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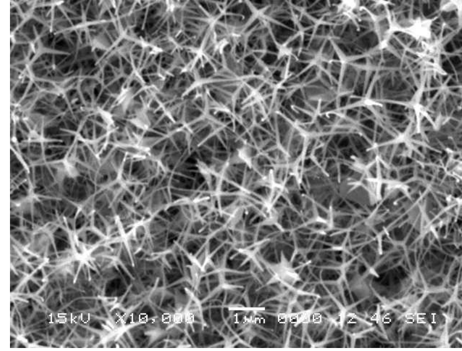
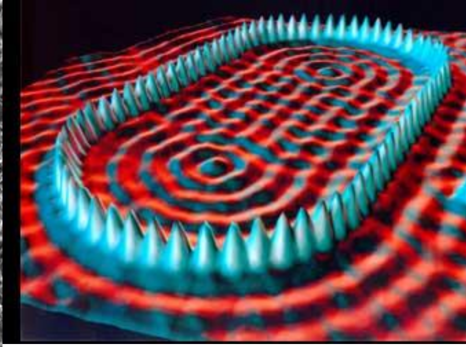
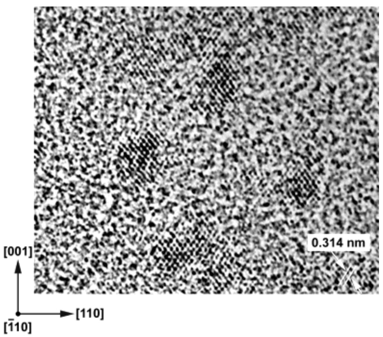




NANOTECHNOLOGY FOR THE PETROCHEMICALS INDUSTRY

CENT as an example..



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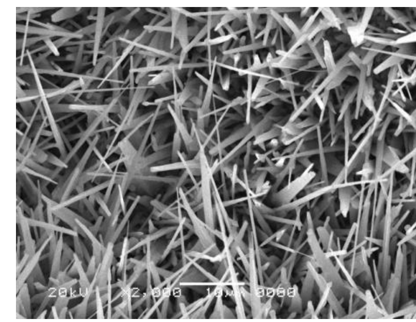

Zain Hassan Yamani
CENT Director
KFUPM

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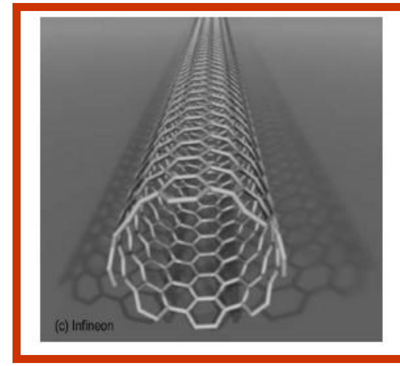
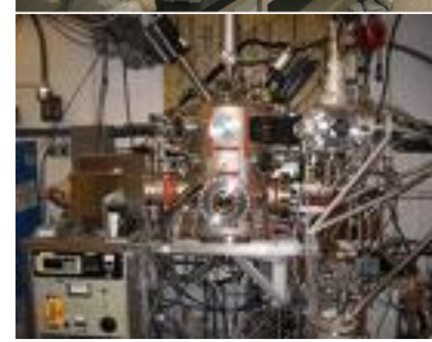


Outline

1. What do we mean by nanotechnology?
2. How is nanotechnology 'special'?
3. The impact of nanotechnology
4. Nanotechnology and Petrochemicals
5. King Abdullah Vision
6. CENT as an example
7. Conclusions



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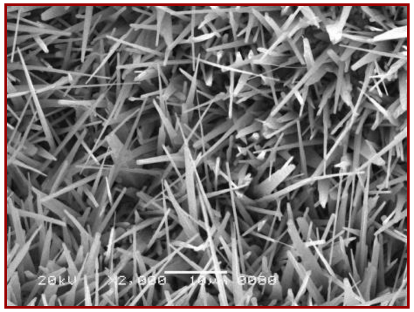
What do we mean by nanotechnology?



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What is "nano"

Nano: a prefix which means 1/1000,000,000

Nanometer = 1/1000,000,000 of a meter

= 1/1000,1000 of a millimeter

= 1/1000 of a micrometer

Less than a nanometer
Individual atoms are up to a few angstroms, or up to a few tenths of a nanometer, in diameter.

Nanometer
Ten shoulder-to-shoulder hydrogen atoms (blue balls) span 1 nanometer. DNA molecules are about 2.5 nanometers wide.

Thousands of nanometers
Biological cells, like these red blood cells, have diameters in the range of thousands of nanometers.

A million nanometers
The pinhead sized patch of this thumb (circled in black) is a million nanometers across.

Billions of nanometers
A two meter tall male is two billion nanometers tall.

Nanotechnology:

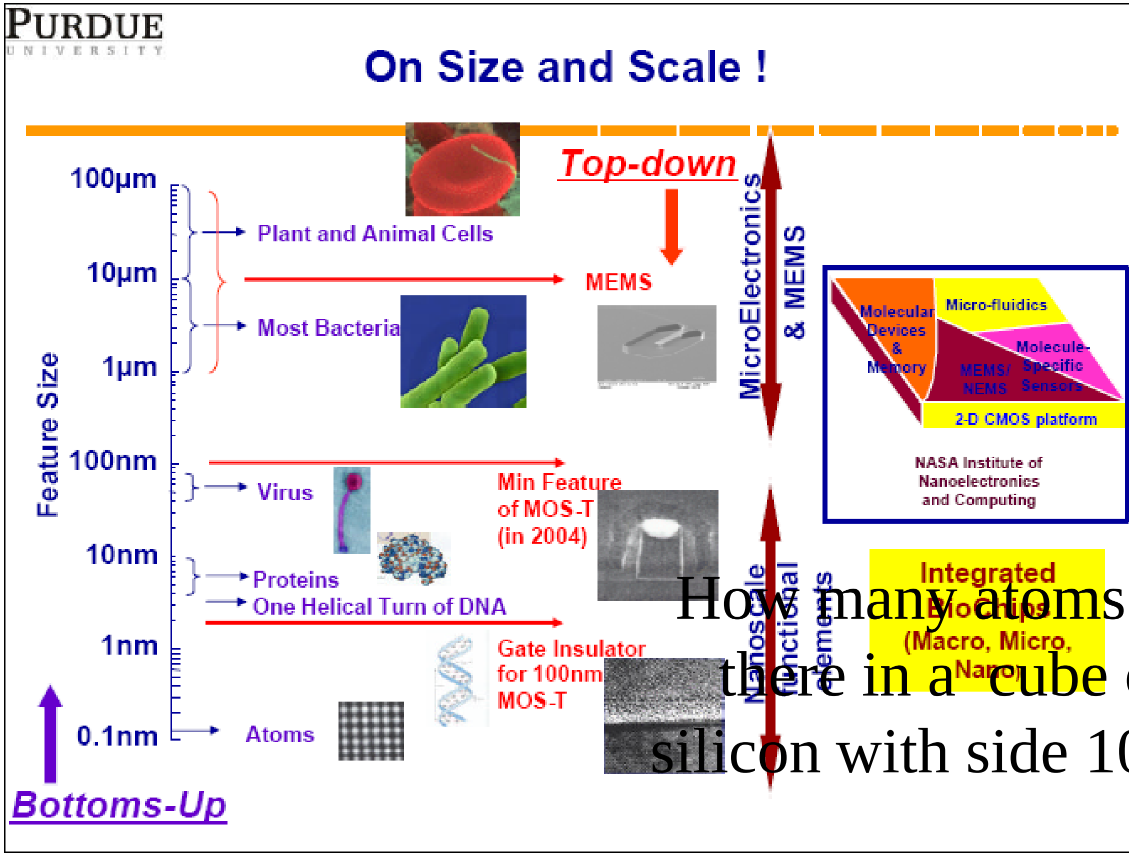
Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications.

Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

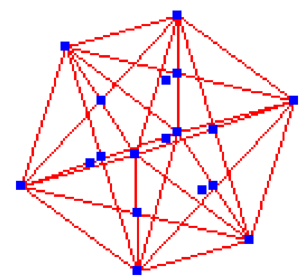
http://www.nano.gov/html/facts/whatIsNano.html

Nanometer, Nanogram, Nanonewton, Nanojoule, Nano..

Imagine the nano-scale



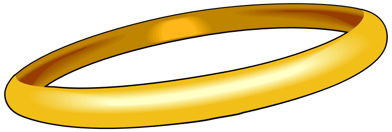
How many atoms are there in a cube of silicon with side 10 nm



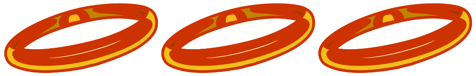
Not one atom, but many (many) atoms

How is nanotechnology 'special'?

Optical qualities

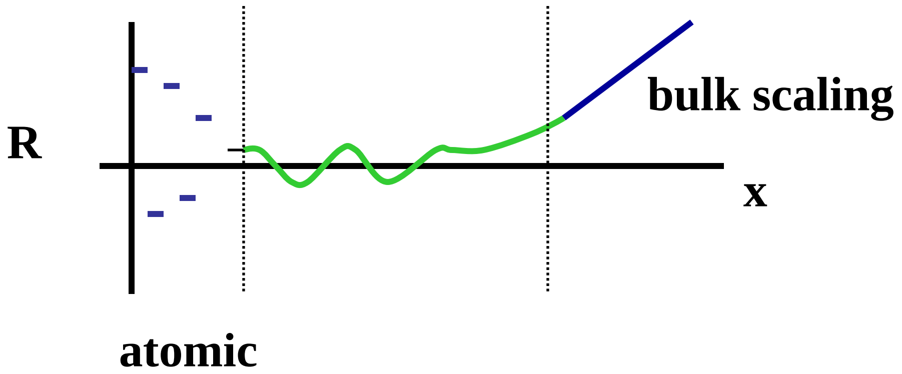


Bulk Gold = Yellow

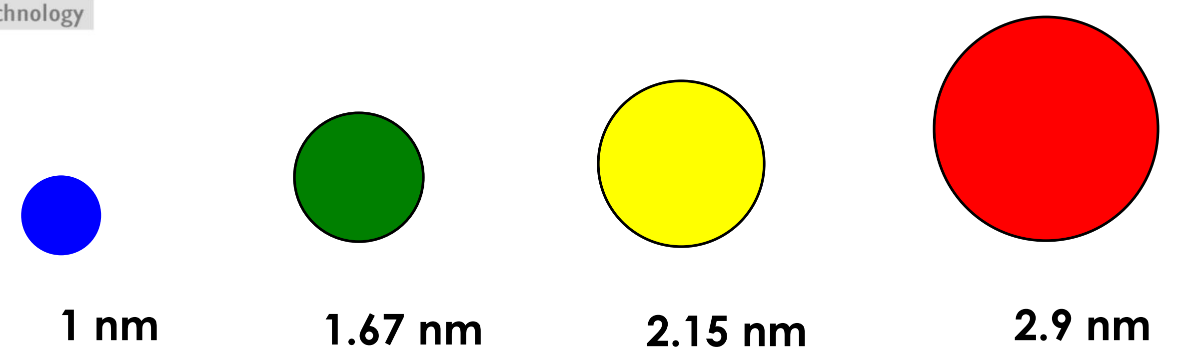


Nanogold = Red

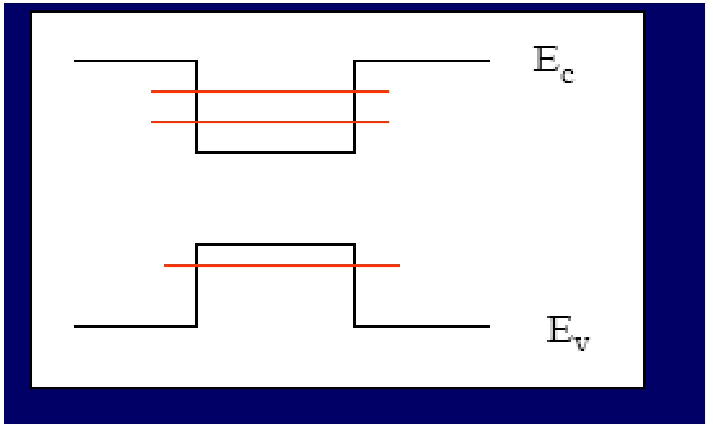
Quantum effects

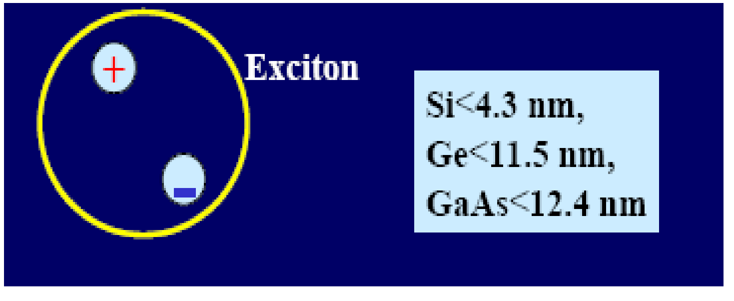


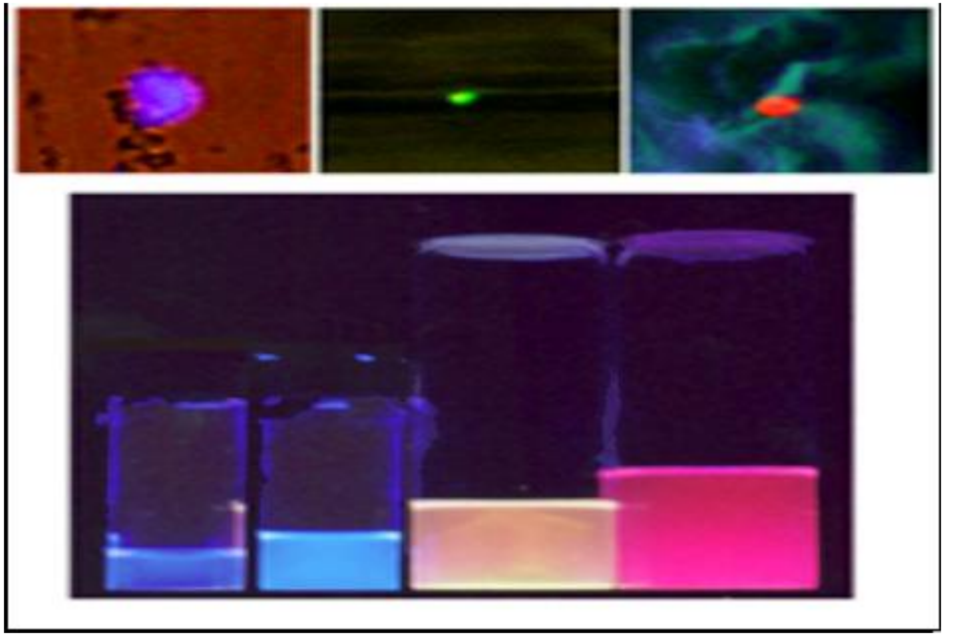
Small and Luminescent



Sizes



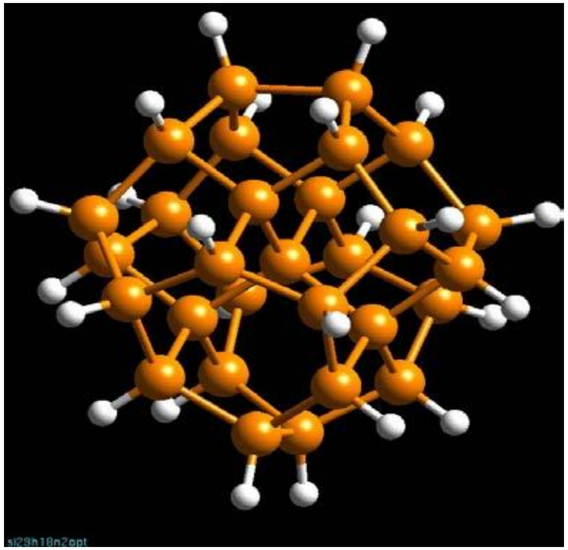


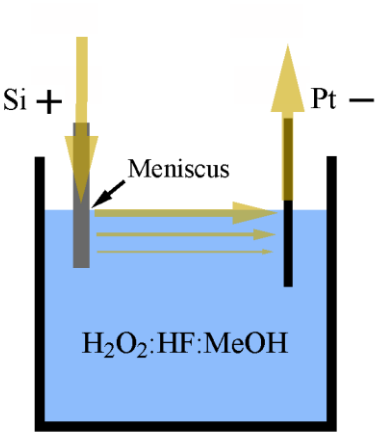


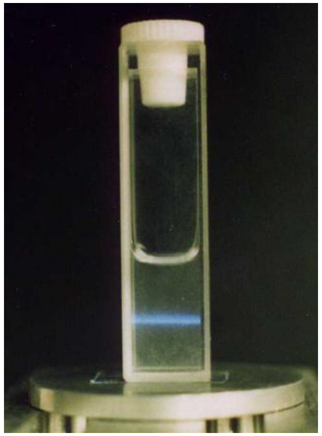
Z. Yamani and M. Nayfeh

Silicon Nanoparticles

Nayfeh/ Yamani et. al (physics)







Z. Yamani, H. Thompson, L. AbuHassan, and M. H. Nayfeh , Appl. Phys. Lett. **70**, 3404-3406 (1997)

M. Nayfeh, J. Therrien, and **Z. Yamani: Method for producing silicon** nanoparticles, US 6,585,947 with a publication date of July 1, 2003.
M. Nayfeh, J. Therrien, and **Z. Yamani: "Silicon Nanoparticle and Method for Producing the Same"** 6,846,474; January 25, 2005.

Silicon nano-crystallite synthesis, characterization, functionalization, applications, computation

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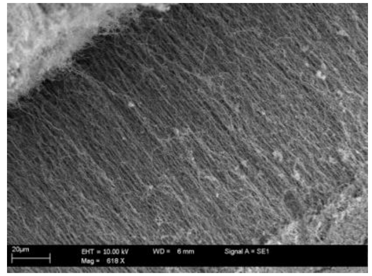


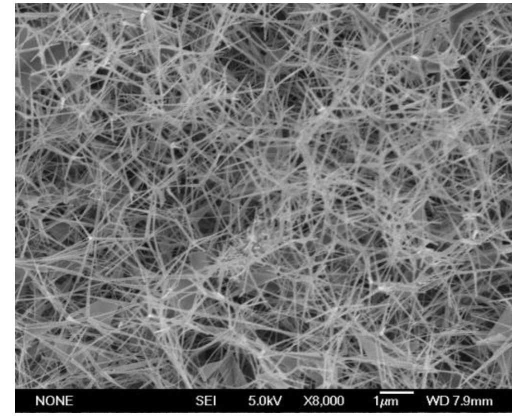
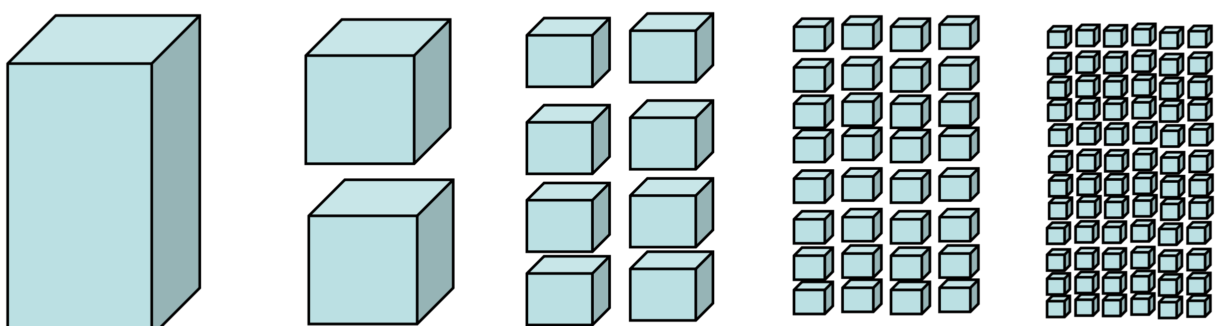


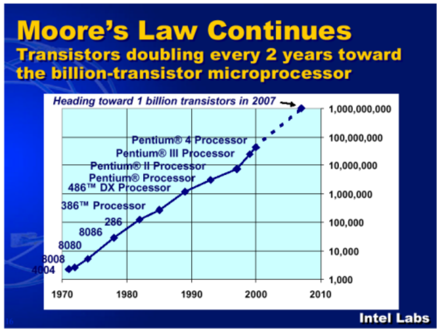
Table 1
The relation between the total number of atoms in full shell clusters and the percentage of surface atoms (reprinted from [5] with permission from John Wiley & Sons)

Full shell clusters	Total number of atoms	Surface atoms (%)
One shell	13	92
Two shells	55	76
Three shells	147	63
Four shells	309	52
Five shells	561	45
Seven shells	1415	35

Extremely important for catalysis, sensors, purification and the like.

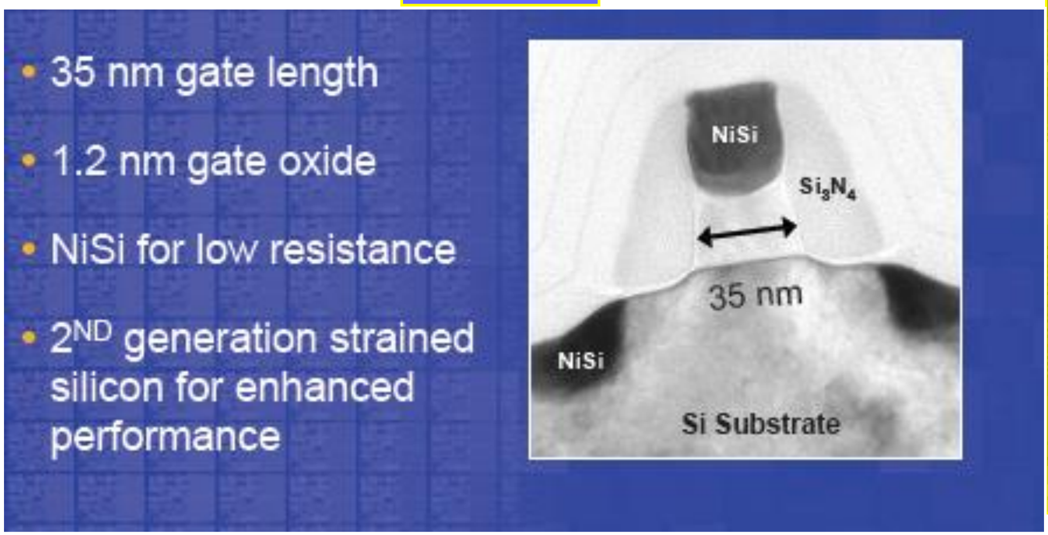
Specific surface





Larger number of smaller devices that consume less energy

2005



~ 350 Million Transistor Chip

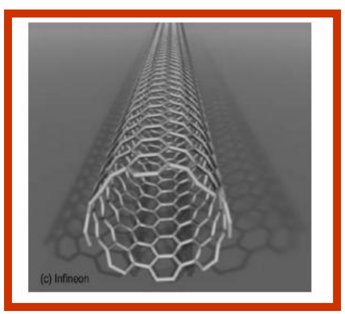
ENIAC, 1945

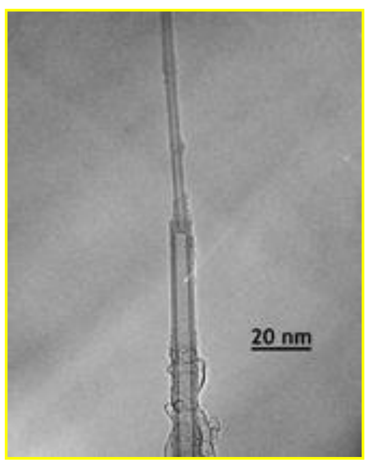
DNA delivery

27,000 kg
1800 vacuum tubes
140kW

CNT: Very light/ very strong

Ijima, 1991





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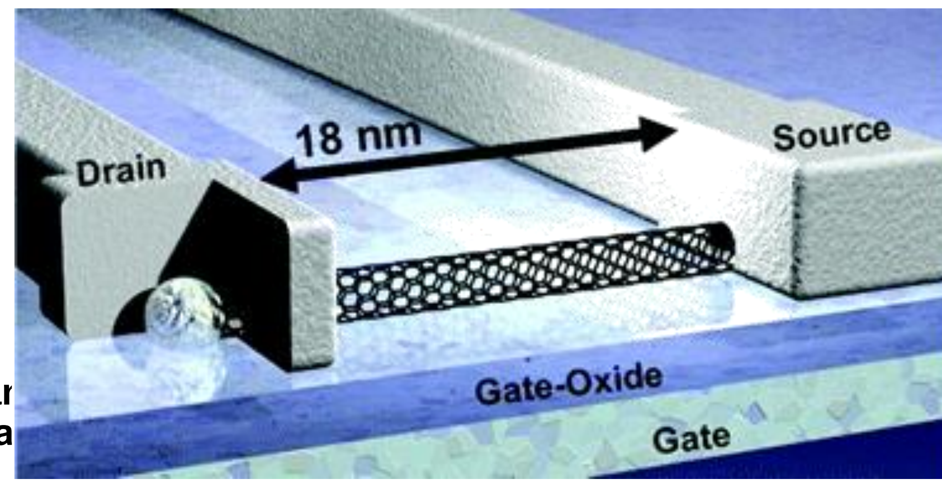

Seidel et al Nano-letters- Vol. 5, 1, (2005) 147

http://www.lbl.gov/Science-Articles/Research-Review/Magazine/2001/Fall/features/02Nanotubes.html

The impact of nanotechnology

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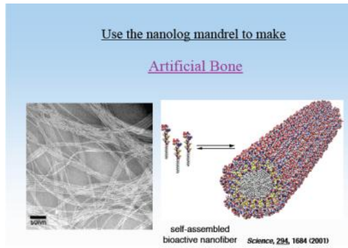

Energy/ photovoltaics

Membranes/ water purification

Porous material/ hydrogen storage

Nano-engineered catalysis

Petrochemicals/ fuel cells

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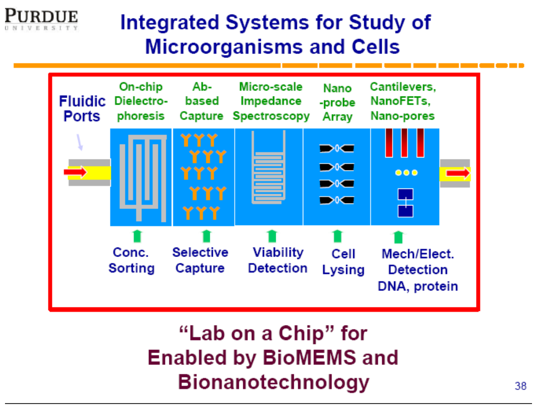
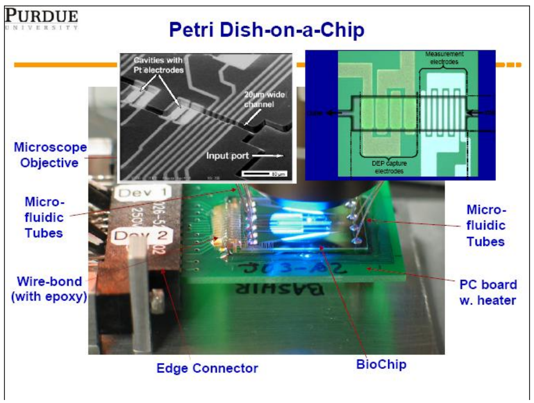
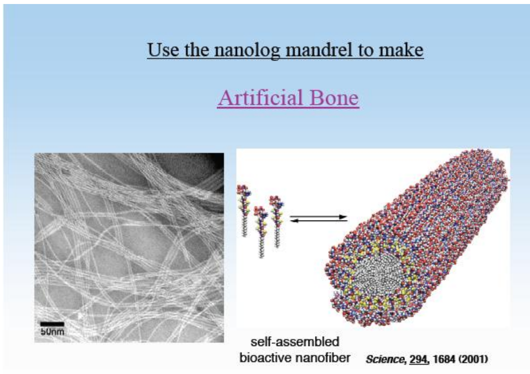
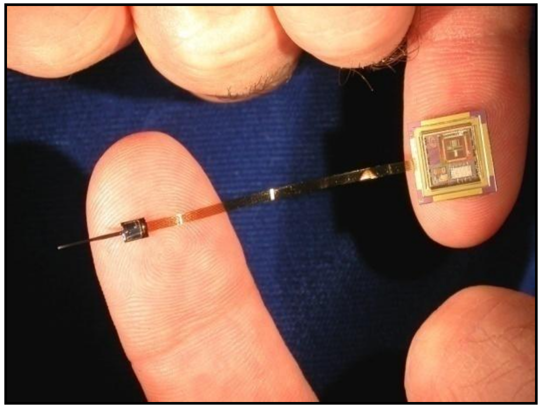
in medicine.. diagnostic and therapeutic







Nanoscale "vacuum tube"



DNA delivery

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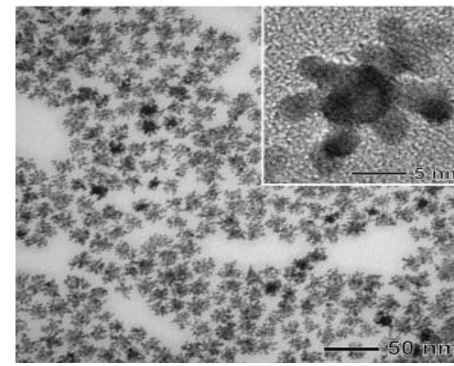
Nanotechnology For Clean Transportation

Increase in oil demand and environment concerns, Industrial world shift attention toward novel sources of energy such as:

- **Hydrogen –air fuel cells**
- **Solar cells**
- **Wind and geothermal powers**

Fuel Cell Nanocatalyst



Fuel Cell Power System

Nanotechnology can make our future more green less noisy

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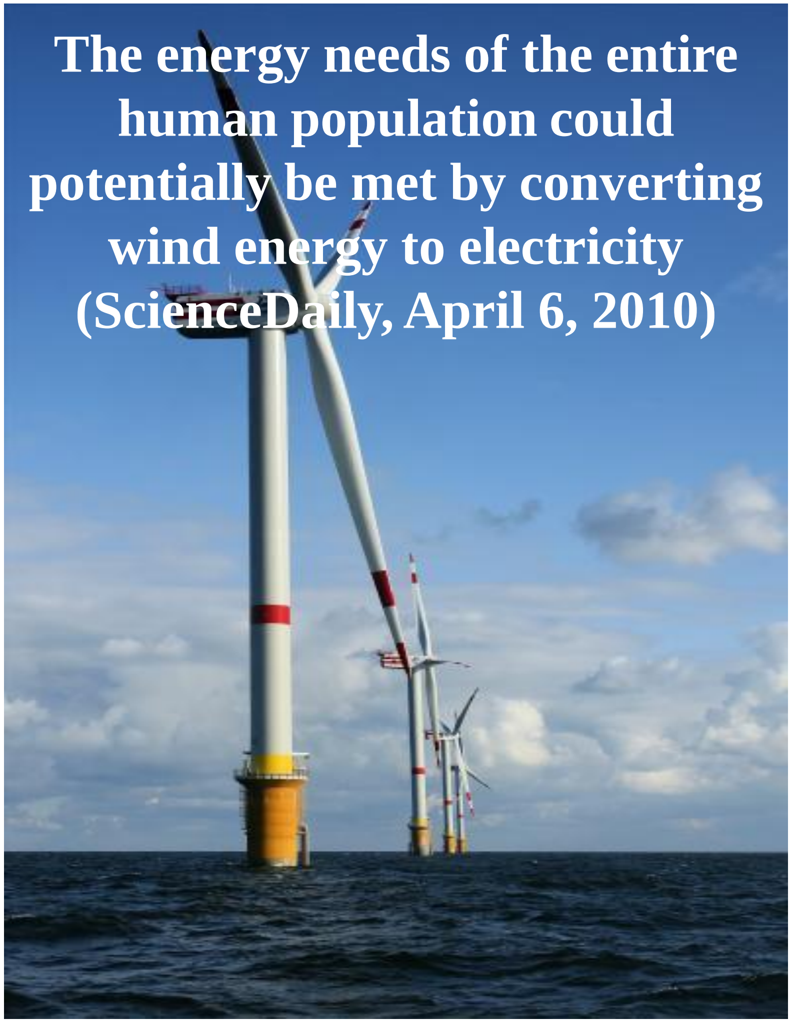
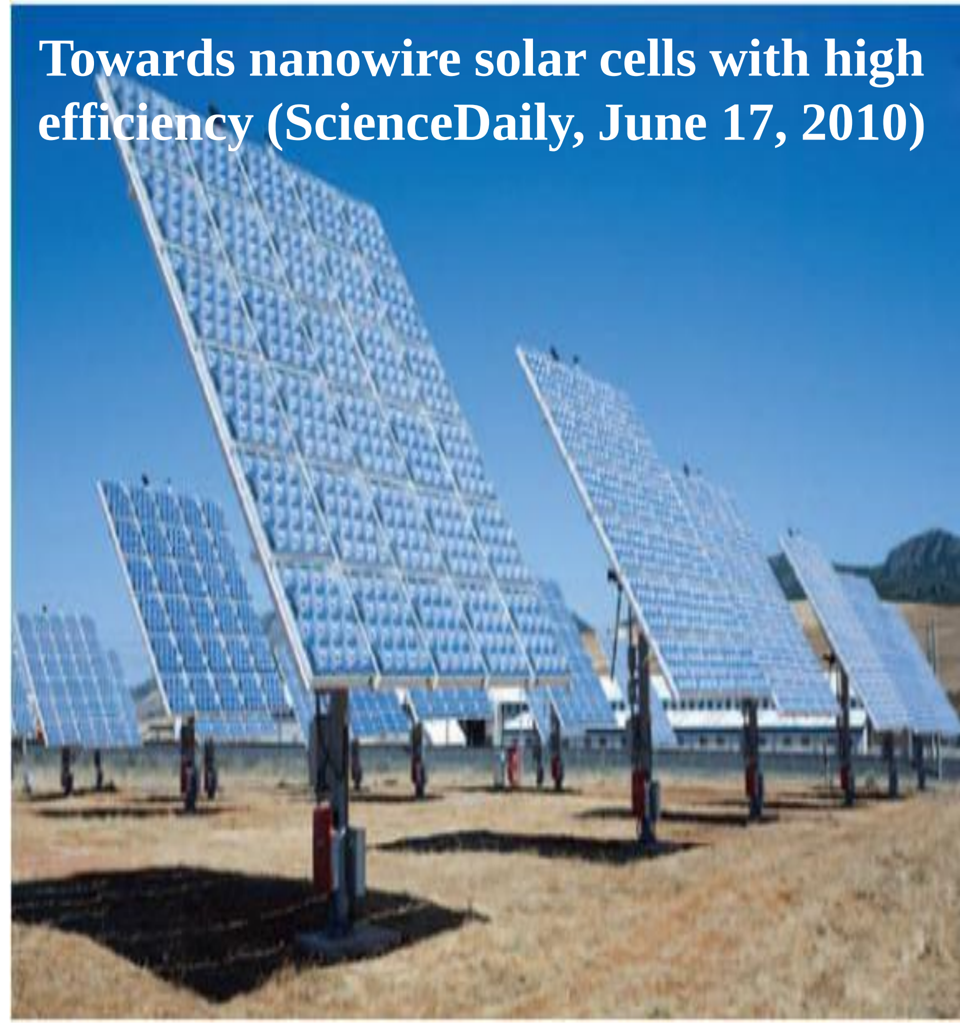
Nanotechnology For Clean & Cost Effective Stationary Power



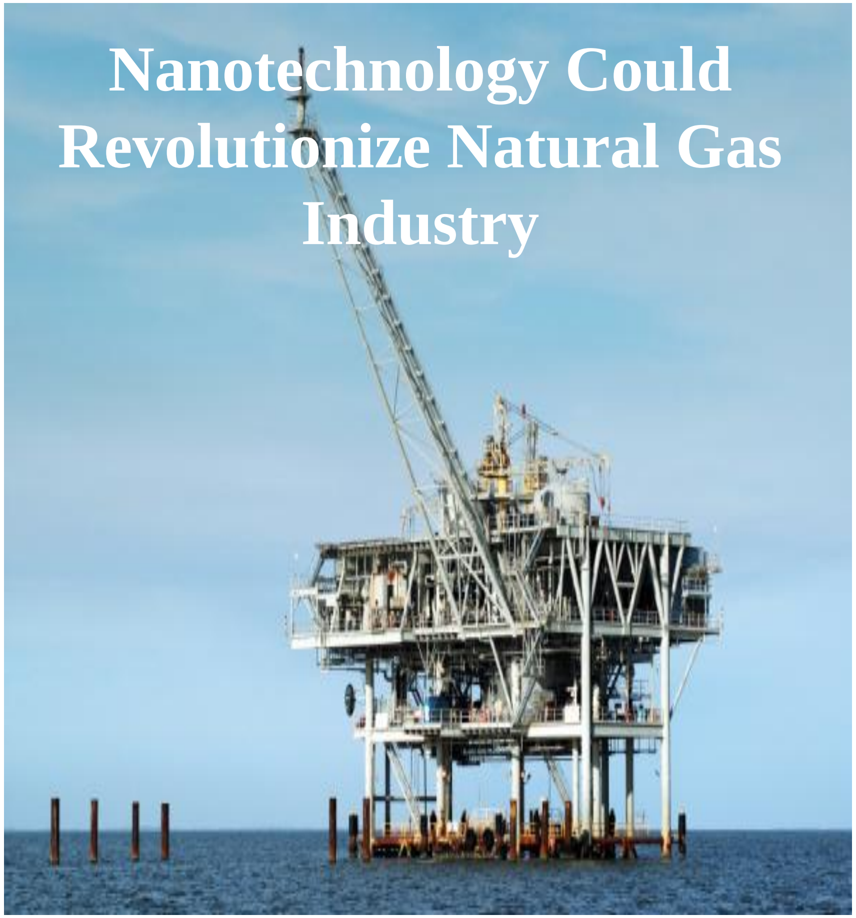


Nanotechnology can enhance the efficiency of alternative powers with low cost.

Nanotechnology for Petroleum Industries

Researchers describe the potential benefits of nanotechnology as:

- **Enhanced material properties that provide strength and endurance to increase performance and reliability in drilling, tubular goods, and rotating parts.**
- **Design properties to enhance hydro-phobic or hydrophilic behavior.**
- **Lightweight, rugged materials that reduce weight requirements on offshore platforms, and more-reliable and more-energy-efficient transportation vessels.**
- **Nanosensors for improved temperature and pressure ratings in deep wells and hostile environments.**
- **New imaging and computational techniques to allow better discovery, sizing, and characterization of reservoirs.**
- **Small drill-hole evaluation instruments to reduce drilling costs and to provide greater environmental sensitivity because of less drill waste.**



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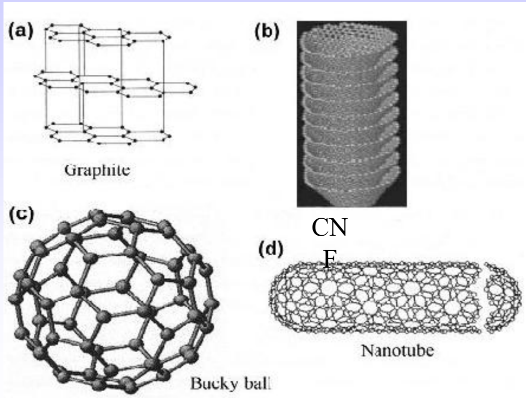
Nanotechnology in Petrochemicals Industry!!

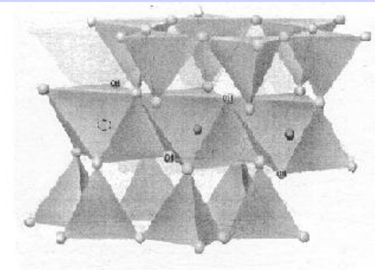
Nanomaterials for the Petrochemicals Industry

Nanomaterials

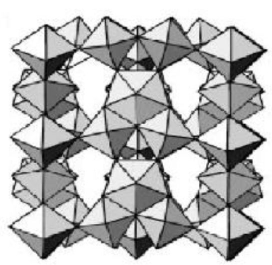
Carbon, Inorganic and Hybrid



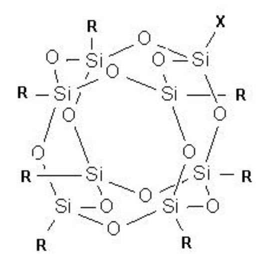
Carbon nanomaterials



Nanoclay/ layered silicate
www.nanocor.com



Zirconium Tungstate



POSS Nanoparticle, Hybrid

- **Nanosize materials have different properties than microsize materials.**
- **Very high surface to volume ratio.**
- **High strength to weight ratio.**
- **Exceptional mechanical, thermal, and electrical properties.**

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Polymer Nanocomposites

Polymer nanocomposite is defined as combination of polymer matrix and a material which has at least one dimension in nanometer scale.

Superior Properties at Low Nanoparticle Concentration << 10 V %

- Improved Mechanical Properties
- Improved Barrier Properties
- Flame Retardant Properties
- Improved electrical and Thermal Conductivities
- Lower Thermal Expansion
- Low Specific Gravity Compared to Traditional Composites

Degree of property enhancement is a function of particle dispersion and Matrix-Particle interaction.

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Polypropylene- Layered Silicate (Clay) Nanocomposite

Mechanical Properties of Injection Molded HPP Nanocomposites

Process	PP Type	Addition Level (%)	Tensile Mod. (Mpa)	Flexural Mod (Mpa)	HDT (C)
Injection Molding	Homopolymer (Low melt flow)	-	1412	1148	87
		6%	2804 (+98%)	2043 (+78%)	116 (+33%)
Injection Molding	Homopolymer (medium melt flow)	-	1327	1196	86
		6%	2180 (+64%)	1777 (+49%)	109 (+26%)

Barrier Properties of Polyolefin Nanocomposite Films

Film Process	PP Type	Addition Level (%)	OTR (cc-mil/m^2 day)	CO_2 (cc-mil/m^2 day)	H_2O (g-mil/m^2 day)
Cast	Random Copolymer	-	3.35 E+03	1.38 E+04	0.22
		6%	2.54 E+03 (+24%)	0.72 E+03 (+47%)	0.19 (+14%)
Cast	TPE	-	1.82 E+03		
		6%	1.27 E+03 (+30%)		

Substantial improvement in the Mechanical and in the Barrier properties of nanocomposites of injection- molded and extruded polypropylene at small (6 %) nanofiller fraction

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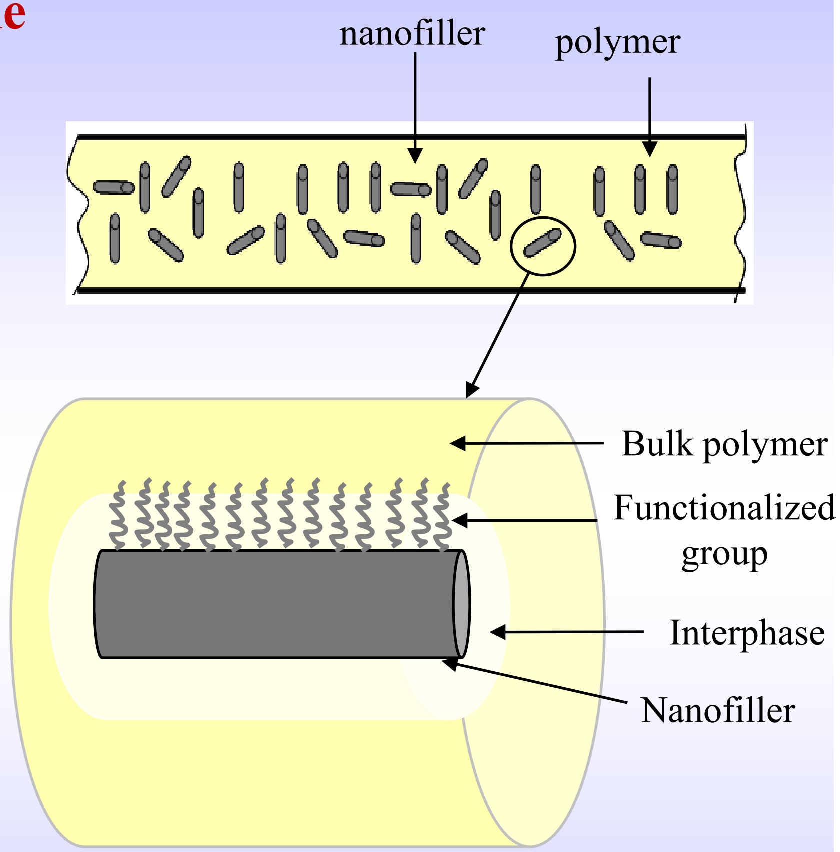
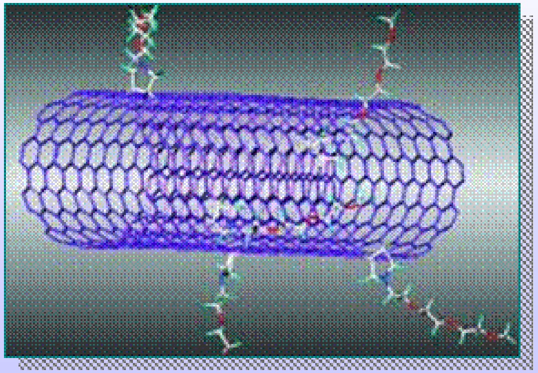
In Search of a Quantum Leap in performance improvement at less than 1% nanoparticle

- Proper functionalization of nanomaterials is critical for increased matrix compatibility and optimum dispersion

- Performance of a nanocomposite is based on three characteristic.
  - Properties of polymer and nanofiller.
  - Interfacial interaction between the nanofiller and the polymer matrix.
  - Orientation of the nanofillers.





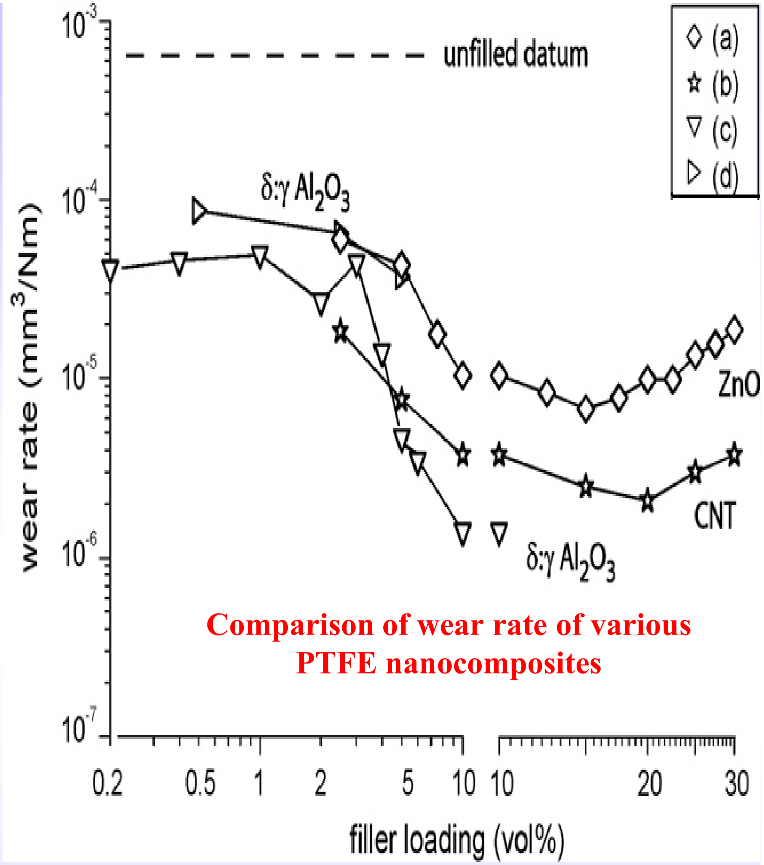
Functionalized Carbon nanotube

Wear Rate Reduction in Polymers by the Incorporation of Nanomaterials

Fluoropolymers (TEFLON)

Characteristics

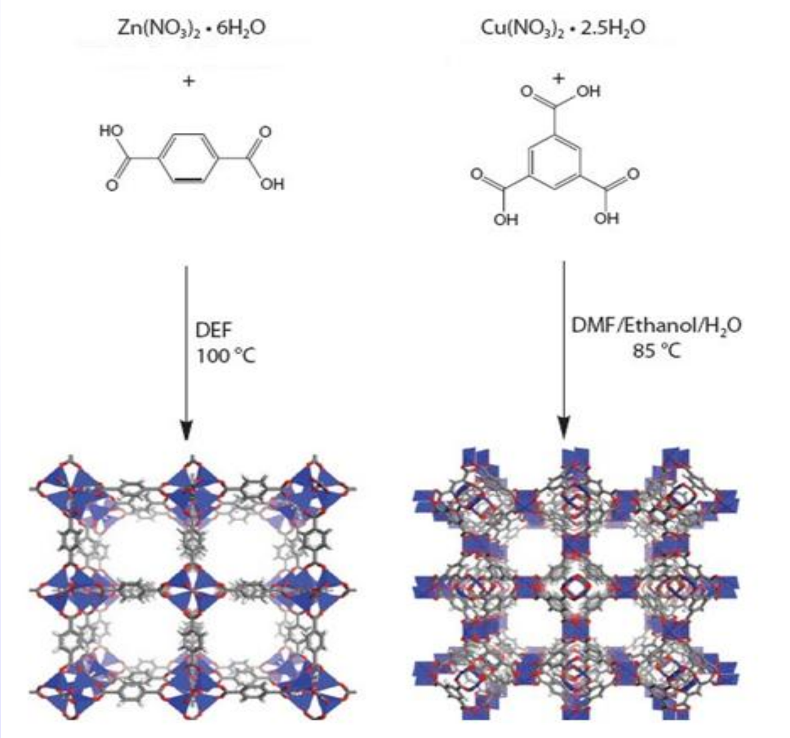
- Low Friction
- High Temperature
- Chemically Inert
- Hydrophobic
- High Wear Rate
  - Lower wear rate by incorporation of filler particles - at the expense of other properties
  - **Nanofillers** – more effective at small percentages - can have high number density and surface area



Comparison of wear rate of various PTFE nanocomposites

It takes 10% of unfunctionalized nanoparticle to lower the wear by 2 orders of magnitude

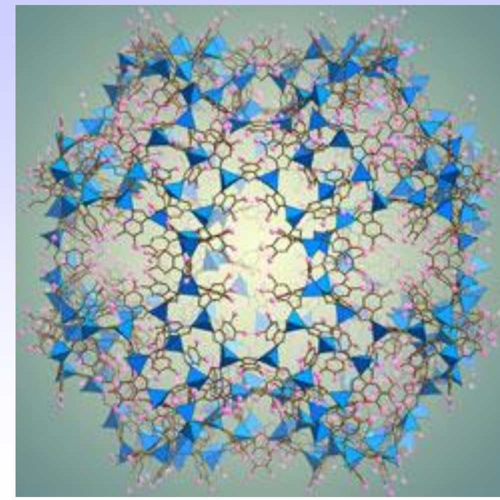
- Metal-Organic Frameworks (MOFs)
  - Crystalline Compounds
  - Make up: Metal Ions, Ligands, and Linkers (Inorganic Polymers)



MOFs of Different Pore Size Resulting from Different ligands and Metal Ions

- Metal-Organic Framework (continued)
  - Easy and Inexpensive Synthesis
  - Tailored to Specific Applications by Varying the Metal, Ligands, and Linkers
  - Limitless Number of MOF’s with Distinct Properties
  - Can be Porous with the Pore Size Dictated by Metal and Linkers
  - Highest Surface Area > 6000 m^2/g

- Applications
  - CO_2 Separation and Capture
    - Gas Streams
      - Fuel Gas
      - Sour Natural Gas
      - Flue Gas
    - Different Pressures and Concentrations
    - Chemical Binding Capability is Necessary for Low Concentration and Low Pressure CO_2
    - MOFs Highly Selective Membranes for CO_2 Separation
    - MOFs can Trap and Store CO_2 (low temperature adsorbents for carbon dioxide)
    - Can Store Hydrogen Gas

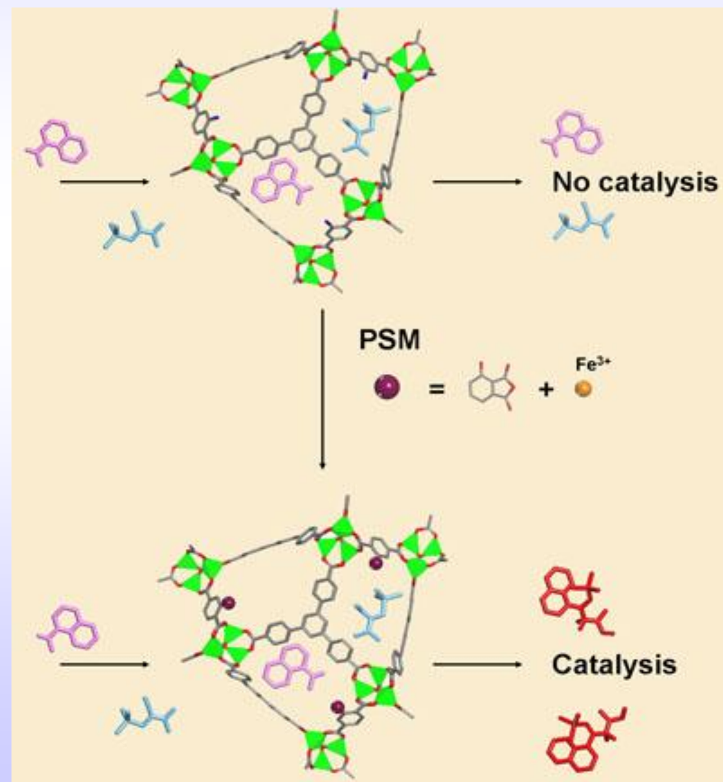


The structure of ZIF-100 MOF

– Catalysis

- Catalytic Function Tethered to Framework
- Post Synthetic Modification
- Efficient Catalyst
- Can be Recovered and Recycled

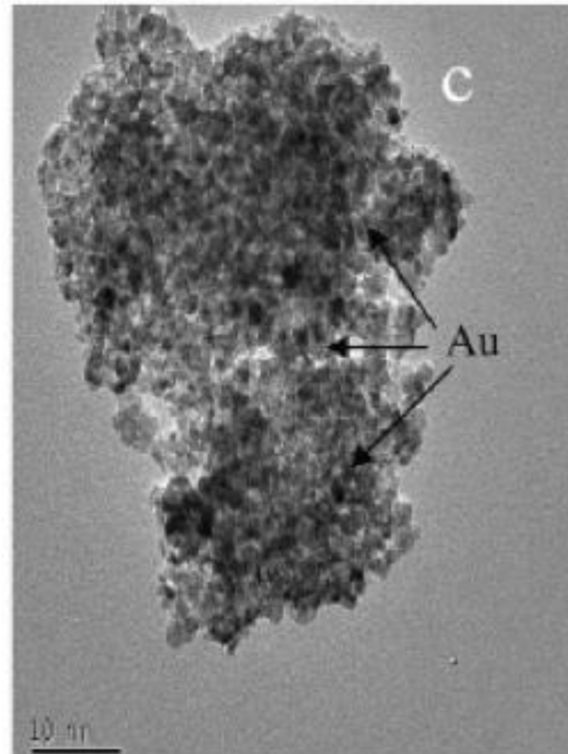
A metal-organic framework is metalated and transformed into an active, robust, reusable catalyst using postsynthetic modification (PSM)



Heterogeneous Catalysis: An early adoption area of Nanotechnology

Heterogeneous catalysts contain highly dispersed metal or metal oxide particles (<1 nm - 100 nm) on high surface area oxide supports

S. Rojluechai, S. Chavadej, J. Schwank, V. Meeyoo, Catalysis Communications 8 (2007), 57-64



Au/TiO_2

The next 10 slides are taken (with permission) from Nano-catalysis: a new frontier?

Johannes Schwank/ Professor of Chemical Engineering/ Director, Transportation Energy Center/ University of Michigan/ Ann Arbor, MI 48109-2136/ schwank@umich.edu/ 734-764-3374

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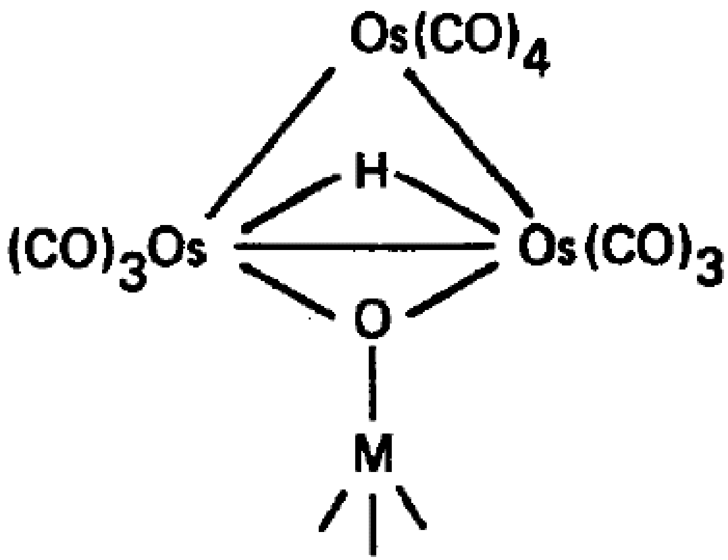
Synthesis of nanostructured catalytic materials

- Conventional preparation of supported catalysts
  - Impregnation of support with solution of precursor of the catalytic species
    - Challenge: controlling particle size distributions
  - Incipient wetness or capillary impregnation
  - Precipitation
  - Ion exchange
- Advanced methods:
  - Anchoring of organometallic clusters onto oxide supports
  - Electrostatic adsorption
    - Precursor ions having charge opposite to that of support (surface charge of Al_2O_3 or SiO_2 tend to be negative)
  - Successive ionic layer deposition (SILD)
  - Sol-gel synthesis
  - Spray pyrolysis
  - Pulsed laser deposition
  - Electron beam evaporation
  - Molecular beam epitaxy (MBE)

Pulsed Laser Deposition System

Controlled synthesis of nanostructured catalytic materials

Anchoring of organometallic clusters



Refluxing n-octane solution of cluster in presence of γ-alumina support particles

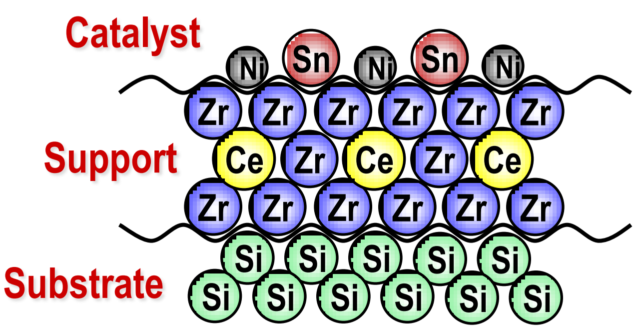
'Alumina-Supported Triosmium Clusters and Ensembles: Characterization by High-Resolution Transmission Electron Microscopy', J. Schwank, L. F. Allard, M. Deeba, and B. C. Gates, Journal of Catalysis **84,** 27-37 (1983)

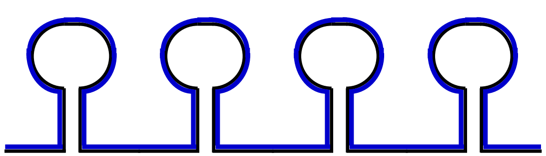
Successive Ionic Layer Deposition (SILD)

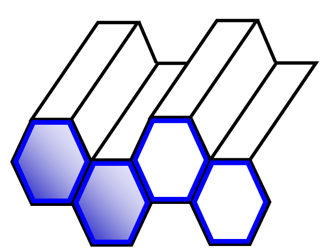
- Aqueous technique for synthesizing thin solid films on a support in a layer-by-layer fashion.
- Monolayers of aqueous cations and anions are repeatedly adsorbed on the support
- Flexibility to systematically choose the deposited material's composition and thereby produce multicomponent or functionally graded nanolayers
- Low-cost fabrication method for
  - biochemical or gas sensors
  - optoelectronic devices
  - biocompatible or passivating coatings
  - electrocatalysts
  - heterogeneous catalysts

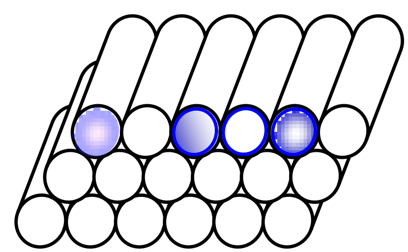
SILD

- Inexpensive technology
  - Simple, benchtop equipment
  - Low temperatures, atmospheric pressure
- Nanoscale surface modification
  - Controlled by the chemistry
- Multicomponent functionality
- Conformal deposition
  - Allows one to coat the surface of complex geometries or inside of channels and pores









Computational approaches for predicting properties and function of nano-engineered catalytic surfaces

Density-functional theory (DFT)

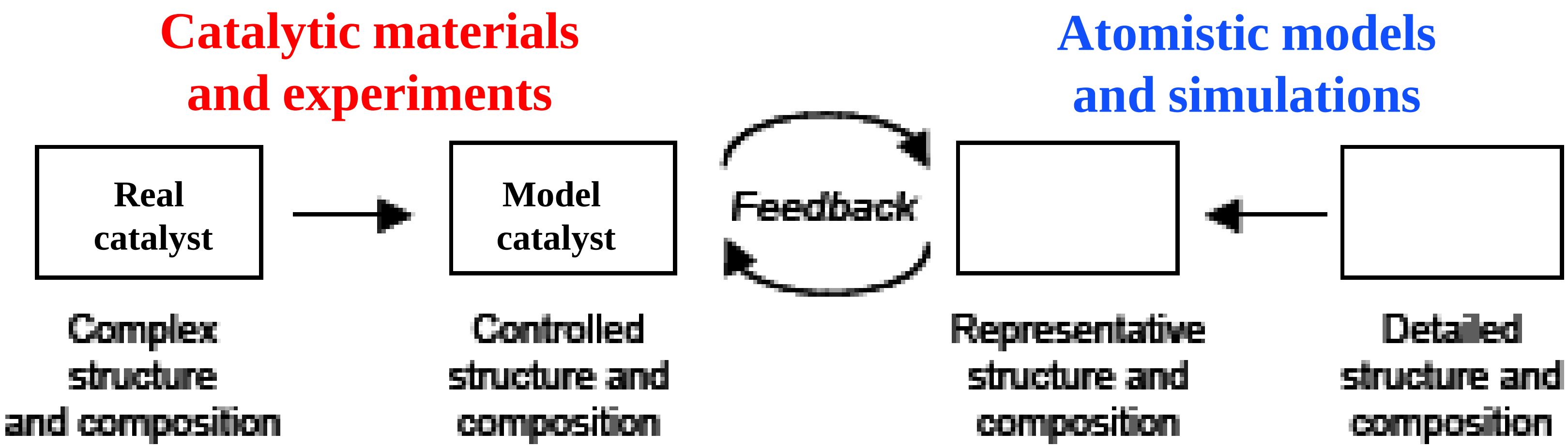
Electron density is a very convenient variable

- Physically observable
- Has intuitive interpretation
- Depends only on three spatial coordinates

DFT Simulations:

- Energetics and stability of catalytic surfaces
  - Particle nucleation, agglomeration, and sintering
  - Surface reconstruction
  - Surface alloys vs. bulk alloys
  - Surface segregation
- Gas-solid interactions
  - Adsorption strength
  - Reaction kinetics
  - Molecular transport
  - Mechanistic aspects

Bridging the materials gap



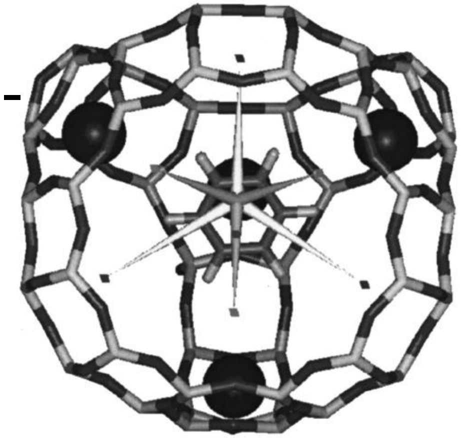
Developing deactivation-resistant nickel catalysts

- Utilize DFT to study
  - Carbon chemistry over Ni surfaces
  - Develop carbon-tolerant alloy catalysts
- Steam reforming of hydrocarbons on Ni and Ni alloy catalyst
- Characterize the catalysts using various microscopy and spectroscopy techniques

Eranda Nikolla, Adam Holewinski, Johannes Schwank, and Suljo Linic
J . AM. CHEM. SOC. 2006, 128, 11354-11355

The new frontiers

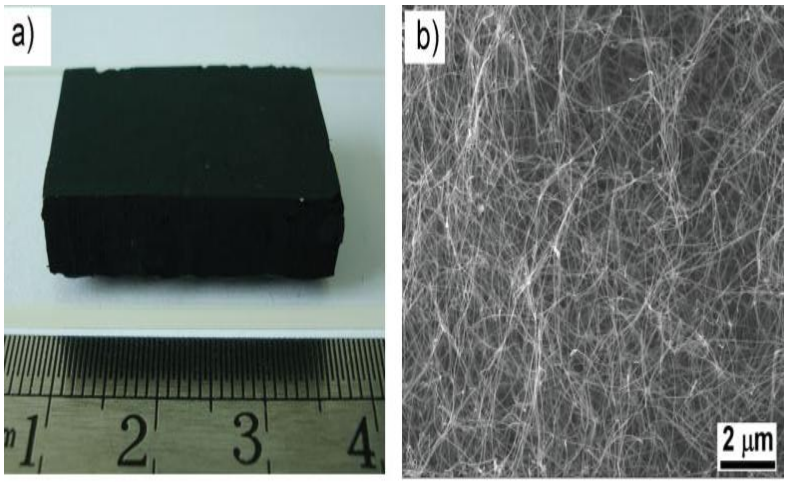
- Use nanotechnology, coupled with high-throughput combinatorial synthesis of materials to discover new catalysts
- Develop methods for preparation of uniformly dispersed nanoparticles on support
  - Sintering resistance via nano-composite structures
  - Deactivation resistance through theory-guided synthesis of multi-component surfaces
- Incorporate nano-scale catalyst particles into well-defined three-dimensional multifunctional structures
  - Zeolites with well-defined pore diameters
  - Monoliths

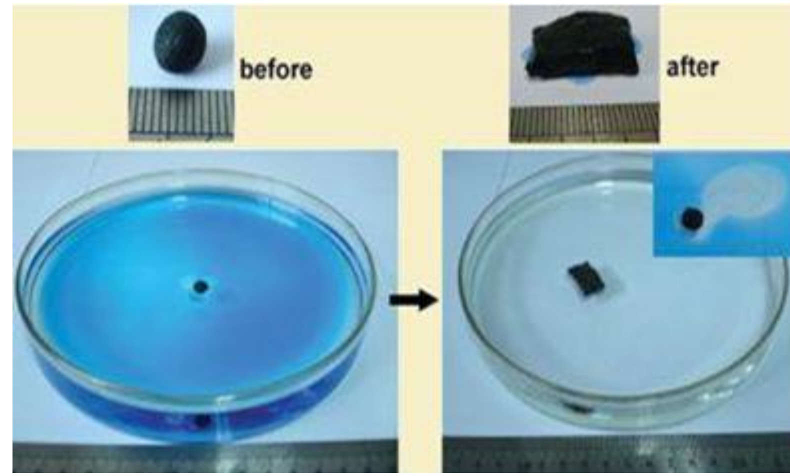


The future: “smart catalytic devices” ?

- Thin film deposition has progressed far beyond simply putting nano-films on substrates.
- Micromachining permits the fabrication of smart catalysts with embedded chemical microsensors.
- The field of heterogeneous catalysis will move towards “smart” catalytic systems with integrated sensors and distributed temperature and multi-port feed control systems.
- These new nano-engineered smart catalyst systems will revolutionize the ways catalytic processes are used for protecting the environment and for manufacturing petrochemicals.

Nanotechnology For Clean Air and Water





CNTs can absorb up to 180 times of its weight for wide range of oils and solvents in water

X. Gui et al., Adv. Materials, Adv. Mater. 2010, 22, 617–621

Nano metal oxide as air purification catalyst

Nanotechnology can improve the quality of our live

Current state of the art Gas Sensor Technology

❖ **Current sensors are generally based on thin films**

- ✓ **These sensors have limited detection (generally ppm level detection)**
- ✓ **The power consumption is in mW.**
- ✓ **These thin film based sensors operate relatively at higher temperatures (above 200°C)**
- ✓ **Poor selectivity and expensive**

Gas sensors demand in petrochemicals industry

- ✓ Room temperature operation
- ✓ Miniature sensor devices (nanomaterial based)
- ✓ Detection level (ppb)
- ✓. High selectivity
- ✓ Robustness, stability and durability
- ✓ Low power consumption

Engineered Metal-oxide Nanostructures (MOXN) provides solutions to overcome the problems of conventional gas sensor devices

1. **MOXN and modified MOXN based sensors can operate at room temperature.**
2. **Nanostructured material can provide miniature and portable sensor devices**
3. **MOXN based sensors can provide best selectivity, stability and sensitivity and durability based on their small size but large surface-to-volume ratio.**

Engineered Metal-oxide Nanostructures (MOXN) provides solutions to overcome the problems of conventional gas sensor devices

- ✓ We also should be able to optimize the detection sensitivity for various gases by controlling the properties of the MOX nanostructures.

- ✓ The power consumption of the MOXN gas sensors is very low compared to conventional thin film sensors and is in the mW range.

- ✓ Particularly Metal oxide core-shell heterostructured nanomaterials are expected to give us added flexibility in terms of improving the detection sensitivity, recovery characteristics and long-term stability

Center of Excellence in NanoTechnology

King Abdullah Vision on Nanotechnology

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King Abdullah Vision on Nanotechnology

- رافدا من روافد التنمية والاقتصاد الوطني في عصر المنافسة الحرة
- مصدرا من مصادر تنوع الدخل وتوفير المزيد من فرص العمل النوعية للشباب
- تشكيل صناعة المستقبل وتعزيز عناصر استمرار التنمية بأبعادها الحقيقية
- طريقا إلى تبوأ المملكة مكانة مرموقة على المستويين العلمي والتعليمي
- تفعيل كافة الجوانب البحثية للتطبيق العلمي في مشروعات المملكة التنموية
- أن تصبح التقنية الحديثة إحدى الركائز الصناعية


الرياض

الملك عبدالله يرعى المؤتمر العالمي لصناعات تقنية النانو في القرن ال 21 .. الأحد المقبل


معهد الملك عبد الله لتقنية النانو يلحق بركب التقدم

الثورة التقنية التي تلغي العلوم التقليدية وتغير جوهر الصناعات


جامعة الملك عبدالله.. تواجه تحديات المملكة بتقنيات النانو لتحقيق اقتصاد معرفي


الشرق الأوسط

الملك عبد الله يتبرع بـ 3.2 مليون دولار لاستكمال برنامج النانو في جامعة الملك سعود

King Abdullah Vision on Nanotechnology

- جعل المملكة فى مصاف الدول المتقدمة في تسخير مواردها للبحث العلمي واحتضان العلماء ليكرسوا خبراتهم وتجاربهم لوضع الحلول للعقبات التي تعترض التنمية والاقتصاد والبيئة والصناعة وترتبط مباشرة بالعجلة الاقتصادية لكي تزاوج بين البحث العلمي وحاجات التنمية الصناعية والاقتصادية في البلاد
- الاستفادة من التطبيقات الحديثة في العالم من أجل الوصول بالمملكة العربية السعودية إلى مصاف الدول الأكثر تقدما في استخدامات تقنية النانو في مجالات التنمية
- تأهيل الخبراء السعوديين في هذا المجال
- الدفع بالوطن قدماً نحو مجالات تقنية متقدمة
- توطين التقنية وتأهيل الخبرات المحليّـة في العلوم الأساسية والتطبيقية


arabianbusiness.com

/ تقنية / أخبار

ملك السعودية مهتم جداً بتقنية النانو

منذ فترة والملك السعودي عبدالله بن عبدالعزيز يولي إهتماماً شديداً بالتقنية المتناهية الصغر "النانو". ولعل من آخر أوجه إهتمامه بهذا المجال الذي أحدث ثورة علمية هو رعايته الشخصية للمؤتمر الدولي للتقنيات متناهية الصغر)النانو) والذي تنظمه جامعة الملك عبدالعزيز في مدينة جدة في يونيو القادم.

وستدعى السعودية نخبة من أبرز المتخصصين في علوم وتقنيات النانو على المستوى العالمي ليشاركوا في هذا المؤتمر.

ولعل عنوان المؤتمر « الفرص والتحديات» يبين التطلعات المرجوة من خلفه ,وستتمثل المحاور الرئيسة للمؤتمر في مناقشة التحديات العالمية والفرص لتقنيات النانو، ومناقشة الحاضر والمستقبل لوحدات البناء وتقنية النانو الحيوية. كما سيتم تخصيص محور للحديث عن الأنظمة والأدوات النانية وتقنية النانو من أجل طاقة نظيفة متجددة، هذا بالإضافة إلى مناقشة صناعة تقنية النانو في المملكة والعالم العربي.

ويهدف المؤتمر كما ذكر بين رسمي نقلته وكالة الأنباء السعودية، إلى فتح نافذة جديدة على آخر المستجدات بمختلف تخصصات تقنيات النانو، كما سيتم التركيز على الجوانب والتطبيقات والفرص المتاحة في المملكة لبعض الصناعات الجديدة التي تعتمد أساساً على تقنيات النانو.

Nanotechnology R&D in the Kingdom

KAU

KAIN

KAUST

KACST/ CENA

universities

CENT

NSTP

CENT
KFUPM
Center of Excellence in NanoTechnology

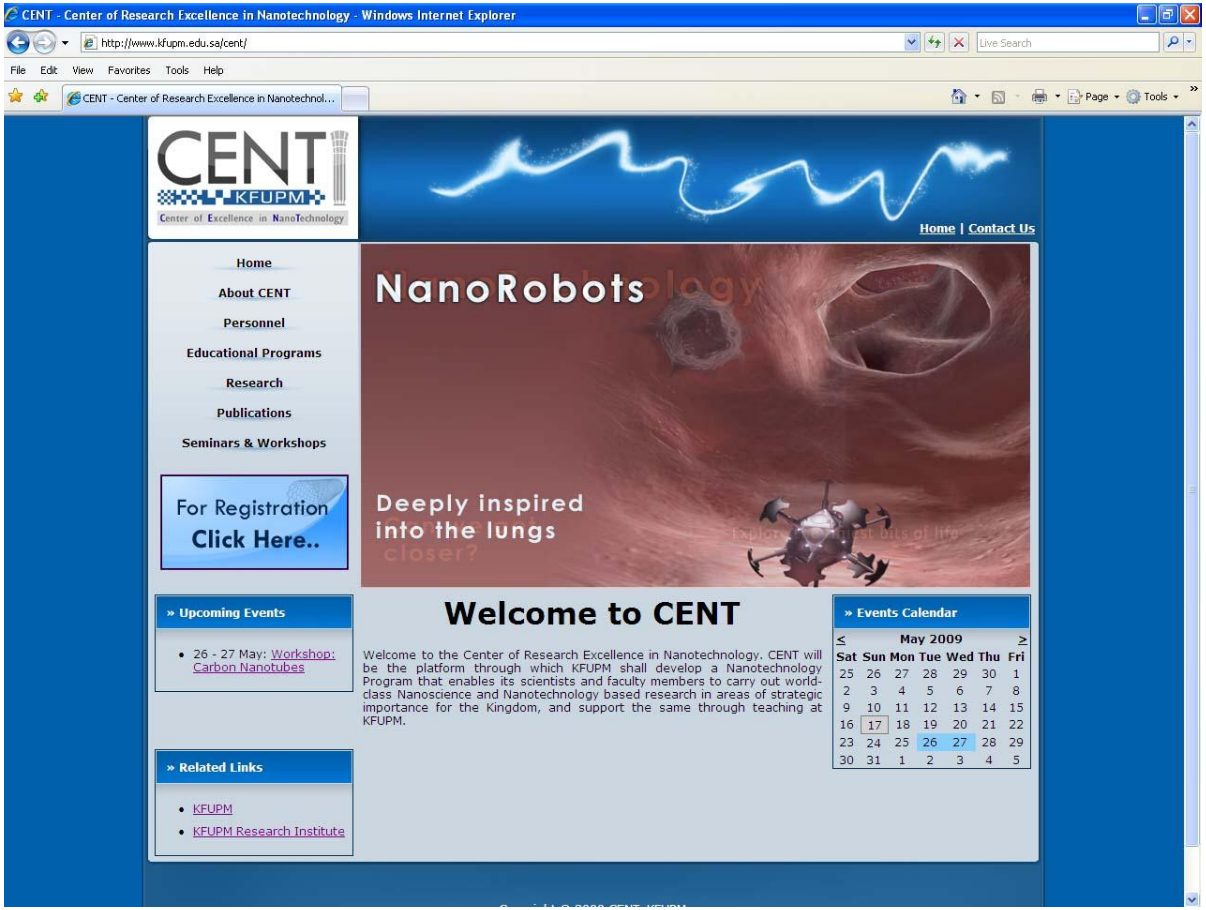
Where are we?

CENT is here!!!!

What is CENT?

Center of Excellence in NanoTechnology

Check our website



www.kfupm.edu.sa/cent

CENT: Vision and Mission

Vision:

CENT shall be an internationally recognized leading research center that develops innovative research and cutting edge knowledge in the field of Nanoscience and Nanotechnology

Mission:

CENT will be the platform through which KFUPM shall develop a Nanotechnology Program that enables its scientists and faculty members to carry out world-class Nanoscience and Nanotechnology based research in areas of strategic importance for the Kingdom, and support the same through teaching at KFUPM.

CENT KFUPM
Center of Excellence in NanoTechnology

CENT: Objectives

1. To build up a world class human resources research capacity including highly qualified scientists and staff and trained graduate students in the field of nanomaterials synthesis and their characterization & applications.

2. To develop a research infrastructure including state of the art facilities that enables the Center to achieve its goals.

3. To develop innovative nanotechnology-based solutions in **strategic areas for the Kingdom related mainly to petroleum and petrochemicals industries**.

4. To establish Industrial Partnerships with relevant companies and entrepreneurships as a step toward commercialization, in coordination with DTV.

5. To contribute to the development of teaching graduate programs and training students in the field of nanotechnology.

6. To promote public awareness regarding the benefits and the risks of nanotechnology.

CENT Areas of Focus

focusing on the *petroleum and petrochemicals industries*.

1. **Nano-engineered Catalytic Materials**
2. **Nano-structured Materials for Sensing Applications**
3. **CNT Applications**

CENT KFUPM
Center of Excellence in NanoTechnology

Equipments

Focused Ion Beam Stations

Tensile testing machine for metals and polymers

Advanced Optical Microscope

Gas Chromatograph

Gas Chromatograph Mass Spectrometer

Ultra Performance LC

Micro CT Scanner

Autoclave

CENT KFUPM
Center of Excellence in NanoTechnology

Spectrofluorometer with combined steady state and lifetime capabilities

Glove Box

Raman System

Pulsed Laser Deposition System

Surface area analyzer

Furnace

Semiconductor device analyzer

Tunable pulsed dye laser

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Potentiostat/galvanostat

Contact Angle Measuring Device

Solar Simulator

Sputtering Device

Planetary Ball Mill Machine

Ultra Sonicator

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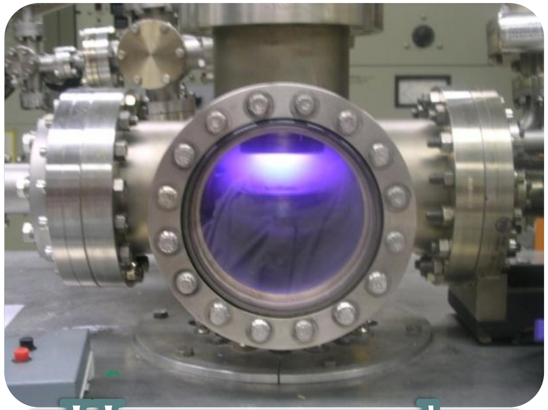
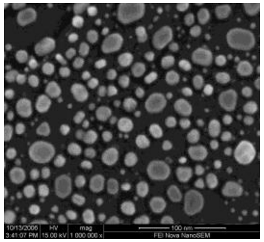


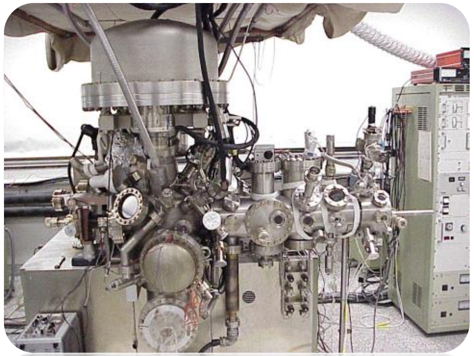
Home-made DC-Magnetron

XPS

XRD



TEM



XPS- Spectrometer

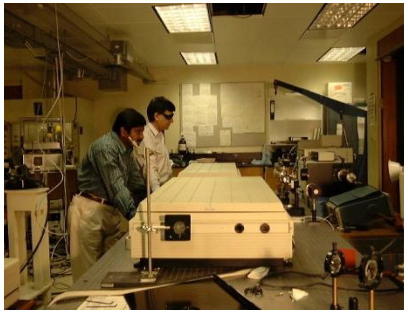
SEM

AFM/ STM

Lasers

AFM/STM

http://www.veeco.com/promo/innova/



PVD/ CVD

CENT Capabilities and Research Areas of Interest

- Development of highly active and nanostructured catalysts for ultra-clean fuel. This includes the removal of sulfur and nitrogen containing compounds. In addition, removal of heavy metal complexes from natural gas is also under the scope of CENT research activities.

- CENT team has the expertise to conduct research and development activities in the area of composites, such as PP/CNT, PE/CNT, PTFE/CNT, etc., for many applications, including electronic packaging, coating, and electrochemical devices.

- CENT team has also the expertise and "know how" to convert the oil residues into manageable and valuable products.

- Develop sensors with quick responses and cost effective . With expertise of CENT team, it is possible to invent new nanostructured materials for sensing volatile organics and inorganics with ultra-low concentrations.

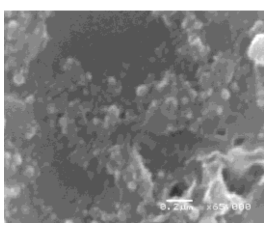
- Research and development of catalyst based on core-shell and nanostruture materials for clean energy processes, such as photocatalysis, hydrogen generation, carbon management, and fuel cells.

CENT KFUPM

Center of Excellence in NanoTechnology

Synthesis, characterization and applications of nanostructured materials

We use different synthesis methods: CVD, laser ablation, sputtering, flame pyrolysis, [laser pyrolysis], microwave combustion, sol-gel, chemical dispersion and functionalization



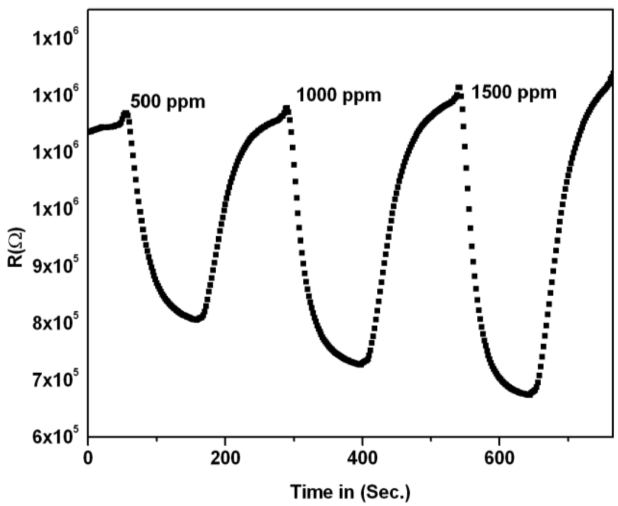
Laser and Nanotechnology

CENT KFUPM
Center of Excellence in NanoTechnology

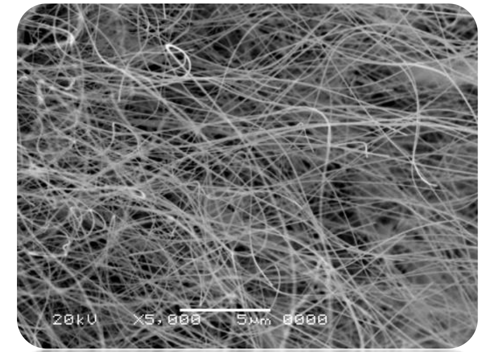
Zinc Oxide Nanowires/ Nanodots

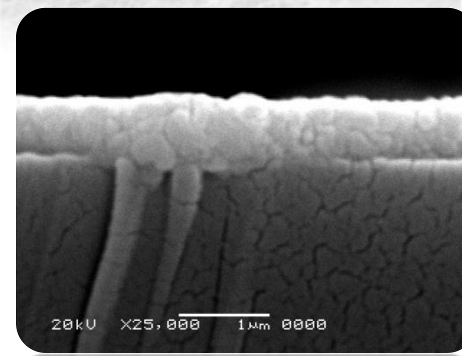
N. Tabet et. al (Physics & CENT)

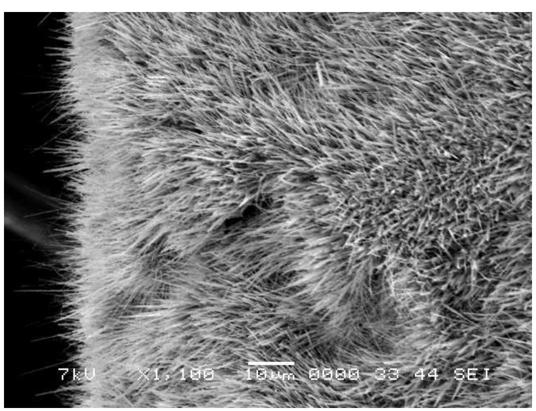
Dynamic and fast response of MW ZnO nanowires to H_2 gas at different temperatures

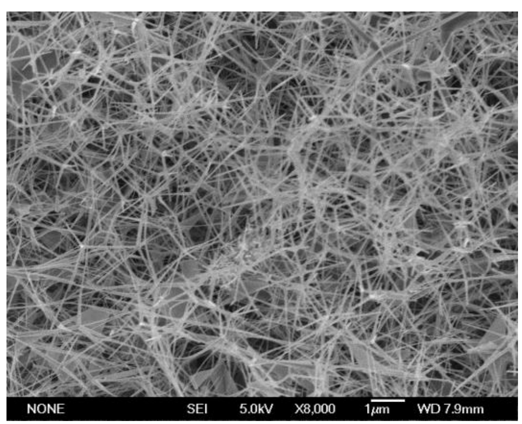


Operating temp. 200°C temp.
Measured by Dr Ahsan,
Tokayama, Japan, Oct. 2008.
Unpublished

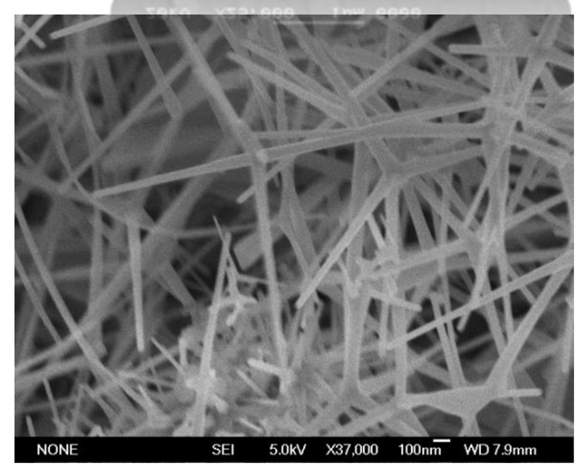




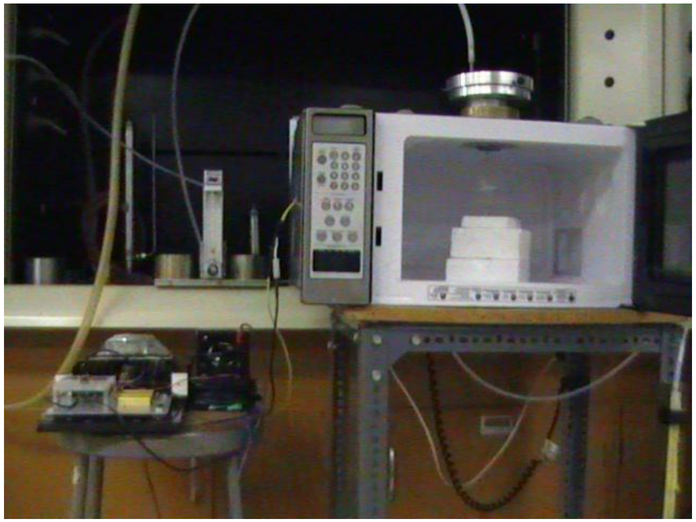


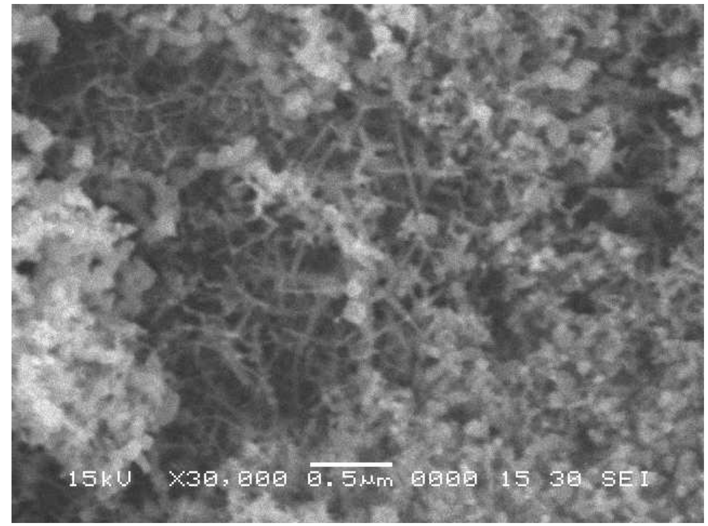


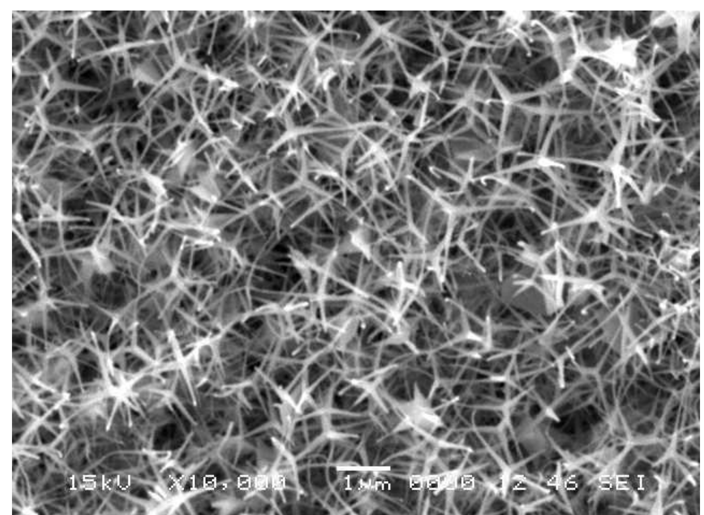
VIDEO



Flame Pyrolysis and
Microwave Combustion
Saleh Al-Quraishi/ N. Tabet







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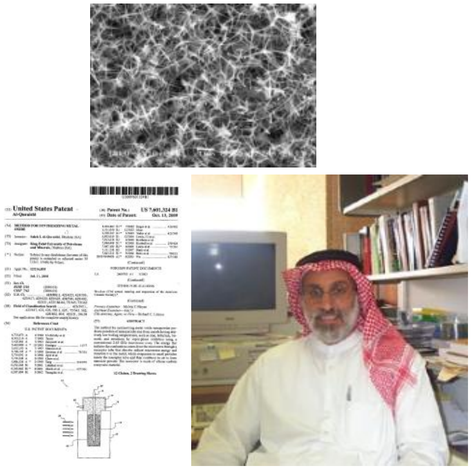
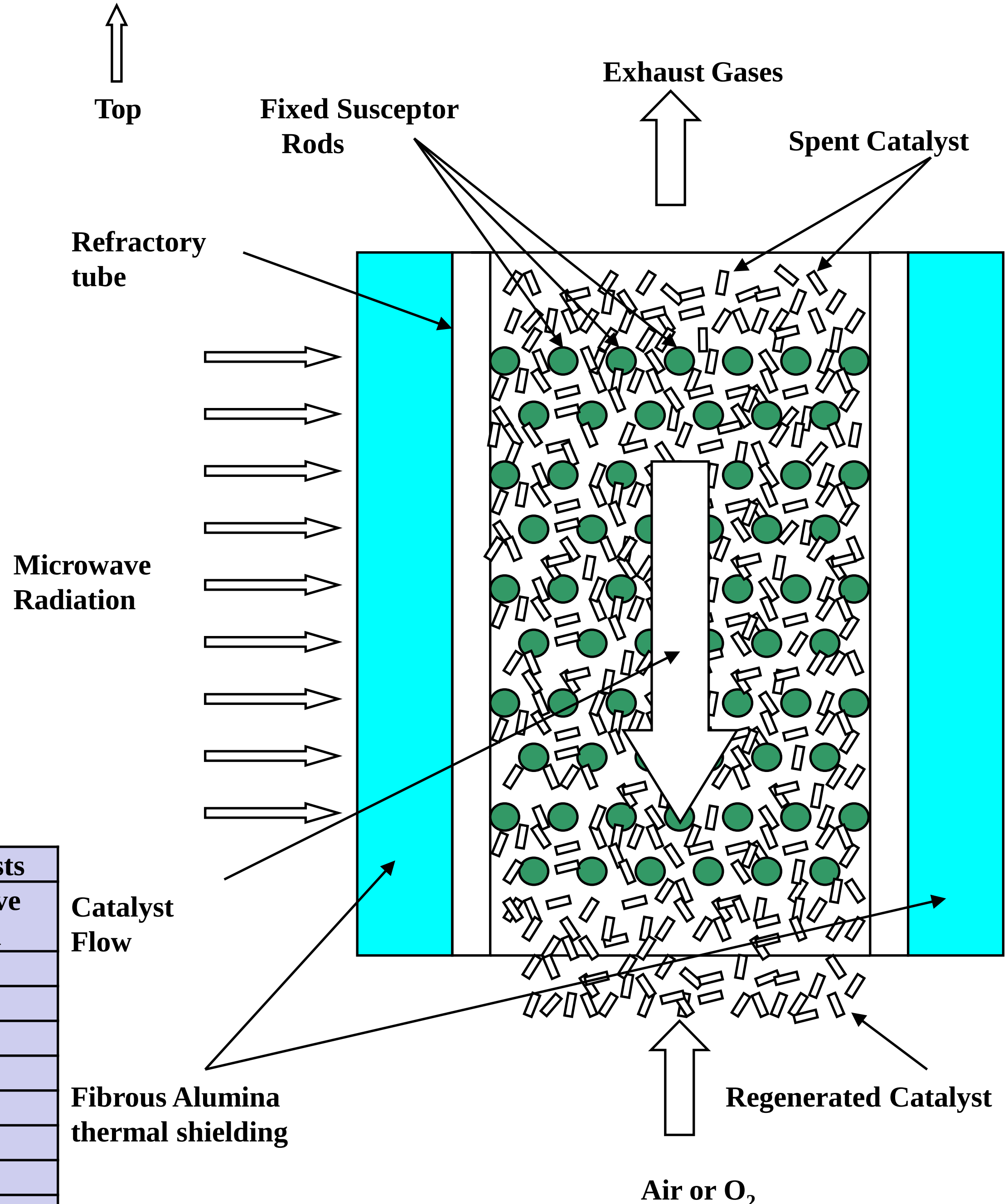
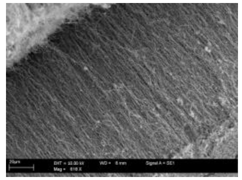
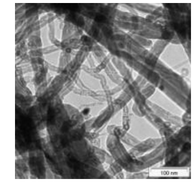


Dr. Saleh Al-Quraishi

Composition	Feed	Product with Catalysts	
		Fresh	microwave Treated
Wt. %			
N-Paraffin	5	3.1	1
I-Paraffin	56	50	47
Olefin	0	0	0
Naphthenes	31	40	46
Aromatics	8	7	6
Octane number	68	78	79
Delta Octane	base	10	11
Activity, %	base	29	48







Carbon Nanotube Research Unit (CNRU)

PhD and MSc Students working under CNRU

Issam Amr (PhD. Student)

Zahid Koker (PhD. Student)

Omar Bakather (MSc. Student)

Osama Bin Dahman (MSc. Student)

Mahmoud Ghassan Halim (MSc. Student)

Salaman Al-Khaldi (MSc. Student)

Project Title: Study of the Structural Properties and Hydrodesulfurization Activity of MoS_2 and Co/Ni/MoS_2 Catalysts Prepared by Laser Pyrolysis

Investigators:	PI: Zain Yamani[(1)] Co-I: N. Tabet[(1)], Co-I: S. Ali[(2)] Frederick Schuster[(3)] Hicham MASKROT[(3)] (1) Center of Excellence in Nanotechnology and Physics Department, KFUPM (2) Center for Refining and Petrochemicals, KFUPM (3) Advanced materials Program, CEA-France

Fabrication of NP

Impregnation

Characterization

Testing for HDS

A 3-way collaboration, a subject that is important to the Kingdom, potentially supported by the Industry, potential IP ownership, not that much overhead

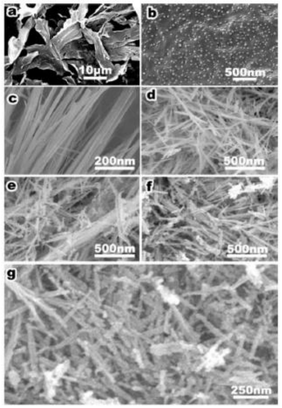


Figure 1. SEM images of a) 2H-MoS_2 powder, b) 2H-MoS_2 powder with 5.8 wt% Ni, c) MoS_2 nanotubes, d) MoS_2 nanotubes with 5.3 wt% Ni, e) MoS_2 nanotubes with 25.5 wt% Ni, f) MoS_2 nanotubes with

Adv. Mater. 2006, 18, 2561–2564

By *Fangyi Cheng*, *Jun Chen*,* and *Xinglong Gou*

Schuster, CEA-France

We like to <u>build a larger teams in the field of nano-engineered catalysis</u>

CENT sponsored NSTIP Projects

[May 2010]

Development of advanced and functional nano-structured mesoporous zeolites for hydrodesulphurization and other catalytic applications in petroleum and petrochemicals

Zeolite Nanosheets as a Materials Platform for Improved Refining Catalysts

Carbon Nanofibers Grown on 3-D Solid Structures for Applications in Energy-Related Catalysis

Development and characterization of high surface area metal carbides modified mesoporous carbons and ceramics for clean fuel and catalysis applications

Development of nano-structured metal phosphides for ultra-clean fuel and fuel cell applications

Development of Nitrogen-Modified CNTs as Pt-Free Catalysts for Fuel Cells

Electrochemical engineering of nano-structured materials for clean energy and energy conversion applications

Synthesis of Metal-Organic Framework Nanostructures for uptake of CO_2 and Hydrogen Storage

Design of Smart Fluids for Acid Delivery in Well Stimulation Treatment

CENT sponsored NSTIP Projects

[May 2010]

Electrospinning of Semiconductor Metal-oxide and Polymer Nanofibres for Ultra-sensitive Amperometric Sensor

Synthesis of Mesoporous and Microporous Metal-oxides Nanostructured Materials for Hydrocarbons and NO_x Sensors

Comparative Study of Conversion of Carbon dioxide into high-value hydrocarbons using nano- structured materials by solar and laser irradiation

Development of highly efficient visible-light-driven nanostructured materials for photocatalytic applications

Photocatalytic Splitting of Water over mixed metal oxyhalides-based Catalyst using Laser Radiation

Activity of laser enhanced nano-structured oxides of tungsten, nickel, zinc, iron and titanium against Candida and Aspergillus

Lanthanide-doped oxide nanoparticles for Multi-modality Molecular Imaging Agents

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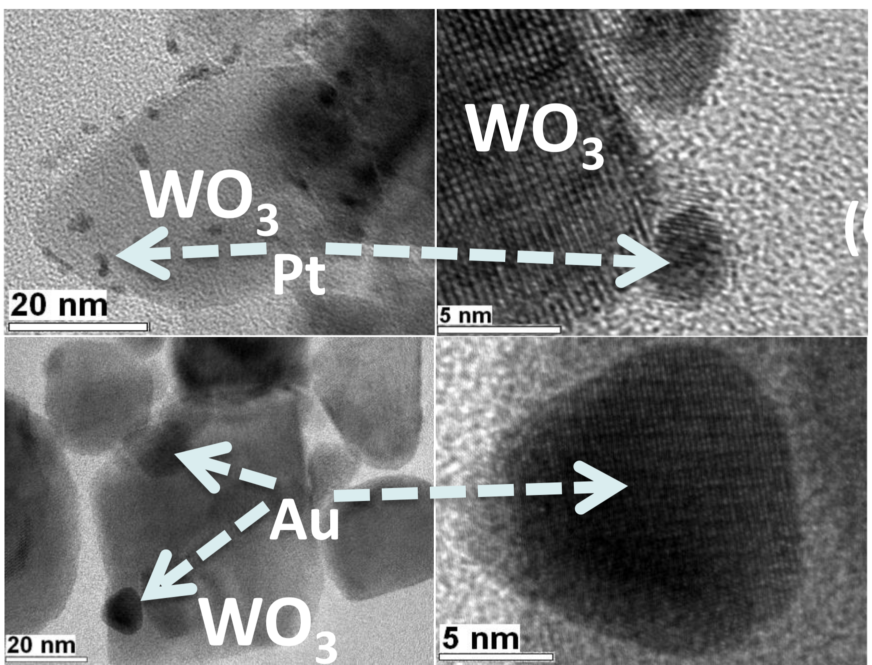
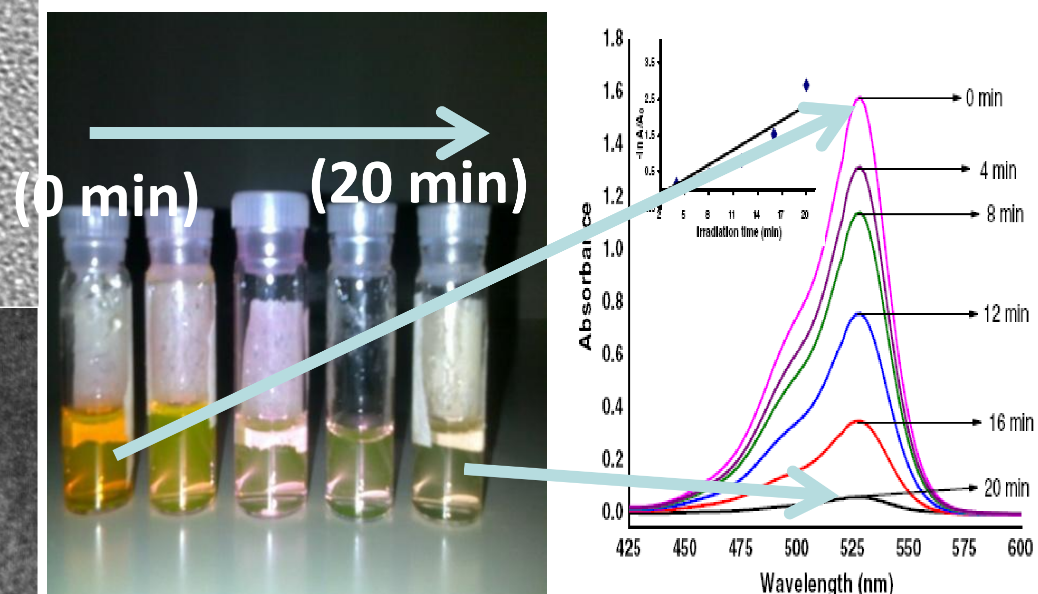
CENT cares about the environment

Development of nano-photocatalysts for water purification





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Future Development: Scaling up photocatalysis

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Catalysis Communications

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ELSEVIER

Synthesis of highly active nanocrystalline WO_3 and its application in laser-induced photocatalytic removal of a dye from water

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ABSTRACT

Tungsten oxide nanoparticles were synthesized using the sol–gel process and applied for heterogeneous photocatalytic removal of a dye using a 355 nm laser radiation generated from Nd:YAG for the first time. Effect of various parameters, such as calcination temperature, calcination time, catalyst concentration and laser energy on the photocatalytic removal of dye has been investigated. The study showed that

Contents lists available at ScienceDirect

Journal of Hazardous Materials

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ELSEVIER

Laser-induced removal of a dye C.I. Acid Red 87 using n-type WO_3 semiconductor catalyst

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ABSTRACT

Water contamination by organic substances such as dyes is of great concern worldwide due to their utilization in many industrial processes and environmental concerns. To cater the needs for waste water treatment polluted with organic dyes, laser-induced photocatalytic process was investigated for removal of a dye derivative namely Acid Red 87 using n-type WO_3 semiconductor catalyst. The degradation was investigated in aqueous suspensions of tungsten oxide under different experimental conditions using

Contents lists available at ScienceDirect

Catalysis Communications

journal homepage: www.elsevier.com/locate/catcom

ELSEVIER

Synthesis of nano-WO_3 and its catalytic activity for enhanced antimicrobial process for water purification using laser induced photo-catalysis

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ABSTRACT

Nano-WO_3, synthesized by sol–gel method, in conjunction with 355 nm pulsed laser showed a significant enhancement in the photo-catalytic activity in the process of disinfecting *Escherichia coli* microorganism in water. The bacteria decay rate was estimated for different catalytic concentrations and laser pulse energies and the decay rate increased as high as 0.94 min^{-1} as compared to 0.65 min^{-1} for the micro-

Contents lists available at ScienceDirect

Applied Surface Science

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ELSEVIER

Spectroscopic characterization approach to study surfactants effect on ZnO_2 nanoparticles synthesis by laser ablation process

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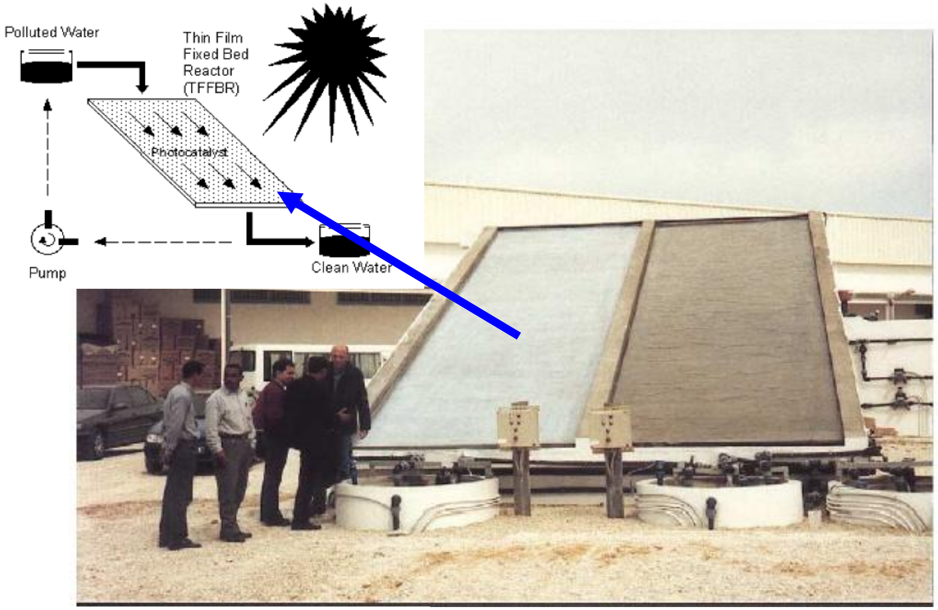

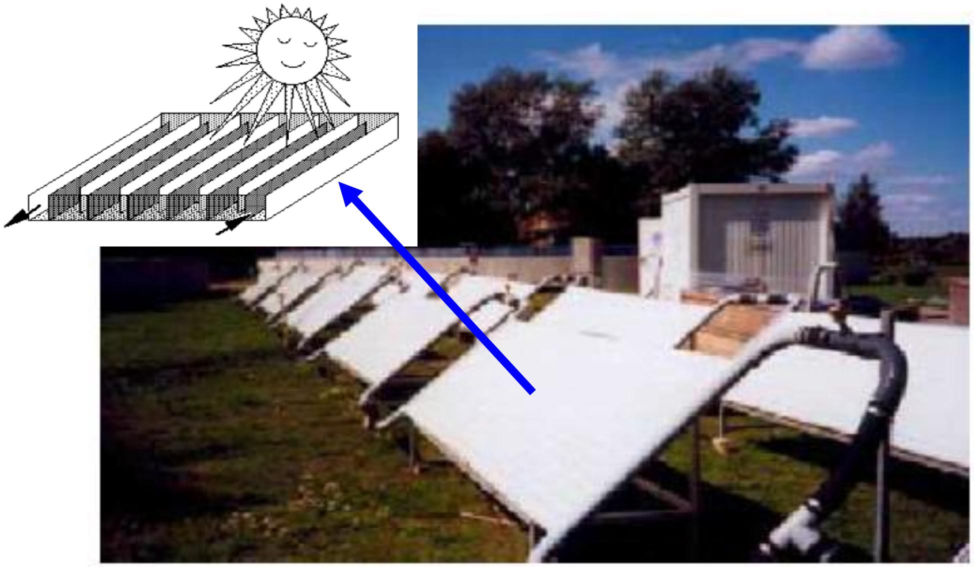

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- 1997-1999, Post-doc, Univ. of Windsor, Canada
- 1999-2006, Fuel Cells Research Scientist, GM, R&D, Mi, USA
- 2006-2010, Research Staff, UTC, CT, USA
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- 2008-present, Joined CENT at a Post Doctoral Fellow
- 2 South Korean patents
- Over 25 International journal papers

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- **Over 30 papers in international journals**
- **Presented more than 45 papers in international and domestic (Japan and Korea) conferences and proceedings oral as well as posters.**
- **Best poster Award (Korea Japan materials conference 2007) etc.**
- **Regular reviewer Sensors and Actuators B, Material research Bulletin Jalcom etc.**

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- **2008-2009, Research assisnt. Polymers and Materials Science (ECPM) of Strasbourg.**
- **2009-2010, Research assisnt, Laboratory of Applied Organometallic Chemistry (LCOA) at the University Louis Pasteur of Strasbourg**

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- **2009, Ph.D, Pennsylvania State University, University Park, PA, USA**
- **He has been graduate research assistant at National Research Center, Cairo, Egypt and Pennsylvania State University, USA**
- **Visiting Scholar (internship), Max Planck Institute for Iron Research, Düsseldorf, Germany**
- **Served as assisnt lecturer and teaching at National Research Center, Egypt and Pennsylvania State University USA.**
- **Over 15 papers in International journals in addition to few invited talks**
- **Received several distinctions and awards**

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• 2009, Ph.D, Chemical engineering, Technische Universiteit Eindhoven , Netherlands.

•Visiting researcher Laboratory of Industrial Chemistry, Åbo Akademi Process, Finland .

• Visiting research associate at Catalysis and Process Intensification group, The Petroleum Institute, Abu Dhabi, UAE.

• worked as Production supervisor in many industries including DOW Chemical Indonesia, Shell Global Solutions International BV etc.

• Received many awards and scholarships

• Over 20 publications including international journals and proceedings

Dr. NEDAL Y. ABU-THABIT

• 2010, Ph.D, Chemistry, KFUPM Saudi Arabia.

• Familiar with many characterization tools including NMR, GC, GC-MS, HPLC, Raman, AFM, SEM and so on.

• Since he is a fresh graduate, his works have been submitted in international journals for publication

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Other Activities/Programs Maintained by CENT

- Strengthening Collaborations
- Hosting seminars and organizing workshops.
- Visiti professors (B Ahsan, Zerko
- Partici on in scientific ev
- St rs
- s:
  Advanced Materi
- Computational G

- Kick-Off
- DLS
- Veeco

- **Professor Ian Bruce (Kent University)**
- **Dr. Paulo Morais is the head of the Brazilian Nanobiomagnetism Network (BNN) through S. Aramco/ Naizak**
- **Dr. Mark Geoghegan (Sheffield University)**
- **Professor Edward Cupoli (CNSE NanoEconomics Constellation Head) through Arba7 Capital**
- **Gregory Lance (Hystiron) through Naizak**
- **Jim Tour (Rice University)**
- **Stephan Podzimek (Wyatt Technology, USA)**
- **Mohammad Rab’ah (KFUPM)**
- **Ahsanul-Haqq (Material Engineering Toyama University Japan)**
- **Zain Yamani (CENT)**
- **Many more.. [check web-site]**

Other Activities/Programs Maintained by CENT

Bi-weekly seminars:
-Al-Somali, Bani-Yaseen,
Ahmad Omar, …etc.

Publishing papers
Patent Applications:
MK, SQ, NT, MA, …

Visiting professors:
- Syed Qadri (NRL,USA)
- Collaborators/ Consultants

CENT Affiliates Meetings

Developing CENT labs on campus

Increasing Capacity

Workshops under preparation:
- CNT Applications
- X-ray Characterization Techniques

Graduate Program

More inter-Centers collaborations

Collaborations potentially with:
DuPont, Dow Chemicals, S. Aramco, SABIC

KAUST, KACST, KSU, Taibah, KFU,…etc

Conclusions

- Nanotechnology is an interesting subject.
- Nanotechnology is not all fake! ☺☺
- CENT is the nanotechnology platform at KFUPM.
- In coordination with other sisters centers and academia, we are developing human competency, building capacity and transfering technology and experience] in the fields of:

    1. Catalysis,
    2. Gas sensing
    3. Environment [photocatalysis and CNT work]

- There are other (soft-core) activities at CENT, including seminars, developing a Masters program, mailing list..

Conclusions

- We are open arms and minds for developing strategic partnerships with the Industry at Jubail.
- We will continue to study the main technological challenges that face Jubail Industry; this said, we are set up to jointly lead in research.

We'd be happy to add you to Friend's of CENT (e-)mailing list.

Just sent us a note: cent@kfupm.edu.sa

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-The CENT research teams, both employees and affiliates

- Johannes Schwank

- KFUPM Administration.

Thank you for your attention