



**NORTHWESTERN
UNIVERSITY**

PREM PIs Meeting

Novel Nanomaterials and their Potential for Biomedical Applications

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May 20, 2013

Goals and Objectives

- Develop Novel NPs with potential for Medical Applications
- Enhance the fundamental understanding of the *nano-bio interface*
- Educate the next generation of materials scientists and increase *diversity* in the scientific community

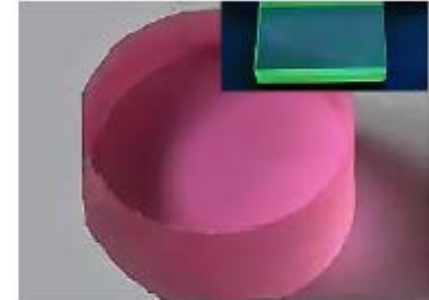
RE-Doped Materials



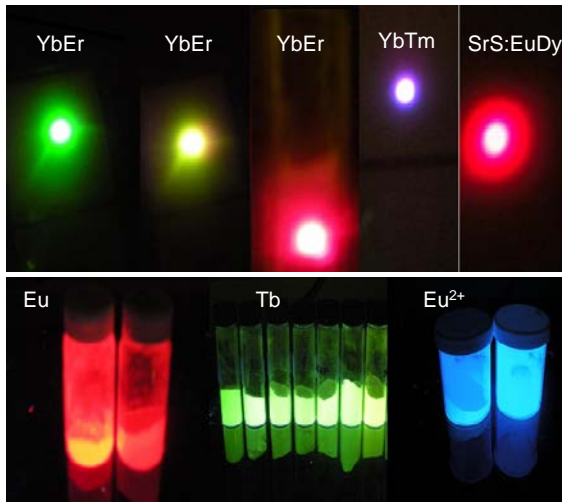
Nd:YAG Single Crystal



Transparent Nd:YAG Ceramic



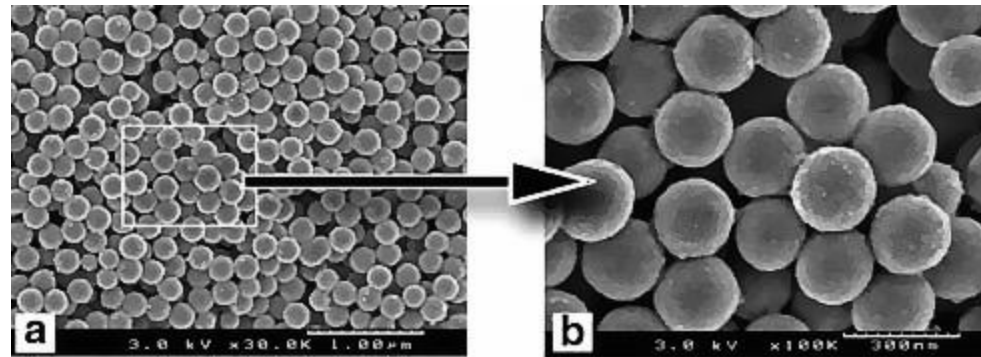
Yb,Er :Phosphate Glass
Inset:Pr :Phosphate Glass



Host: $\text{La}_2\text{O}_3\text{S}$

Top: 980 nm Ex (10mW)

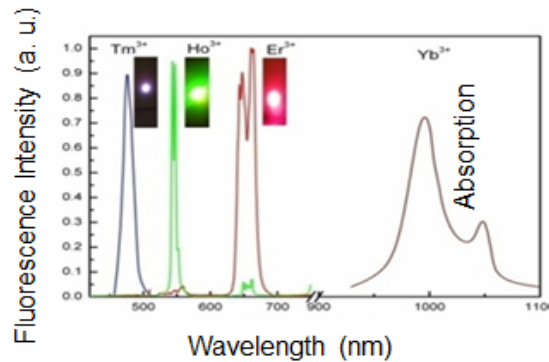
Bottom: 320 nm Ex



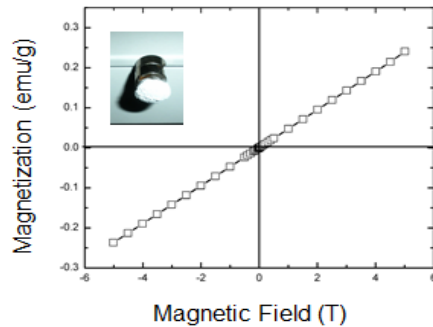
Eu: Y_2O_3 nanoparticles
(Homogeneous precipitation)

Up and Down Conversion Phosphors
(Imaging, Display, Therapy, Sensing, Security, Lighting, etc.)

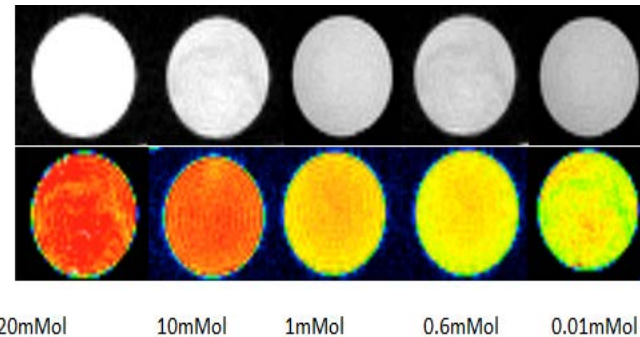
RARE EARTH BASED DUAL PURPOSE BIOSENSORS



Upconversion emission spectra of Yb/Tm, Yb/Ho, and Yb/Er in Gd₂O₂S at 980 nm excitation



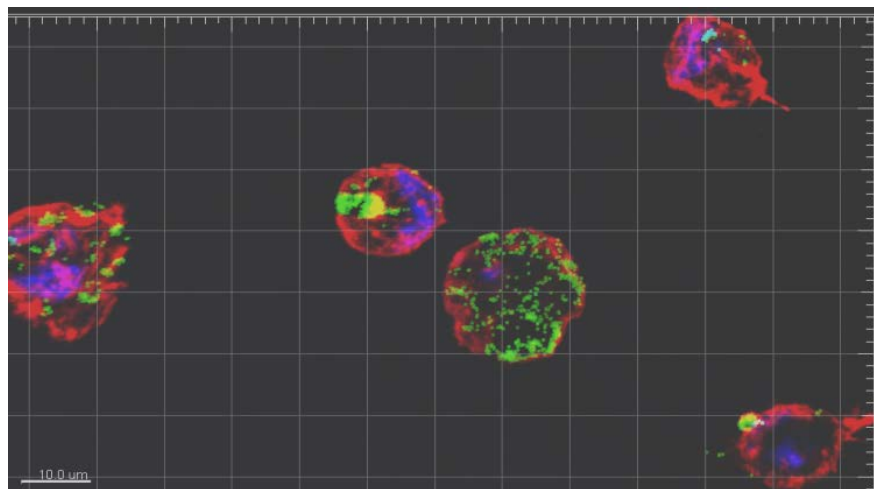
Magnetization curve of Gd₂O₂S:Yb/Er nanoparticles
Magnetic moment of nanoparticle is 1400 μ_B



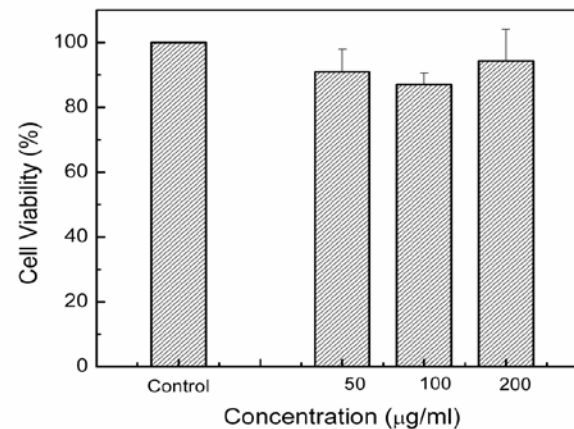
T1 weighted gray scaled and color mapped MR images of Gd₂O₂S:Yb/Er nanoparticles in deionized water.

J. Mat. Chem. B, 1, 1561-1572 (2013); Science of Advanced Materials 4, 5-6, (2012);
Journal of Alloys and Compounds, 513, 559- 565 (2012).

RARE EARTH BASED DUAL PURPOSE BIOSENSORS

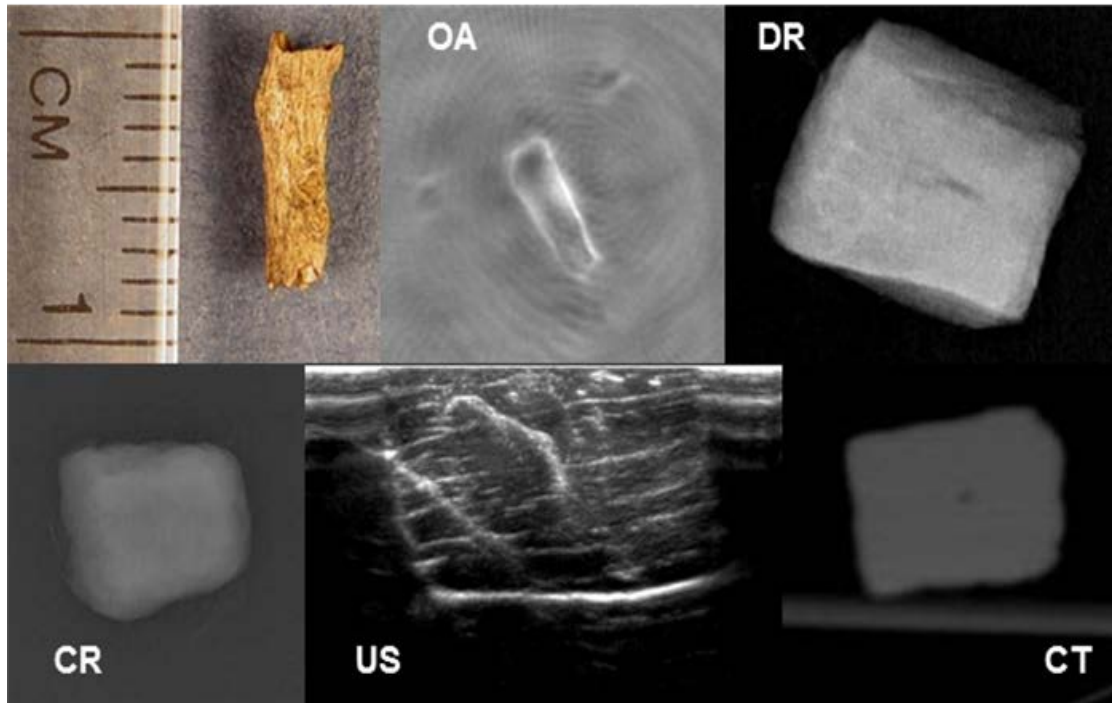


Uptake of $Gd_2O_2S:Yb/Er$ NPs by fibroblast cells.
Blue = Nucleus stained with DAPI; Red = Cytoplasm stained with Alexa fluor; Green = NP emission inside cytoplasm; Light Blue = NP emission inside nucleus



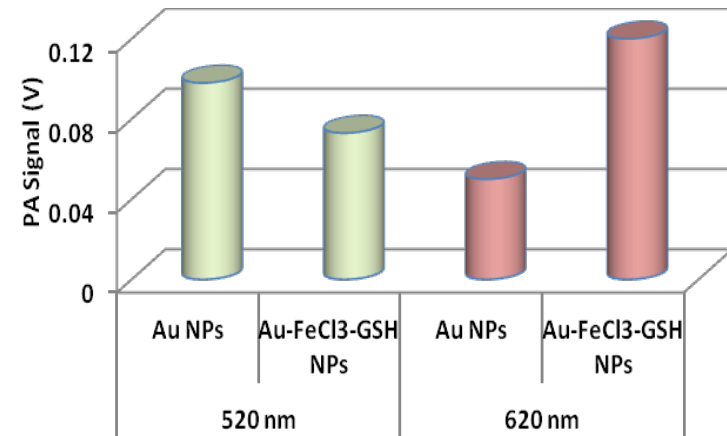
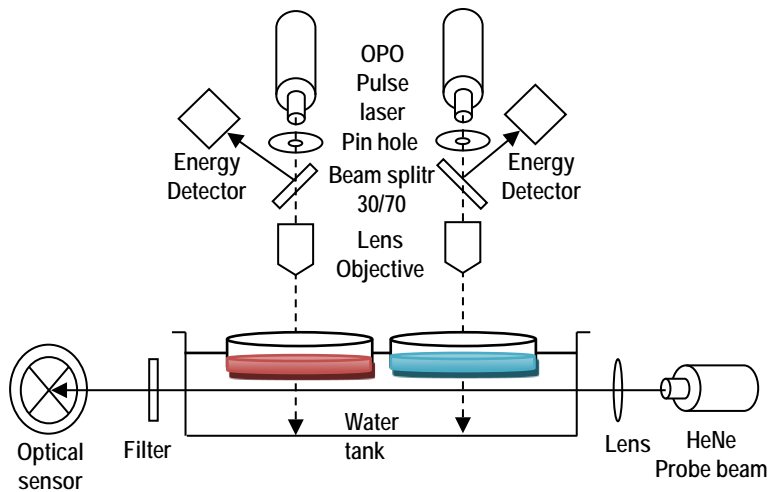
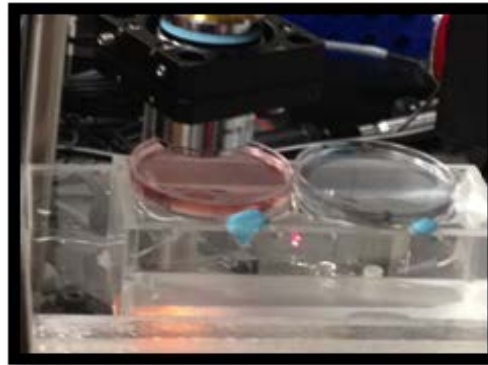
In vitro cell viability of Sk-N-SH(Human neuroblastoma cell line) cells incubated with $Gd_2O_2S:Yb/Er$ at different concentrations for a period of 48 Hrs.

Optoacoustic Imaging of a Splinter Embedded in Tissue

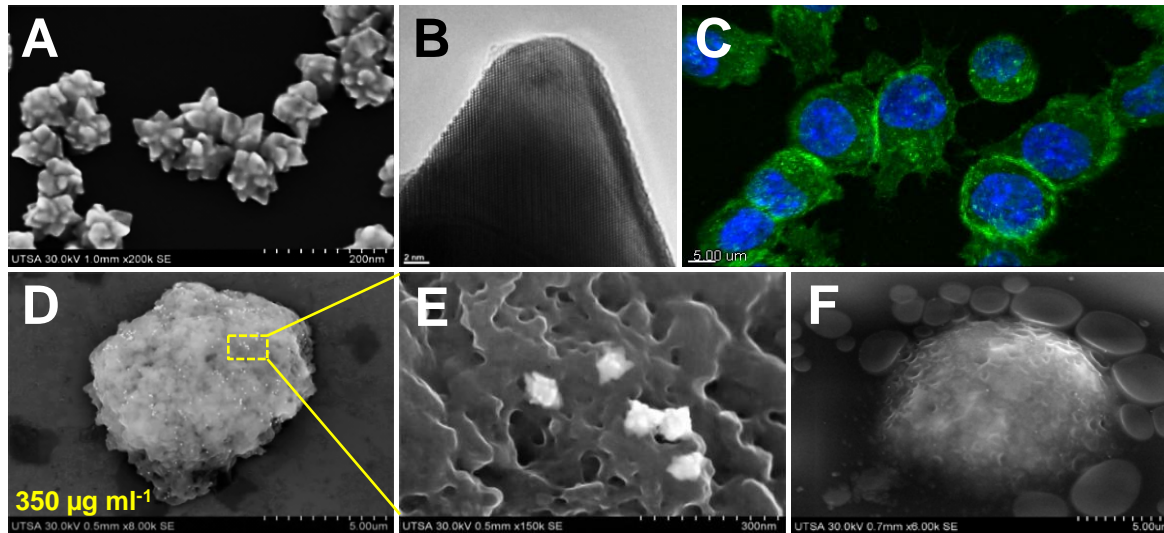


MEDICAL APPLICATIONS OF NANOPARTICLES: TARGETED CONTRAST AGENTS

Sensing of Oxidative Stress of RPE Treated with Au NPs



NOVEL NANOMATERIALS AND THEIR APPLICATIONS IN BIOLOGY

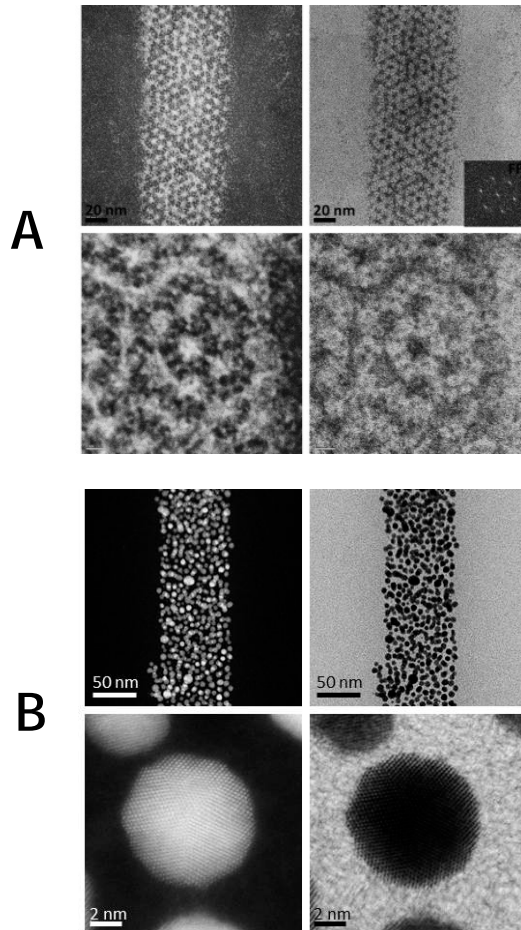


Advanced microscopy of biocompatible gold nanostars and their adsorption-uptake by macrophages.

- (A) UHR SEM image of Au nanostars.
- (B) Atomically resolved TEM image of a Au nanostar branch.
- (C) Confocal microscope image of a cell: Blue: Nucleus; Green: Endosome.
- (D) UHR image of macrophage treated with Au nanostars.
- (E) Details of adsorption-uptake of Au nanostars on membrane of macrophage.
- (F) Stereoimaging of macrophage showing endosomes and gold nanostars.

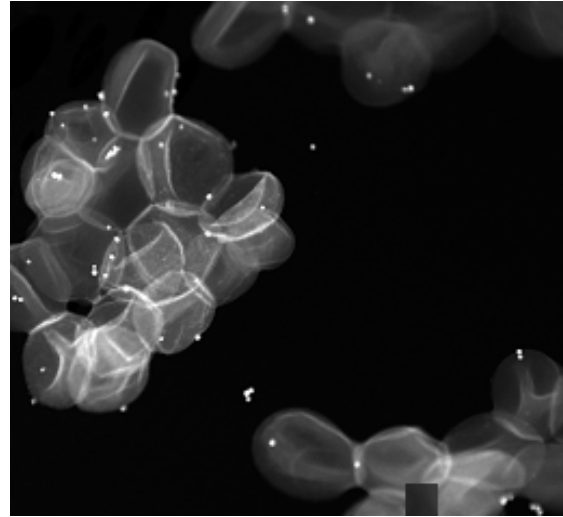
Plascencia-Villa G, Bahena D, Rodríguez A, Ponce A, and José-Yacamán M, *et al.*, *Metallomics* (2013).

NOVEL NANOMATERIALS AND THEIR APPLICATIONS IN BIOLOGY



HAADF-STEM images of self-assembled rotavirus.

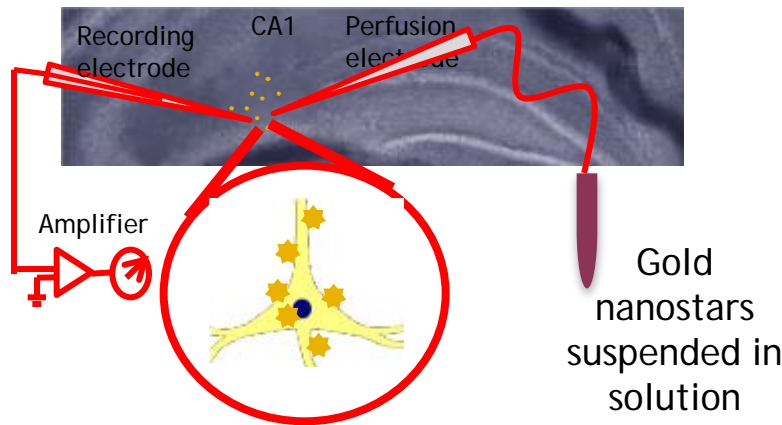
- (A) Rotavirus with hexagonal patterns.
(B) Rotavirus used as a platform for *in situ* synthesis of Au nanoparticles.



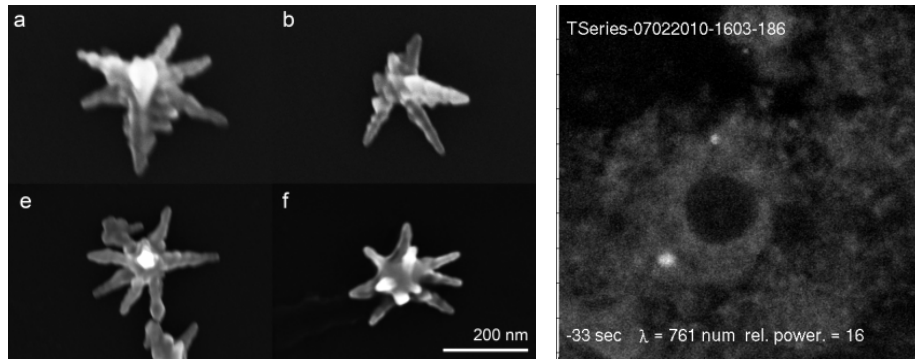
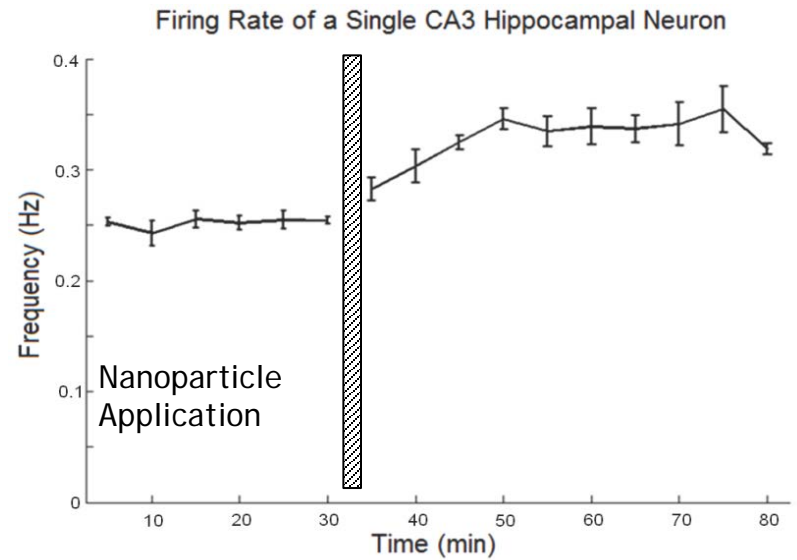
Staphylococcus bacteria labeled with Au NPs functionalized with antibodies to visualize 3-D structure.

Nanoparticles in Biology and Medicine Methods in Molecular Biology, Vol. 906, Springer Protocols, 2012.

METAL NANOPARTICLES IN NEUROSCIENCE



GOLD NANOSTARS CAN INTERNALIZE IN CELLS AND BE USED FOR PHOTO-THERMAL THERAPY; INTRODUCTION OF NANOPARTICLES CAUSES AN INCREASE IN THE FIRING RATE OF CA3 NEURONS.



Nano-ablation with gold nanostars,
Journal of Visualized Experiments, (2012) e3570.



PREM-PREM Interactions

Publications

- “Popcorn Shape Magnetic Core-Plasmonic Shell Multifunctional Nanoparticle for Targeted Magnetic Separation & Enrichment, Label-Free SERS Imaging and Photothermal Destruction of Multi Drug Resistance Bacteria”, *Chemistry: A European Journal*, 19(8), 2839-2847, DOI: 10.1002/chem.201202948 (2013).- [Jackson State University](#)
- “Platinum Electrodeposition on Unsupported Carbon Nano-Onions” , *LANGMUIR* Volume: 28 Issue: 49 Pages: 17202-17210 DOI: 10.1021/la3031396 : DEC 11 2012 – [UT El Paso](#)

Interchange of equipment with [Texas State University \(TSU\)](#)

- Students from TSU utilize the Electron Microscope Center at UTSA
- Students and Postdocs from UTSA utilize the Focused Ion Beam at TSU
- TSU has donated TEM sample preparation stations to UTSA

Texas State University- Dr. Sardar and Dr. Yacaman are External Advisory Committee members for TSU-PREM

PREM K-12 Outreach

Engage PREM students, faculty and UTSA Society of Physics Students (SPS) with the community through participation in local science events and signature programs.



NanoDay at UTSA

Goals:

- Expose high school students to nanotechnology with the state-of-the-art research environment.
- Raise their awareness about the rewards and benefits of pursuing a career in STEM fields.



San Antonio Prefreshman Engineering Program



- **Founded in 1979 and currently under the direction of Dr. Rudy Reyna.**
- **Host 1300 middle and high school students**
- **7 week summer program housed at local colleges (UTSA, NVC, St. Philips, etc.)**
- **Academically intense experience focusing on the fundamentals of STEM.**



PREP Pipeline

Junior &
High School
Students

PREP
Program
PREP I-IV +
UPREP

College Bound
(90% enter
college since
its inception)

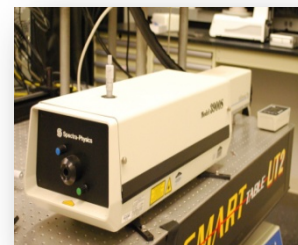
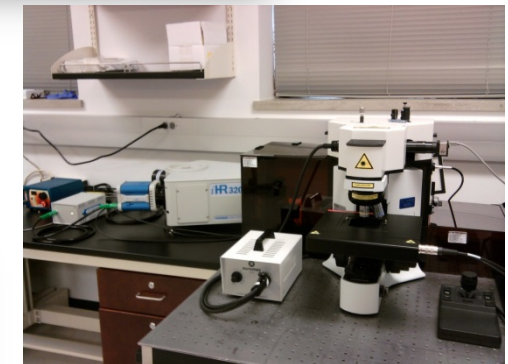
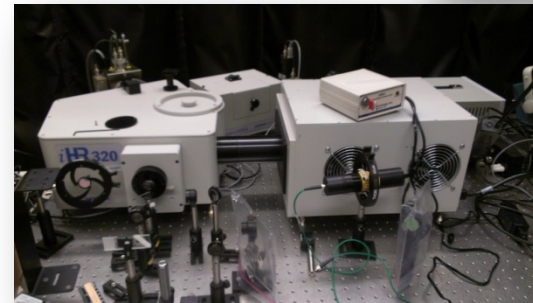


UTSA[®]

Research Infrastructure

List of selected equipment:

- TEM-STEM ARM-200 with aberration correction (0.8 \AA)
- AFM-SPM systems
- Zeiss 710 multiphoton/confocal microscope with live cell imaging incubator
- JEOL 1230 TEM
- Hitachi 5500 High Resolution SEM
- Hitachi 1510-variable pressure
- Fiber-coupled IR spectrometer
- Titanium-Sapphire laser system
- Variable angle spectroscopic ellipsometer
- Raman Microscope with dual laser (red/blue)
- Laser engraver
- Atomic absorption spectroscopy
- iHR320 Spectrophotometer



Kleberg Advanced Microscopy Center

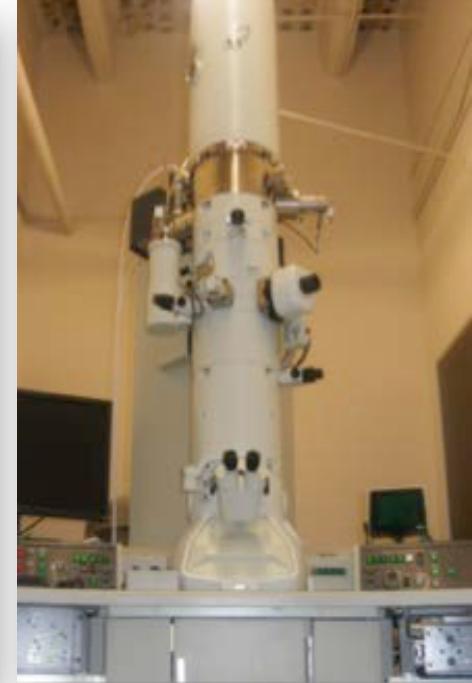
JEOL ARM 200F



Hitachi S-5500



JEOL 2010F



**HOLDERS: Nanomechanical,
Tomography, and Optical Stage**



Computational Facilities



TEXAS ADVANCED COMPUTING CENTER

Powering Discoveries That Change The World

THE UNIVERSITY OF
TEXAS
AT AUSTIN

Number of Nodes: 3,936

Number of Processing Cores: 62,976

Total Memory: 1.73PB (shared) 31.4TB (local)

The Computational Biology Initiative

A joint project of the University of Texas at San Antonio and the University of Texas Health Science Center San Antonio.
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Biotechnology, Sciences and Engineering Building Room 3.114
One UTSA Circle - San Antonio TX 78249 - (210) 458-7078

The logo for the University of Texas at San Antonio (UTSA), featuring a stylized orange and white design.

High Performance Computing
(HPC) Cluster
(cheetah.cbi.utsa.edu)
392 processing cores
2GB RAM per core
Linux



DELL Blade Cluster
Intel Xeon X5675 3.06 GHz ,
Number of Nodes: 6 ; six-core each
Memory distribution: 96Gb, 48GB and 24GB
42-processors

Summary and Outlook

Summary:

- Multimodal Biomedical Applications of RE NPs
- PA Technique for Sensing Oxidative Stress in Cells and Tissues
- Developed Novel Metal NPs for Biomedical Applications
- Au Nanostar Ablation: Selective killing of Neurons
- We have a strong Outreach and Education Program
- UTSA has established a strong collaboration with other PREMS
- World-class facility with the state-of-the-art equipment

Outlook:

- Optimize the Nanoparticles for Biomedical Applications
- Committed to building a *flagship* center for Materials Research at San Antonio and South Texas