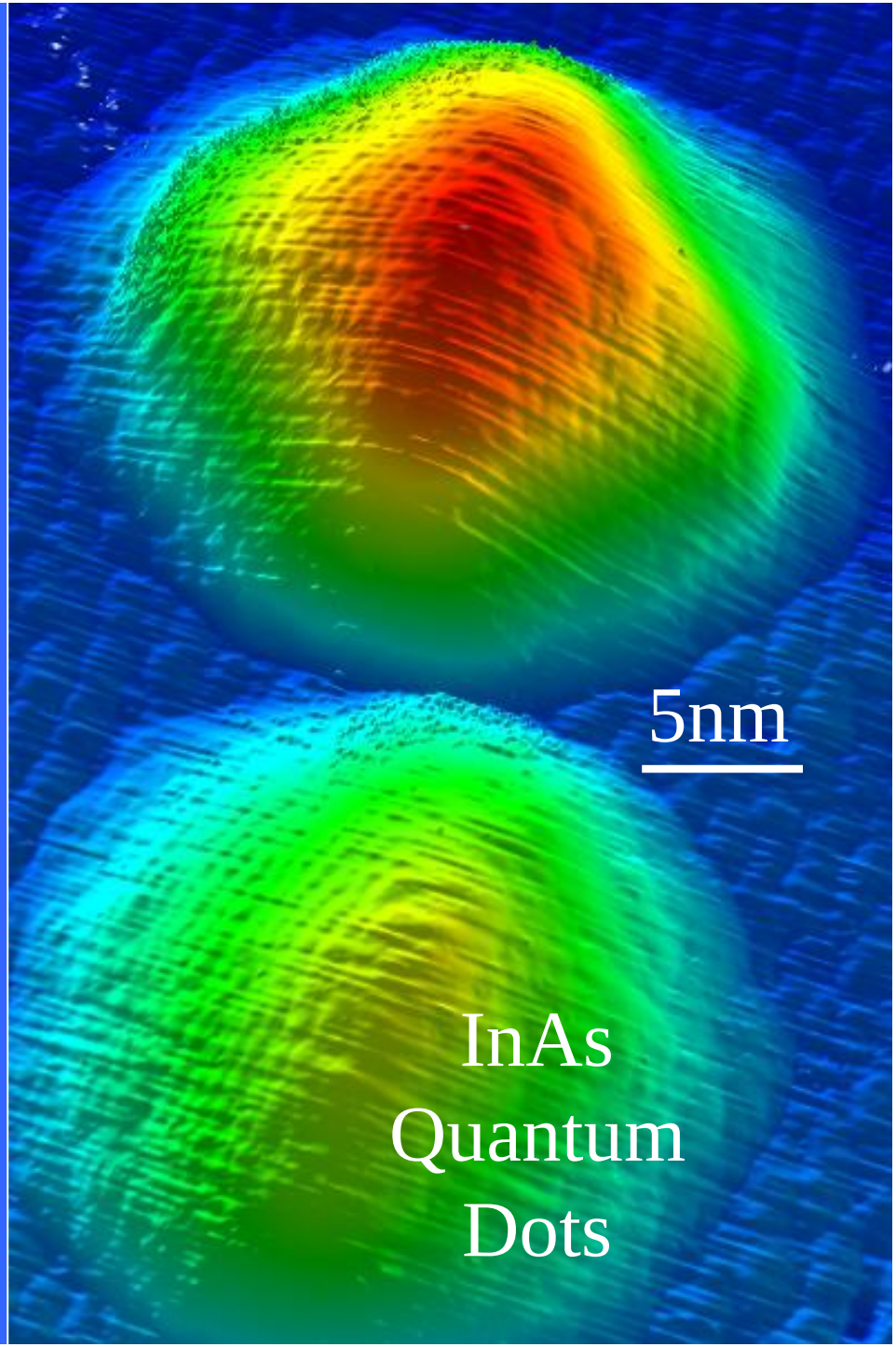
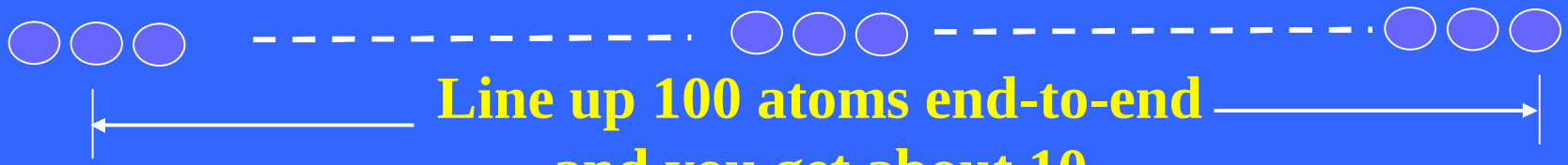
Nanoscale Materials Inspires Innovation and Drives Economic Development

Greg Salamo
&
Alex Biris

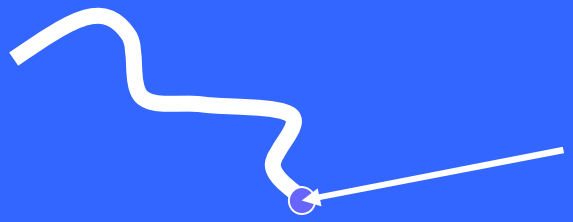


What is Nanoscience ?

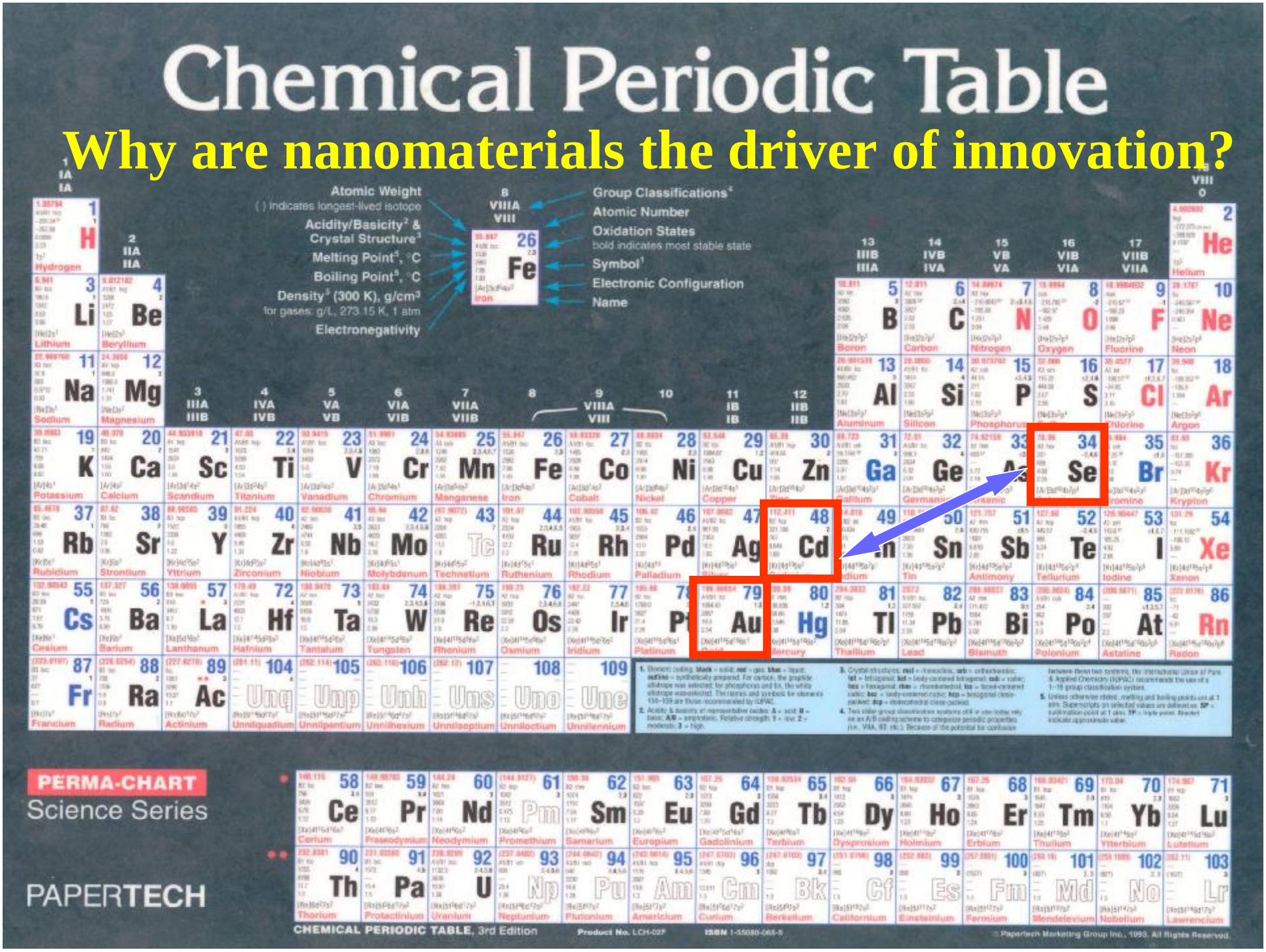
The effort to understand and design structures at the nano size and seek their application



Line up 100 atoms end-to-end and you get about 10 nanometers

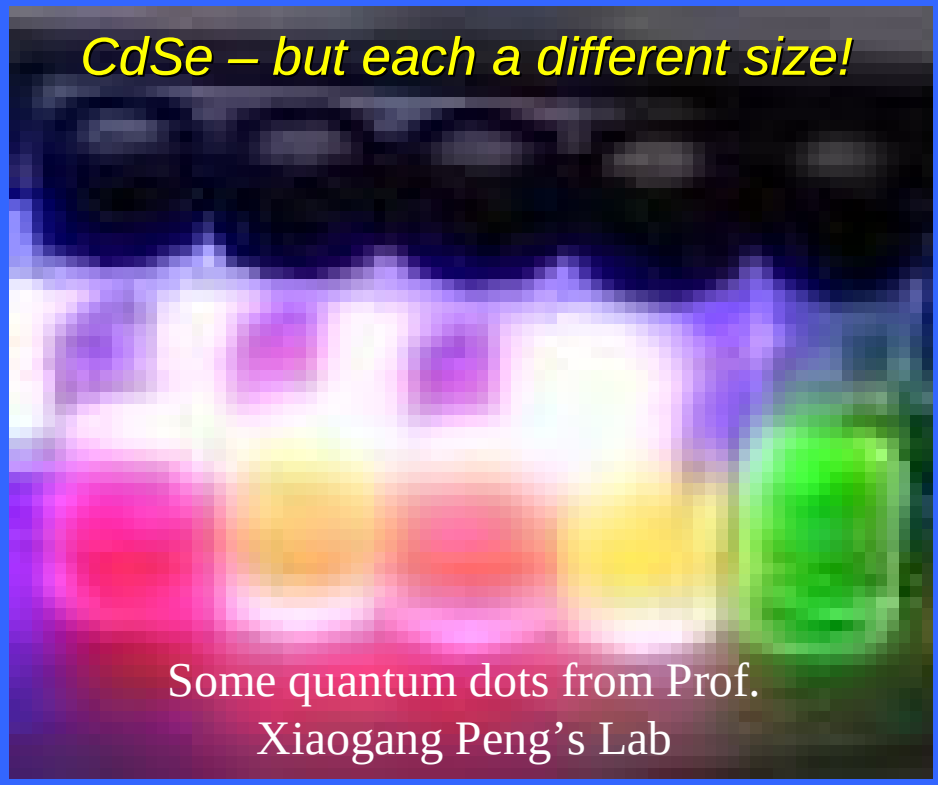


Take the diameter of a hair and divide by 100,000 and you have a diameter of nanometer size


Chemical Periodic Table
Why are nanomaterials the driver of innovation?
Atomic Weight
( ) indicates longest-lived isotope
Acidity/Basicity & Crystal Structure
Melting Point, °C
Boiling Point, °C
Density (300 K), g/cm³
for gases: g/L, 273.15 K, 1 atm
Electronegativity
Group Classifications
Atomic Number
Oxidation States
bold indicates most stable state
Symbol
Electronic Configuration
Name
PERMA-CHART
Science Series
PAPERTECH
CHEMICAL PERIODIC TABLE, 3rd Edition
Product No. LCH-02F
ISBN 1-55080-065-5
Papertech Marketing Group Inc., 1993. All Rights Reserved.

Take Any Element in the Periodic Table

It will have very different optical, electrical, or mechanical properties depending on its size!

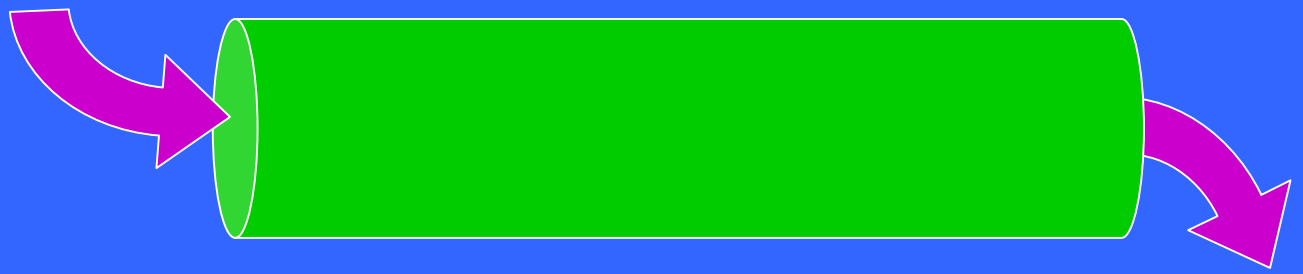


Some quantum dots from Prof. Xiaogang Peng's Lab

Throughout history new materials inspired innovation

Why this Change in Behavior? New Rules When We Go Very Small

Easy to Cause Flow



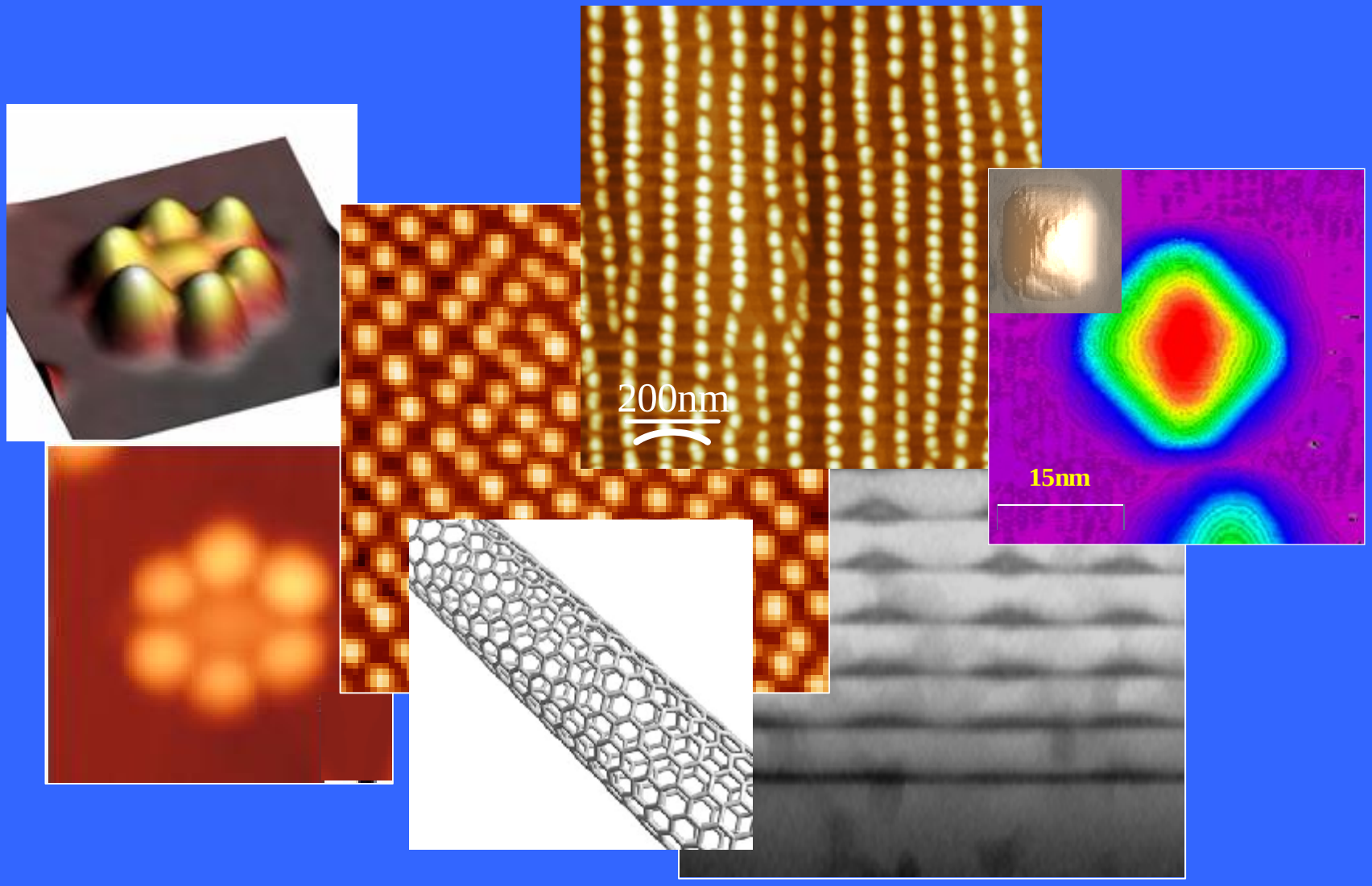
If it's Small it is Difficult to Cause Flow

?

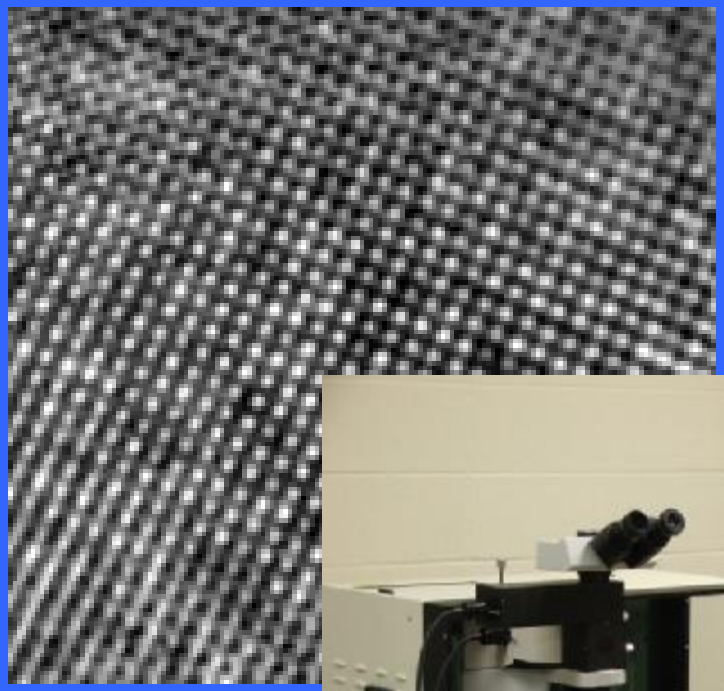

Impact of
Nanotechnology
in
Healthcare, Energy Efficiency, and
Renewable Energy
MISSOURI
Springdale
Fayetteville
White
Blytheville
Jonesboro
Arkansas
ARKANSAS
Fort Smith
West Memphis
TENNESSEE
OKLAHOMA
OUACHITA
MTS.
North
Little Rock
Jacksonville
LITTLE ROCK
Hot Springs
Nat'l. Park
Pine Bluff
MISSISSIPPI
Ouachita
Texarkana
Mississippi
TEXAS
LOUISIANA

State-of-the-Art Growth & Fabrication Facilities

Form Molecules or Chains or 3D arrays made of Nanoscale materials

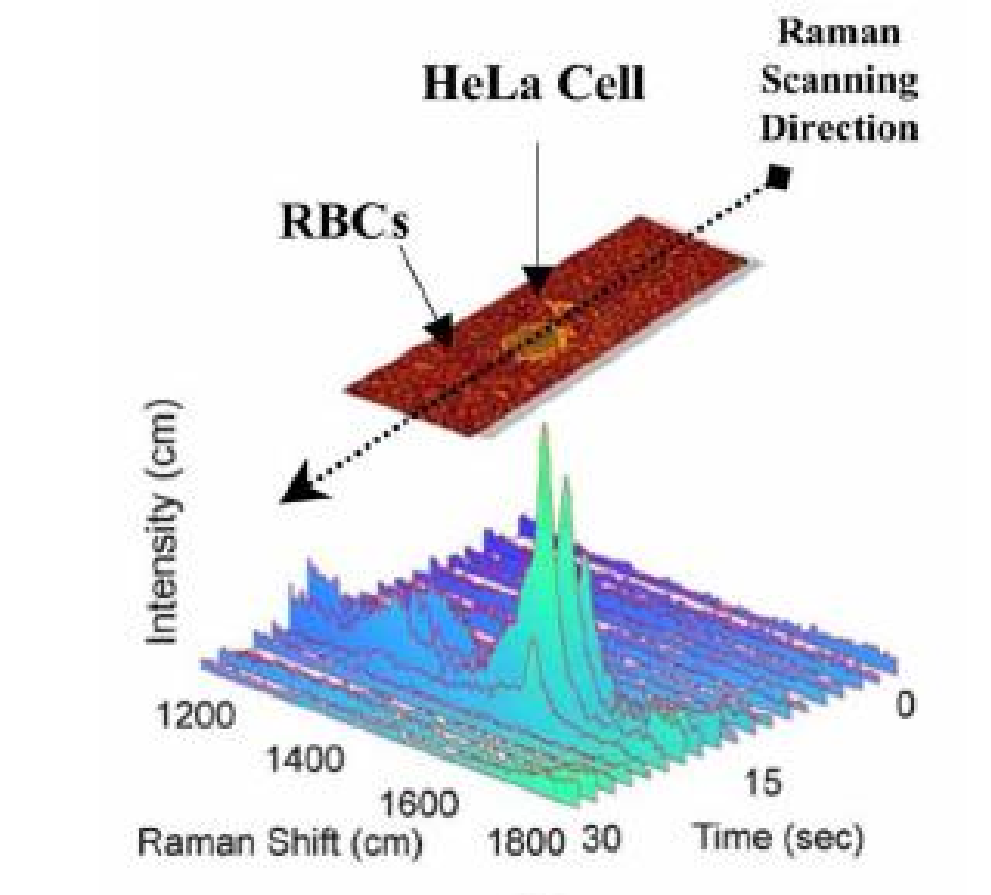


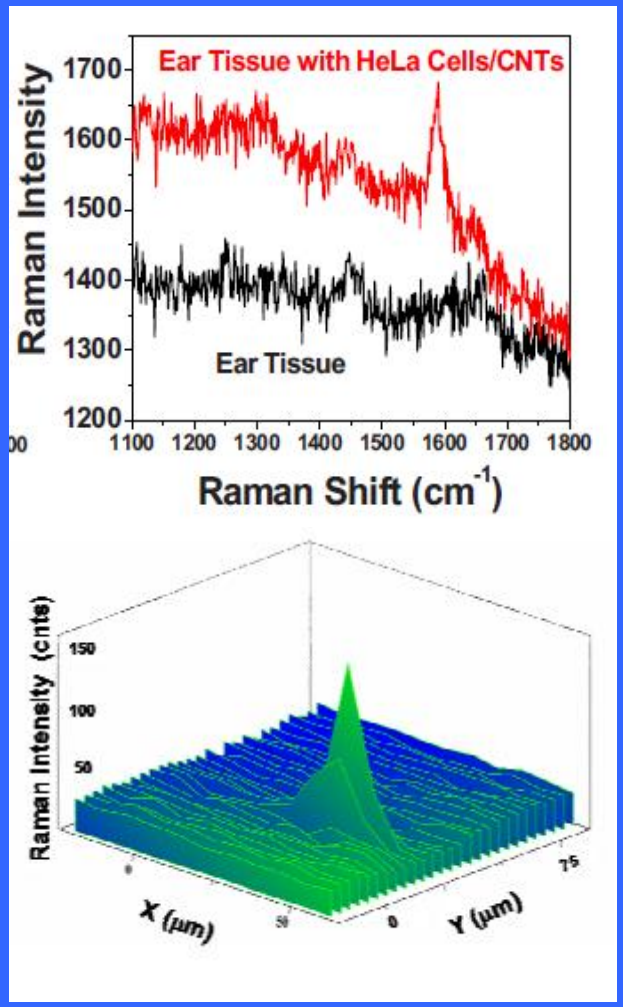
State-of-the-art Nanoscale Materials Imaging Tools



FIB, STM; AFM; SEM, STM/SEM X-Ray; XPS; TEM, etc.

Healthcare: Cancer Cell Detection in Blood/Ear Tissue (Zharov – Biris)

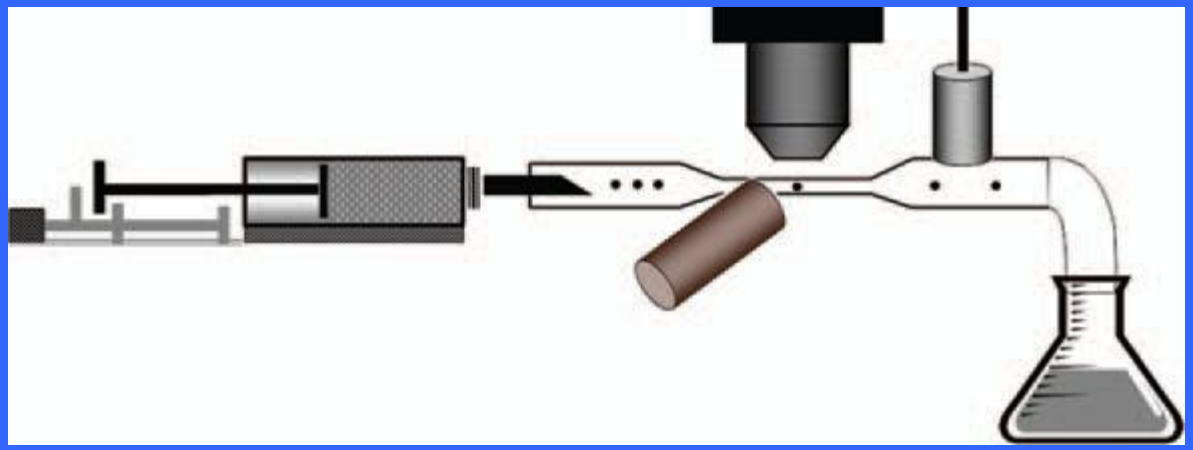


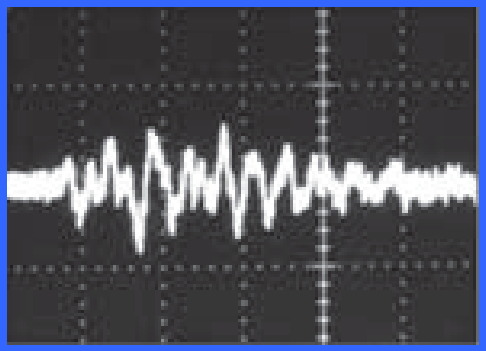


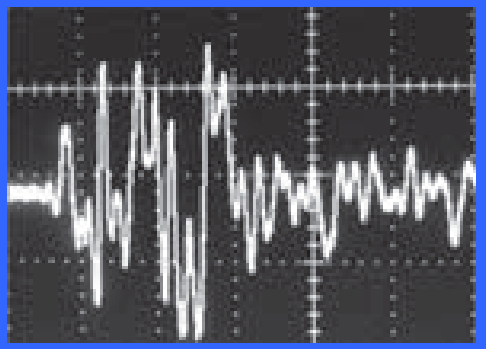
What is new here – Detection of a Single Cell in Blood

Healthcare: In Vivo Magnetic Enrichment & Photoacoustic Detection of Circulating Tumor Cells

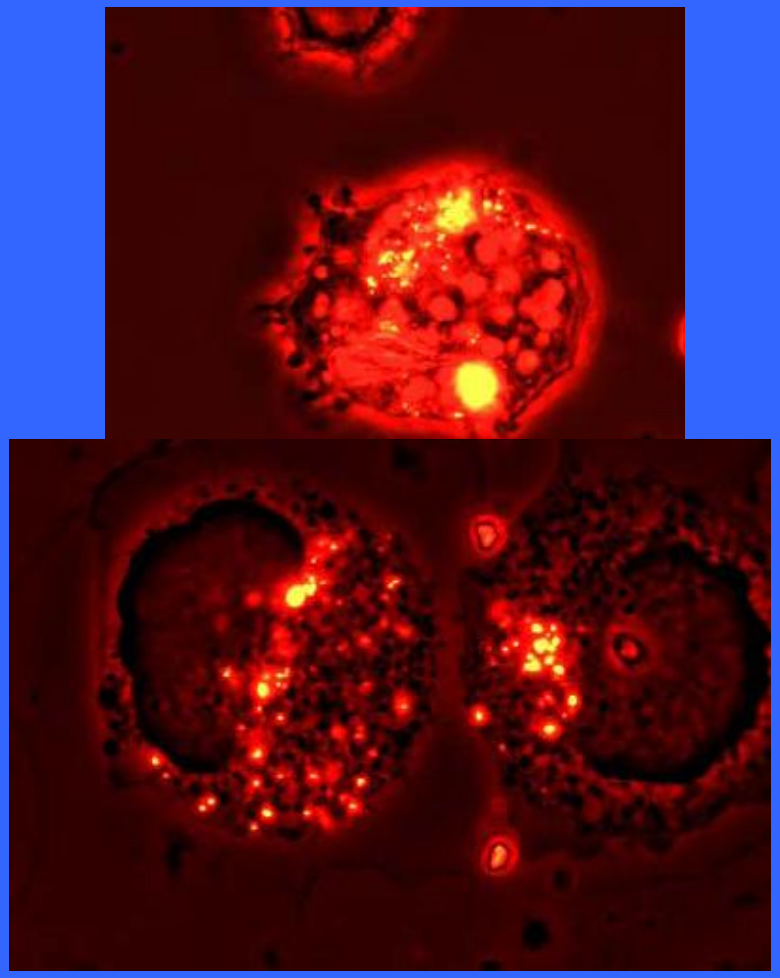
(Zharov and Kim)

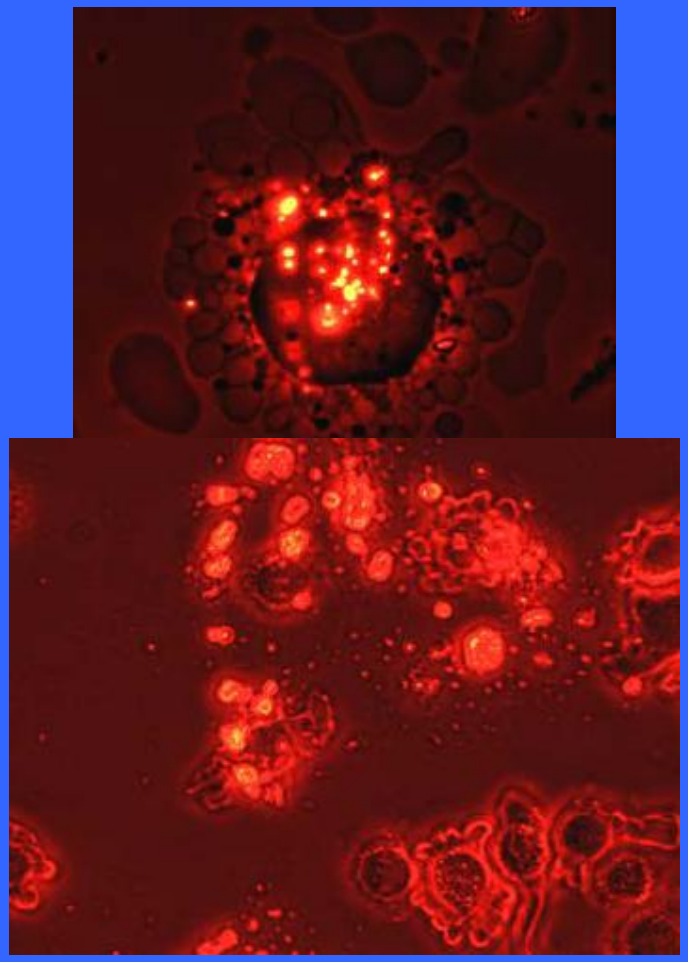






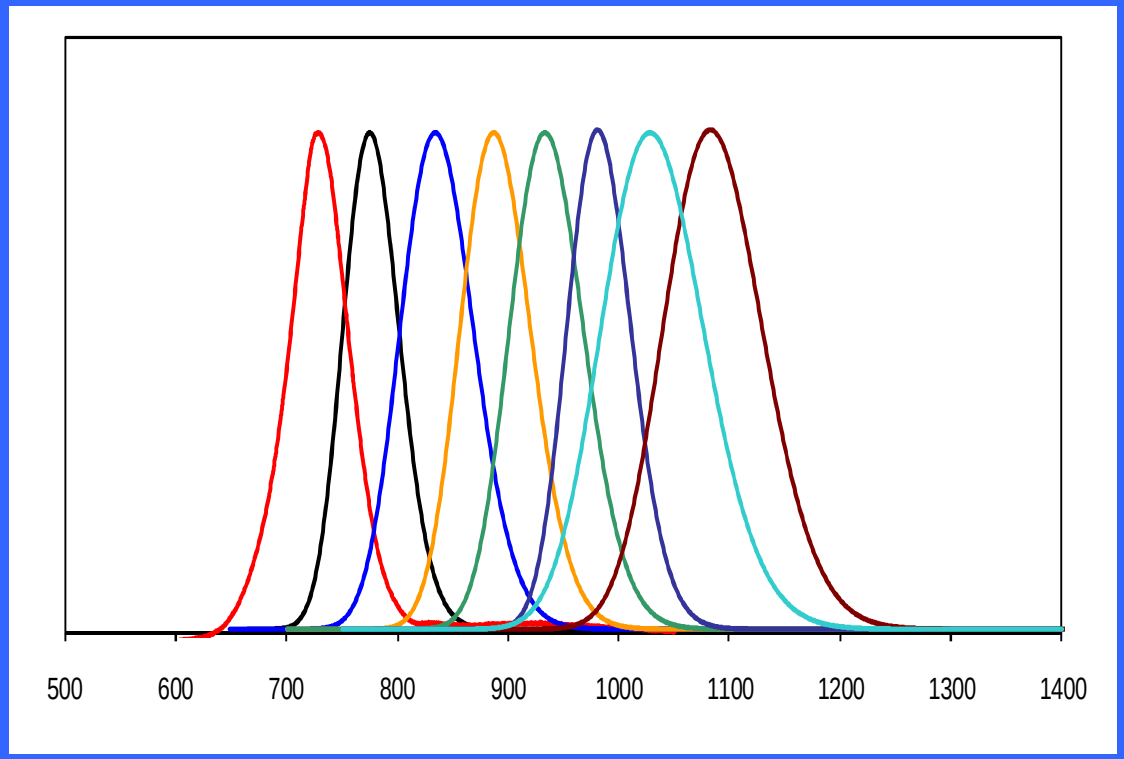
Healthcare: Optical-Magnetic Nanoparticles for Cancer Treatment (Biris)

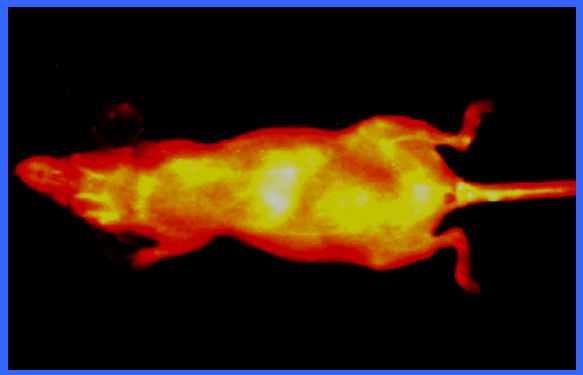




What is new here: Exploding Cells under RF

Healthcare: Imaging Through Tissue
InAs/InP/ZnSe Q-dots (Peng)



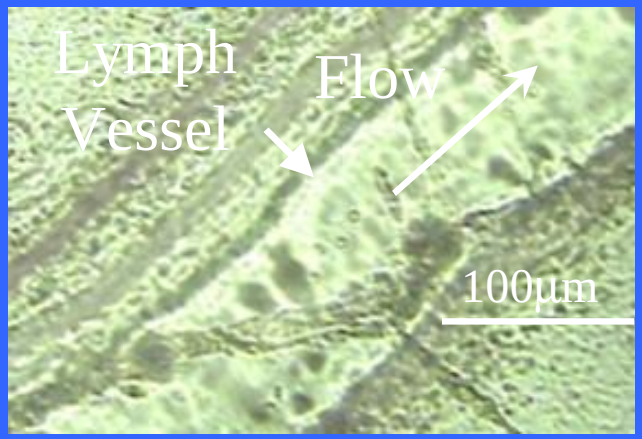


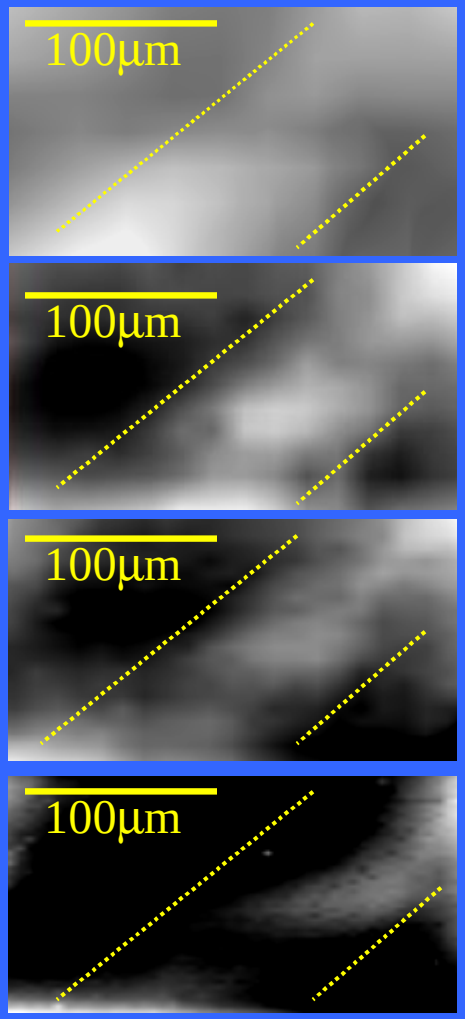
InAs dots (NIR) *in vivo* imaging

What is new here – flexible Infra-red emission

Healthcare: Uptake and Clearing of CNTs by Lymph Vessel (Zharov & Biris)

Raman Analysis





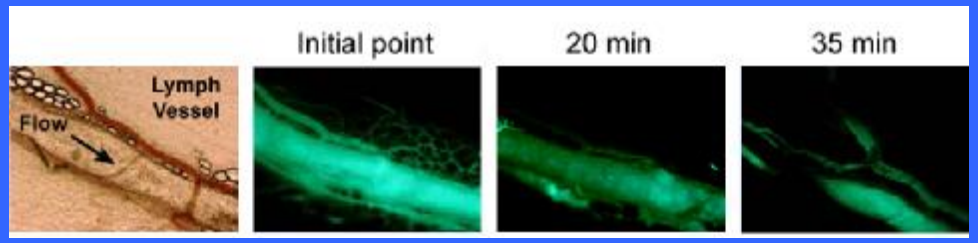
Time – 2 min

Time – 12 min

Time – 22 min

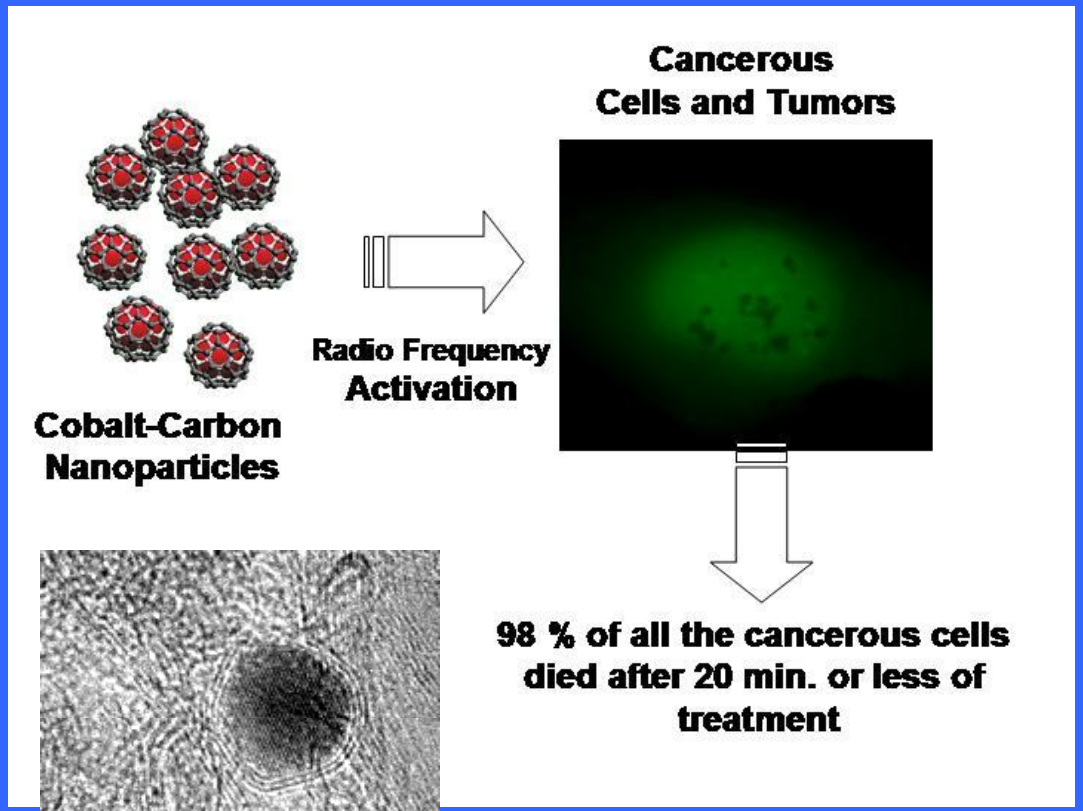
Time – 32 min

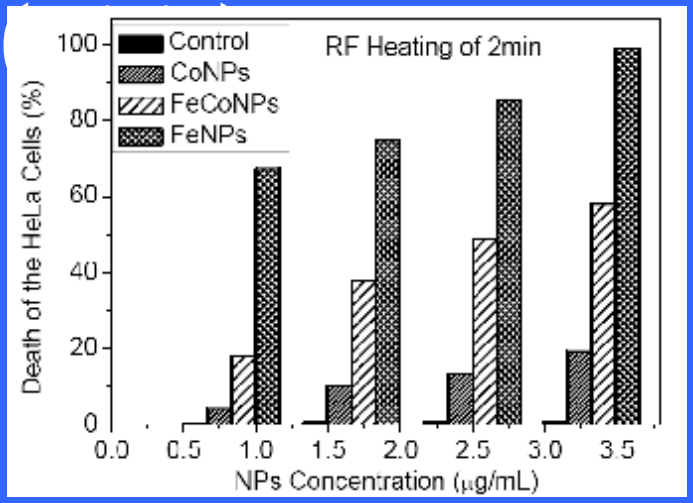
Fluorescent Dye Analysis

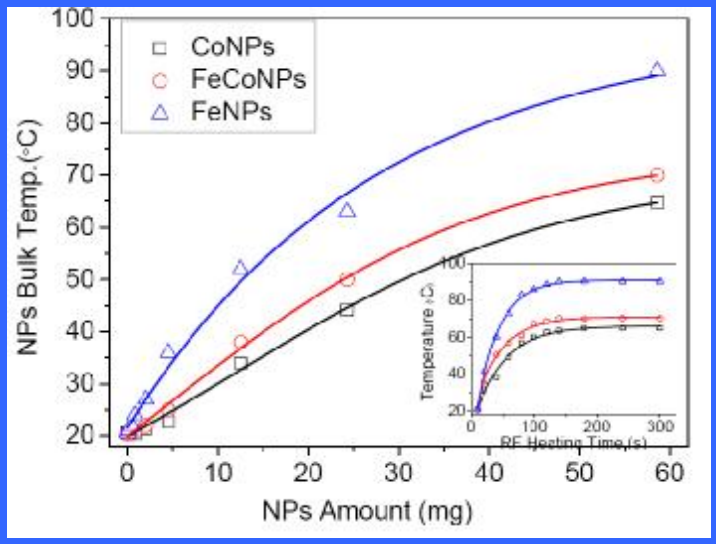


What is new here – CNT enter and propagate in Lymphatic

Healthcare: Graphitic Coated Magnetic Nanoparticles for Heating Cancer Cells with Radio Frequency

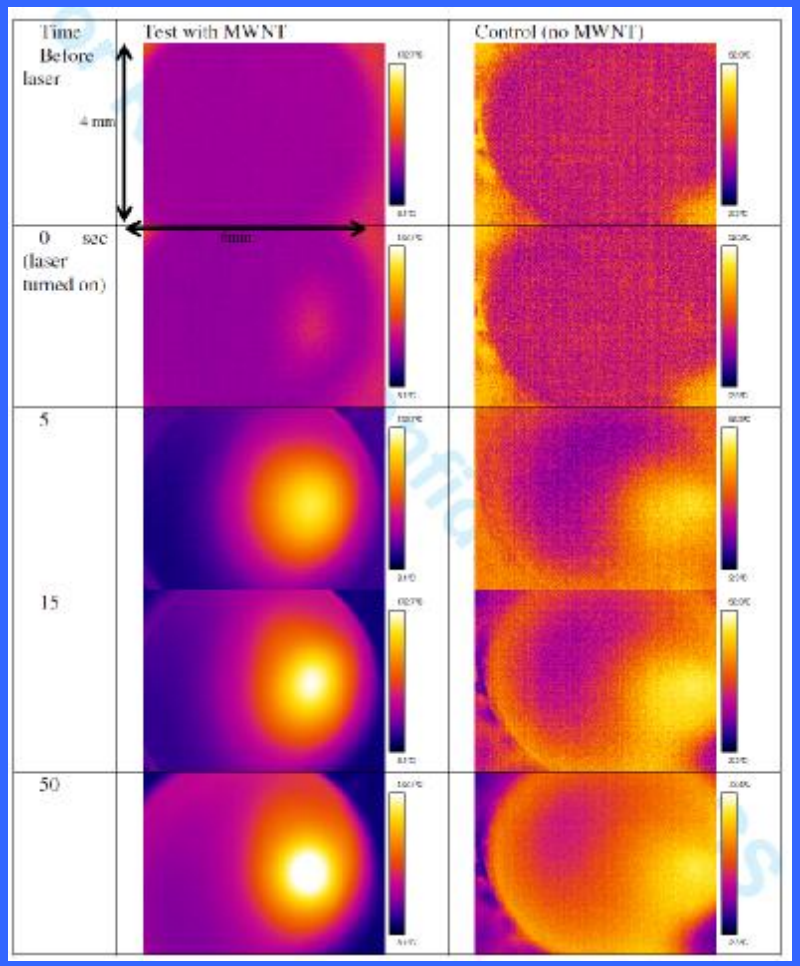


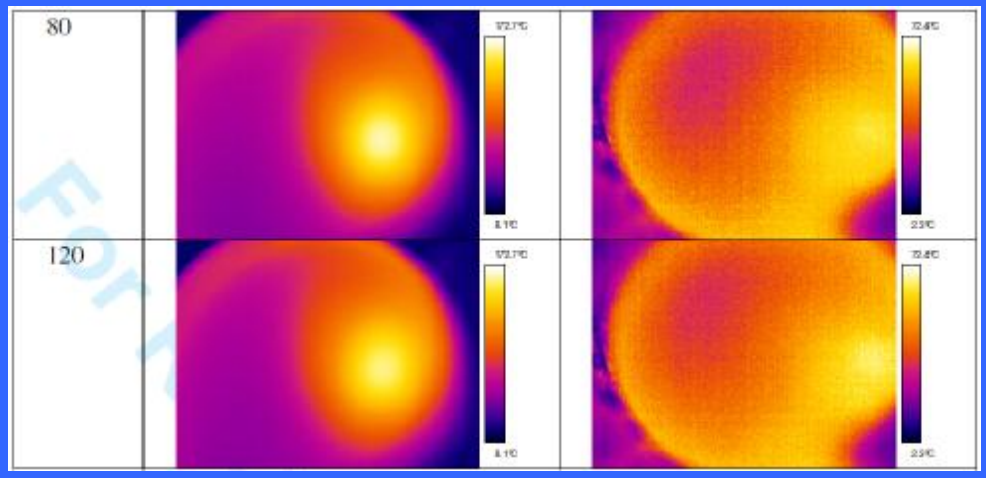


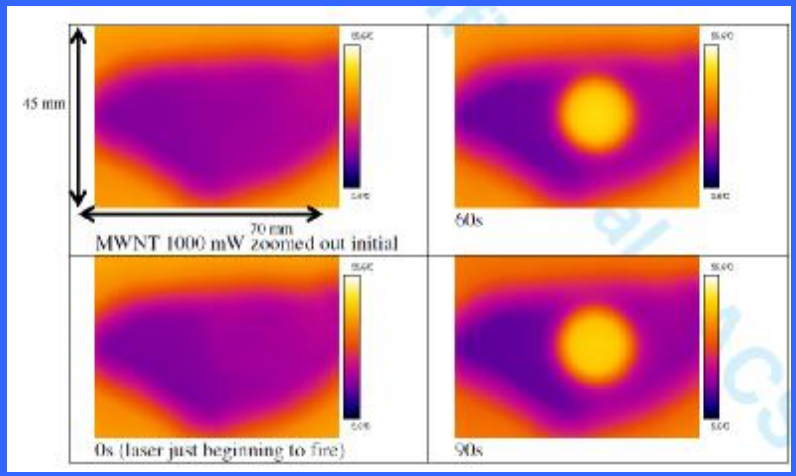


What is new here – Heating Cancer Cells with Radio Waves

Healthcare: In Vivo Nano-Thermolysis of Biological Tissues under Near-Infrared Laser Radiation (Biris & Boldor)

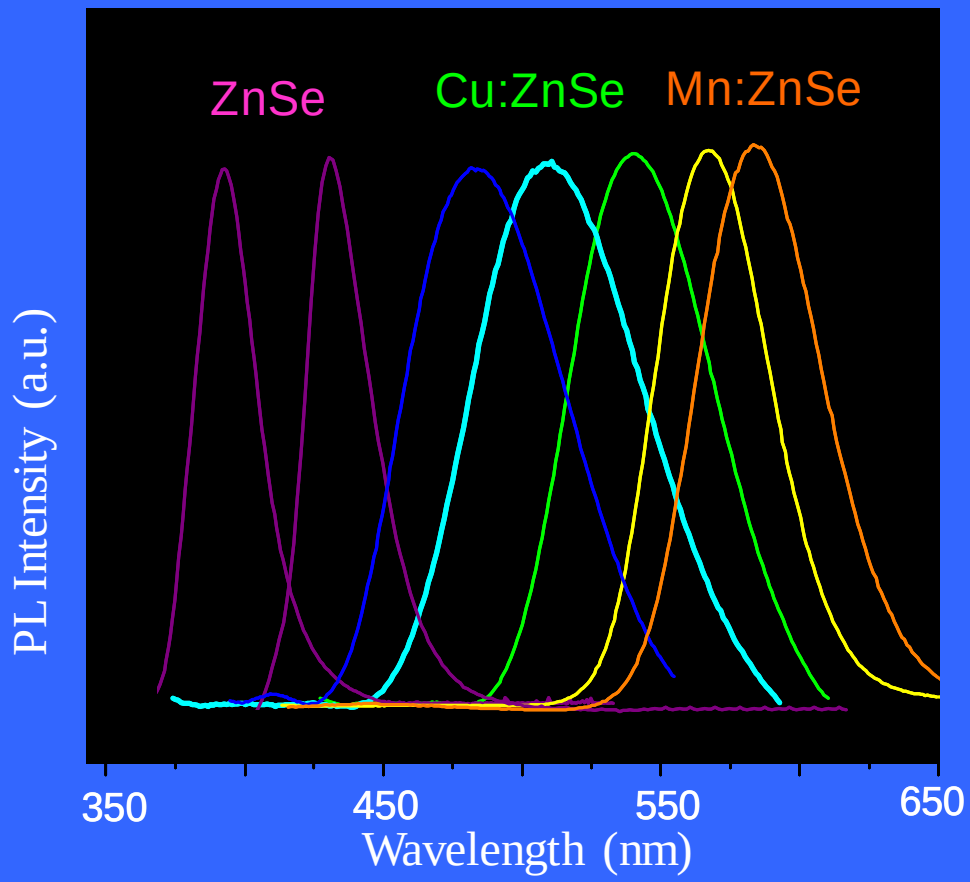






What is new here – Localized Thermal heating-Cancer Tissue

Energy Efficiency Nanoscale Materials (Peng)



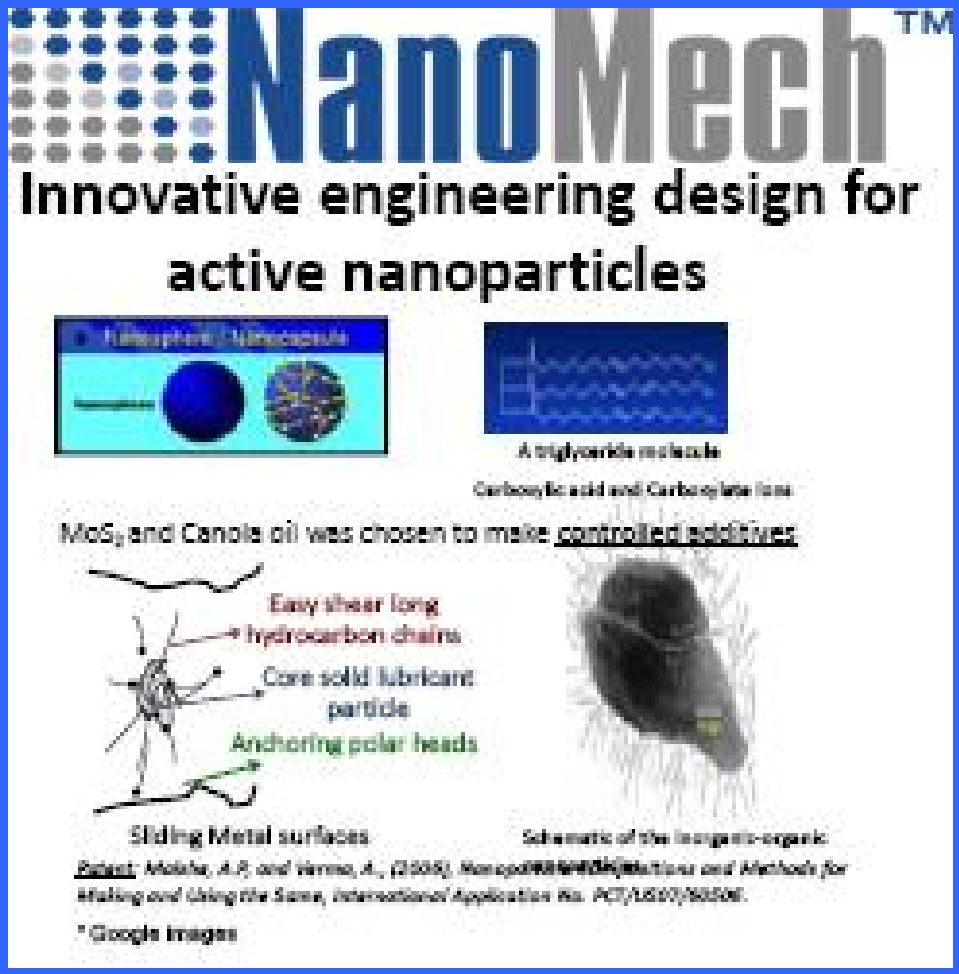
What is new here – absorption /emission do not overlap & flexible emission

NN Labs – our spin-off company

Energy Efficiency: Nanoscale Materials to Reduce Friction (Malshe)

Novel Nano-Bio Materials that reduce friction in mechanical systems

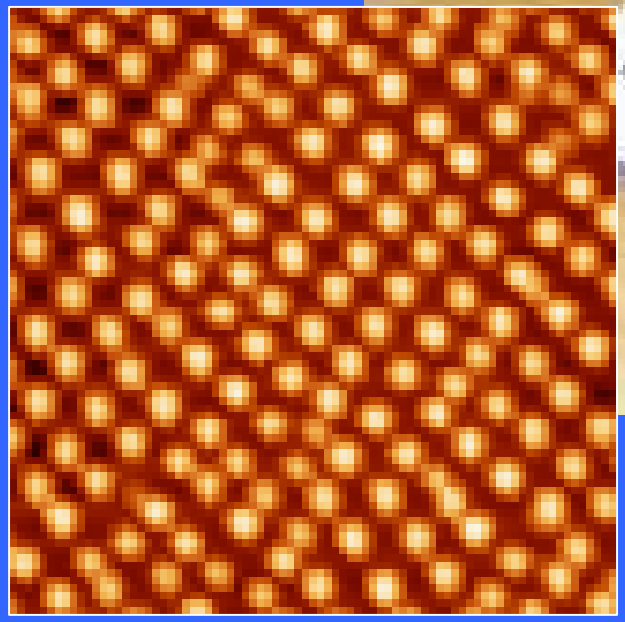
NanoGlide®

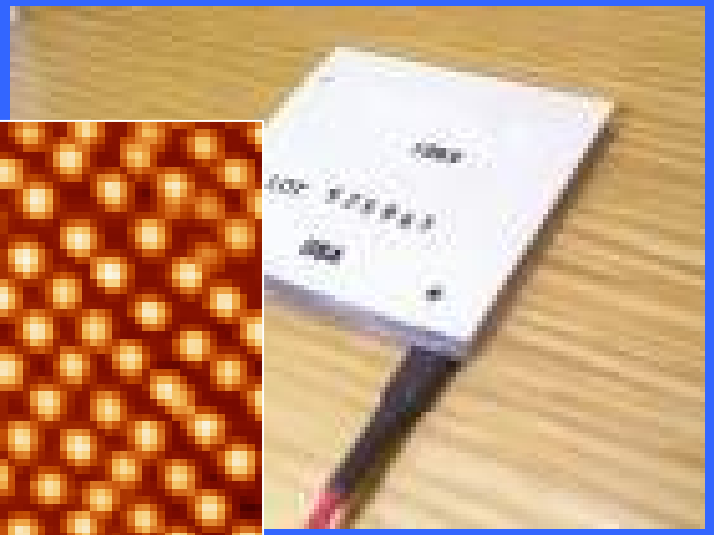


What is new here – lowers friction better than anything else

Energy Efficiency: Nanoscale Materials with Large Thermo to Electric Conversion (Tchakhalian & Salamo)

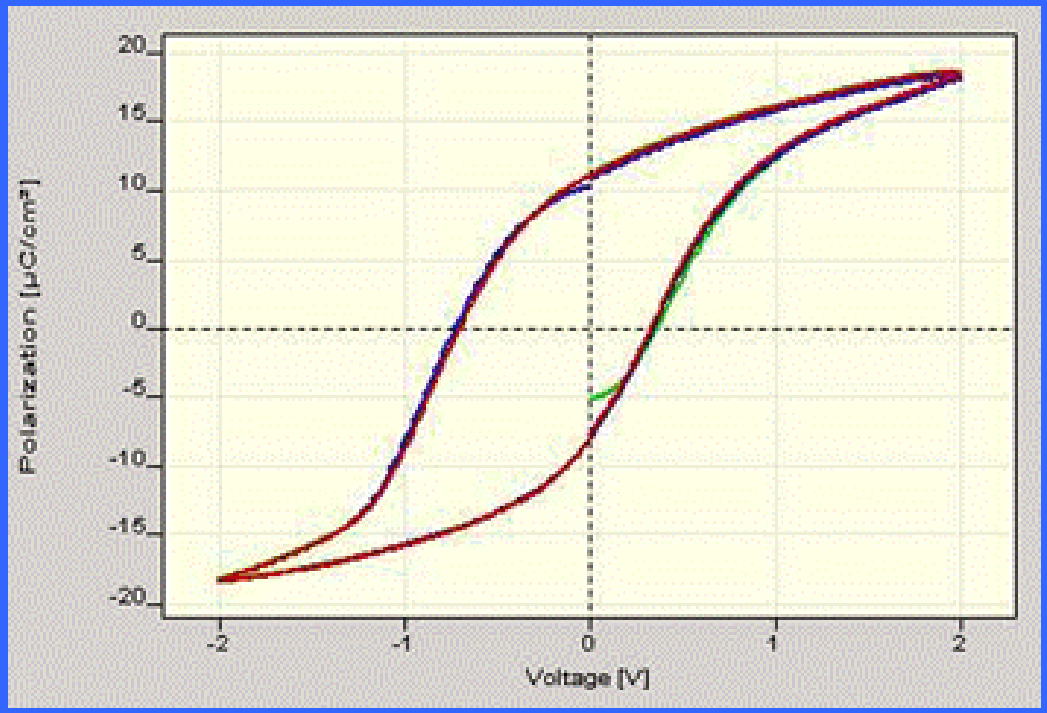
Devices that can convert wasted heat to electricity



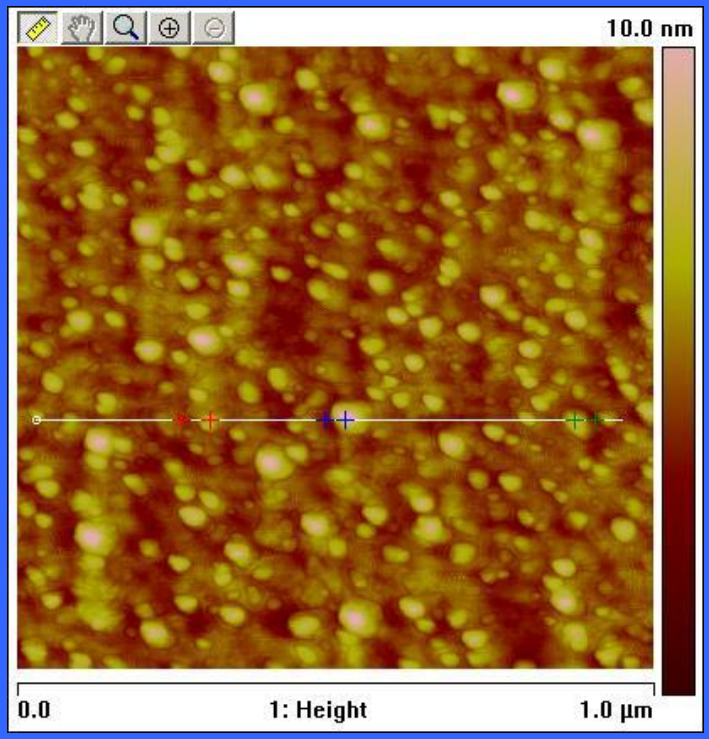


What is new here: *Current Figure of merit is about ZT ~ 1. Our nanoscale oxide material is already about 1.5 and has potential to reach 3*

Energy Efficiency: Nanoscale Ferro-electrics (Bellaiche & Salamo)



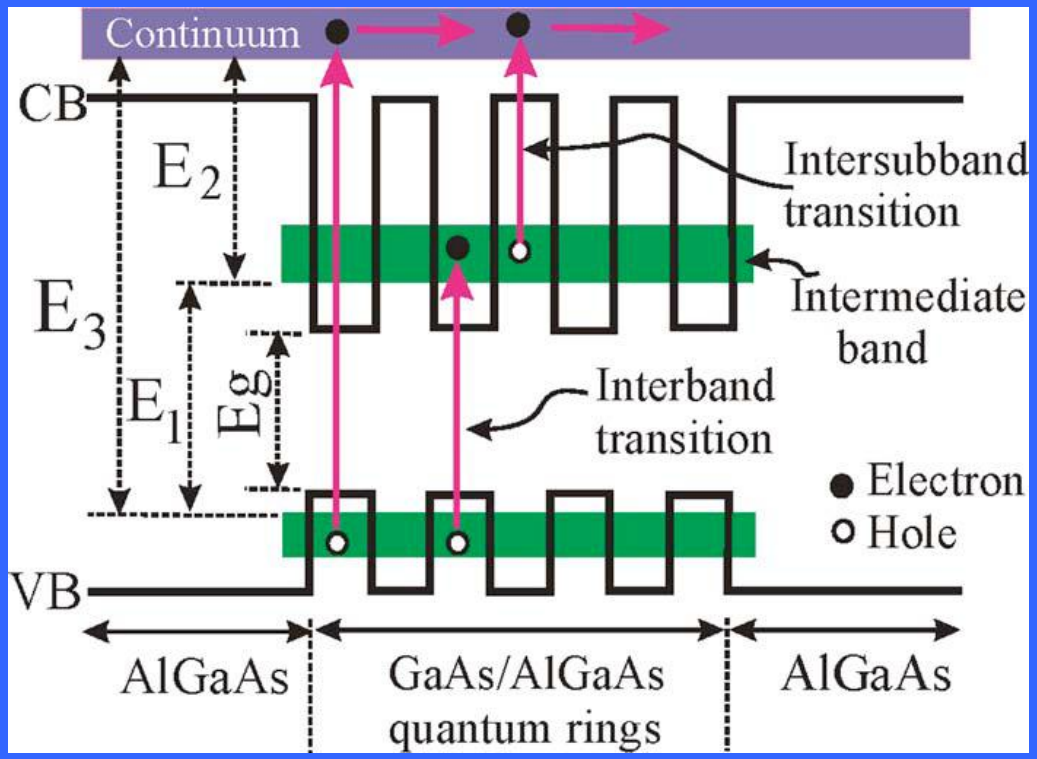
Hysteresis (Memory Element)

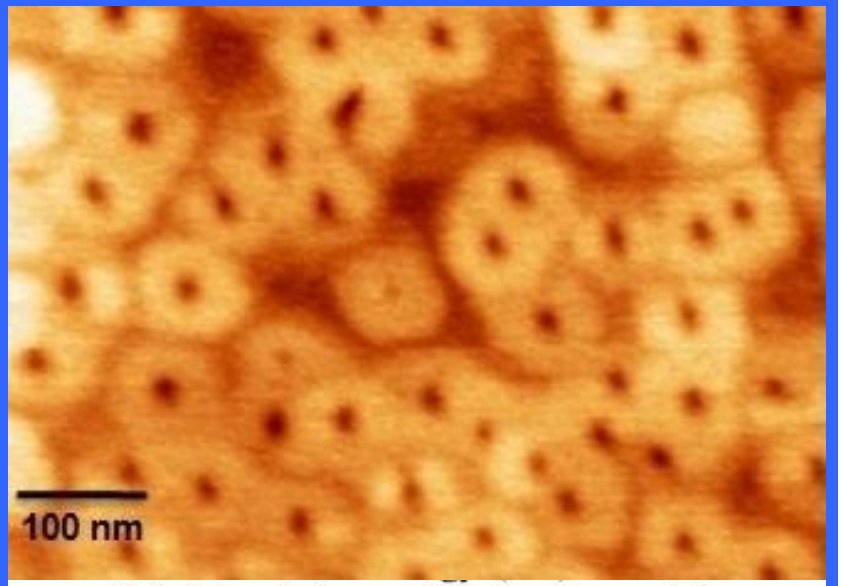


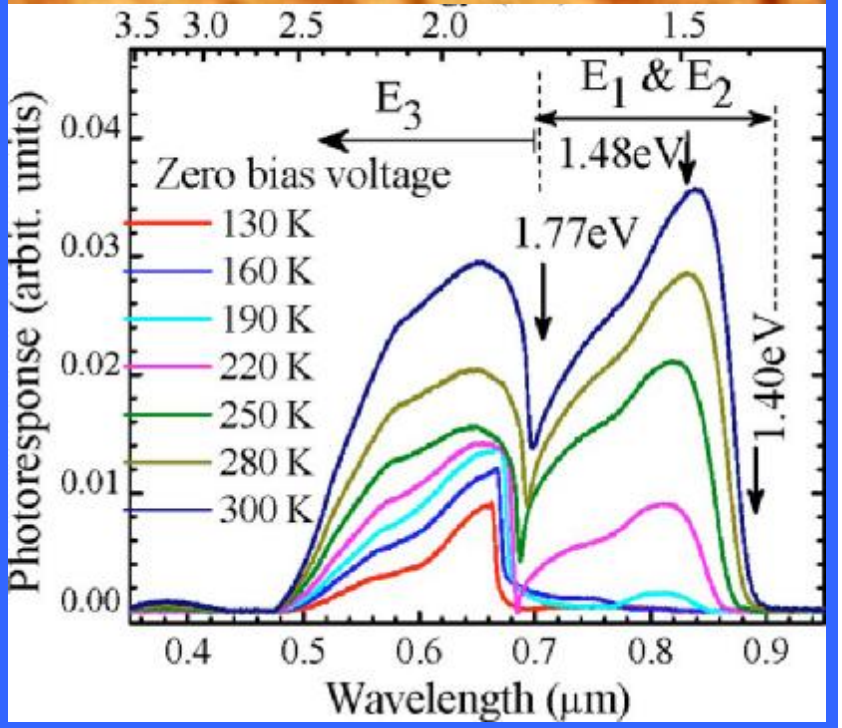
$BaTiO_3$ Dots

What is new here –*ferroelectric quantum dots form 10,000 times smaller memory*

Renewable Energy: Novel Solar Cell Nanomaterial (Manasreh & Salamo)







What is new here – board band absorption for high efficiency

Impact in nanoscale materials and application

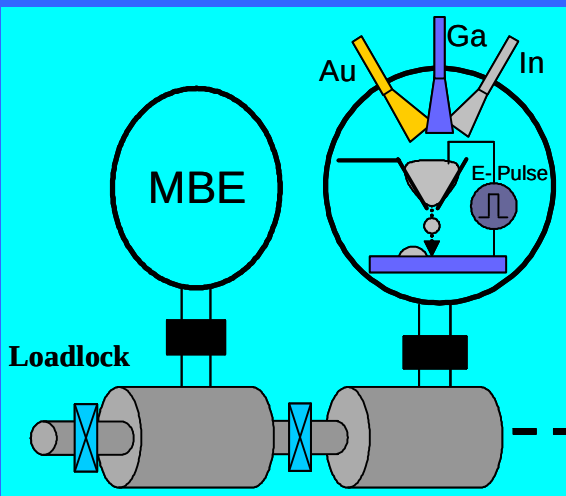
Evidenced by:

- *(NSF) Materials Research Science and Engineering Center (MRSEC)*
- *6 spin-off companies with over 40 employees (Orlumet, Synanomet, Provectus, NNLabs, NanoMech, Nanoferr)*
- *State-of-the-art device fabrication facility,*
- *Authored some of the most compelling ideas in the field.*

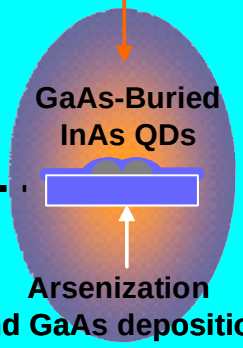
2009 -About 150 Publications with over 3000 Citations

32 Applied Physics Letters (APL)
12 Physical Review Letters (PRL)
2 Nature Materials
5 Nano Letters (NL)
6 Journal American Chemical Society (JACS)
5 Optics Letters (OL)

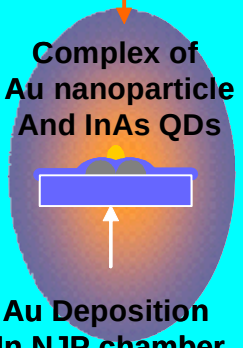
What's Next?



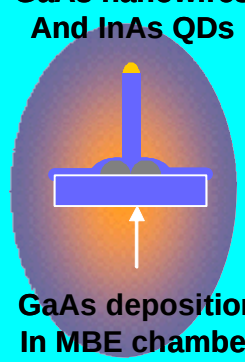
To achieve arrays of Uniform QDs or QD molecules like never before

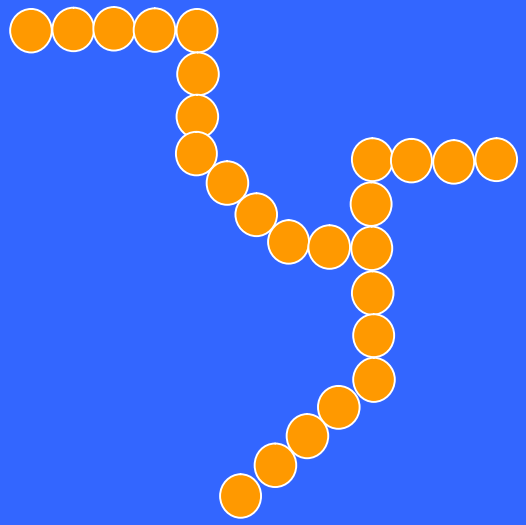


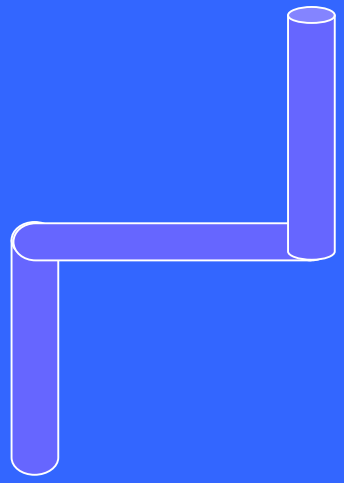
To study plasmon Enhanced QD behaviors



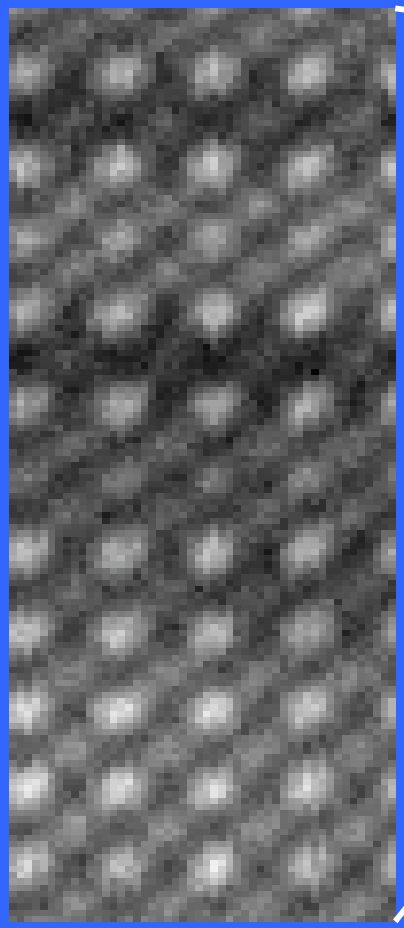
Nanostructure complex Like never before





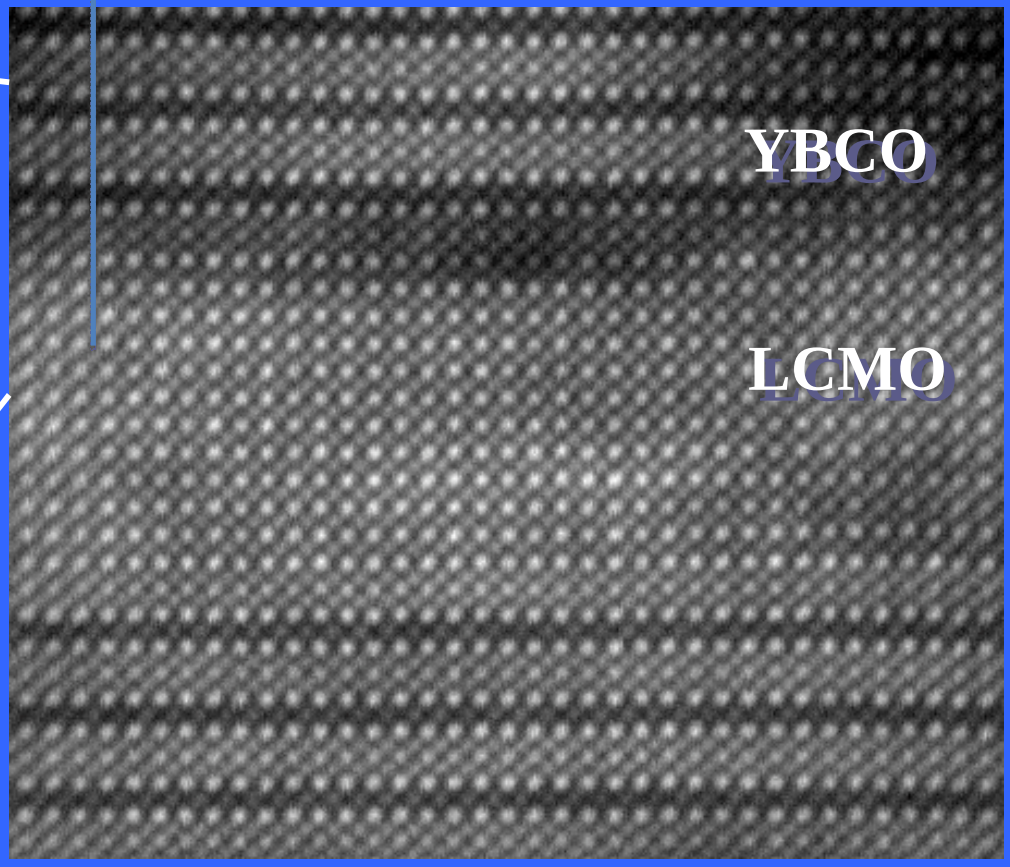


One Layer of Atoms at a Time Creates a New Material Never seen Before



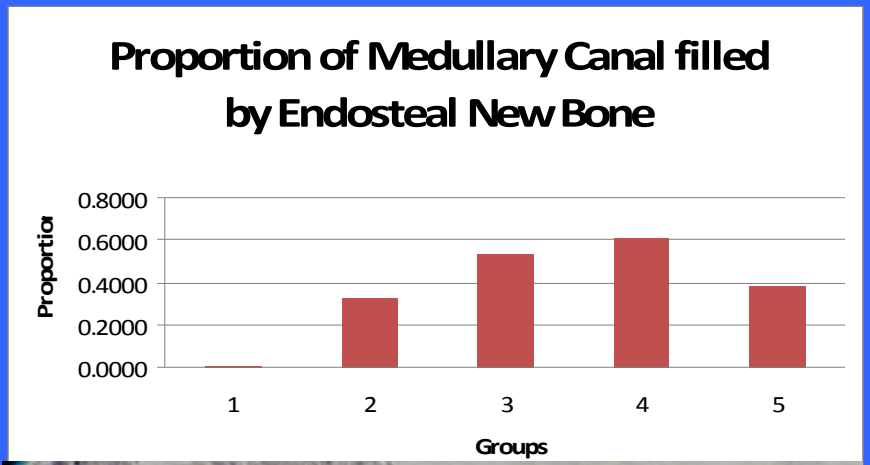
YBCO

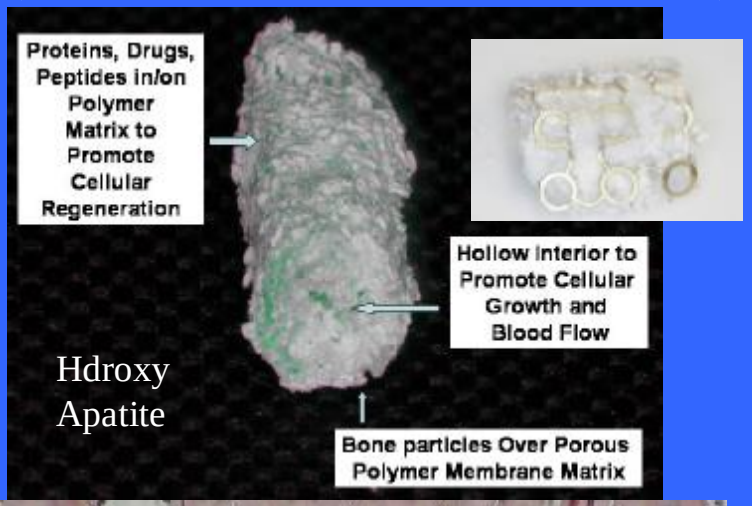
LCMO

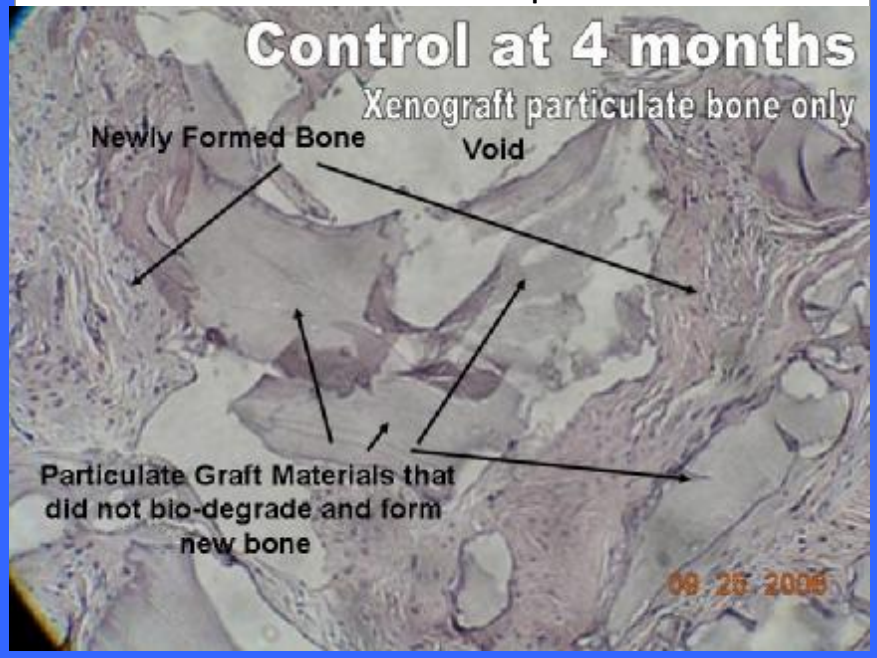


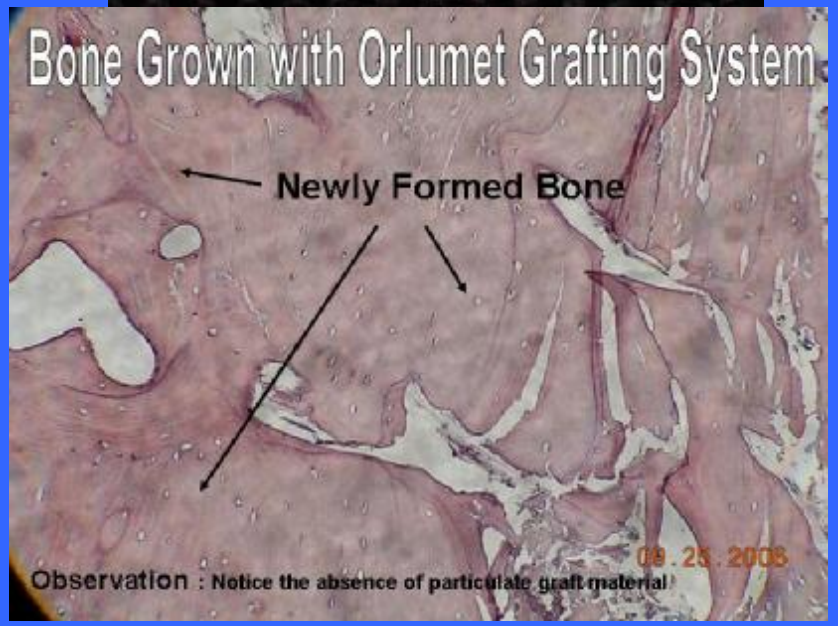
What is new here –*The data indicates a strong chemical bond between Cu and Mn* ***and a new superconductor***

Bone Regeneration (Biris & Jensen)



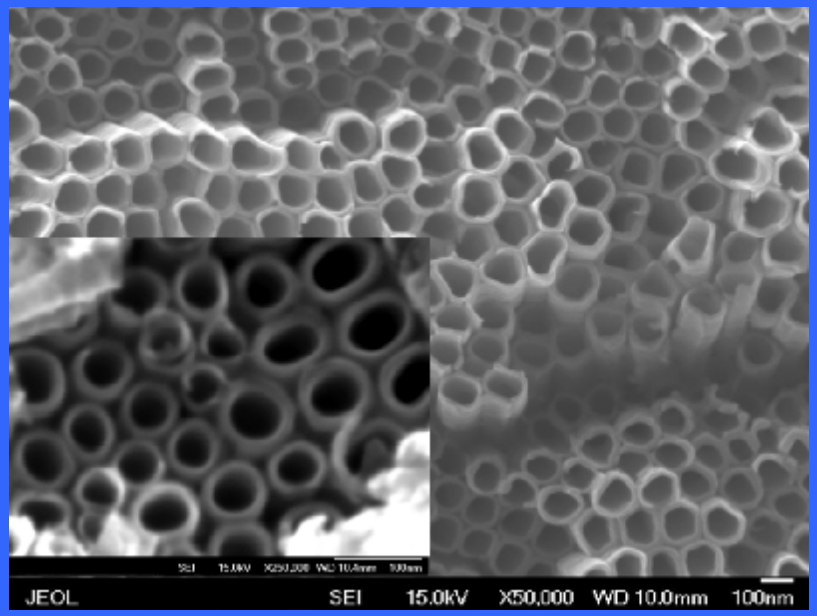


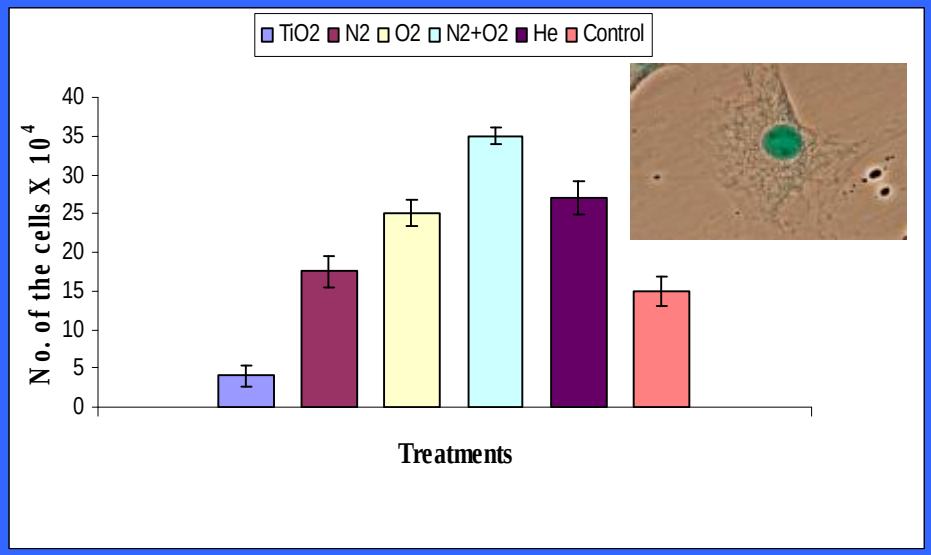


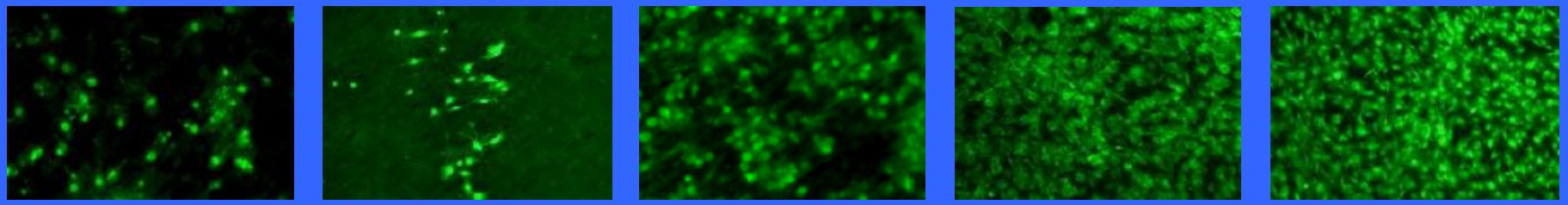


What is new here – 43 human pre-clinical cases and 36 goat models

Nanostructural TiO_2 Nanotubes For Implant Coatings (Biris)





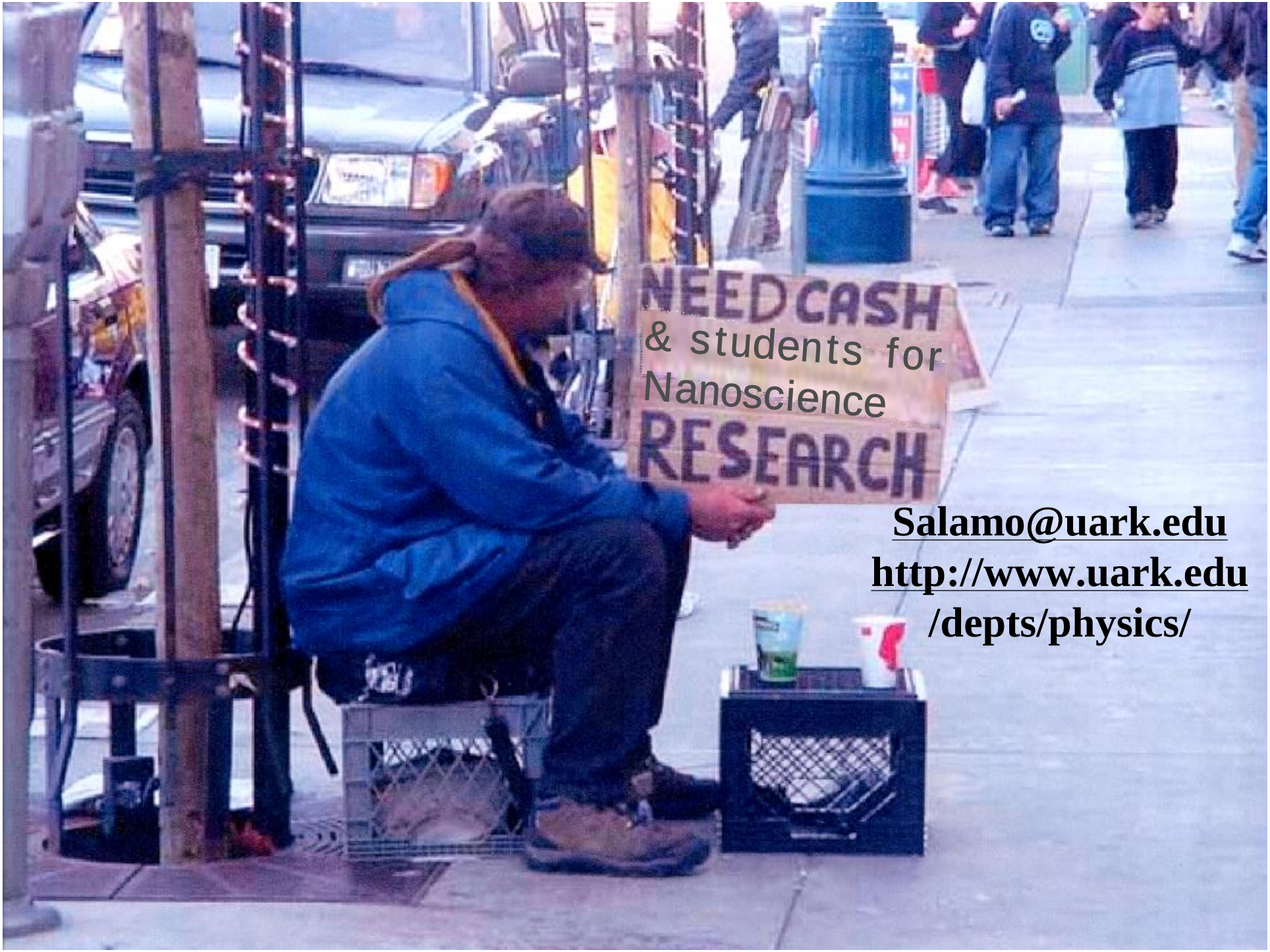


O N

What is new here – TiO_2 enhances tissue regeneration

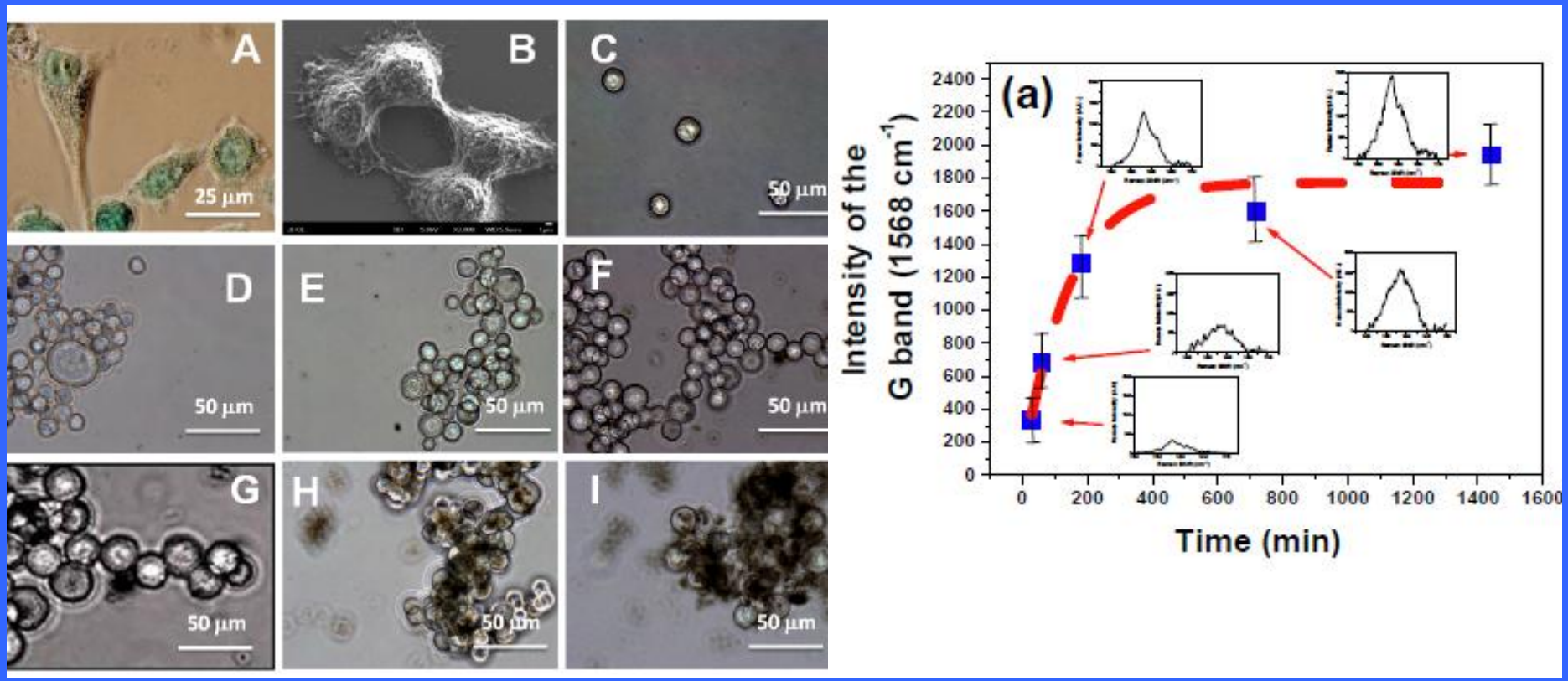
We Supplying Nanoscale Structures to many Research Organizations

The Future of Nanotechnology In Arkansas



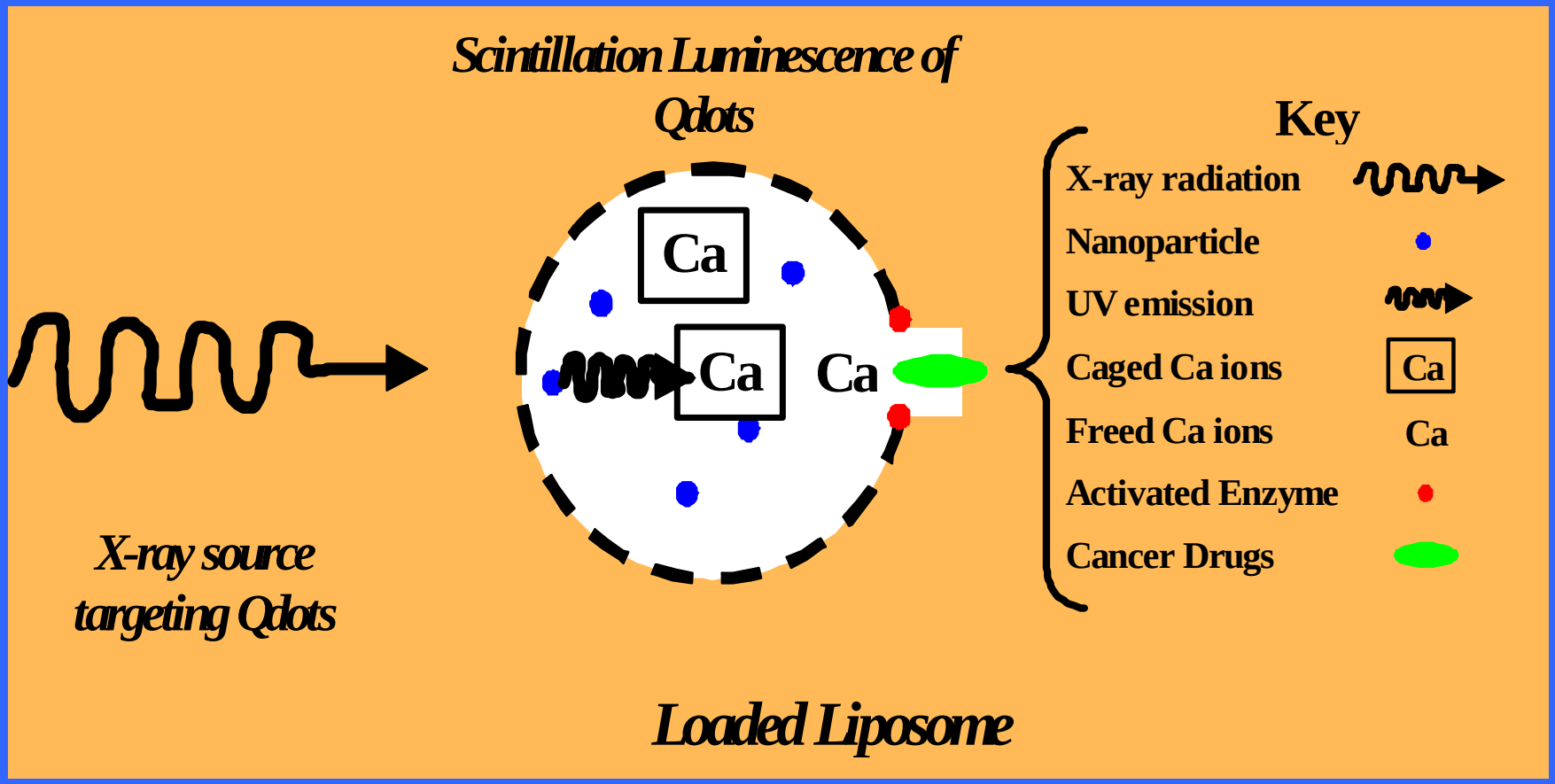
Salamo@uark.edu
http://www.uark.edu
/depts/physics/

Specific Delivery of CNTs Time Dependence (Biris)



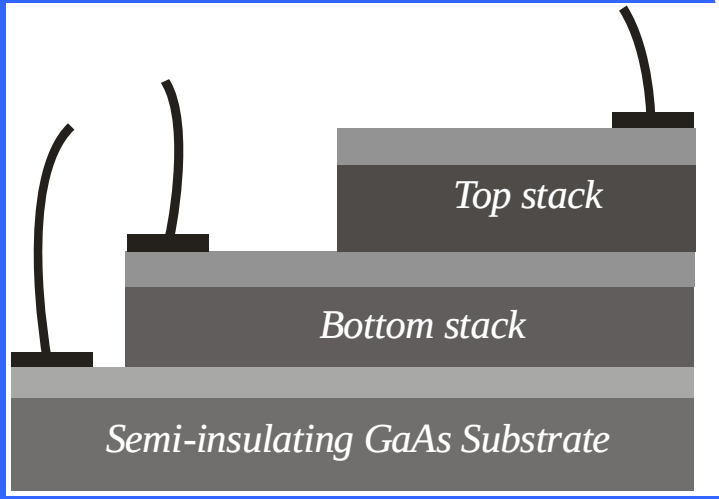
What is new here – Demonstrated CNT delivery to a Cancer Cell

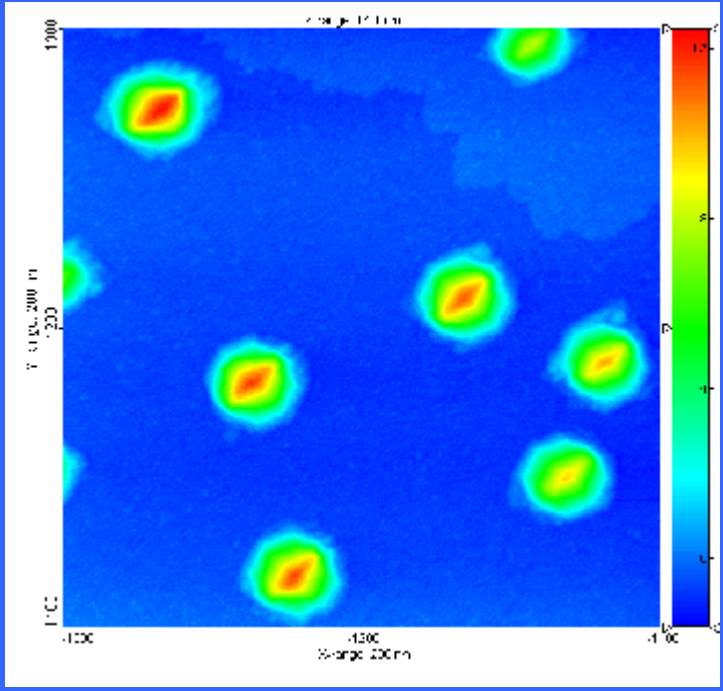
Drug Delivery (Fologea & Borrelli)

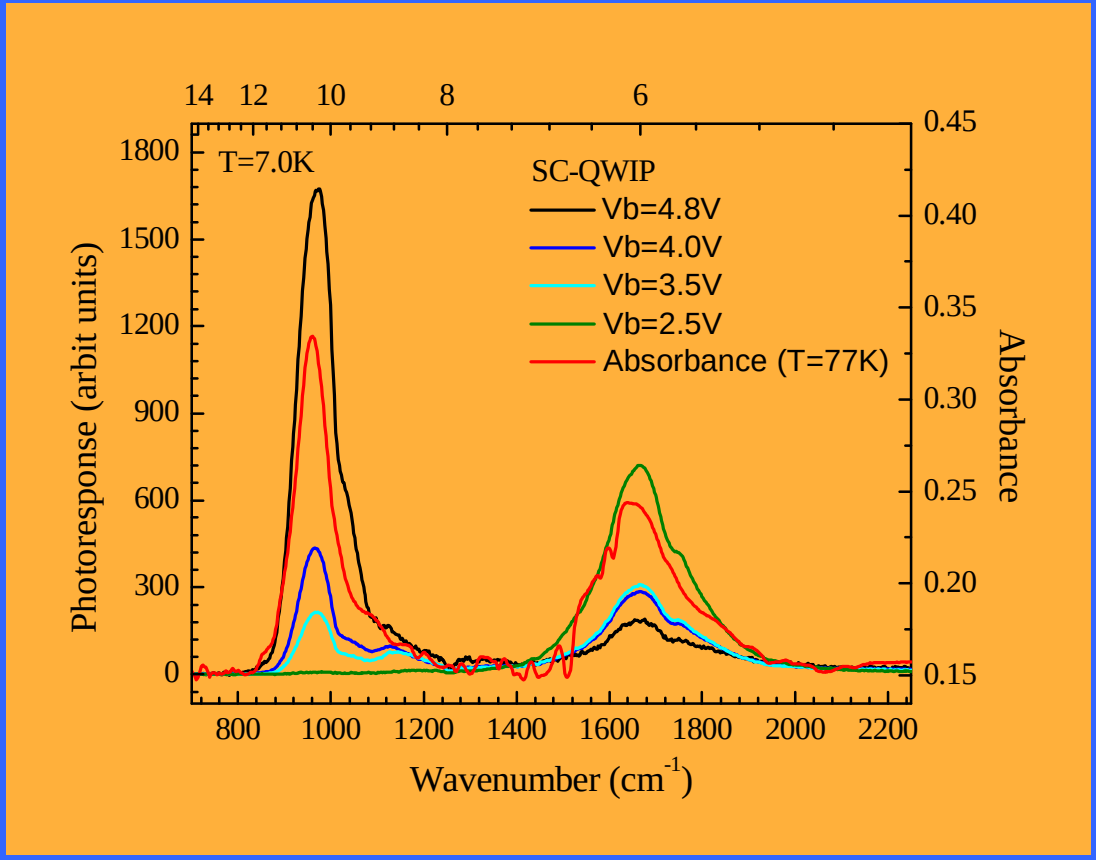


What is new here: *Utilize X-ray absorbing Q - dots that emit UV light to release, caged Ca2+ ions, which activates an enzyme to open the liposome and release the drug.*

Tunable Infrared Photodetector (Manasreh)







What is new here *– voltage tunable color selection*

Arkansas Nano Net