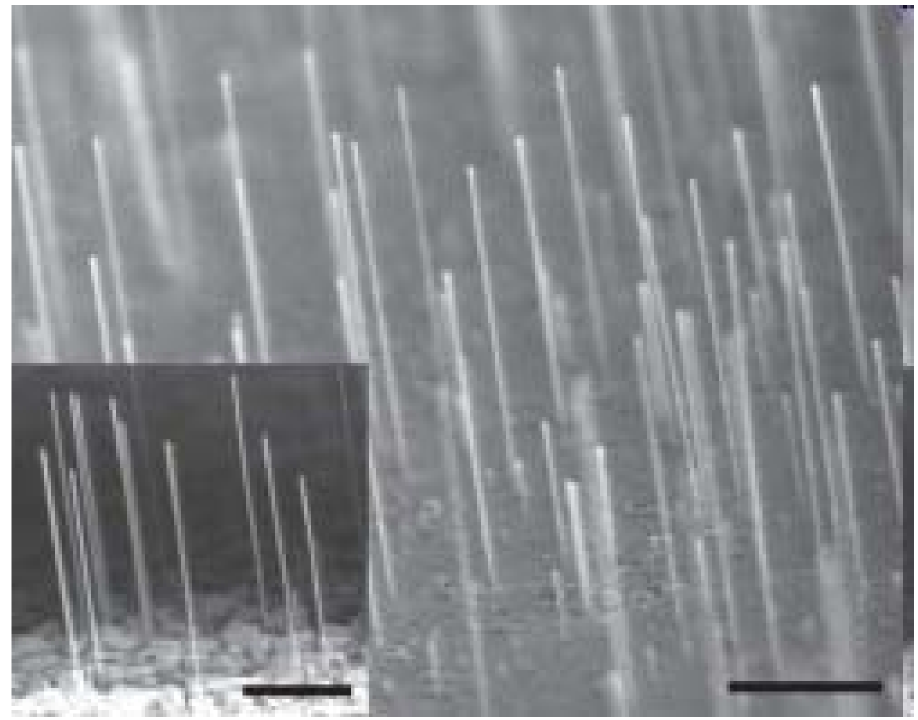


III-nitride-based nanowire radial heterostructures as multicolor and high-efficiency light-emitting diodes.

C. Lieber group

New nanowire devices and structures

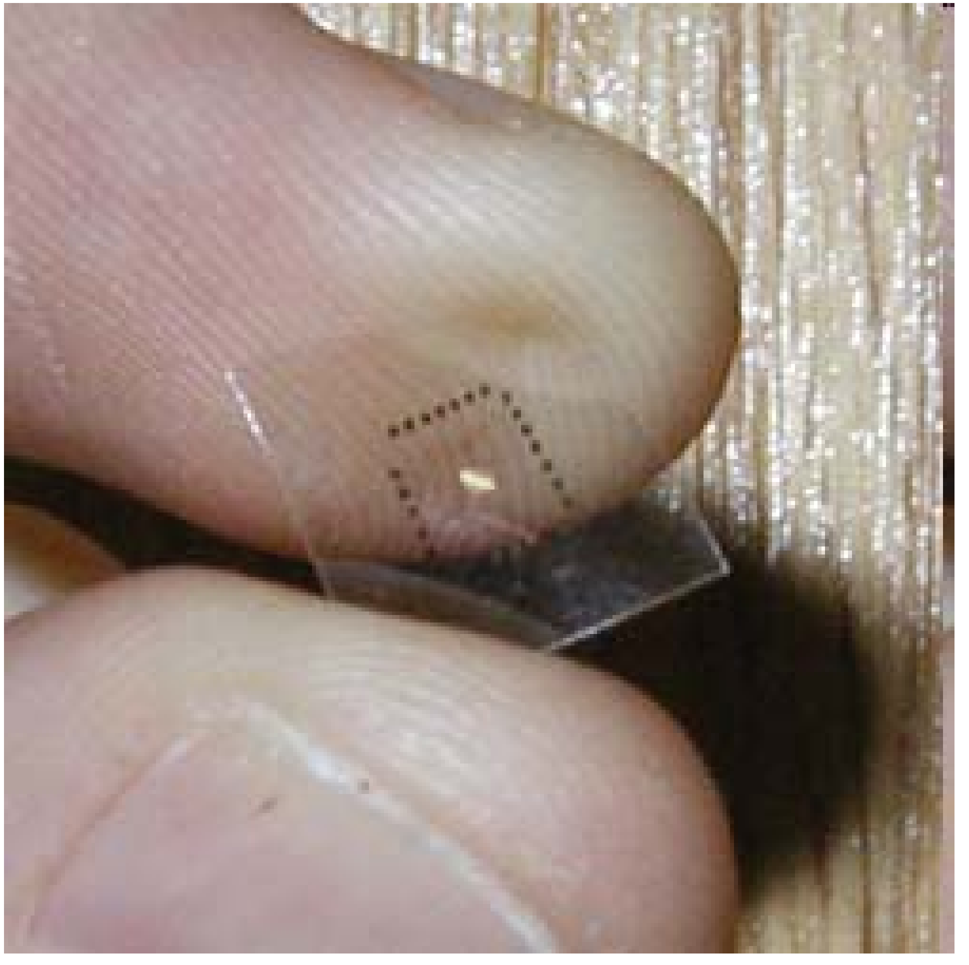




GaN p-n crossed nanowire blue LED.
Nano Lett. 3, 343 (2003).

Epitaxially grown p-type GaN nanowire array.
Nano Lett. 3, 343 (2003).

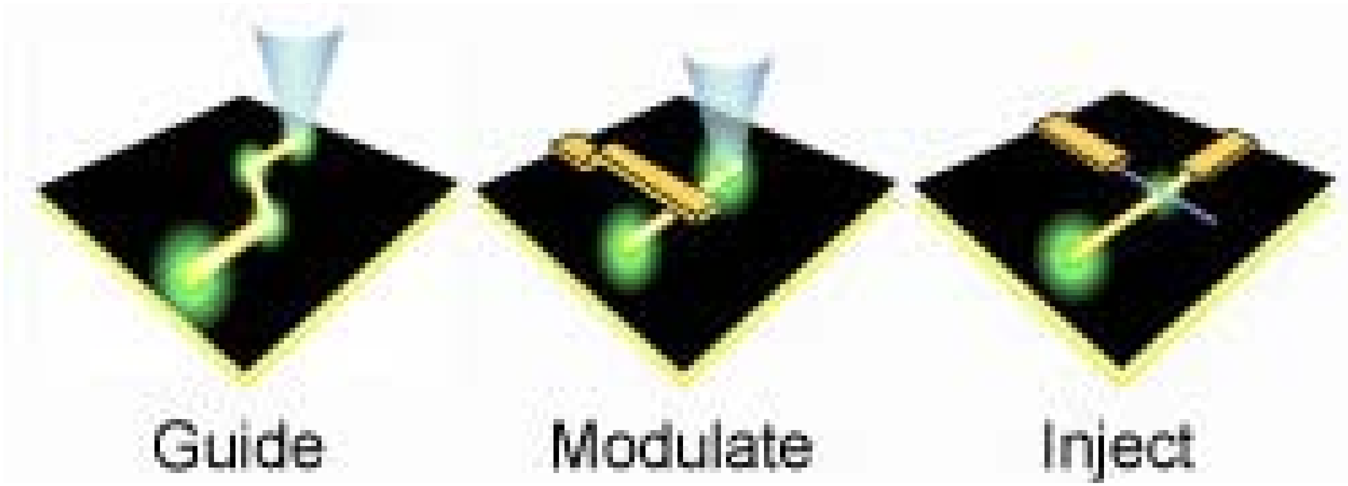
Novel packages of nanodevices



Flexible plastic substrate containing arrays of nanowire devices.
The devices do not degrade under the effect of bending

C. Lieber group

Future nanophotonics

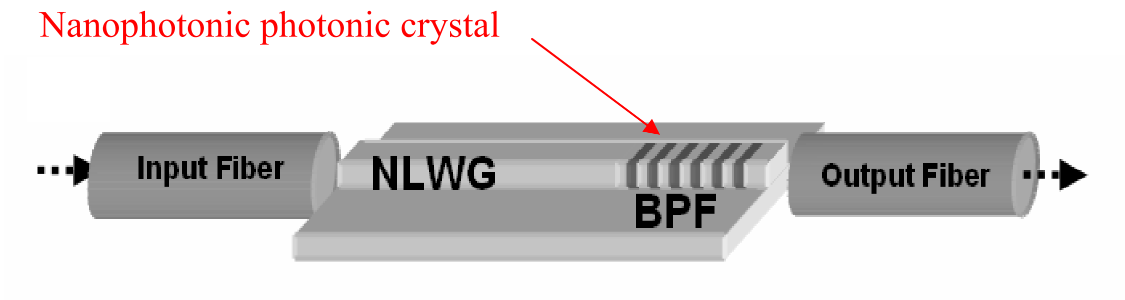


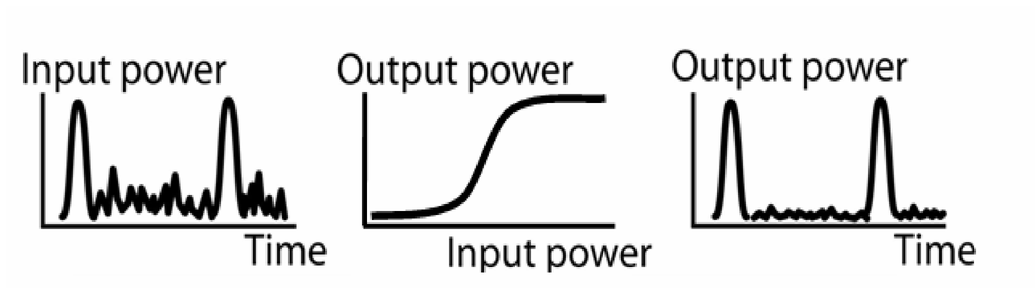
Electrical injection lasers
Single photon detectors
Multi-color LED/laser arrays
Photonic circuits & processors

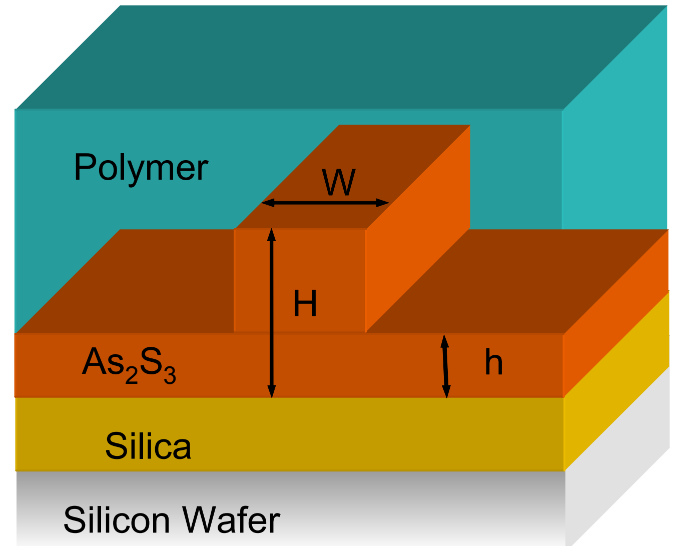
Silicon modulators is a hot topic

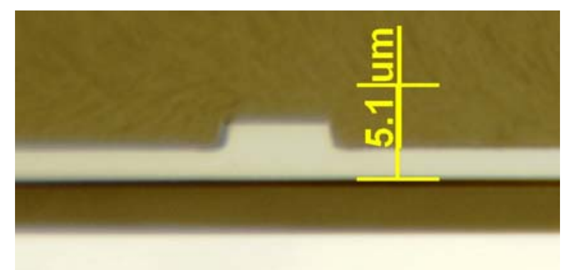
Integration of nanophotonics and silicon CMOS

Integrated all-optical pulse regenerator in chalcogenide waveguides









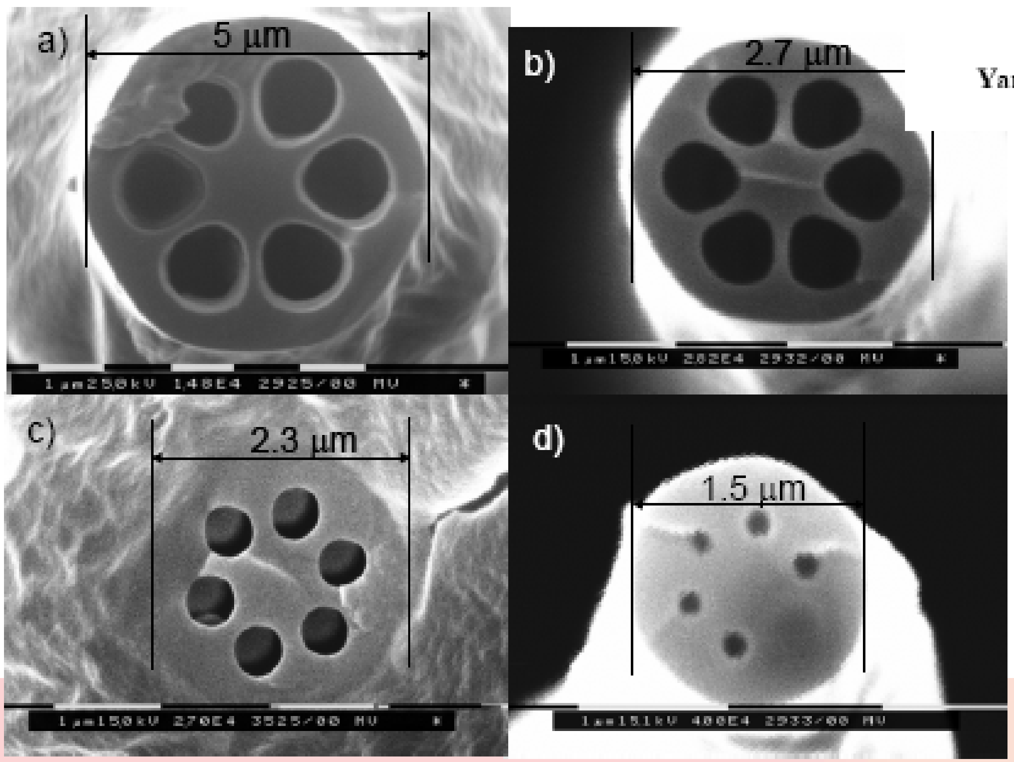
Ben Eggleton's group
CUDOS
University of Sydney
Australia

2900 OPTICS LETTERS / Vol. 30, No. 21 / November 1, 2005

Structure scaling

- Scanning electron micrographs
- Proportions maintained with reduction 50x
- Long wavelengths penetrate cladding – evanescent!

12 July 2004 / Vol. 12, No. 14 / OPTICS EXPRESS 3209



Microstructured optical fiber photonic wires with subwavelength core diameter

Yannick K. Lizé [1,2], Eric C. Mägi[1], Vahid G. Ta'eed[1], Jeremy A. Bolger[1], Paul Steinvurzel[1], and Benjamin J. Eggleton[1,*]

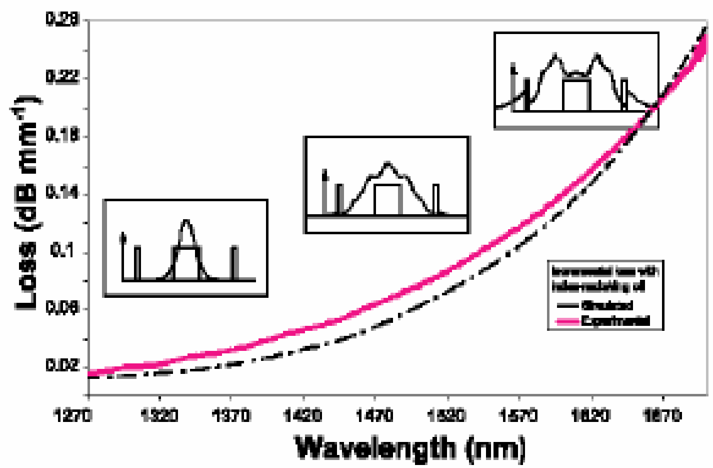
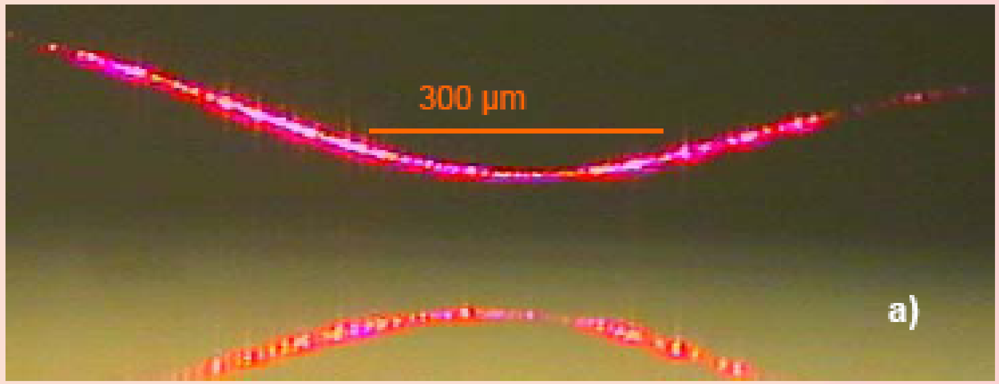
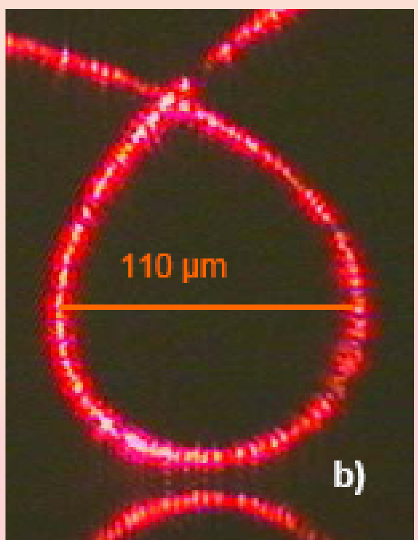
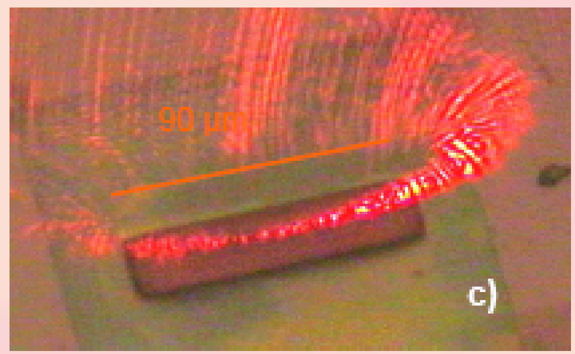


Figure 5. Increased loss of a 3.5 µm outside diameter MOF photonic wire as a function of wavelength when index-matching fluid (n=1.515) covers the device. The solid curve shows the theoretical loss in this device due to radiation, while the dots show the experimental results.

Silica nanowires





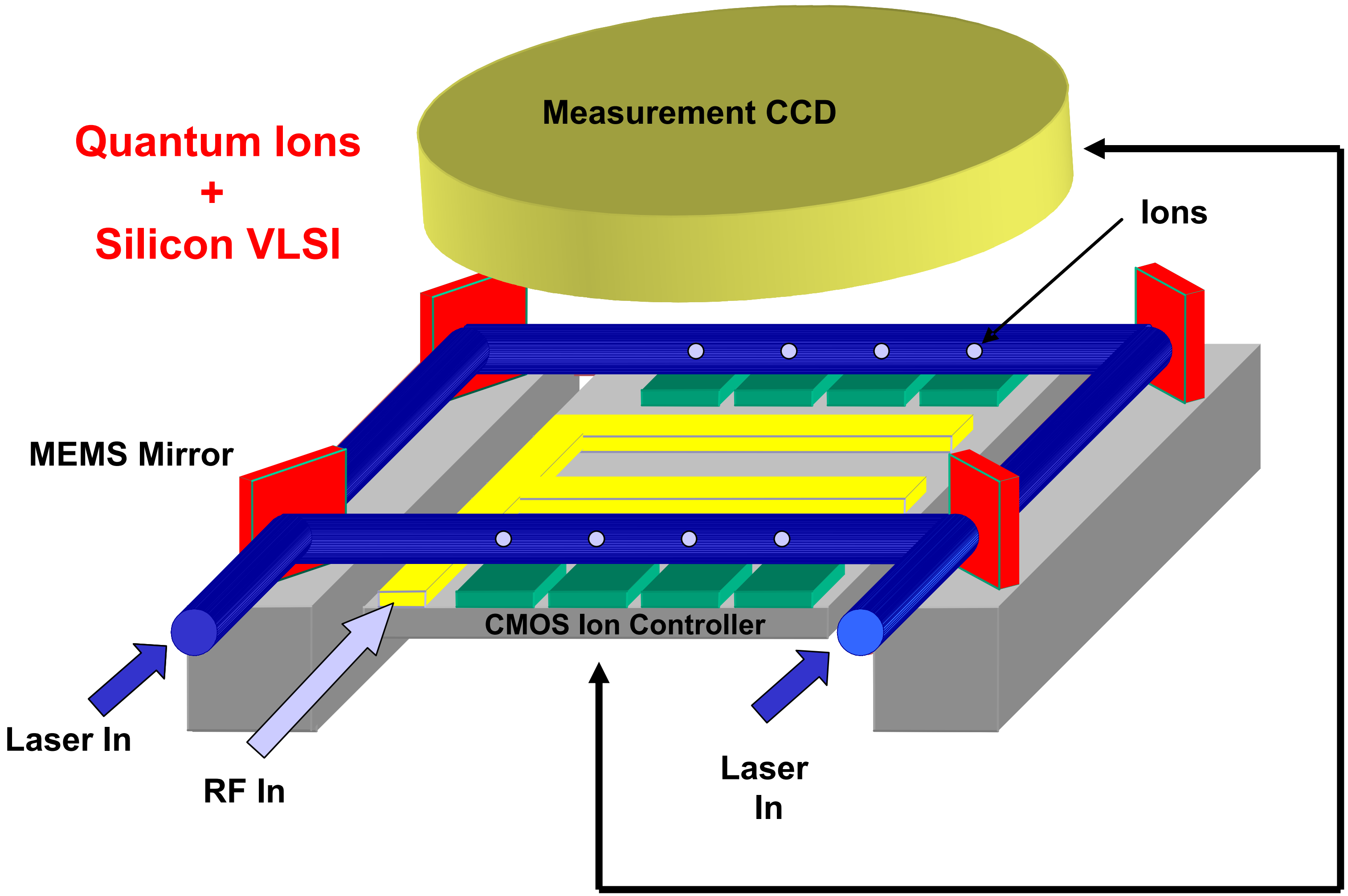


6 February 2006 / Vol. 14, No. 3 / OPTICS EXPRESS 1070

Efficient Coupling to Chalcogenide Glass Photonic Crystal Waveguides via Silica Optical Fiber Nanowires

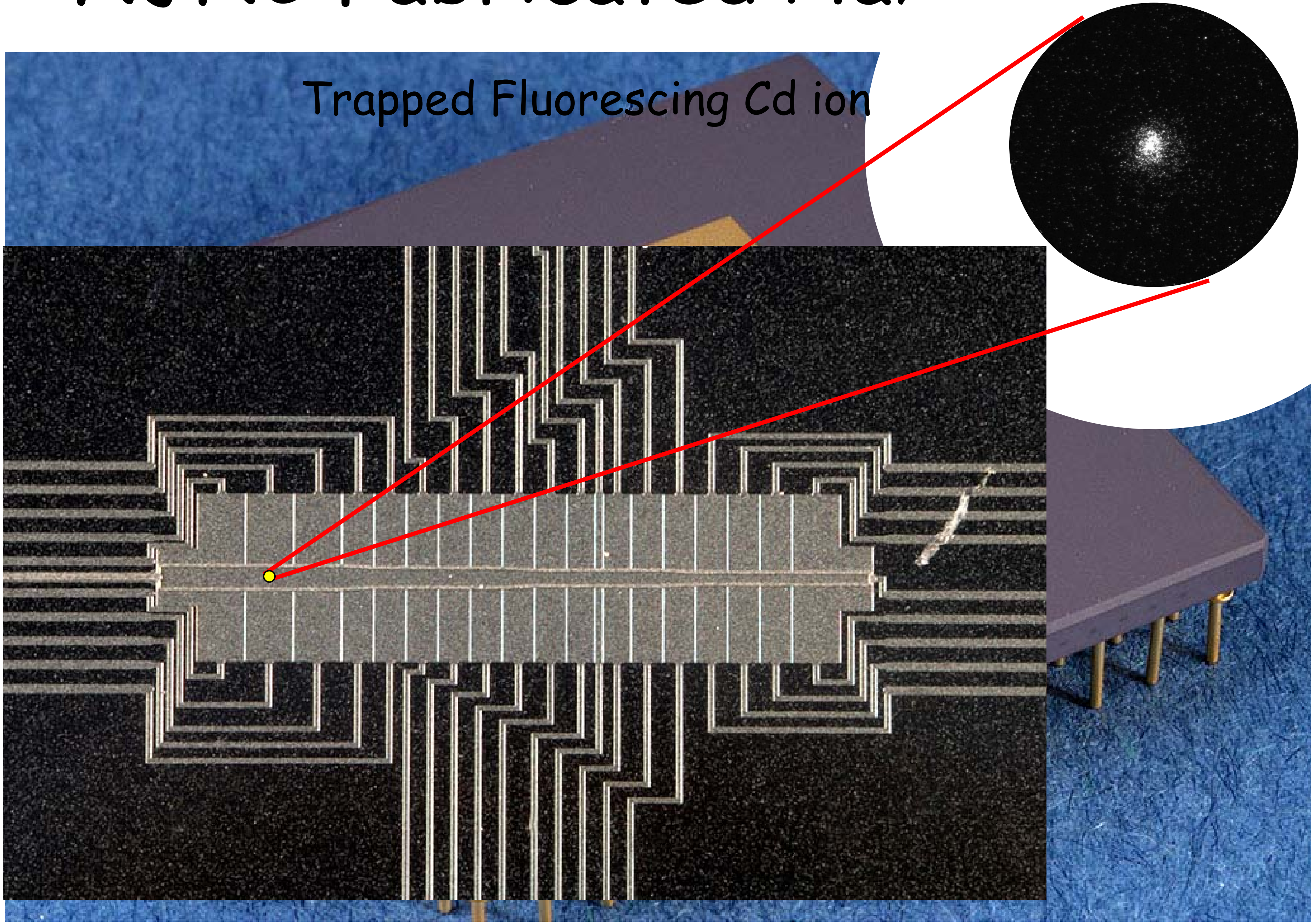
Christian Grillet[1], Cameron Smith[1], Darren Freeman[2], Steve Madden[2], Barry Luther-Davies[2], Eric C. Magi[1], David J. Moss[1] and Benjamin J.Eggleton[1]

Scalable Ion Trap Quantum Computer Vision

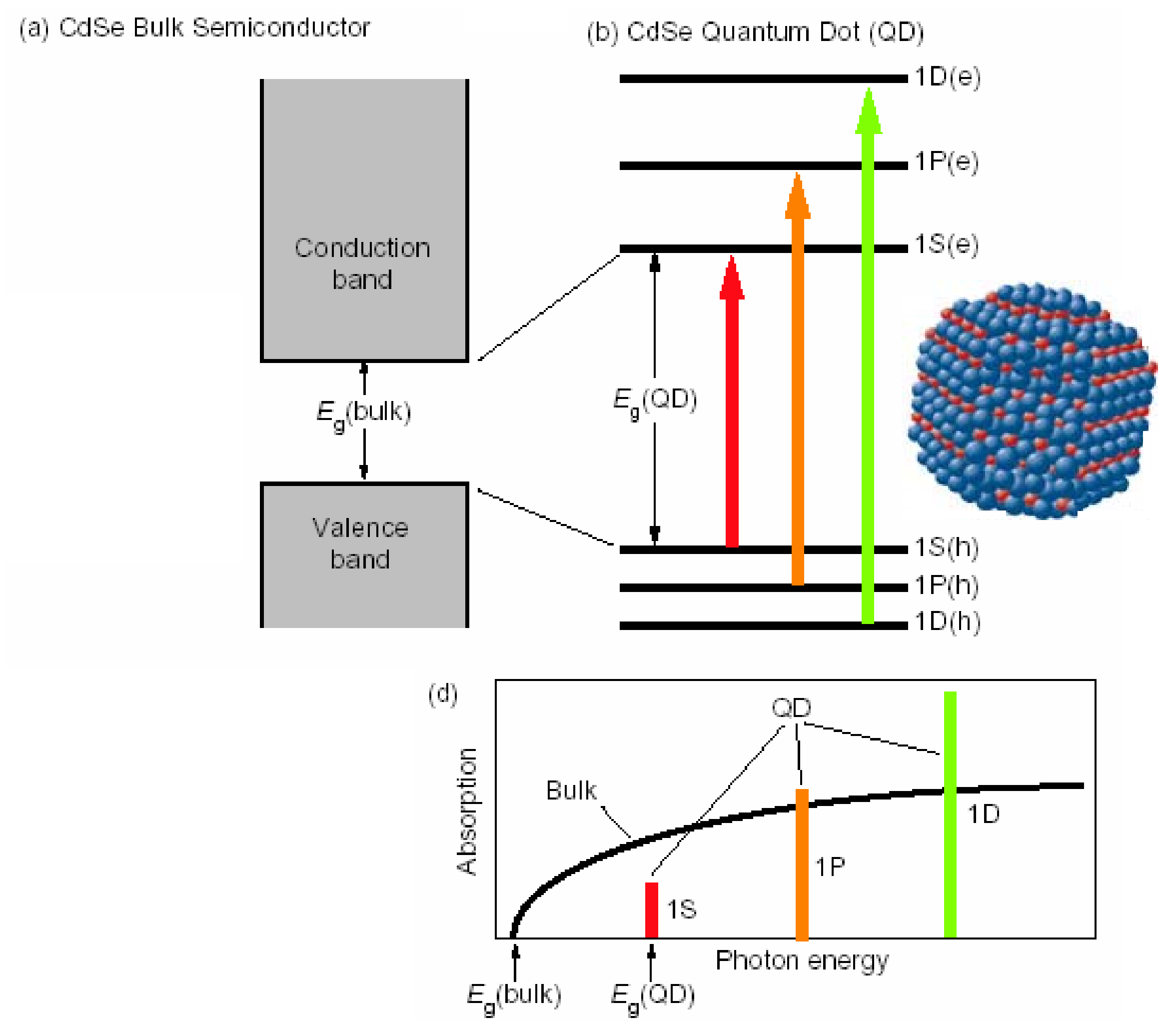


System Compatibility of Quantum & Classical: Spatial Pitch, Clock Speed
Operating Temperature, Power Dissipation

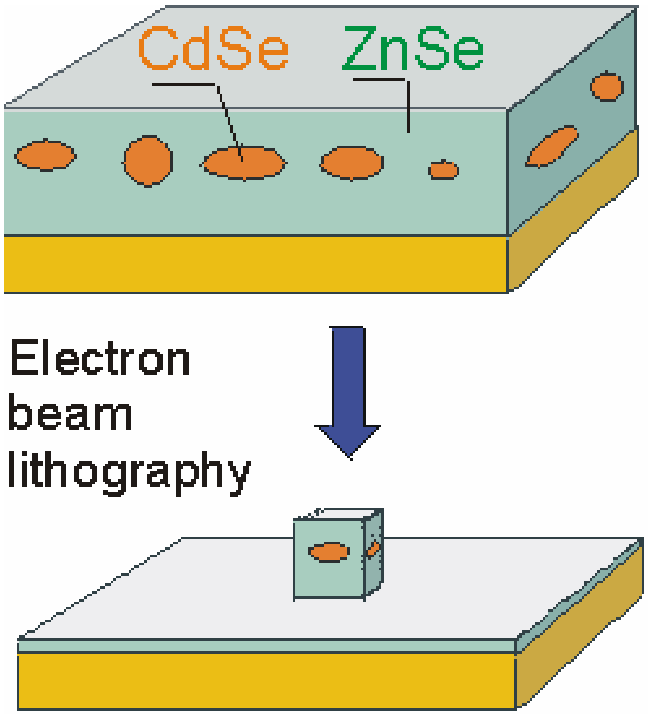
NJNC Fabricated Plar

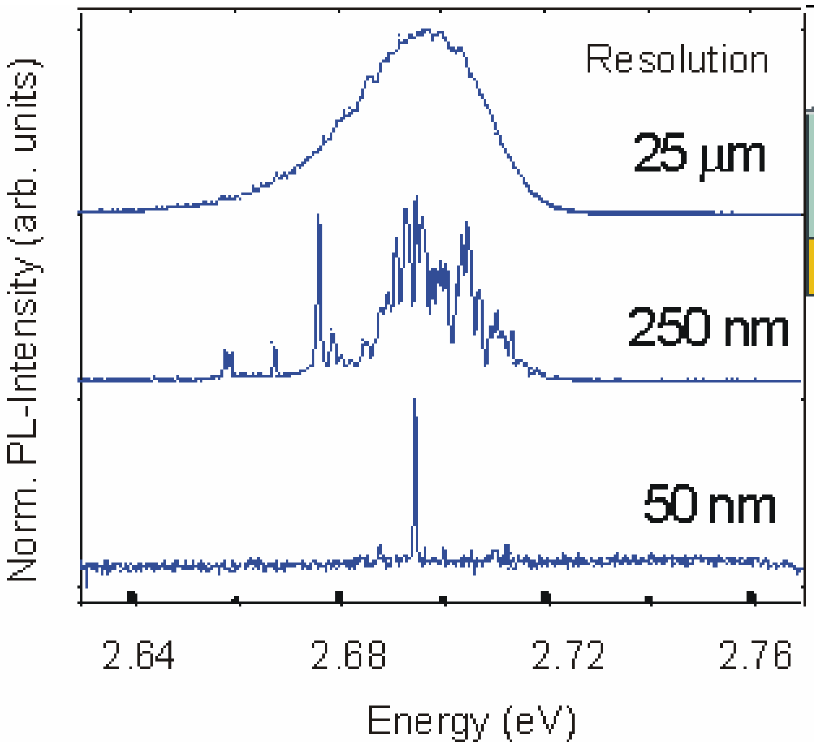


Nanocrystal Quantum Dots: Artificial Atoms



Single Quantum Dot Spectra

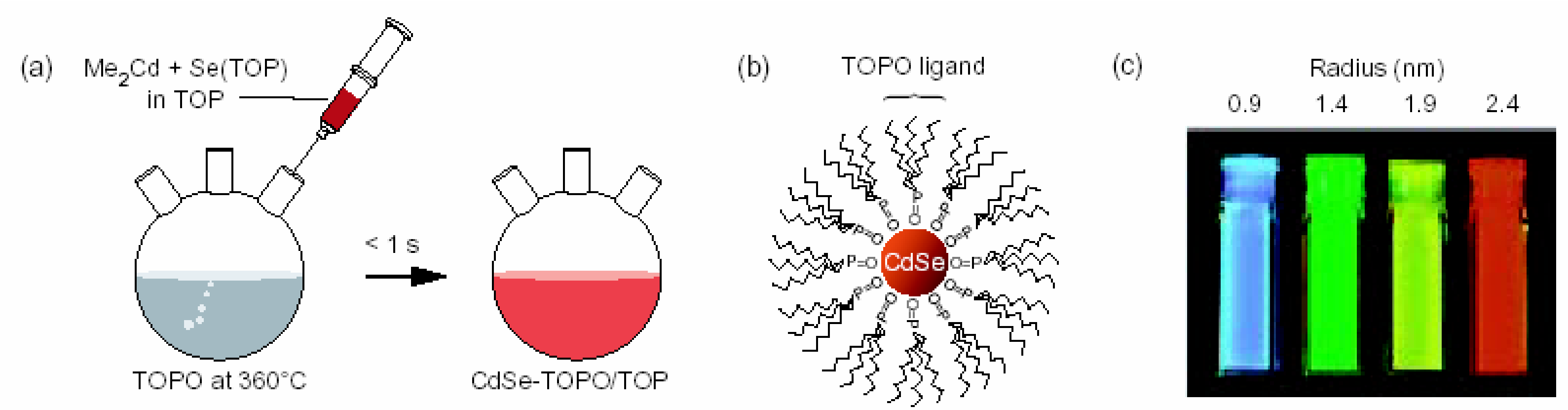




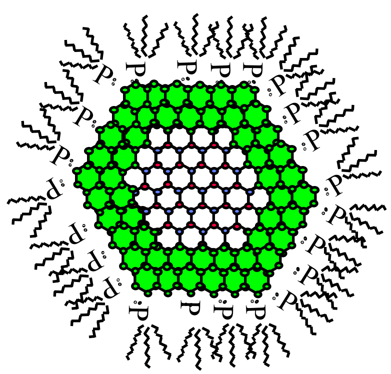
Fabrication of Nanocrystals

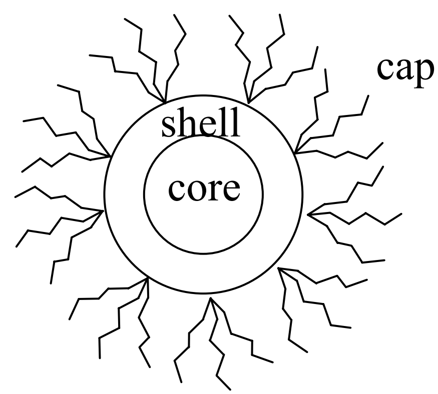
Bawendi Group – MIT

Banin Group – Hebrew Univ.



NQD Light Emission





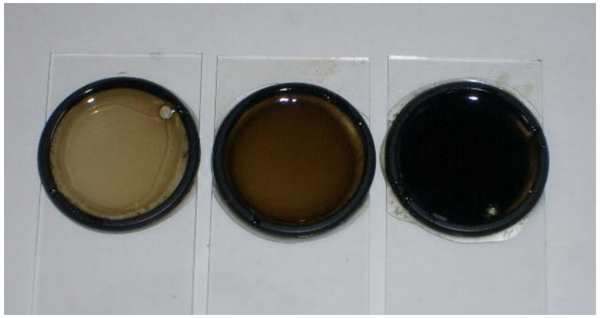
Nanocrystals

CdSe and CdTe -Shell of ZnS
3-6 nm
visible

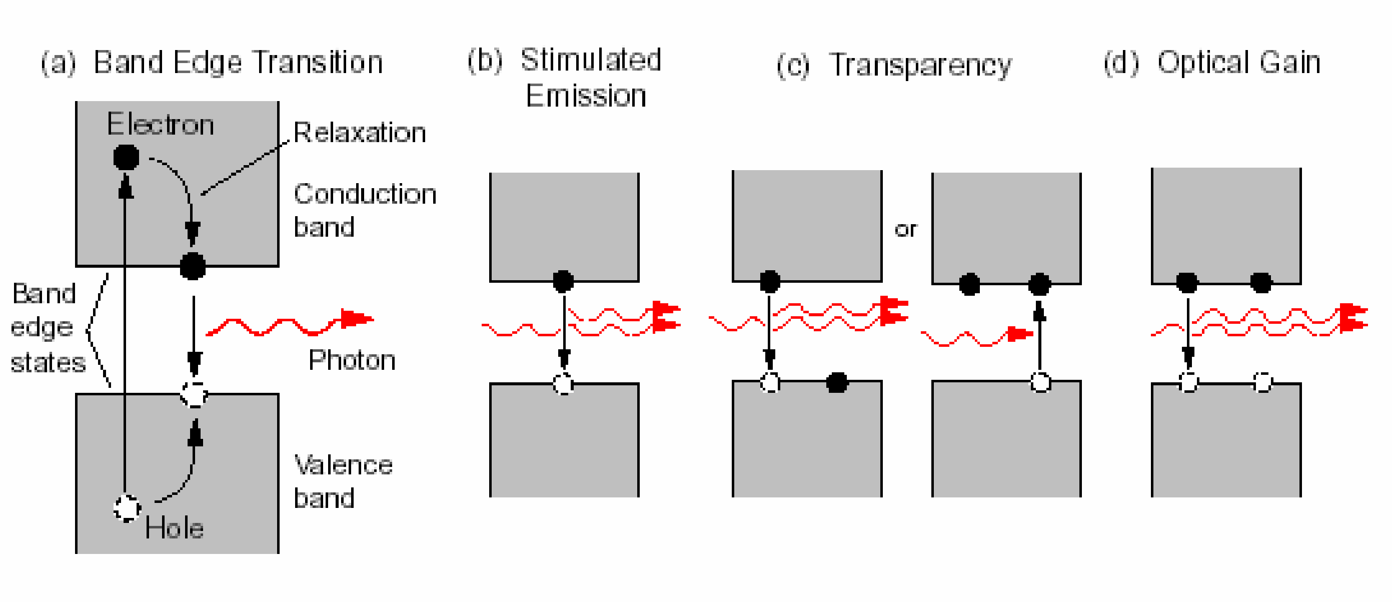
PbSe - No shell
8 nm
infrared (1.5 micron)

InAs - Shell of CdSe and ZnSe
7-8 nm
infrared (1.5 micron)

Photography by Felice Frankel



Nanocrystal Quantum Dots as Lasing Media



- Lower threshold than 3D and 2D lasers
- Wavelength (size) tunability
- Thermal gain stability

Summary

- Nanophotonics
  - New lights sources
    - Single photon sources
    - Lab on chip sources (e.g. biophysics, cell studies)
  - Nanowires
  - Quantum dots
  - Nanostructures fibers

- Quantum information
  - Microfabrication of traps for ions, atoms and molecules
    - Ions traps
    - MEMS SLMs for atom traps
    - Dipolar molecule traps
  - Progress toward controlling many ions and atoms
    - First studies of large controlled quantum assembles