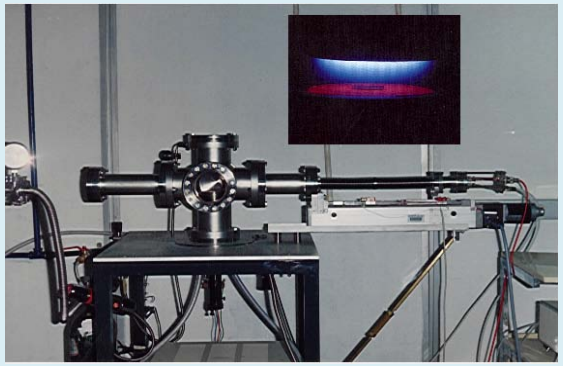
EXCELLENCE CENTER FOR NOVEL MATERIALS - CENM

Pedro Prieto, Dr.rer.nat

Purdue University, October 2010

EXCELLENCE CENTER FOR NOVEL MATERIALS - CENM

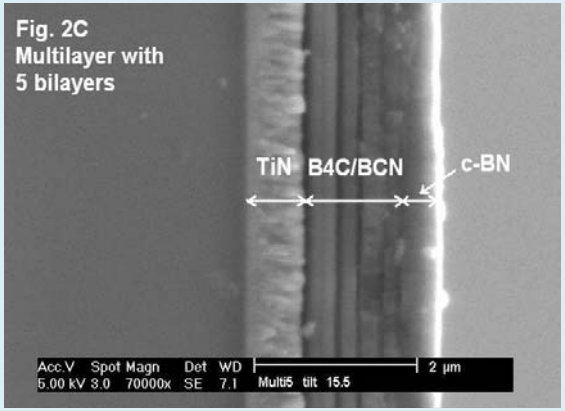
Enhancing academy-industry-state ties

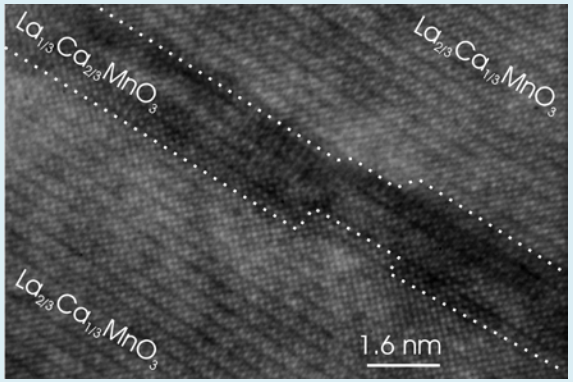


www.cenm.org

CENM

Director
Pedro Prieto





ECNM

Excellence Center for Novel Materials

Welcome

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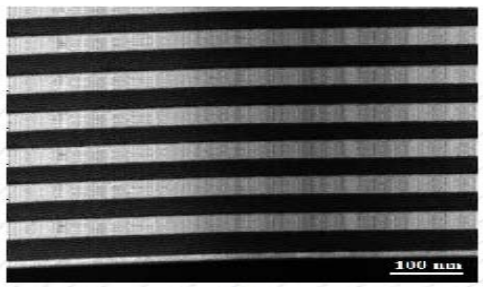
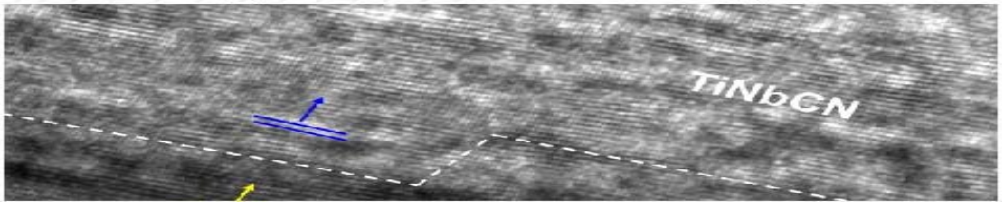
www.cenm.org

Resultados de la Investigación sobre
Multicapas de TiCN/TiNbCN
Julio Cesar Caicedo, investigador CENM



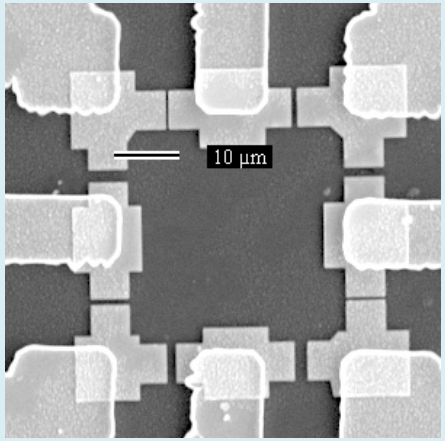
(a)

(b)

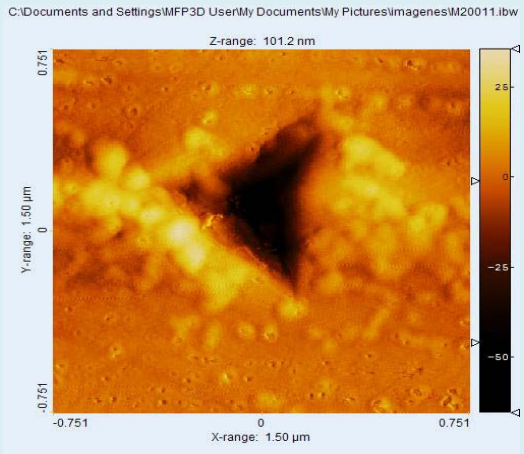


About CENM

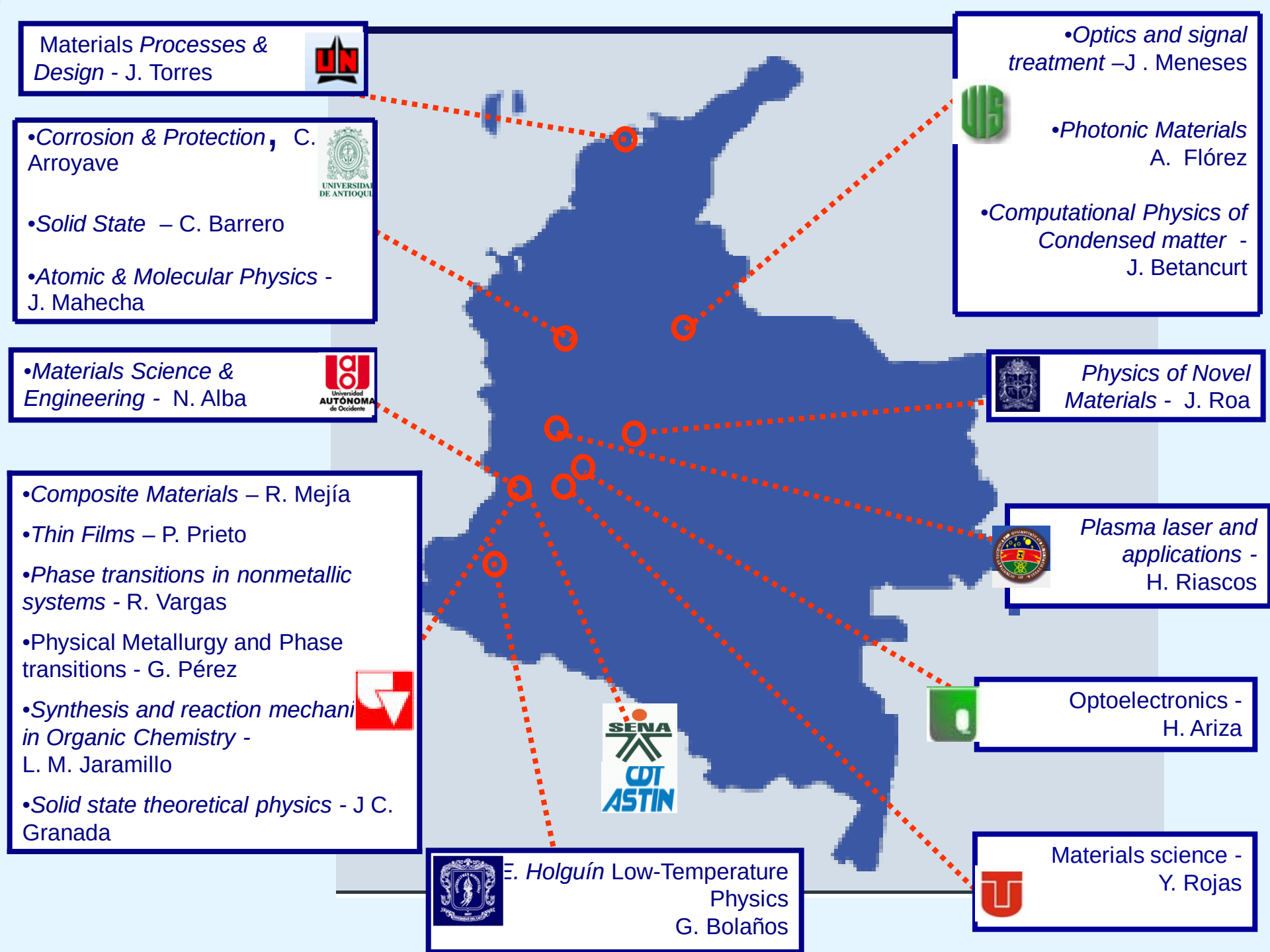
The Excellence Center for Novel Materials is part of a high-priority Colombian effort supported by 19 recognized multidisciplinary research groups from 10 universities across the nation. Additionally, the Center receives international support from world-renowned institutes on materials research.



VO_2 Pattern fabricated using e-beam and Photo lithography - UCSD



AFM image of Nanoindentation print - CENM


Materials *Processes & Design* - J. Torres
•*Corrosion & Protection*, C. Arroyave
•*Solid State* – C. Barrero
•*Atomic & Molecular Physics* - J. Mahecha
•*Materials Science & Engineering* - N. Alba
•*Composite Materials* – R. Mejía
•*Thin Films* – P. Prieto
•*Phase transitions in nonmetallic systems* - R. Vargas
•Physical Metallurgy and Phase transitions - G. Pérez
•*Synthesis and reaction mechani in Organic Chemistry* - L. M. Jaramillo
•*Solid state theoretical physics* - J C. Granada
•*Optics and signal treatment* –J . Meneses
•*Photonic Materials* A. Flórez
•*Computational Physics of Condensed matter* - J. Betancurt
Physics of Novel Materials - J. Roa
Plasma laser and applications - H. Riascos
Optoelectronics - H. Ariza
Materials science - Y. Rojas
E. Holguín Low-Temperature Physics G. Bolaños
SENA
CDT ASTIN

National and International Collaborations

General Objetives and Strategies

To aid in Colombia‘s technological & scientific development through the formation of specialized human resource working with novel materials technologies

- Greater R&D investment
- Acquisition of robust equipment
- Formation of young talents
- Support a knowledge-based economy for growth

CENM Immediate Strategies

- Establish technology transference policies from the universities to the industrial sector
- Build infrastructure to share knowledge; facilitate awareness in nanotech research and support commercialization of nano-products in the short term
- Establish close ties with industry for joint research projects
- Seek State policies to identify key interest areas for the benefit of society, industry, and academia
- Seek public and private funding to support research and increase potential coverage

Sustainability Strategies

Strategic alliances with industry

Seek benefactors

Project formulation & presentation to international entities

Strategic alliances with universities

Social responsibility efforts with NGOs and government

Strategic alliances with R&D centers

Formation of new talents

Sell services & consultancy

Creation of CENM foundation

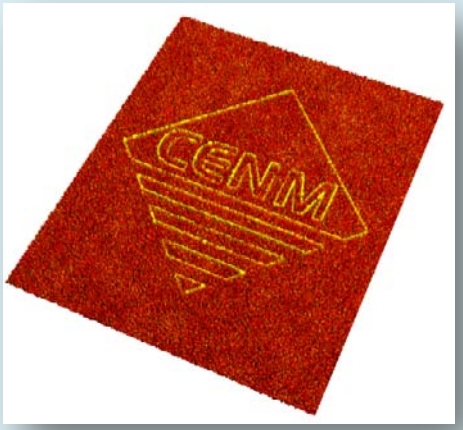
National & international positioning

CENM VIDEO

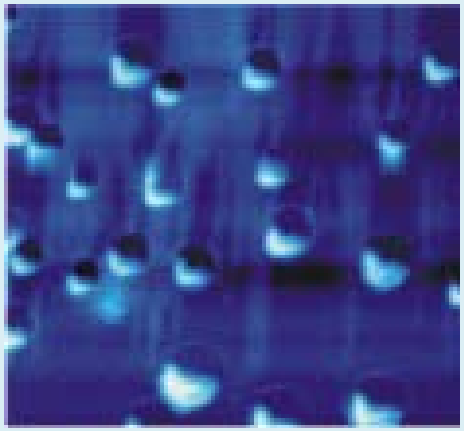
Areas of Research

Research work at CENM is organized around 4 Interdisciplinary Research Themes (IRTs):

- Composite Materials
- Advanced Coatings
- Nano-magnetism
- Solid-State Devices, Sensors, and Mesoscopic Systems



AFM image of nanolithography over a polymer surface - CENM



MFM image of magnetic nanoparticles $CoZnFe_2O_4$ - CENM

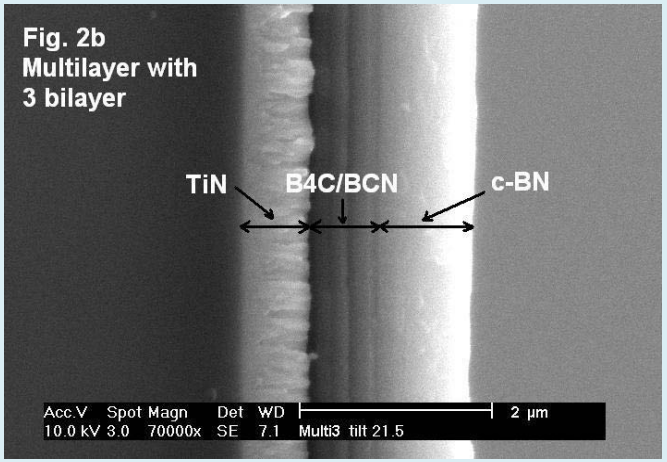
Nanocomposite Materials: Goals

- Development of new materials for construction applications appertaining to the development of civil engineering infrastructure in Colombia
- Active nano-powders for cementitious-based materials from industrial waste and industrial by-products to produce cementing materials with high-mechanical performance and durability, contributing to environmental sustainability

Nano-powder in Cement Materials
CENM

COATING MATERIALS: Goals:

- Development of novel materials with improved resistance to corrosion and wear, with high-temperature hardness conditions:
  - ✓ Composite coatings (SiC and diamond nanoparticles in Ni and Ni-Cr matrixes and nano-sized iron oxide particles in Ni-P)
  - ✓ Multilayered coatings (W/WC and TiN/ZrN TiCN/TiCNbN Multilayers)



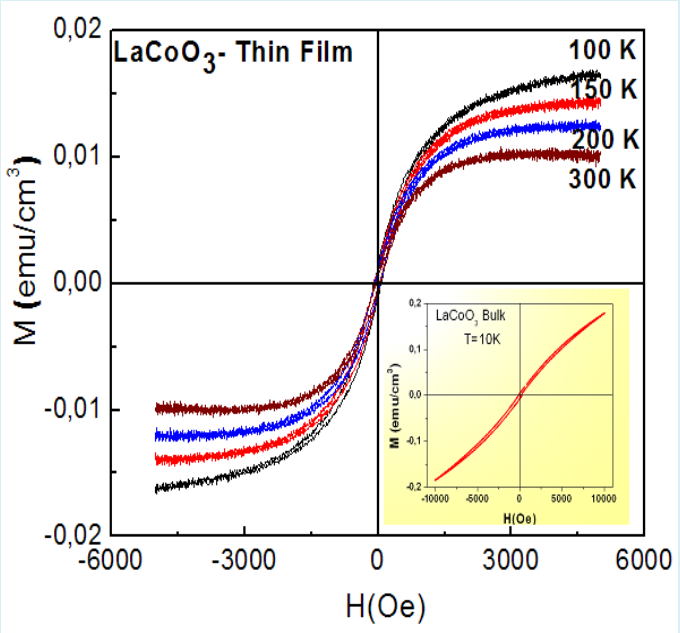
EM micrograph of a TiN/B_4C/BCN/c-BN multilayered hard coating - CENM

Nanomagnetism: Goals

- Gain basic understanding of nanoscale magnetic properties and knowledge on improving magnetic properties for broader applications in industry

- **Areas of study:**

  - ✓ Fe- and Mn-based Magnetic systems
  - ✓ Oxide-based magnetic thin films and hetero-structures
  - ✓ Theoretical and numerical simulation of magnetic behavior
  - ✓ Nanocomposite and nano-structured magnetic alloys for hard and soft magnetic materials

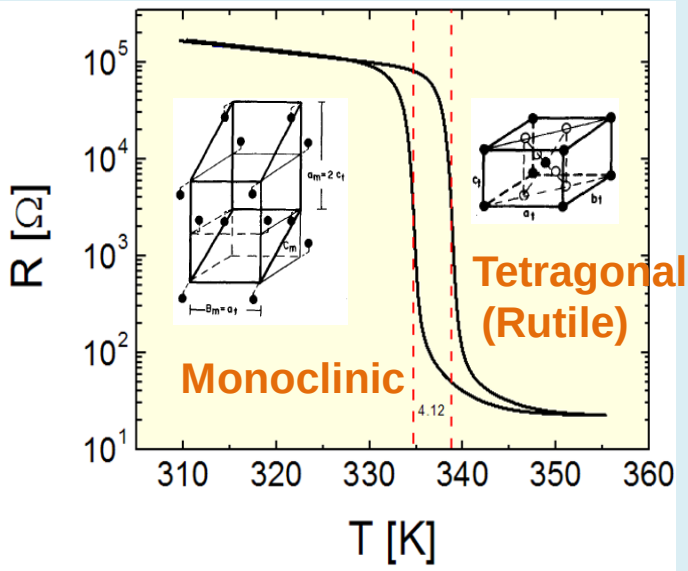


Magnetization curve of $LaCoO_3$. CENM

Solid-State Devices, Sensors, Mesoscopic Systems: Goals

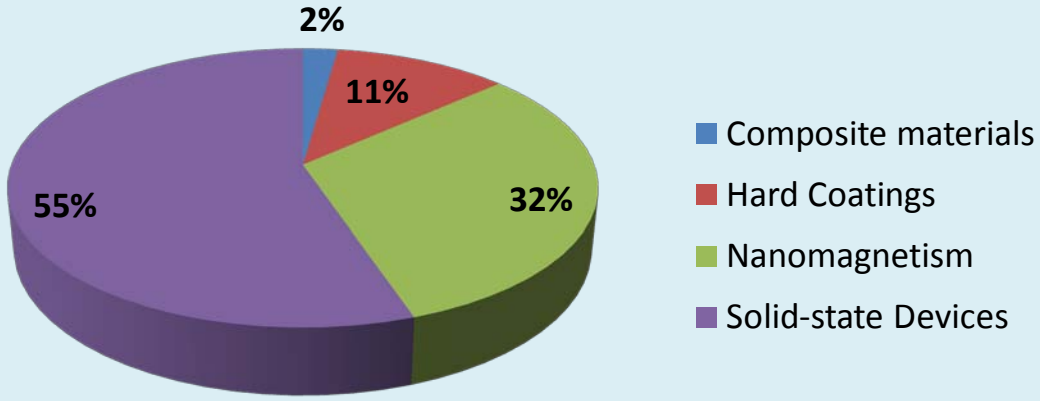
- Performance of new materials, focusing on quaternary semiconductors, ionic crystals; Mn, Sn, and Mo-based oxides
- Characterization of optical, electrical, and magnetic properties fundamental for the design of devices
- Study the effects of dimensionality reduction and the presence of confinements on properties of materials

- Development of theoretical models and simulations
- Study focuses mainly on optical, electric and magnetic properties of GaInAsSb quaternary systems, ionic materials, Photonic materials, VO_2 thin films.

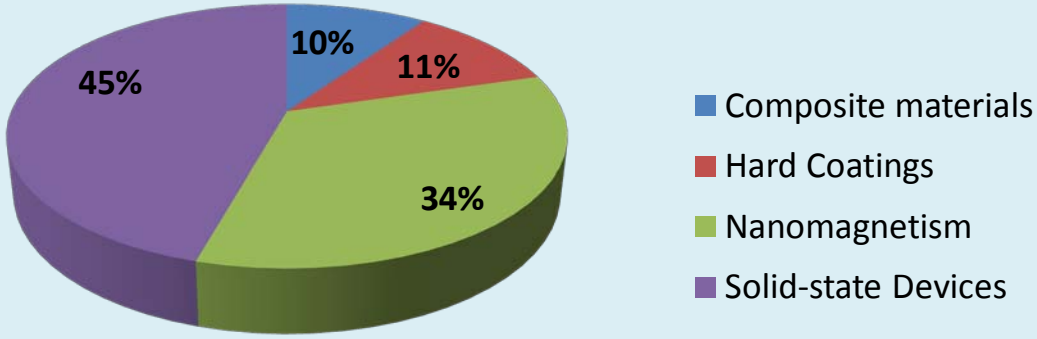


Ramirez, et al. PRL 101 (2008)

Scientific production per research area



International Papers 183



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CENM IN FIGURES

Participation in Scientific Events	
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Students supported by CENM

PhD students	4
Masters students	4
PhD students graduated with CENM support	14
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Graduate students participating in projects	46
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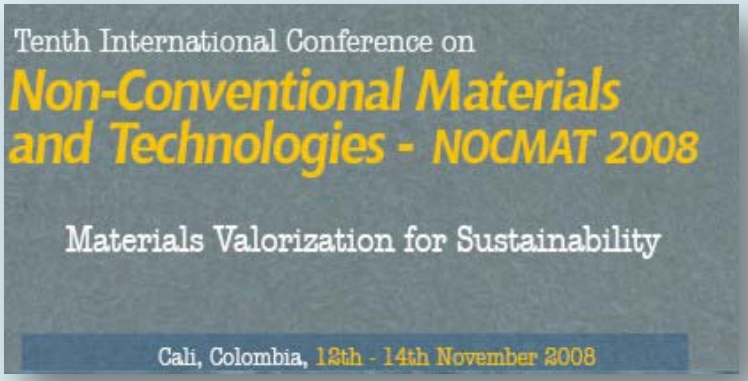
Events held by CENM

Held in Santa Marta – Colombia, October 16 to 20, 2006.

Held in Cartagena de Indias – Colombia, October 13 to 17, 2008.



Held in Cali – Colombia, November 12 to 14, 2008.

EVENTS HELD BY CENM

Held in Cali – Colombia, August 8 to 10, 2007

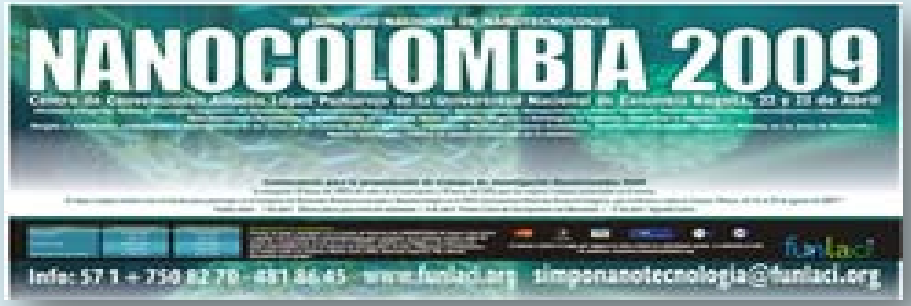
Held in Cali – Colombia, April 8 to 10, 2008

Held in Cali – Colombia, February 25 to 27, 2010

EVENTS HELD BY CENM

Held in Bogotá – Colombia,

Event will be held in Barranquilla – Colombia on October 21 – 23, 2010



Held in Bogotá – Colombia, on April 22 and 23, 2009

Robust Equipment acquired by CENM

Physical Property Measurement System – PPMS Quantum Design™

Robust Equipment acquired by CENM

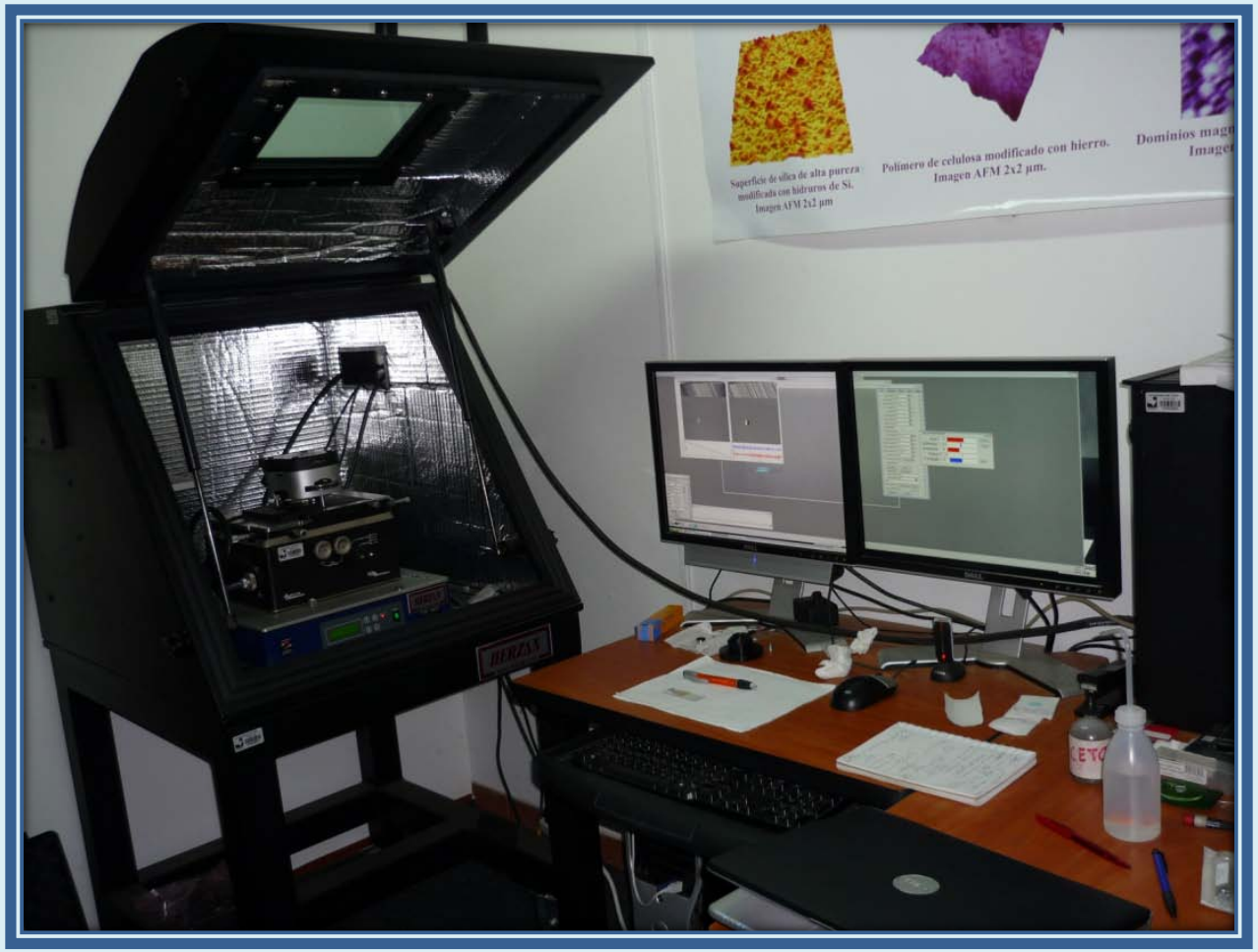
Mastersizer Laser Granulometer

Attrition Mill

Robust Equipment acquired by CENM

Universal Hystron Press

Robust Equipment acquired by CENM



Atomic Force Microscopy- AFM ASYLUM RESEARCH

Robust Equipment acquired by CENM

MICRO-RAMAN Jobin Yvon, Model Labram HR

Robust Equipment acquired by CENM

Desktop Scanning Electron Microscope – PHENOM - FEI

Robust Equipment acquired by CENM

SPECTROPHOTOMETER Jasco. Modelo V 7200

Robust Equipment acquired by CENM

DILATOMETER

Cooperation Agreements

2006 - 2009

Prodenvases Crown S. A.
Hacemos su producto más atractivo

2006 - 2008

FUNDICIONES UNIVERSO
INGENIERÍA & MANUFACTURA

2006 - 2008

cujae

Instituto Superior Politécnico
José Antonio Echeverría

2007 - 2010

Centro de Investigaciones en Tecnología Aeronáutica

2007

NRG

Nino Research Group
2007

2007 - 2010

Arrocera la Esmeralda

Cooperation Agreements

2009 - 2010

GENERAL METALICA S.A.

2008

Resortes HERCULES

2006 - 2008

CARTONES AMERICA S.A.

CAJAS DE CARTON CORRUGADO

2008 - 2010

Universidad de San Buenaventura

2007 -2010

Universidad del Tolima

2006 - 2008

IMPADOC S.A.

CARBONATOS DE CALCIO PARA LA INDUSTRIA
YESOSO Y ESTUCOS PARA LA CONSTRUCCION

CDT ASTIN

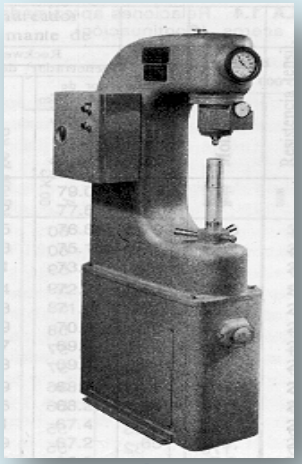
Centro Nacional de Asistencia Técnica a la Industria

UNIVERSIDAD DE ANTIOQUIA 1803

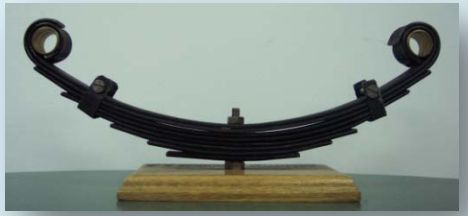
2007

Project carried out with Resortes Hércules

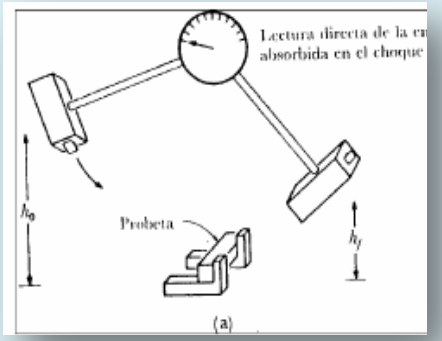
Determination of optimal parameters of the tempering process of SAE6150 steel as an alternative for the manufacture of leaf springs.



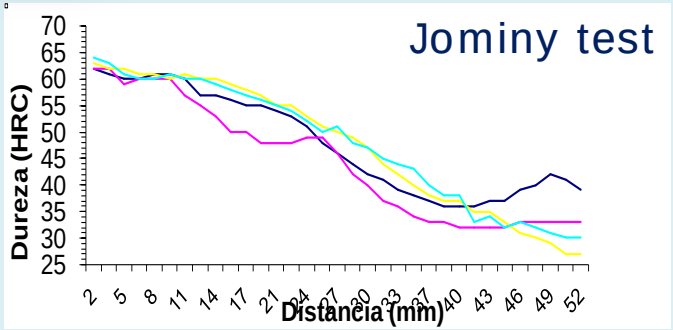
Hardness

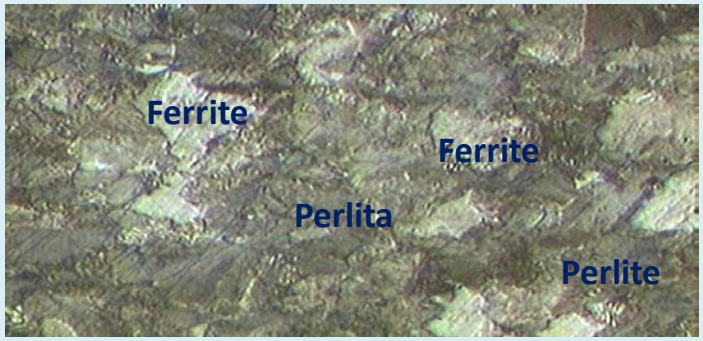


Leaf spring quality was clearly improved with SAE 6150 steel in calibers greater than 20 mm.



Charpy test





A process was begun between the university and the enterprise to support research projects

Project carried out among CDT ASTIN – CENM – AGRAF S.A.

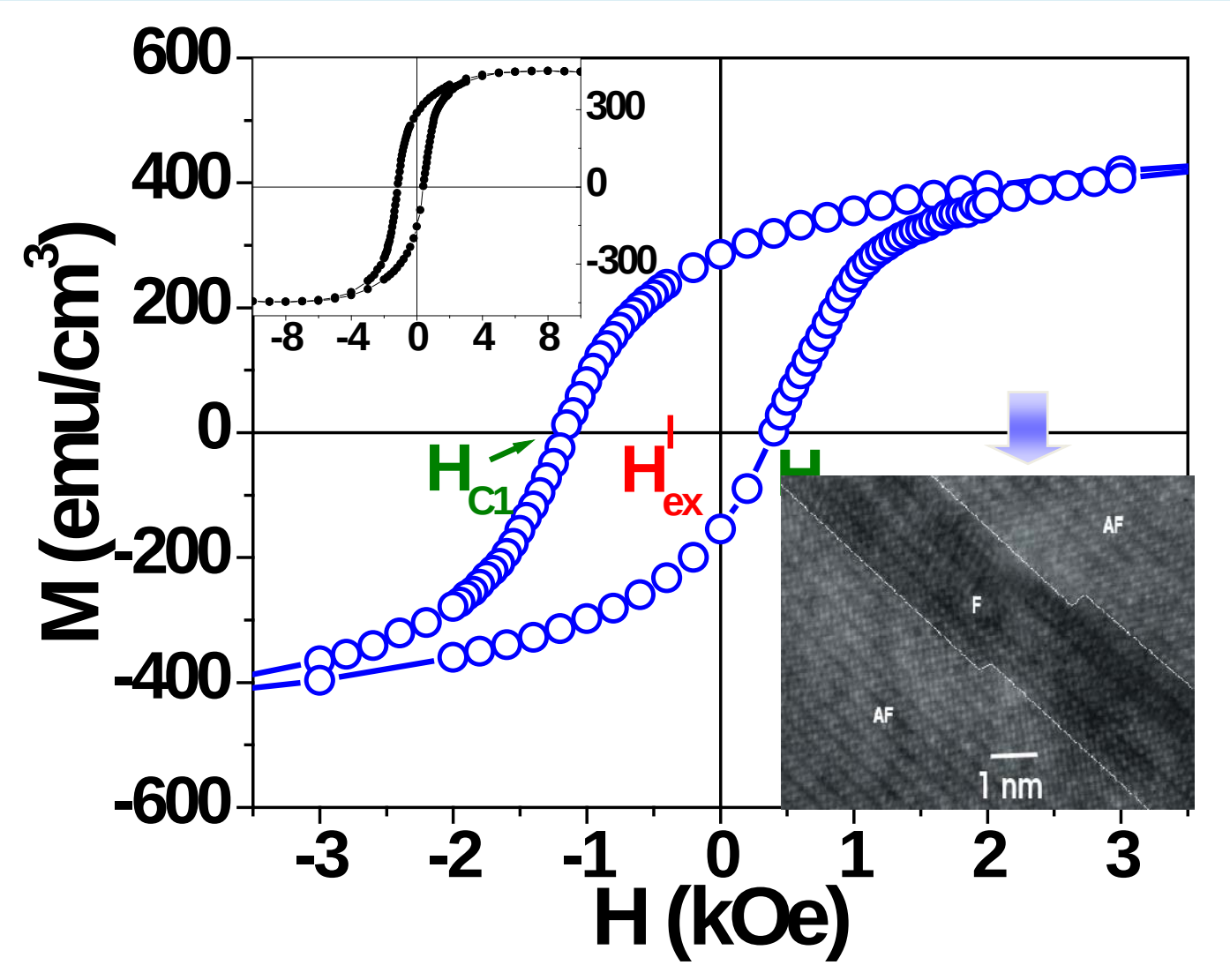
Immediate application of B_4C/BCN/c-BN multilayers

"Improvement of the design of cutting blades at AGRAF S.A via the application of B4C/BCN/c-BN, TiN/ZrN, and TiN/TiAlNbN multilayers"

General Objective: to increase the useful life of cutting blades by at least 35% at the paper conversion plant in AGRAF S.A., increasing profits in said production line by 70% by using TiN/TiAlNbN, TiN/ZrN, and B4C/BCN/c-BN multilayered hard coatings

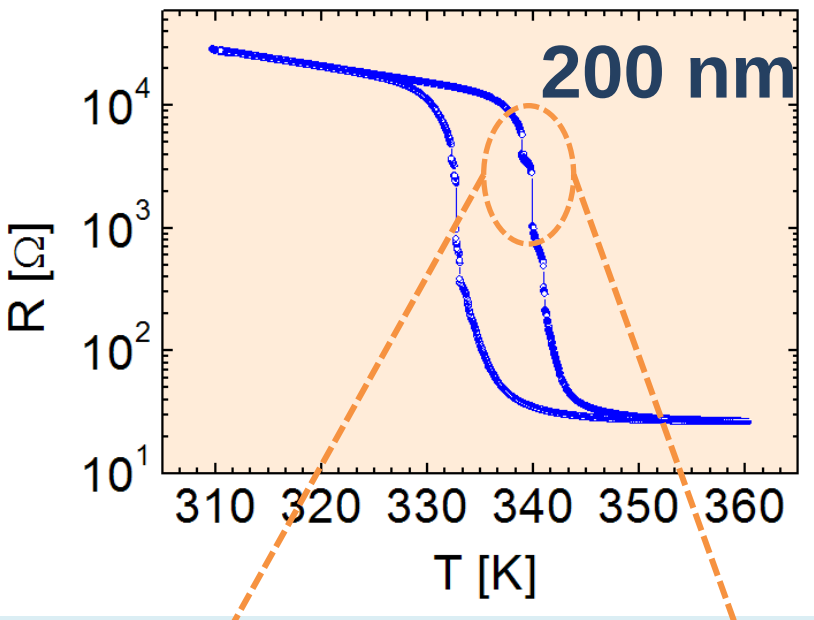
Projected savings in production costs at the AGRAF S.A. paper conversion plant for the first year: **$96,286,000**
Projected savings for the first year for Cartón Colombia:
90 hours of additional cutting
153 tons of additional paper
$382,500,000

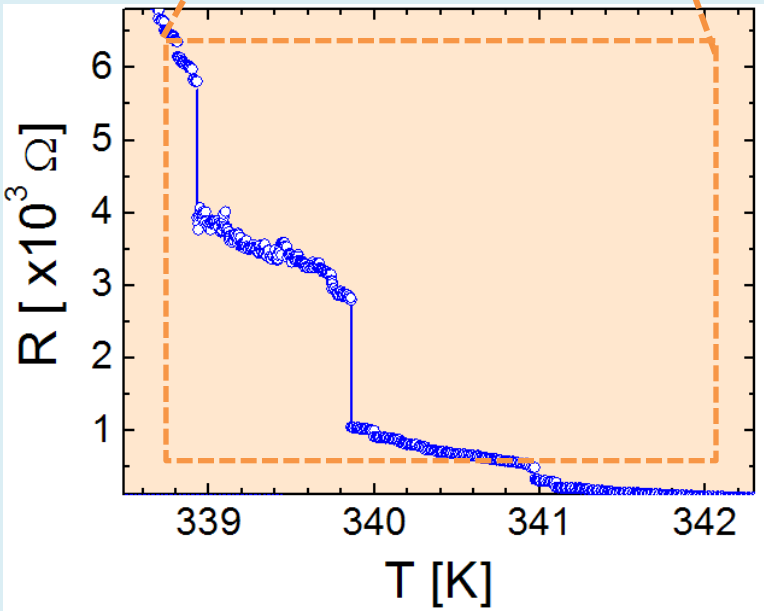
Exchange Bias in $[La_{1/3}Ca_{2/3}MnO_3/La_{2/3}Ca_{1/3}MnO_3]$ superlattices

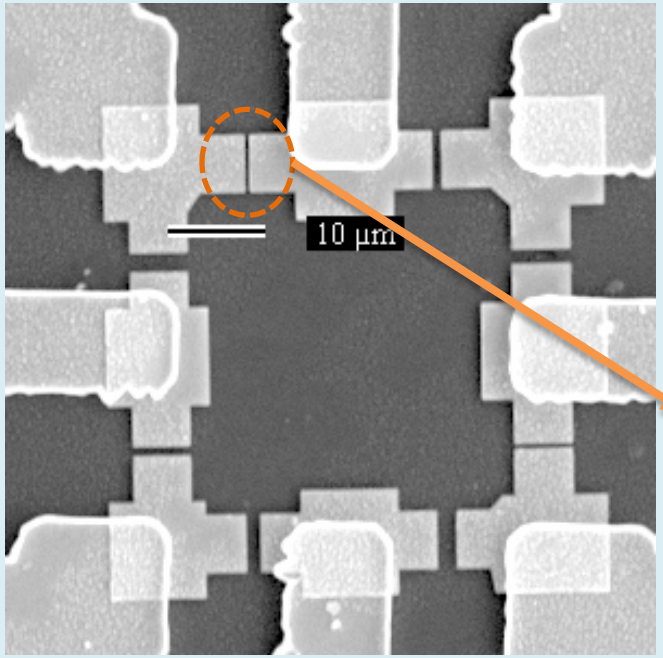


P. Prieto et al.; J. Appl. Phys. 99 08C106 (2006)

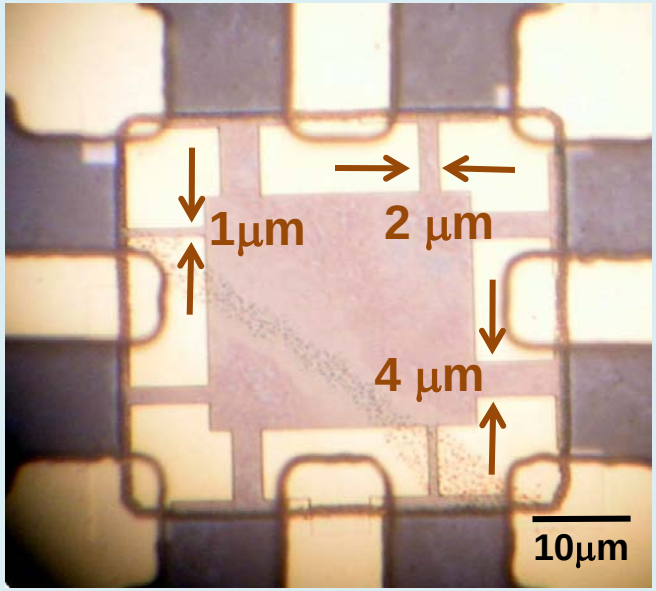
VO_2 at nano-scale

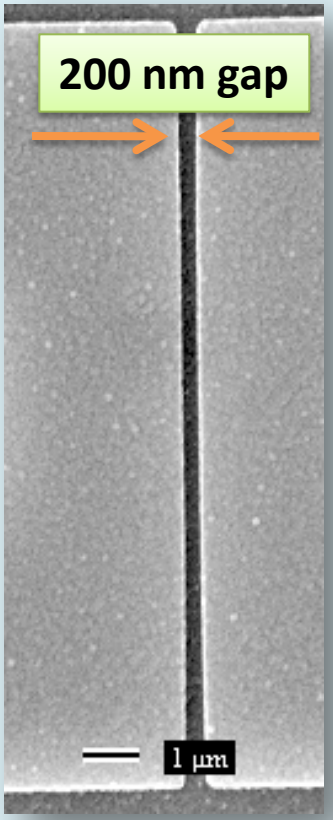






VO_2 Pattern fabricated using E-beam and Photo lithography Techniques.





Sharoni, Ramirez, Schuller. PRL 101 (2008)

MOCVD growth of TiO_2 nanotubes and nanomembranes


physica status solidi a
www.pss-a.com
applications and materials science

TiO_2 nanostructures prepared by ferrocene/cobalt catalyst agents

A.-M. Lazar[1–3], D. Chaumont[1], Y. Lacroute[2], M. E. Gómez[4], J. C. Calcedo[4], G. Zambrano[4], and M. Saciotti[3]

[1] LRRS and FR 2604 Université de Bourgogne 21078 Dijon, France
[2] Faculté de Science et Ingénierie des Matériaux, Univ. Transilvania, Brasov, Roumanie
[3] CMN and LPUB, UFR Sc. Techn. 2604 – Université de Bourgogne, 9 avenue A. Savary, BP 47870, 21078 Dijon Cedex, France
[4] Thin Film Group, Department of Physics, Universidad del Valle, A. A. 25360 Cali, Colombia

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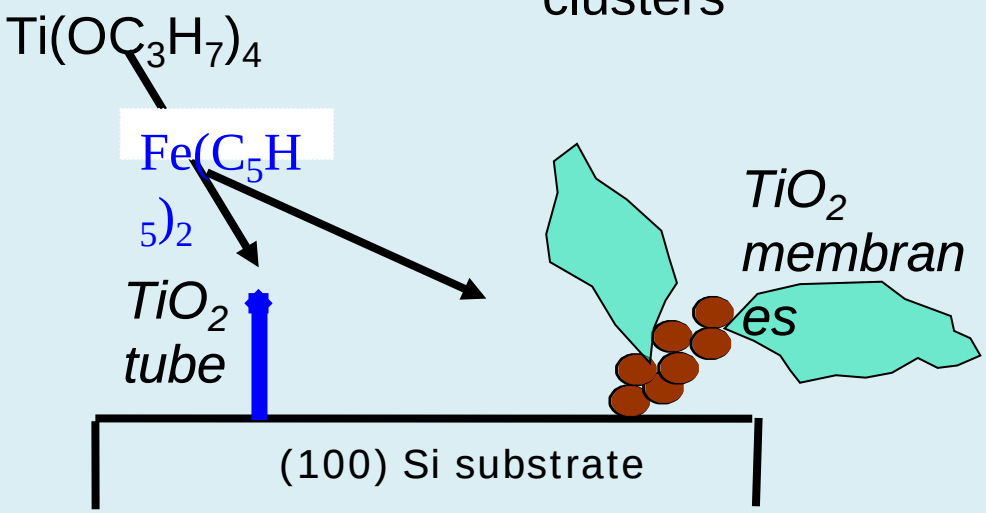
Published online 6 February 2008

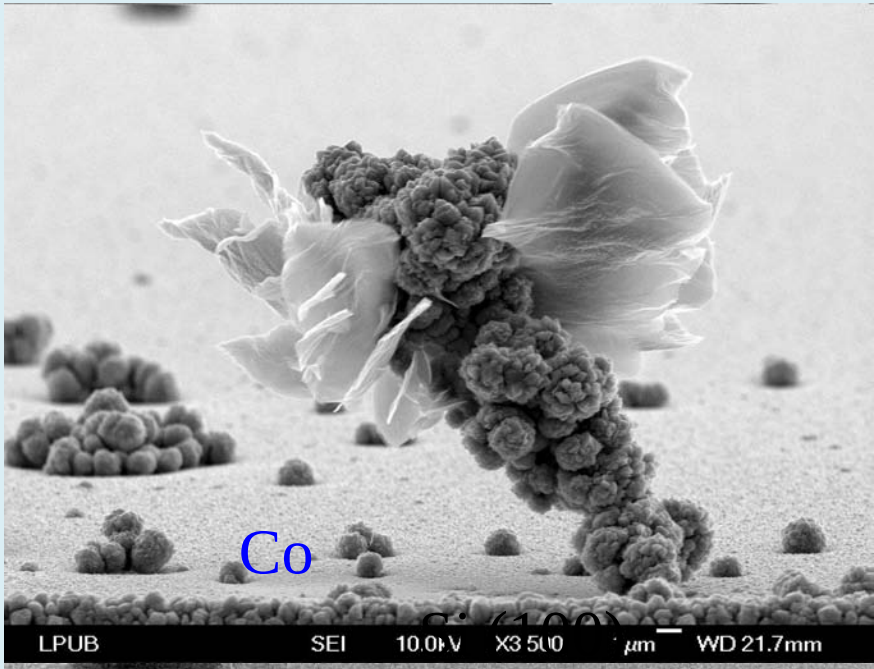
PACS 61.46.–w, 62.23.St, 81.07.Bc, 81.15.Gh, 81.16.Hc

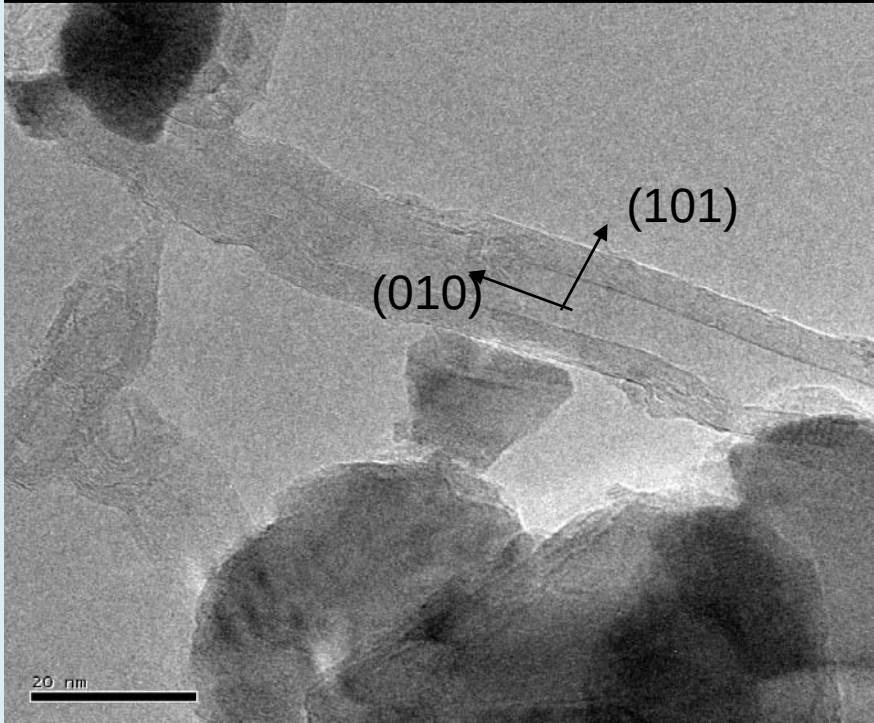
We present the growth and characterization of TiO_2 nanocrystals. Nanostructured growth is obtained in a low-pressure CVD system by using an organometallic precursor ($TiOC_4H_4$), as both the Ti and O source catalyzed by both ferrocene (an organometallic precursor) and cobalt metallic clusters prepared by the microwave-assisted polyol method. Two kinds of TiO_2 structures were obtained in the cobalt clusters: a) pine-tree like (with short-leaf structure) and b) long-leaf structures as large as a few micrometers in size and both under 10 nm in thickness. Long-leaf TiO_2 structures were grown at cobalt grain boundaries. For the growth conditions utilized, the TiO_2 structures are composed of both anatase and rutile crystallographic phases.

phys. stat. sol. (a) 205, No. 2, 289–293 (2008) / DOI 10.1002/pssa.200723134

= Cobalt clusters







Contents lists available at ScienceDirect

Applied Surface Science 256 (2010) 5898–5904

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

TiCN/TiNbCN multilayer coatings with enhanced mechanical properties

J.C. Caicedo [a,*], C. Amaya [a,b], L. Yate [c], M.E. Gómez [a], G. Zambrano [a], J. Alvarado-Rivera [d], J. Muñoz-Saldaña [d], P. Prieto [a,e]

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[b] Laboratory of Hard Coatings, CDT-ASTIN SENA, Cali, Colombia
[c] Department de Física Aplicada i Óptica, Universitat de Barcelona, Catalunya, Spain
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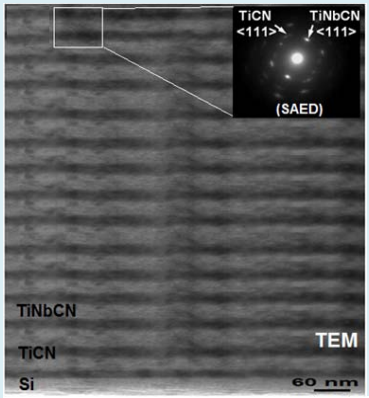
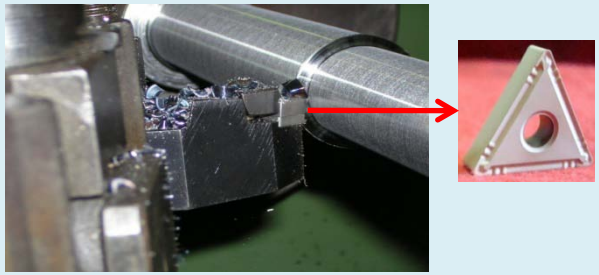
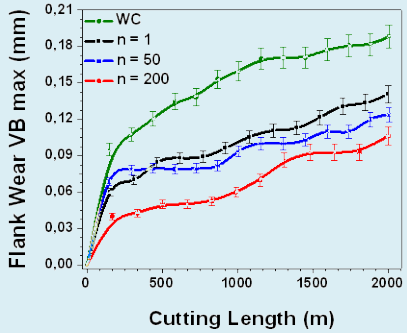
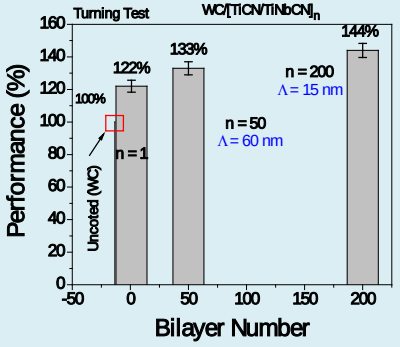
[e] Center of Excellence on Novel Materials, CENM, Calle 13 #100-00 Edificio 320, espacio 1026, Cali, Colombia

HRTEM









A B S T R A C T

Enhancement of mechanical properties by using a TiCN/TiNbCN multilayered system with different bilayer periods (Λ) and bilayer numbers (n) via magnetron sputtering technique was studied in this work. The coatings were characterized in terms of structural, chemical, morphological and mechanical properties by X-ray diffraction (XRD), atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and nanoindentation. Results of the X-ray analysis showed reflections associated to FCC (1 1 1) crystal structure for TiCN/TiNbCN films. AFM analysis revealed a reduction of grain size and roughness when the bilayer number is increased and the bilayer period is decreased. Finally, enhancement of mechanical properties was determined via nanoindentation measurements. The best behavior was obtained when the bilayer period (Λ) was 15 nm (n = 200), yielding the highest hardness (42 GPa) and elastic modulus (408 GPa). The values for the hardness and elastic modulus are 1.6 and 1.3 times greater than the coating with n = 1, respectively. The enhancement effects in multilayer coatings could be attributed to different mechanisms for layer formation with nanometric thickness due to the Hall-Petch effect; because this effect, originally used to explain the increase in hardness with decreasing grain size in bulk polycrystalline metals, has also been used to explain hardness enhancements in multilayers taking into account the thickness reduction at individual single layers that make the multilayered system. The Hall-Petch model based on dislocation motion within layers and across layer interfaces, has been successfully applied to multilayers to explain this hardness enhancement.

Contribution to Local & National Development, Scientific and Technological Capacity

- Work done with 19 highly qualified research groups throughout the nation has strengthened student and researcher participation in the international scientific community.
- CENM has placed scientific & technological knowledge at the highest international levels.
- The Center has done research in key areas for the nation's academic, scientific, and economic benefit.
- CENM research will lead to developing environmentally friendly manufacturing practices and devices.
- Our research represents important potentials in electronics, biomedicine, metallurgy and construction, among others.

Question 1

Question 2

Question 3

Question 4

Question 5

Question 6

Question 7