Scientific Collaborations with UNAM: a Framework for Successful Engagement

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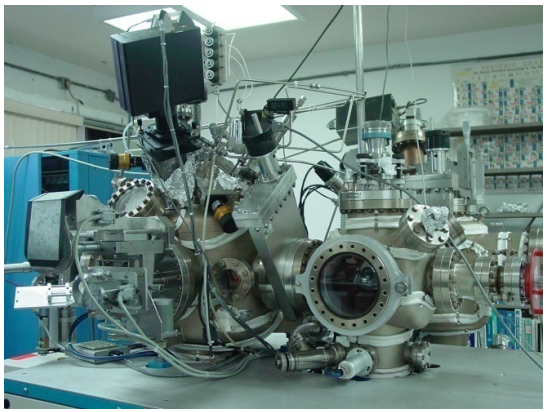
Hitachi Global Storage Technologies



PURDUE UNIVERSITY

Outline

- Introduction to UNAM
- Scientific Research at UNAM
- Engagement I: Scientific Advisor
- Engagement II: Graduate Student Advisor
- Elements for Success and Going Forward

PURDUE UNIVERSITY

UNAM in Numbers

Universidad Nacional Autónoma de México
UNAM

Highest Ranked University in Latin-America
Foundations date back to 1551
Re-inagurated as UNAM in 1910

UNAM by numbers:

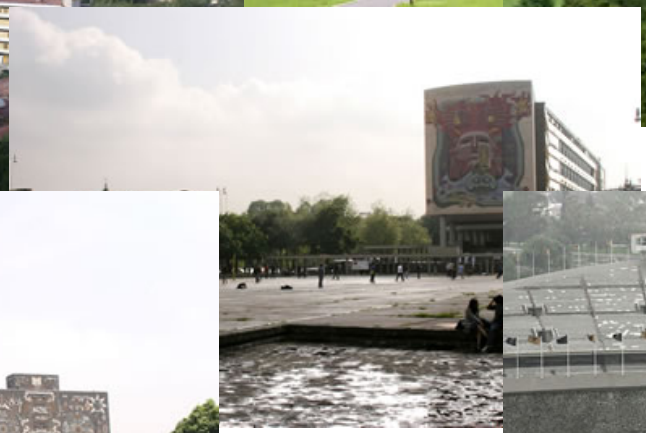
- 2,316,843 m2 of construction and 2,091 buildings
- Six campuses and seventeen schools in Mexico City Installations in 24 states, the USA, Canada and Spain
- Over 305,000 high school, undergraduate and graduate students
- Twenty-two faculties and schools of higher learning, 14 high schools, 53 institutes, centers and research programs, 82 undergraduate programs, 167 specializations and 83 M.A., M.Sc. and Ph.D. programs.
- Annually over two million spectators attend over seven thousand events offering music, literary arts, dance, visual arts and film.
- Fifteen museums, eighteen historical sites and nearly 320 thousand tape recordings, long-play records, films, art objects and video-graphic material.

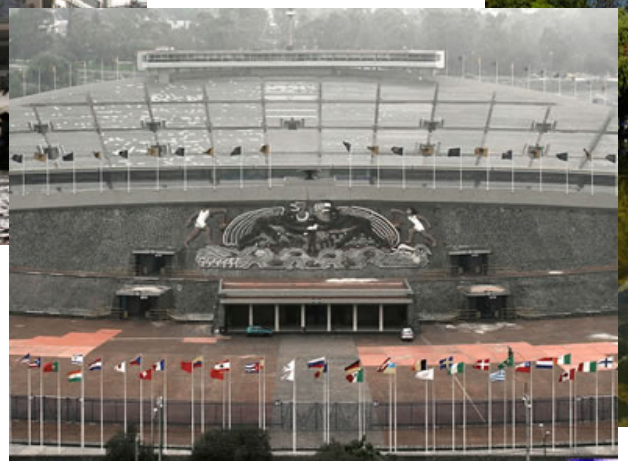
Endowment	US$2.4 billion [] (2012)
Academic staff	36,750 (As of 2012
Students	324,413 (2011–2012 academic year)
Undergraduates	187,195 (As of 2012)
Postgraduates	26,169 (As of 2012[1] []
President	Jose Narro Robles

UNAM Images





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Research at UNAM

Universidad Nacional Autónoma de México
UNAM

- Chemical, Biological and Health Sciences
- Physics and Mathematics
- Earth Sciences and Engineering

Center for Applied Sciences and Technology Development (CCADET)
Center for Atmospheric Sciences
Center for Environmental Sciences
Center for Nanoscience and Nanotechnology (CNyN)
Center for Genetic Sciences
Center for Applied Physics
Center for Geosciences
Center for Ecological Sciences
Center for Research in Environmental Geography
Center for Radio-astronomy and Astrophysics

Institute of Astronomy
Institute of Biology
Institute de Biotechnology
Institute of Renewable Energy (IER)
Instituto of Marine Sciences
Institute of Nuclear Sciences
Institute of Ecology
Institute of Physics
Institute of Physical Sciences
Institute of Cell Physiology
Institute of Geophysics
Institute of Geography
Institute of Geology
Instituto de Ingeniería
Institute of Biomedicine
Institute of Applied Mathematics
Institute of Materials Research (IIM)
Institute of Mathematics
Institute of Neurobiology
Instituto of Chemistry

Nanoscience Research Areas at UNAM/Mexico

- Nanomagnetism
- Nanocatalysis, Photocatalysis, Electrocatalysis
- Nanoelectronics and Optoelectronics
- Nanobiotechnology and Nanobiomaterials
- Nanostructure Characterization
- Synthesis on Nanomaterials: carbon-based, metallic, ceramic and semiconductors
- Nanopolymers
- Theory and Simulation of Nanostructures
- Self-assembled Nanostructures

Center for Nanoscience and Nanotechnology

The Laboratorio of Ensenada del Instituto de Fisica (LE-IFUNAM) opened in 1981.
It was transformed in 1997 to Centro de Ciencias de la Materia Condensada.
In March 2008 was named as Centro de Nanociencias y Nanotecnología (CNyN)

Experimental Physics :

- Structural and Surface Analysis:TEM, XRD, AES, XPS, LEED, SEM, AFM
- Nanostructures, Advanced Materials, Nanocatalysis
- Biotechnology

Theoretical Physics

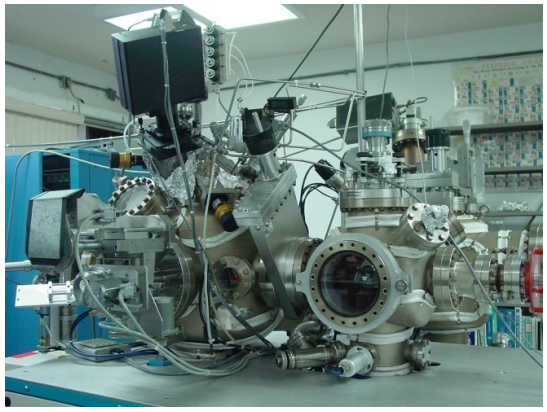
- Low Dimensionality Systems
- Statistical Physics
- Metallic Clusters

CNyN Laboratories

TEM

Microreactor

XRD



Laser Ablation

Catalysis

PLD

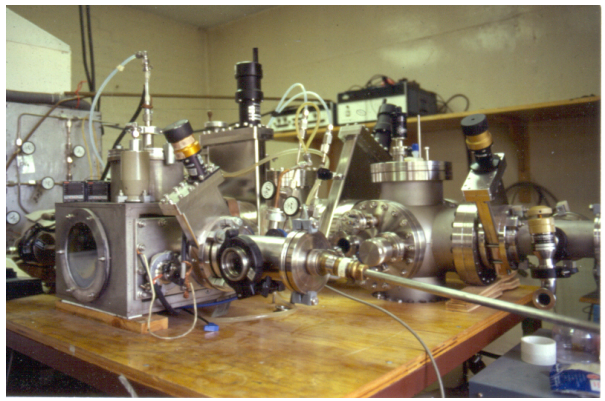
Instituto de Investigacion en Materiales

- Condensed Matter and Cryogenics
- Metallic and Ceramic Materials
- Polymer Materials
- Rheology and Mechanical Properties of Materials
- Special Projects
  - Biomaterials
  - Membranes for Gas Separation
  - Nanomaterials

Research Topics

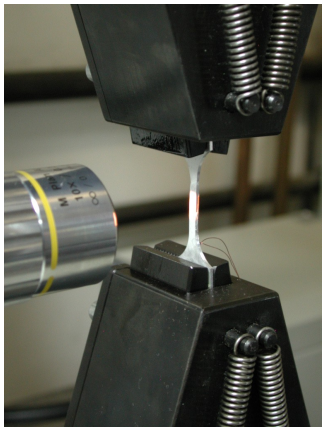
CONDENSED MATTER AND CRYOGENICS DEPARTAMENT

- Preparation of films by means of plasma
- Synthesis and structural characterization of nanoparticles
- Superconducting ceramic materials
- Properties of materials at low temperatures
- Electronic and phononic structure of materials
- Strongly correlated solids and high Tc superconductors
- Materials simulation
- Nanostructured Hard films



Research Facilities

- He and N_2 Liquefier
- XPS, UPS and AES
- Superconductors synthesis and Characterization
- Magnetometry and dilution refrigerators.
- Transport properties and tunneling.
- Electronic materials preparation.
- Semiconductors characterization.
- Mechanical testing
- Electronic microscopes (TEM, SEM, AFM)
- Nanostructured materials synthesis



Proyecto Universitario de Nanotecnologia Ambiental (PUNTA)

(*University Program on Nanotechnology for Environmental Remediation*)

Background

- Created by UNAM President Juan Ramon de la Fuente in Dec 2004 as one 5 components of the Programa de **I**nvestigacion **M**ultidisciplinaria de **P**royectos **U**niversitarios de **L**iderazgo y **S**uperacion **A**cademica (**IMPULSA**) *(Program of Multidisciplinary University Research Projects for Leadership and Academic Advancement)*
- Aimed at coordinating and financing multidisciplinary work within UNAM having short and long term goals in scientific areas strategic to Mexico.
- Seeked to change traditional research culture (single investigator) to foment team formation for solving complex multidisciplinary problems and to bring together researchers from various academic fields to accelerate problem solution.
- Create new strategic educational and research PhD programs to advance scientific and technological development in Mexico.
- Foment national and international collaborations with other academic and research institutions
- Strategic Areas Identified
  - *Nanotechnology for Environmental Applications.*
  - *Stem Cells, Neurone Regeneration and Parkinson Disease*
  - *Taenia Solium Genome*
  - *Water Desalination and Purification of Waste Water*
  - *IT Program for Biodeversity and the Environment*

Air Pollution in Mexico City Metropolitan Area (2006 data)

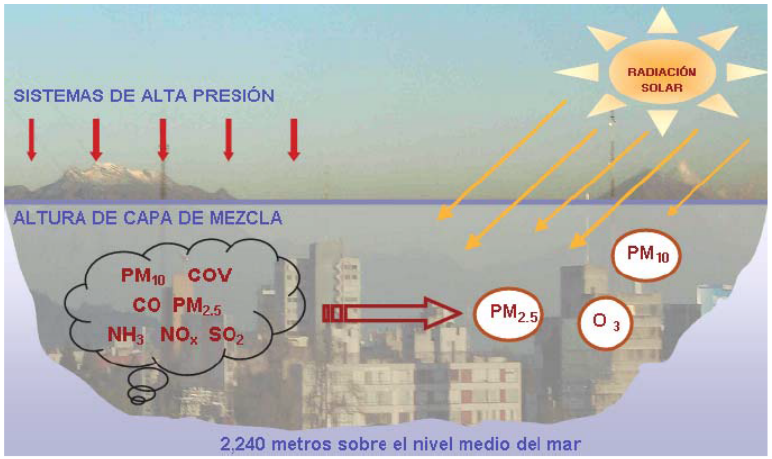
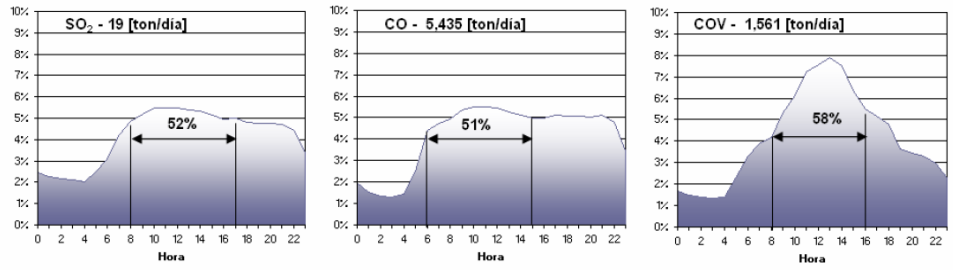


Figura 1.1 Emisión de contaminantes en el Valle de México



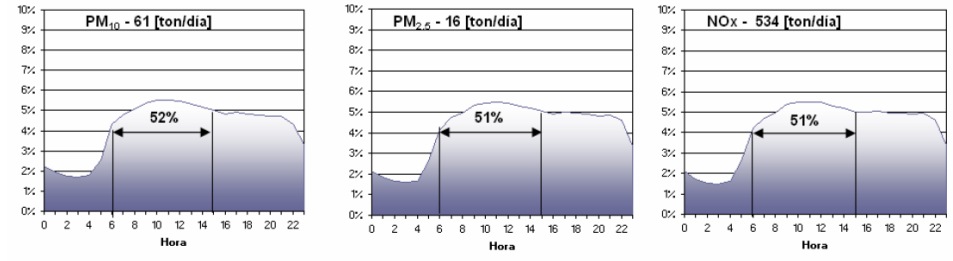


Tabla 3.1.2 Inventario de emisiones horario promedio del año 2006,

Hora	Emisiones [ton/hora]					
	PM_{10}	$PM_{2.5}$	SO_2	CO	NOx	COV
0	1.4	0.3	0.5	107.7	11.2	25.9
1	1.2	0.3	0.4	83.6	9.1	23.3
2	1.1	0.3	0.4	72.8	8.2	21.6
3	1.0	0.3	0.4	69.9	7.9	21.2
4	1.1	0.3	0.4	78.0	8.6	21.5
5	1.6	0.4	0.5	136.3	13.8	35.8
6	2.6	0.7	0.6	239.4	22.6	51.4
7	2.9	0.8	0.8	256.3	25.2	60.6
8	3.1	0.8	0.9	268.7	26.4	65.3
9	3.3	0.9	1.0	290.8	28.7	82.6
10	3.4	0.9	1.0	300.2	29.3	95.2
11	3.4	0.9	1.0	300.0	29.3	112.8
12	3.3	0.9	1.0	296.5	29.2	118.2
13	3.2	0.9	1.0	285.3	28.4	123.0
14	3.1	0.9	1.0	277.4	27.7	117.4
15	3.1	0.8	1.0	270.7	26.8	99.5
16	2.9	0.8	0.9	270.2	26.6	85.8
17	3.0	0.8	0.9	278.9	26.8	80.5
18	2.9	0.8	0.9	276.7	26.6	74.3
19	2.9	0.8	0.9	276.3	26.4	57.1
20	2.9	0.8	0.9	272.7	26.2	53.6
21	2.9	0.8	0.9	277.5	26.4	51.3
22	2.6	0.8	0.8	260.6	24.5	46.6
23	2.0	0.5	0.7	188.2	18.1	35.9
Total al día	**61**	**16**	**19**	**5,435**	**534**	**1,561**

Nota: No se incluyen las emisiones de los incendios forestales y estructurales, así como las emisiones de partículas de la erosión eólica del suelo.

Transportation is the main source

Program on Environmental Nanotechnology

Objectives

- Provide fundamental knowledge on heterogenous catalysis mechanisms for environmental applications. Utilize the outcome of this research to develop nanoscale materials with improved performance characteristics over current materials and devices.
- Priority Areas
  - *Catalytic materials for CO, NO_x, SO_2 and VOCs.*
  - *CO_2 entrapment and storage*
  - *Photocatalytic systems for water purification*
  - *Treatment of enclosed environments*
  - *Computational Catalytic Materials Design and Modeling*

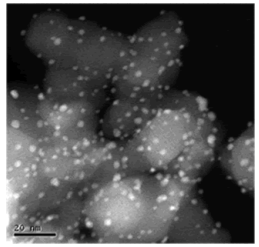
Participant Institutions

- Centro de Ciencias Aplicadas y Desarrollo Tecnológico **(CCADET)**, Centro de Nanociencias y Nanotecnología **(CNyN**), Centro de Física Aplicada y tecnología Avanzada **(CFATA**), Centro de Investigación en Energía **(CIE)**, Instituto de Investigaciones en Materiales **(IIM)**, Instituto de Física **(IF)**, Facultad de Ciencias **(FC)** and Facultad de Estudios Superiores de Cuautitlán **(FES-C**): 55 researchers and over 50 PhD Students

International Advisory Committee

- Professor Catherine Louis, Universite Pierre et Marie Curie, CNRS, France
- Dr. Ernesto E. Marinero, HGST San Jose Research Center, USA
- Professor Jose Luis Moran-Lopez, Faculty of Sciences, UNAM

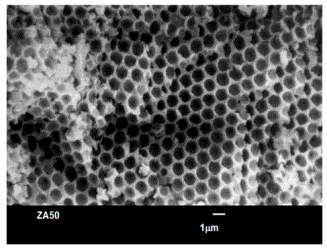
Research Areas (PUNTA)



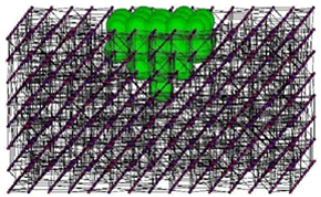
- *Catalytic systems based on Au Nanoparticles*
  - Au, and bimetallic Au-X Catalysts (Ag, Cu) on Titania supports
  - Rare Earth doping of Titania support for catalytic enhancement

- *Catalytic systems based on Pd Nanoparticles*
  - Development of Pd based automotive catalytic convertors
  - Pd-doped nanocarbon electrodes for H_2 generation
  - Dendrimer Pd Nanoparticle systems

- *Photocatalysis for Water Purification*
  - Cu doped TiO2 nanotubes and nanowires Membranes
  - Nanocarbon based catalytic materials
  - Solar concentrator with TiO2 nanoparticles
  - Mesoporous Oxide materials doped with TiO2 for VOC reduction

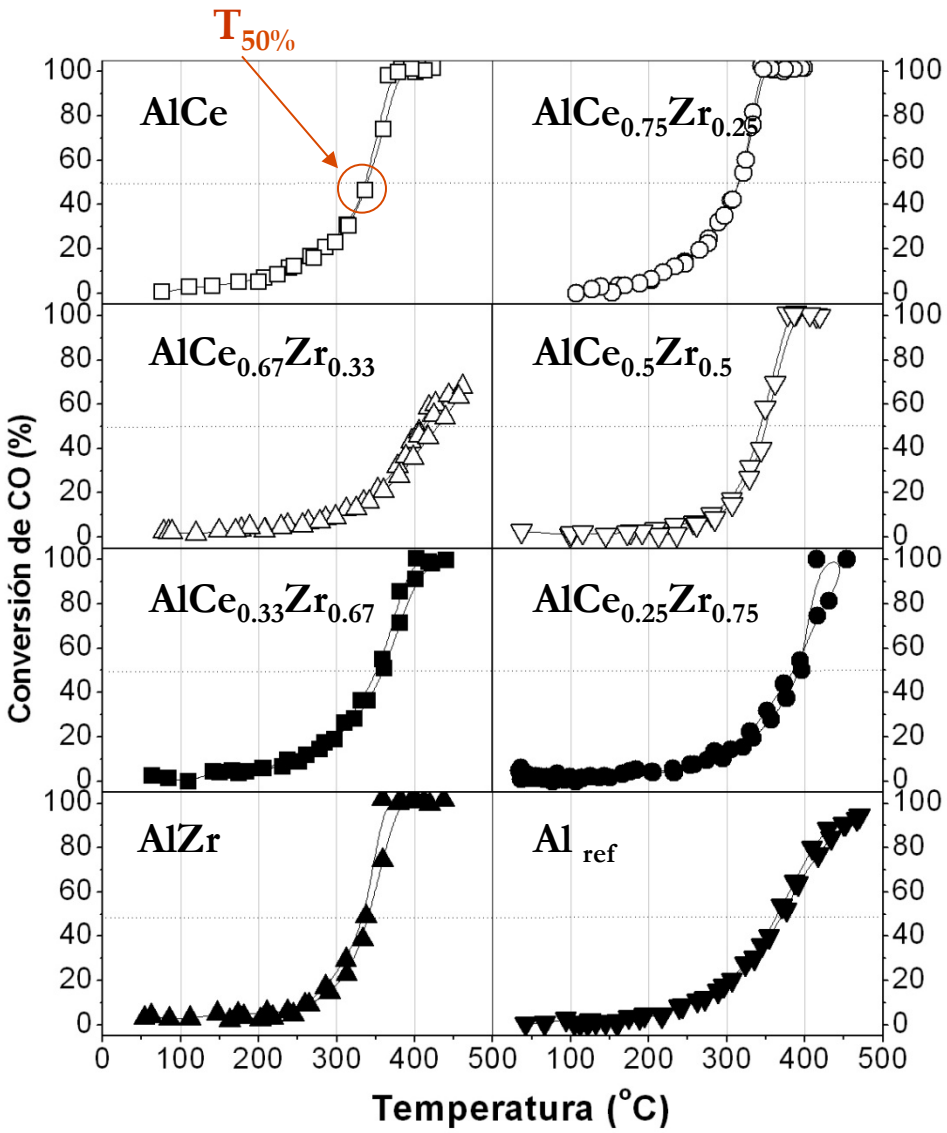


- *CO_2 Sequestration Nanomaterials*
  - Ceramic nanoporous materials



- *Computational Catalysis.*
  - First Principle studies of Metal Nanostructures (Au, Ag, Pd and bimetallic particles
  - CO oxidation on Au nanoparticles: role of support

Catalytic activity of supports



CO conversión on fresh supports after *in situ* pretreatment O_2 at 550 °C.

$$CO + 1/2O_2 \rightarrow CO_2$$

$$2CeO_2 + CO \rightarrow Ce_2O_3 + CO_2$$
$$Ce_2O_3 + 1/2\ O_2 \rightarrow 2CeO_2$$

- **Total conversion of CO at 340 °C for Al_2O_3-$(Ce_{0.75}Zr_{0.25})O_2$**
- **Better CO conversion results that Thammachart *et al*, Catal. Today 58 (2001)**

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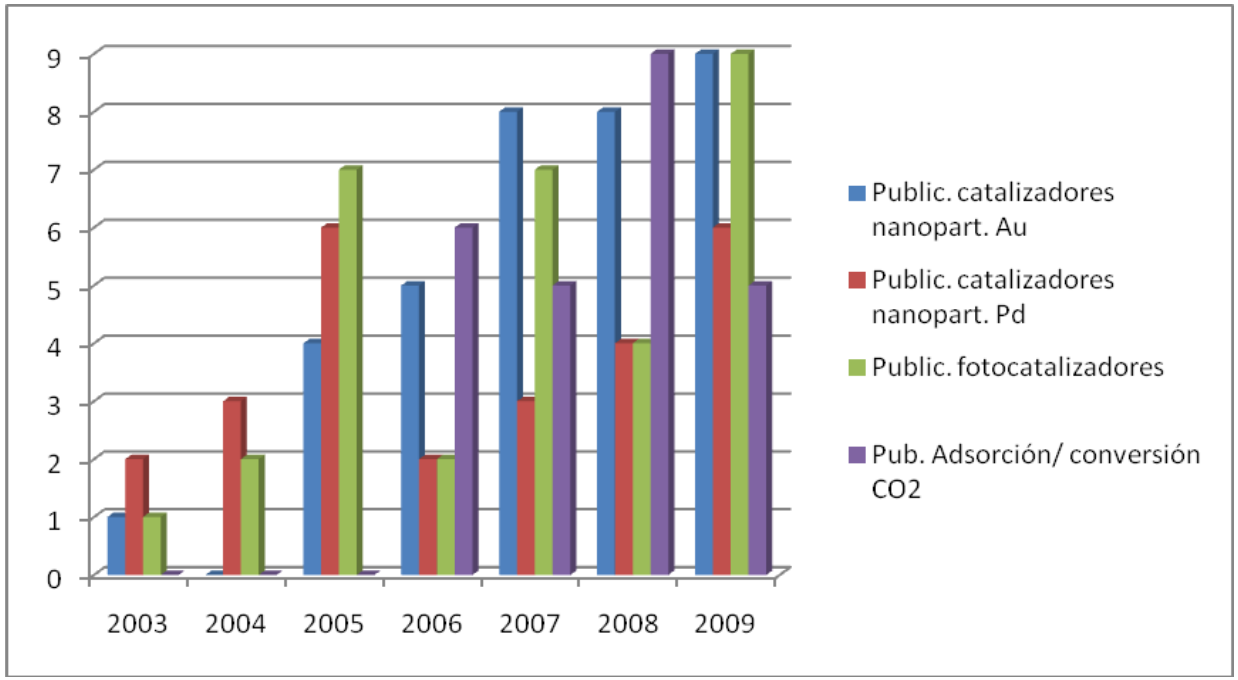
PUNTA: Summary of Accomplishments

- Academic culture change leading to Creation of Interdisciplinary Research Team (Theoretical and Experimental) that work effectively to meet project goals: collaboration vs competition in related fields.
- Significant increment in the number and quality of publications on catalysis, graduate student enrollment and degrees (Masters and PhDs) awarded.
- Generation of Patents
- Development of novel catalytic materials that outperform in cost, efficiency and operating temperature current-art devices for automobile applications.
- Incremented UNAM's visibility nationally and internationally in catalysis field.
- Excellent ROI for ~ USD $1.8M Investment



Centro de Investigación Científica y de Educación Superior de Ensenada

Universidad Nacional Autónoma de México
Centro de Nanociencias y Nanotecnología

PROGRAMA DE POSGRADO EN CIENCIAS EN FÍSICA DE MATERIALES

Estudio de la magnetoconductancia de dispositivos basados en nanoconstricciones cuánticas acopladas

Rubén César Villarreal Sánchez

Dr. Francisco Mireles Higuera

Director de Tesis

Dr. Ernesto E. Marinero

Codirector de tesis

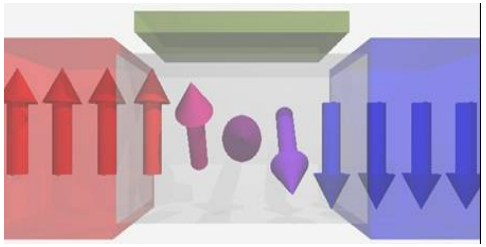
Ensenada, Baja California, México, 11 de abril de 2012

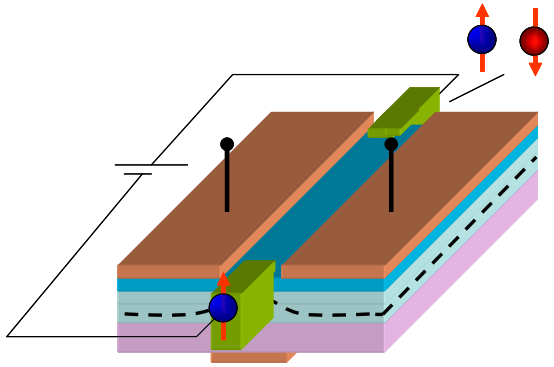
Modelling spintronic nanodevices: CNyN/HGST

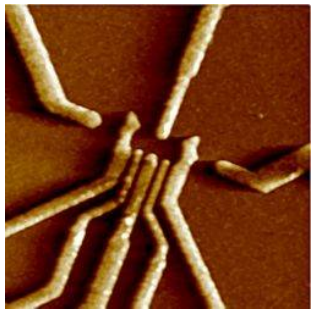
Francisco Mireles and Ernesto Marinero

Nano-Spintronics

Physics and technology of generation, detection and **manipulation** of **electron and hole spins** in nanostructures, e.g. quantum wells, quantum wires, quantum dots (QD's), graphene, CNT´s?



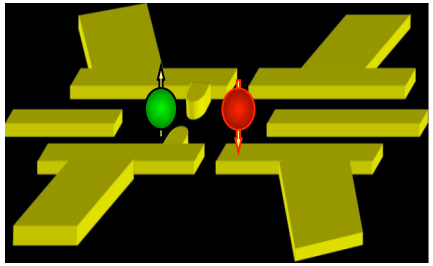


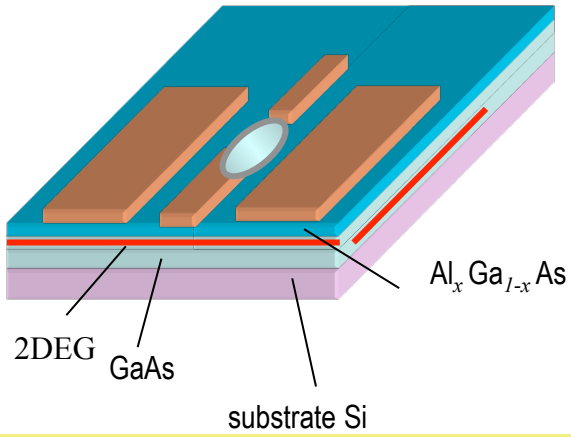


AFM Image of a double QD
(Kowenhoven´s group)

Quantum dots

Interested to model quantum dots (QDs) made in semiconductor heterostructures. QD´s are used to confine electrons in a small space and study its quantum mechanical behaviour.





Tuning Fano-type Resonances in Coupled Quantum Point Contacts by Applying Asymmetric Voltages, *R.C. Villareal, F. Mireles, E.E. Marinero and B.A. Gurney,* Applied Physics Letters, 98, 172102, (2011).

Zero Field Spin Splitting in AlSb/InAs/AlSb Quantum Wells induced by Surface Proximity Effects, *M. Nishioka, B.A. Gurney, E.E. Marinero and F. Mireless,* Applied Physics Letters, 95, 242108, (2009).

Hitachi Global Storage Technologies

IIM/HGST Collaborations

- Synthesis and Characterization Superconductors
  - $Ba(Yb^{3+}_{0.38}, In^{3+}_{0.10}, Sn^{4+}_{0.42}, Pb^{2+}_{0.10})O_{2.66}$ with cubic structure Tc = 85 K (Joel Estrada)
  - New $R_3Gd_3Ba_2Ca_2Cu_7O_{13}:Li_3$ Compounds (R= Rare Earth) (Cintli Aguilar)
- Synthesis and Characterization of Nanostructures
  - V_2O_5 Nanostructure for energy applications (Maria L. Tafoya)
  - $YbFe_{1-x}Mn_xO_3$ $(0.0 \leq x \leq 1.0)$ Multiferroic Perovskites (Carlos Hernandez)
  - $Ca_{1-x}Sr_xRuO_3$ $(0.0 \leq x \leq 1.0)$ Rutanate Compounds (Adolfo Aguilar)
  - $LaAg_{1-x}Sr_xMnuO_3$ $(0.0 \leq x \leq 1.0)$ Thermomagnetic Materials (Israel Betancourt)
  - Pd Nanoparticles on Functionalized Block Copolyemer (Luisa Islas)
- Core-Shell Nanostructures
  - Computational Studies of Graphene overcoated Metal Nanoparticles for Catalysis and Optoelectronic Applications (Enrique Sansores)

Synthesis of V_2O_5 Nanostructure for energy applications.

M. C. María Luisa Tafoya Ronquillo
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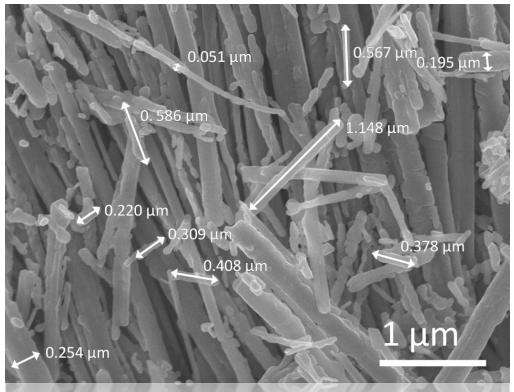
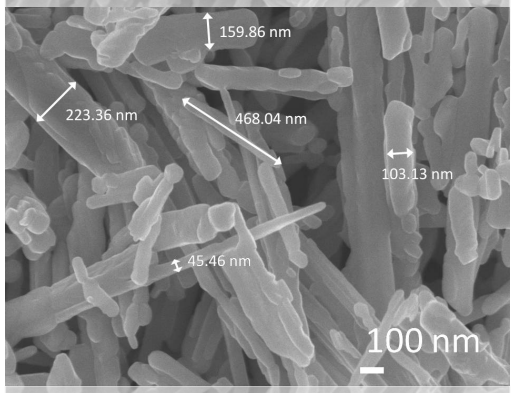
Patricia Santiago Jacinto
Instituto de Física UNAM

Ernesto Marinero
Purdue University

Elizabeth Chavira
Instituto de Investigaciones en Materiales UNAM

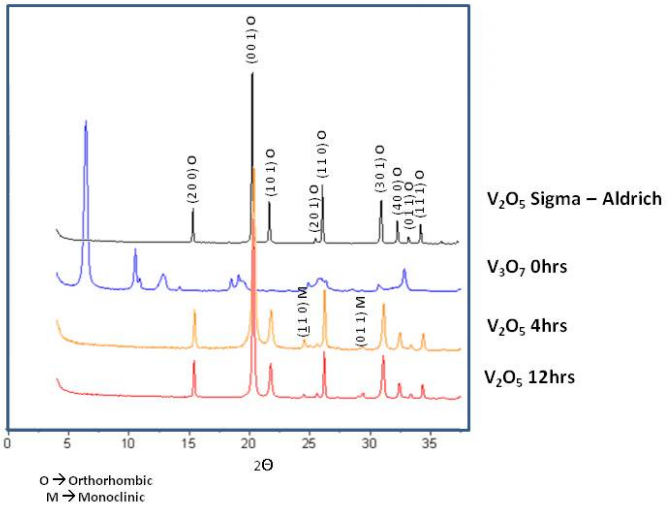
Hydrothermal Synthesis of V_2O_5 Nanostructure for energy applications

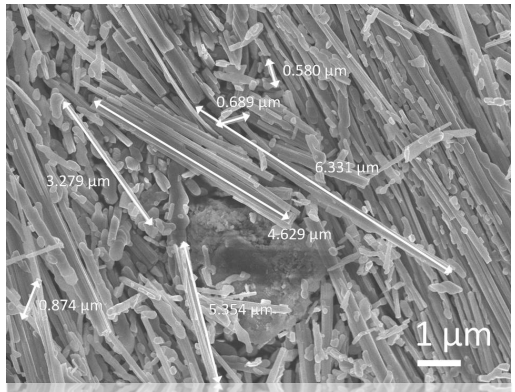


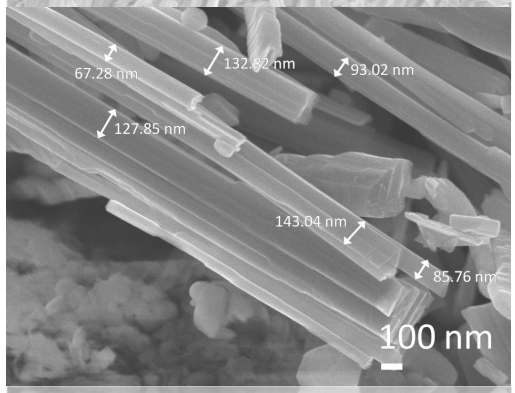


The precipitate heated to 80 °C for 4hrs, nanorods measuring on average 133nm in cross-section and 2um in length are observed.

XRD patterns of the products synthesized at 180 °C



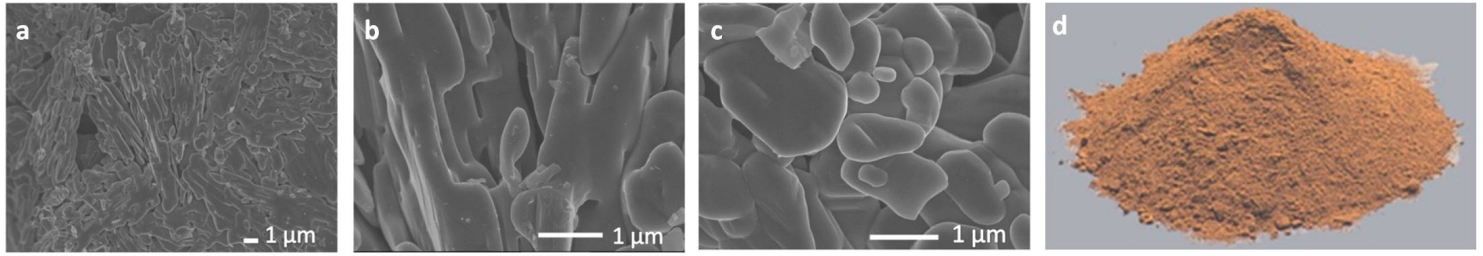




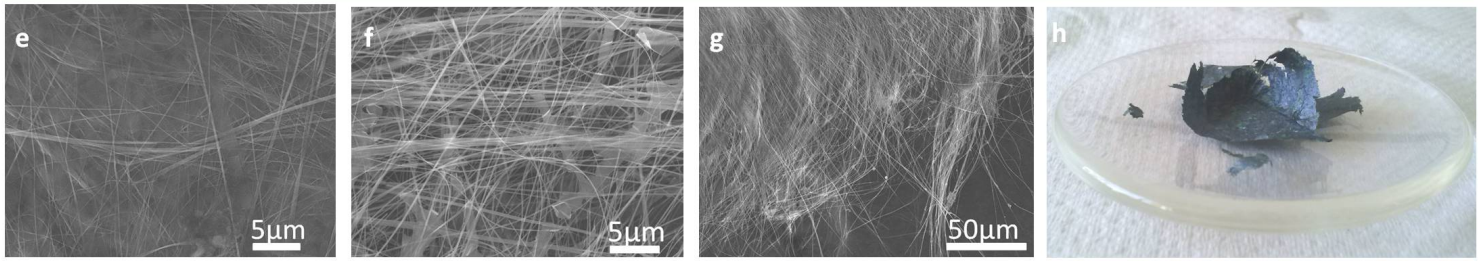
After 12hrs under thermal treatment more homogeneous nanorods measuring approx. 108nm in cross-section and 60µm in length are obtained

Results

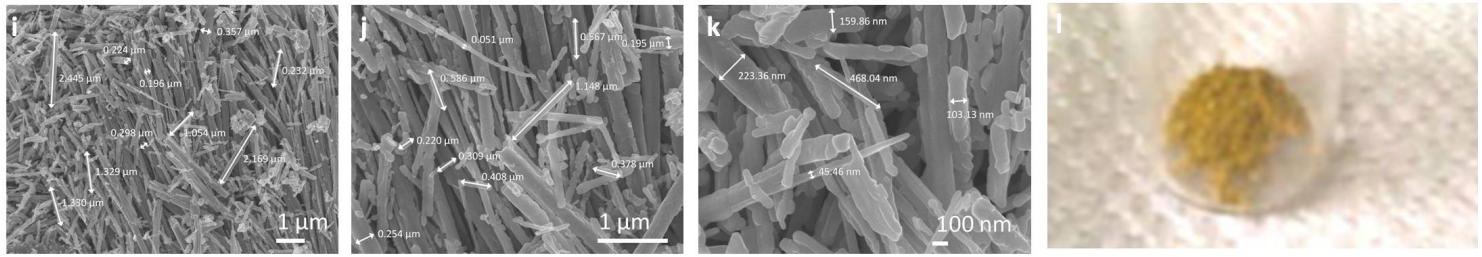
V_2O_5 Sigma – Aldrich



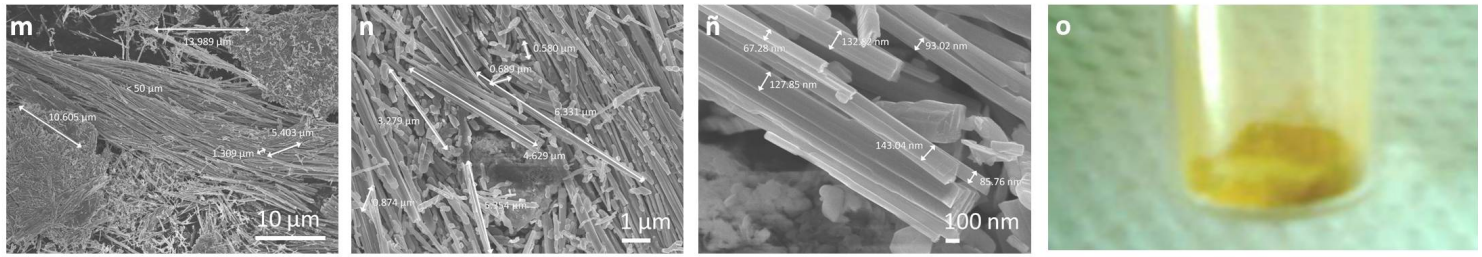
V_3O_7 nanorods heat treatment of 0hrs



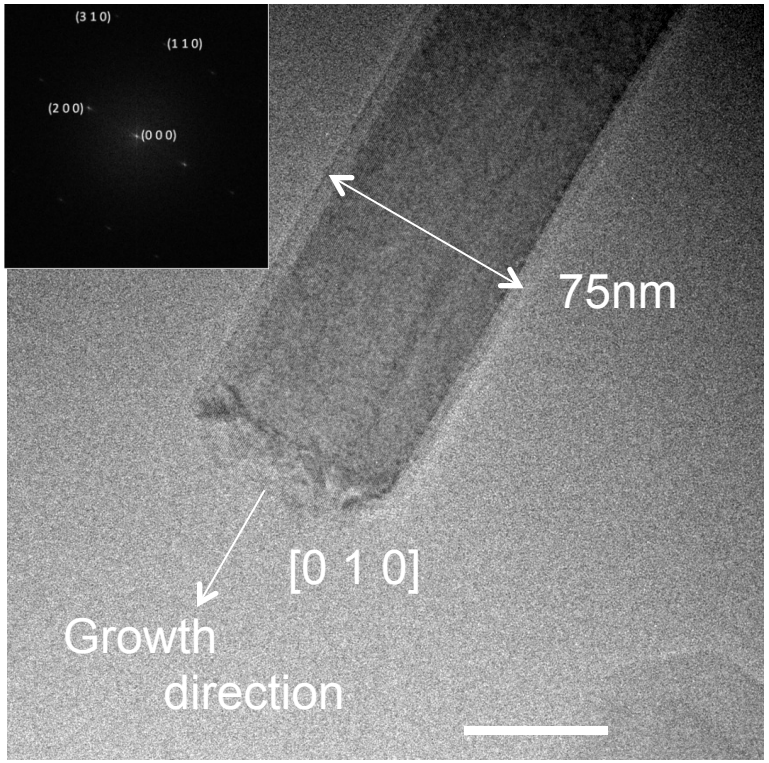
V_2O_5 nanorods heat treatment of 4hrs

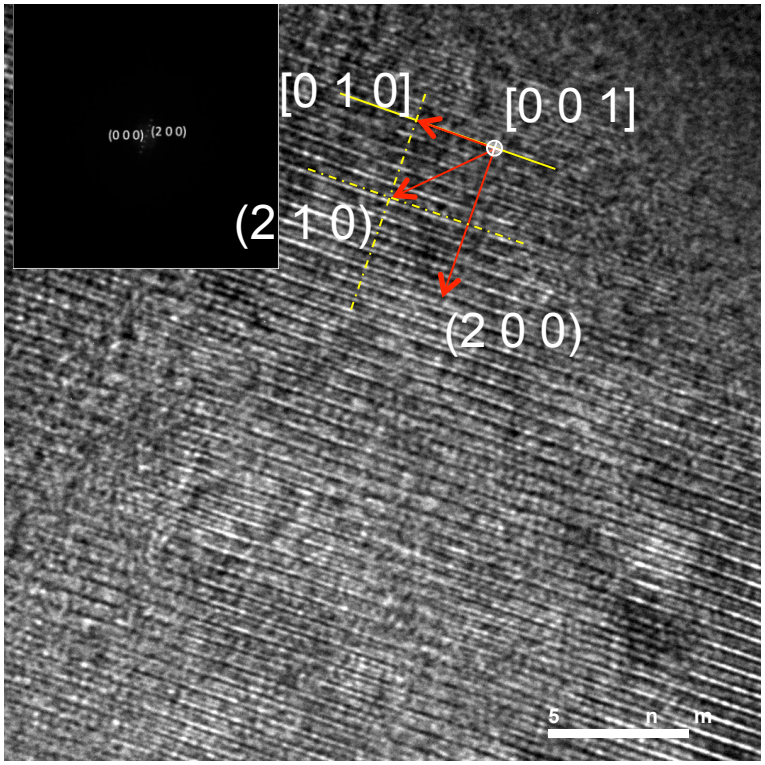


V_2O_5 nanorods heat treatment of 12hrs



Transmission Electron Microscopy





Conclusions

Utilizing as a starting material orthorombic V_2O_5, we have successfully synthesized V_2O_5 nanorods employing a hydrothermal treatment in an aqueous solutions. H_2O_2 is the oxidizing agent that promotes the reduction of V_2O_5 to V_3O_7 forming the nucleation seeds that drives the growth of the nanorods.

The influence on the reaction time affects the crystal structure and morphology.

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Scientific Advisor: the Paradigm

- UNAM is a prime research institution with many world class researchers working on leading-edge science.

- Academic culture Issues hindering greater scientific and societal impact:
  - System rewards Individual-researcher-centric projects
  - No incentives for academics for patent filing or technology transfer
  - Competition rather than collaboration in similar areas
  - Applied and engineering aspects of science not held in high regard
  - Entrepreneurship, technology commercialization not part of DNA

- Institutional Issues hindering greater scientific and societal impact:
  - Reward system does not have mechanisms to reward team work, technology transfer, new business creation and consulting.
  - Lack of research facilities for multidisciplinary work
  - Institutions that handle patent processing and technology commercialization often hinder their intended goals.

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Scientific Advisor: The Potential

- The successful execution of the project PUNTA demonstrates that Academic cultural issues that hinder the successful execution of multidisciplinary complex problems can be readily changed with the correct leadership and stewardship:
  - Define win-win grand-challenges, game-changing programs whose success depend on the individual contributions of all participants.
  - Clear Objectives and deliverables across the program lifetime must be established and tracked for all participant groups and researchers.
  - Hold participants accountable for collective project goal accomplishments both short and long term.
  - Avoid over-engineering knowledge needed for execution of program goals.
  - Build-in flexibility during the program lifetime to exit participants and add new ones driven by the program needs.
  - Adopt entrepreneurial spirit for collaborative experimental, theoretical and engineering work demanded by the program.

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Graduate Student Advisor: Observations

- Highly motivated students, eager to embark in new research projects in particular those leading to applications and societal impact.

- Challenges encountered:
  - Significant differences in student quality and talent.
  - Course work leading to graduate studies often inadequate for graduate program success.
  - Research projects often poorly underfunded.
  - Not accustomed to frequent project reviews and assessment.
  - Self-initiated advisor contact, infrequent.

- Institutional Issues:
  - Student progress and assessment not consistently tracked.
  - Barriers to collaborate and utilize facilities outside advisor team
  - Disconnect between project funding and student scholarship.

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Going Forward: Summary Recommendations

- Mexico has a highly developed research infrastructure whose contributions in multiple fields is world class. This provides a win-win situation for Purdue and Mexico for successful engagement. Key elements for success are:
  - Identify projects that are strategic in nature that would enormously benefit from the formation of COMPLIMENTARY research and engineering activities.
  - Establish research programs with students having research advisors from Purdue and Mexican Institutions.
  - Facilitate the unencumbered flow of students and faculty to both institutions.
  - Create educational programs at Purdue to leverage training of Mexican graduate students and researchers in engineering and science, entrepreneurship and technology transfer.
  - Seek joint funding from national and international funding agencies to sponsor new research programs and student and faculty support.
  - Utilize web-based and internet technology for teaching, project meetings and continuous project assessment.