INCT Engenharia de Superfícies

Fernando Lázaro Freire Junior
Departamento de Física, PUC-Rio

Instituto Nacional de Engenharia de Superfícies

Overview

The National Institute of Surface Engineering

1) Brief Introduction
2) The INCT
3) Research
4) Diffusion of Knowledge
5) Transfer of knowledge to the industrial sector

The Institute

The starting point: 1988 – CNPq individual grants to support scientific collaboration between PUC-Rio (Van de Graaff Laboratory) and UFRGS (ion implantation group).

2001 -First PROCAD (CAPES) grant joint the two teams and mantain the collaboration, now also involving one group from UNICAMP.

2002 - CNPq network on Nanomaterials: coordinator Prof. Israel Baumvol

Besides the groups at PUC-Rio, UNICAMP and UFRGS, others groups were involved in the network: INPE and UFF.

2005 – CNPq/MCT Network Rede Brasil Nano:

Nanostructured Coatings : coordinator Prof. Fernando Lázaro

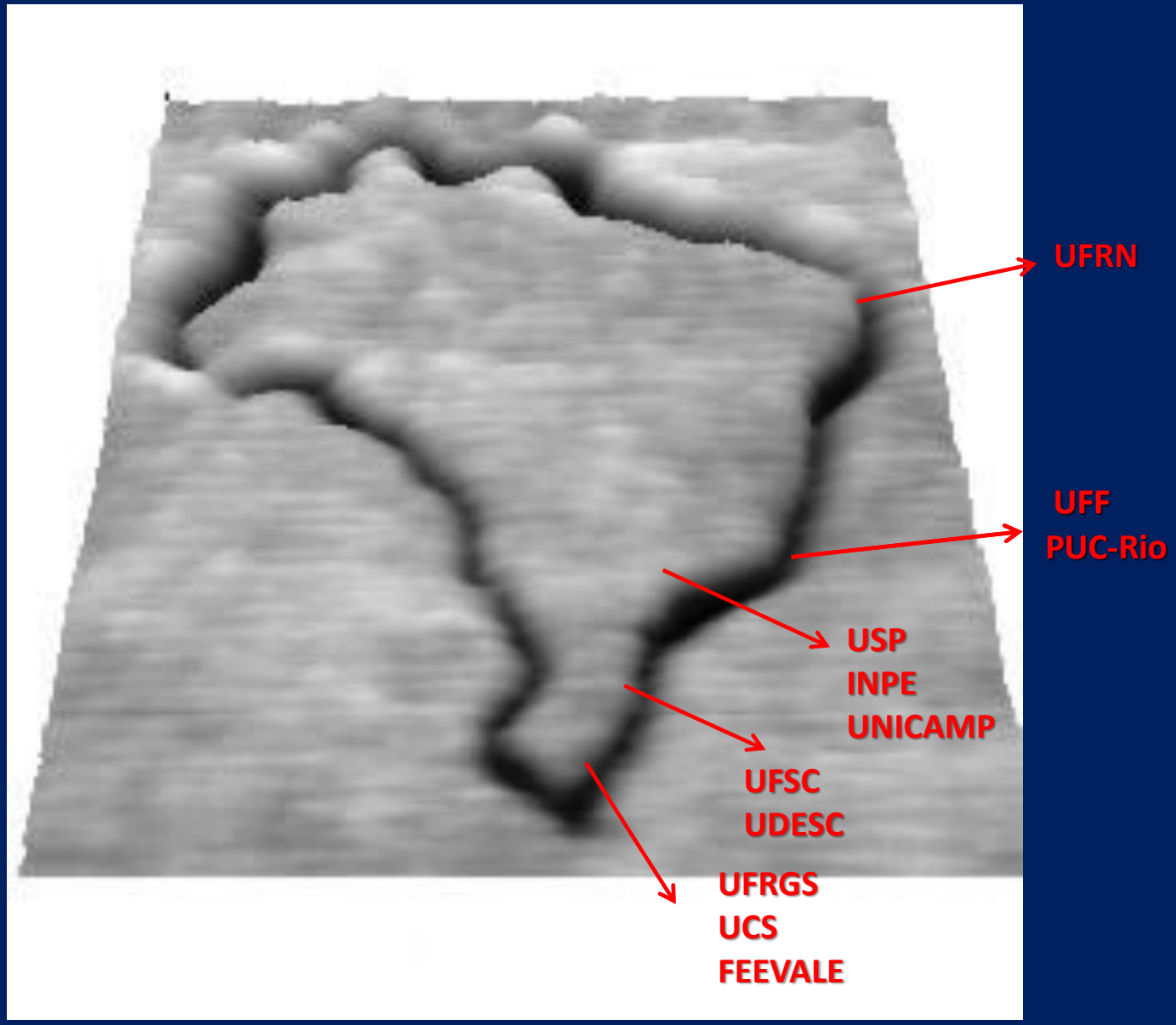
From 2001 to 2009: more than 40 joint international publications

exchange of students and pos-docs

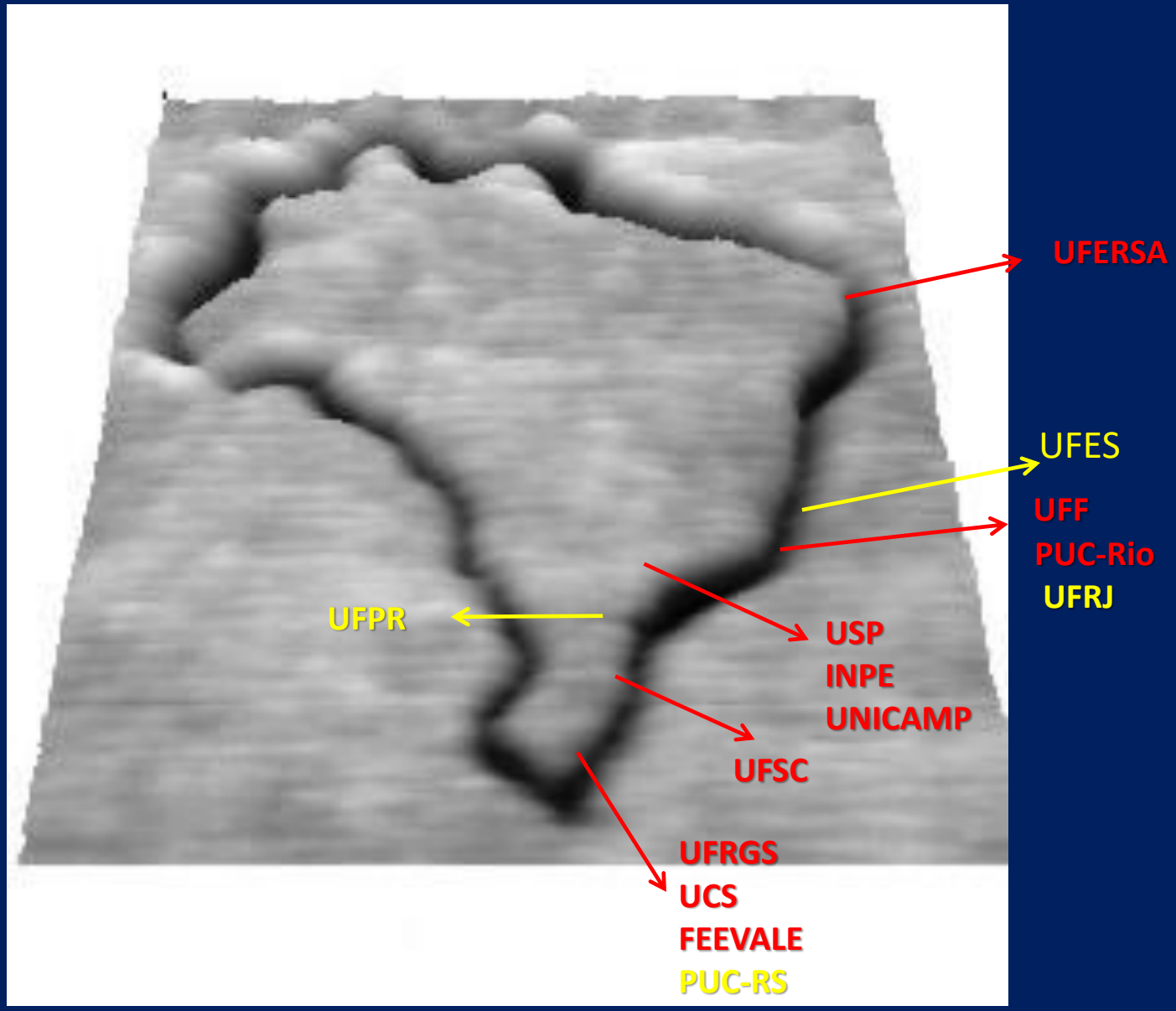
interaction with industries

2009 – INCT National Institute of Science and Technology: Surface Enginnering

INES 2009


UFRN
UFF
PUC-Rio
USP
INPE
UNICAMP
UFSC
UDESC
UFRGS
UCS
FEEVALE

INES 2014


UFERSA
UFES
UFF
PUC-Rio
UFRJ
UFPR
USP
INPE
UNICAMP
UFSC
UFRGS
UCS
FEEVALE
PUC-RS

A new proposal was submited in 2014 and approved in 2016

Coordinator: Fernando Lázaro Freire Junior (PUC-Rio)
Vice-Coordinator: Lívio Amaral (UFRGS)

Steering Comitee:
Pedro Grande (UFRGS)
Francisco Marques (UNICAMP)
Amilton Sinatora (USP)
Vladimir Jesus Trava-Airoldi (INPE)
Carlos Figueroa (UCS)

In 2017, Roberto Martins de Souza (USP) replaced Amilton Sinatora, who retired and went to ITV Vale

48 Principal Investigators (51 when the proposal was submitted)

Laboratories and coordinators

Nanostructured Materials and Coatings Laboratory/Physics Department/PUC-Rio:
Fernando Lázaro Freire Jr.

Thin Films Laboratory /Institute of Physics/UFF:
Dante Franceschini

Surfaces and Thin Films Laboratory/Program of Metallurgy and Materials Engineering COPPE/UFRJ:
Sérgio de Souza Camargo Jr.

Laboratories and coordinators

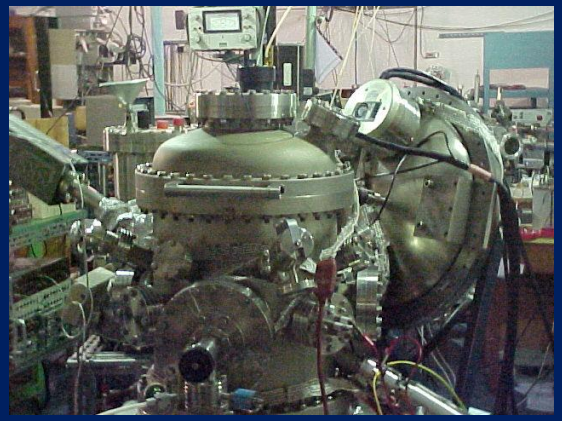
Materials and Sensors Laboratory/INPE:
Vladimir Jesus Trava-Airoldi

Surface Phenomena Laboratory/Department of Mechanical Engineering/USP:
Roberto Martins de Souza

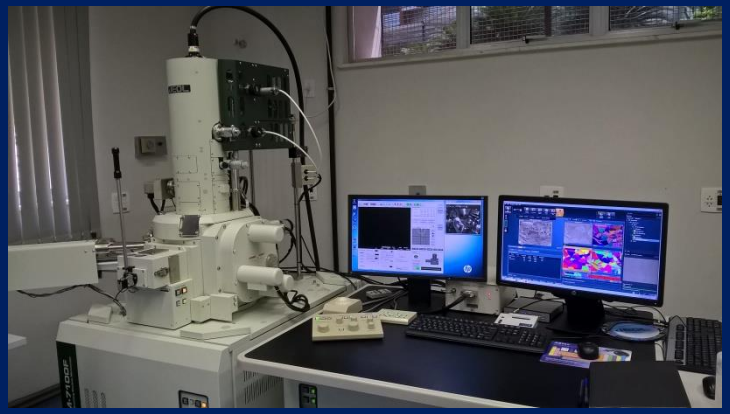
Photovoltaic Research Laboratory/Institute of Physics/UNICAMP:
Francisco Marques

Ion Implantation and Surface Treatment Laboratory/Institute of Physics/UNICAMP:
Fernando Alvarez

Department of Physics/PUC-Rio

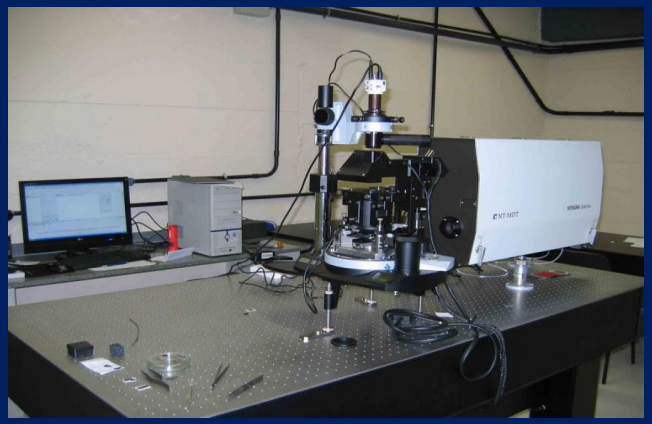


XPS/UPS Thermo (Alpha 110)



FEG-MEV JEOL

STM UHV Omicron



AFM + Raman ND-MDT

Ion Implantation Laboratory/Institute of Physics/UFRGS:
Pedro Grande

Nanometric Conformation Laboratory/ Institute of Physics/UFRGS :
Marcos Z. Vasconcellos

Surface Engineering Laboratory/Materials Program/UCS:
Carlos Figueroa

Materials Characterization Laboratory/Materials Program/UCS:
Carlos Figueroa

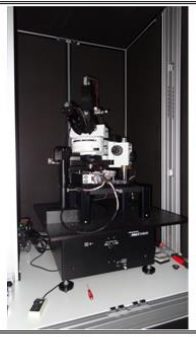
Materials Laboratory/Materials Program/University Feevale :
Claudia Trindade Oliveira

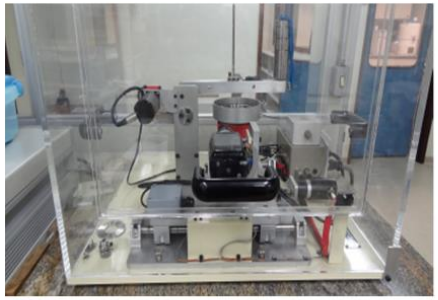
Nanostructures Synthesis Laboratory/ Polytechnic school /PUC-RS:
Ricardo Papaleo

Institute of Physics/UFRGS

Focused ion beam Jeol

Deposição filmes AJA





Atomic force microscope

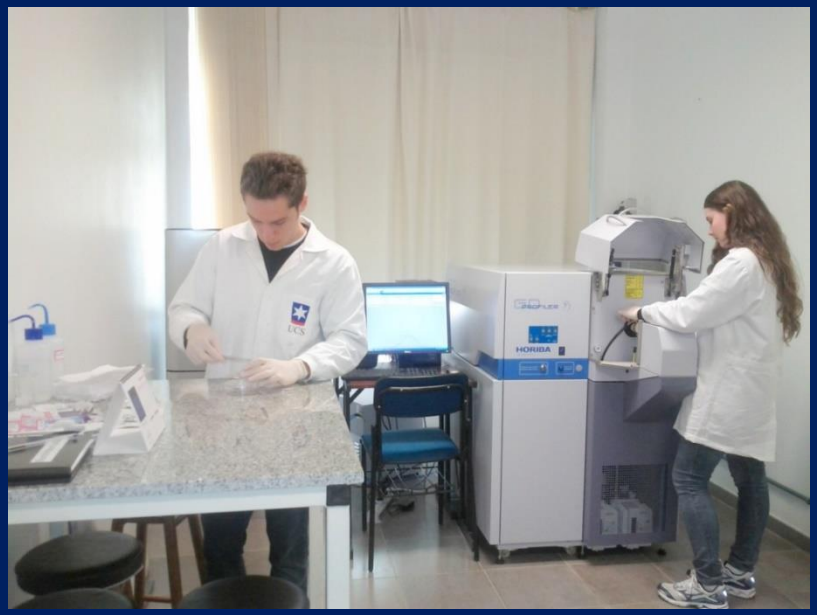
Sistema pino-sobre-disco PLINT

Laboratório de Conformação Nanométrica

Laboratório de Implantação iônica

UCS-Materials Science Program

Nanotribometer



GDOES

Materials and Surface Treatment Laboratory/Department of Mechanical Engineering/UFPR:
Ana Sofia C.M. de Oliveira

Tribology, Corrosion and Materials Laboratory/Department of Mechanical Engineering/UFES
Cherlio Scandian

Tribology Laboratory/Departmento of Mechanical Engineering/UNICAMP:
Paulo Mei

Integrated Center for technological Inovation/UFERSA:
Clodomiro Alves Jr.

Polymeric Materials Laboratory/Chemistry Department/UFSC:
Valdir Soldi
In collaboration with IBTeC, Brazilian Institute of Leather and Shoes Technology, Novo Hamburgo

UFPR/ Department of Mechanical Engineering

High temperature tribometer

Hardfacing by Plasma Transfer Arc Process

INES 2016/2017

Institutos SENAI de Inovação:

Instituto SENAI de Inovação em Engenharia de Superfícies, coordenado por Alexandre Barros (MG).

Institutos SENAI de Inovação em: - em Conformação e União de Materiais, (BA)
- em Manufatura Avançada e Microfabricação (SP)
- em Sistemas de Manufatura (SC)
- em Laser (SC)
- em em Soluções Integradas em Metalmecânica (RS)

Objectives:

The main objectives of the National Institute of Surface Engineering (INES) are:

- investigation of basic aspects of physical-chemical interactions at solid surfaces and interfaces:

1) Synthesis of thin films and interfaces by chemical and physical methods for application in industrial productive system.
2) Investigation of properties of modified solid surfaces.

- applications of surface engineering and transfer of this knowledge to the industrial productive system and to society.

- formation of high level human resources in surface engineering.

Budget submitted in 2014: R$ 9.679.614,59

Budget approved: R$ 6.921.075, 39

CNPq: R$ 2.334.688,73

CAPES: R$ 763.200,00

Federal agencies: R$ 3.090.888,73

FAPERJ: R$ 3.460.537,50

Real money:

CAPES: 20%/year – scholarships ~ R$ 150.000,00/year

CNPq: R$ 1.561.360,18 - scholarships ~ R$ 511.000,00

FAPERJ: R$ 218.400,00 (posdoc scholarship) and more R$ 576.000,00 in December

(atualização em 03/2020: não foi feito o depósito)

TOTAL: R$ 2.229.760,00 – scholarships ~ R$ 1.100.000,00

Budget cuts led to a maintenance strategy

Priorities:

- Scholarships: mainly pos-doc, only one PhD scholarship from CAPES

- Funding: consumption and services
  only small equipments: replacements (R$ 389.000,00)

Research

Scientific production by numbers (2017-2019):

Publications in indexed journals: 395

Book Chapters: 6

Communications presented in International Conferences: 30

Software: 1

Patents: 13 INPI (deposited)

48 principal investigators

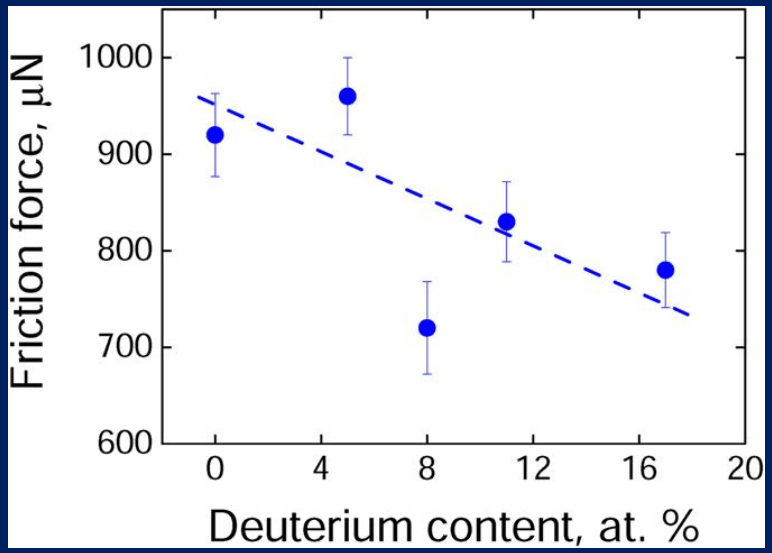
On the phonon dissipation contribution to nanoscale friction by direct contact

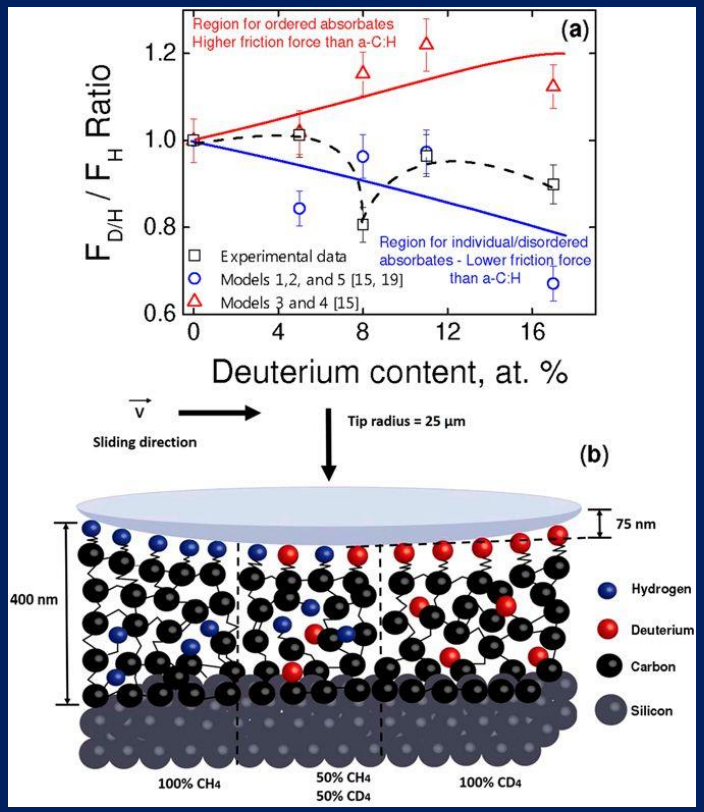
S. R. Sales de Mello1, M. E. H. Maia da Costa2, C. M. Menezes1, C. D. Boeira1, F. L. Freire Jr2, F. Alvarez3 & C. A. Figueroa1

1- UCS: 2- PUC-Rio; 3- UNICAMP

SCIENTIFIC REPORTS

nature





Towards superlubricity in nanostructured surfaces: the role of van der Waals forces†

ECHEVERRIGARAY, F.G.; S. DE MELLO, S.R.; LEIDENS, L.M.; MAIA DA COSTA, M.E.H. **(PUC-Rio)**; ALVAREZ, F. **(UNICAMP)**; BURGO, T.A.L.; MICHELS, A.F. **(UFRGS);** Figueroa C.A**. (UCS).** *Towards superlubricity in nanostructured surfaces: the role of van der Waals forces.* ***PHYSICAL CHEMISTRY CHEMICAL PHYSICS****,* v. 20, p. 21949-21959, 2018

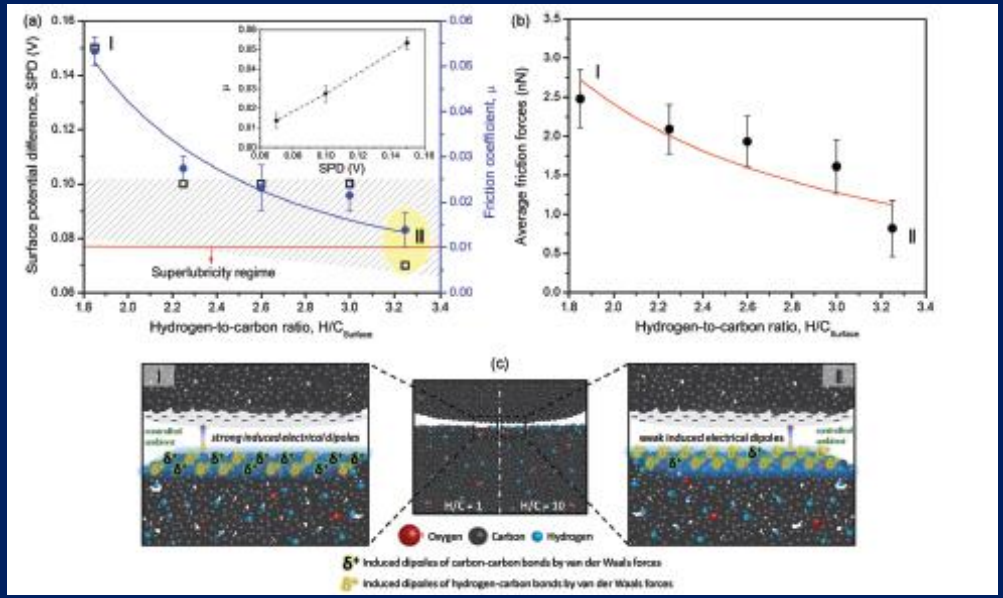


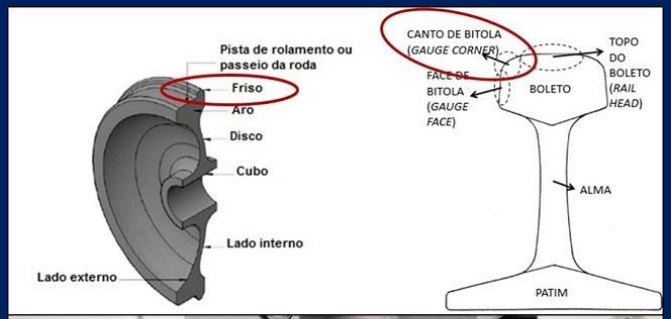
Fig. 6 (a) Evolution of the surface potential difference (SPD) (empty black square) and the friction coefficient measurements (full blue circles) as a function of the hydrogen-to-carbon ratio. The inset provides the friction coefficient as a function of the electrical potential. (b) Evolution of the average friction force obtained by LFM as a function of the hydrogen-to-carbon ratio. (c) Schematic of the physicochemical and electrical interactions for different H-content at the outermost layer of the a-C:H thin films. On the left, strong induced electrical dipoles at the sliding interface associated with a low H/C ratio and, on the right, weak induced electrical dipoles due to a high H/C ratio.

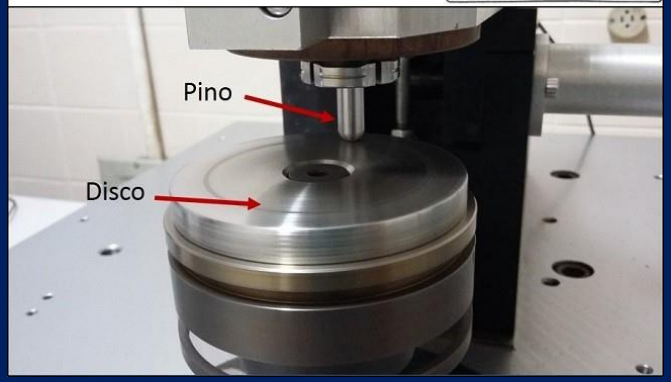
Study of sliding wear of the wheel flange - Rail gauge corner contact conditions: Comparative between cast and forged steel wheel materials. L. P. Ferreira de Almeida, L. E. Falqueto, Hélio Goldstein*, Cherkio Scandian

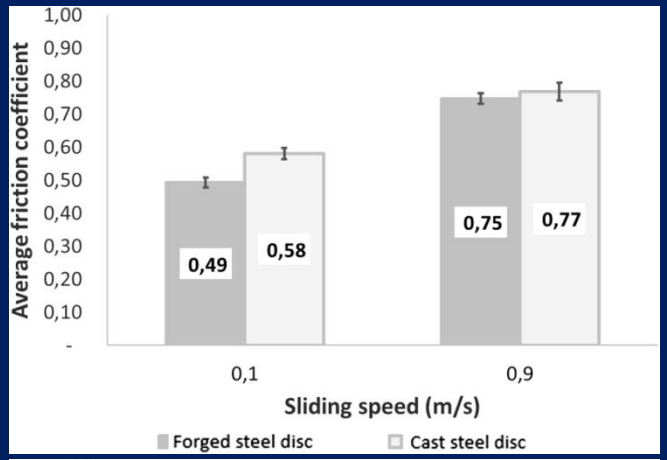
Mechanical Engineering Department. Federal University of Espírito Santo,

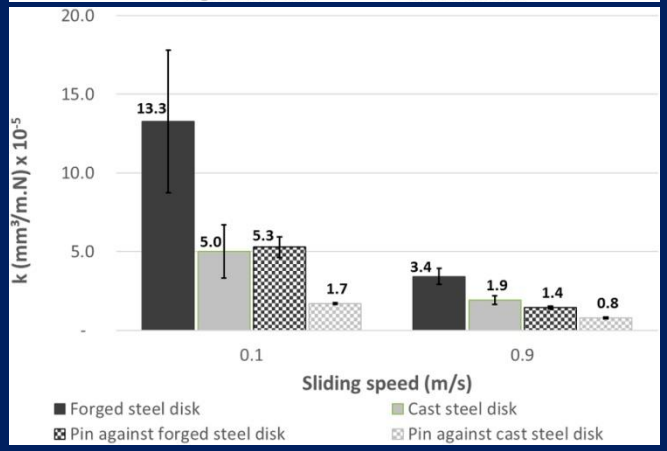
*LFS, Mechanical Engineering Department, University of São Paulo,

• **Wear,** volumes 432–433, 15 August 2019, 102894





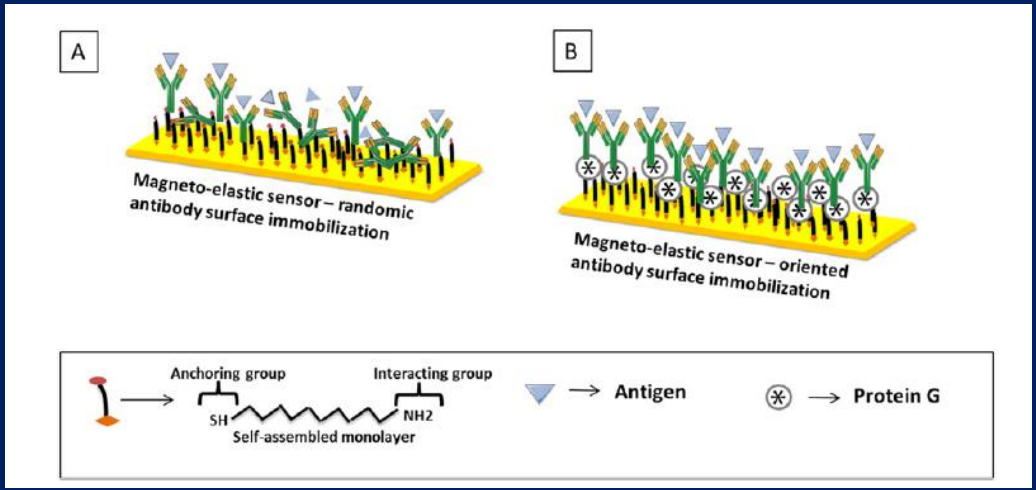




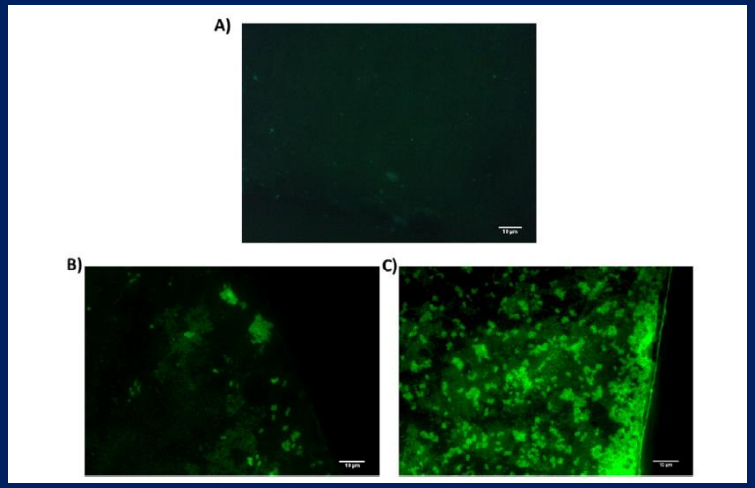
The dominant wear mechanisms of pins and discs were: adhesion, material transfer and *debris* oxidation, to a greater or lesser degree, for each condition tested.

Influence of antibody immobilization strategies on the analytical performance of a magneto-elastic immunosensor for Staphylococcus aureus detection

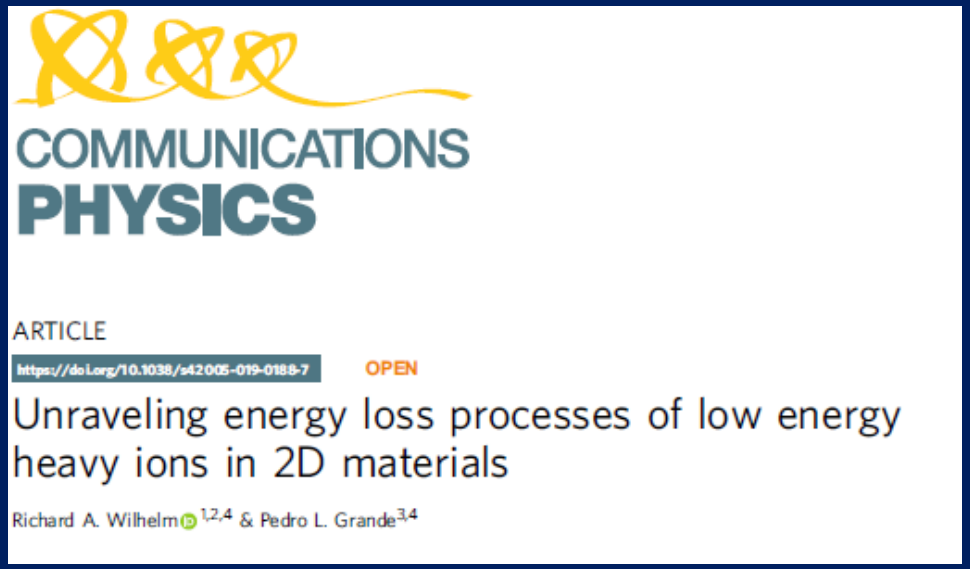
F. P. Missel et al. (UCS). ***Materials Science and Engineering C: Materials for Biological Applications*** *v.76, p1232-1237, 2017*



Schematic distribution of antibody immobilization strategies on magneto-elastic immunosensor surface: (A) random antibody covalent immobilization (CysAb), and (B) specific oriented antibody covalent immobilization (PrGAb).



Fluorescence optical microscopy images of the bacterial capture on magneto-elastic sensor surface: A) control samples; B) CysAb and C) PrGAb immobilization strategy. Note tha tPrGAb immobilization presents an increased density of bacteria over the sensor surface.



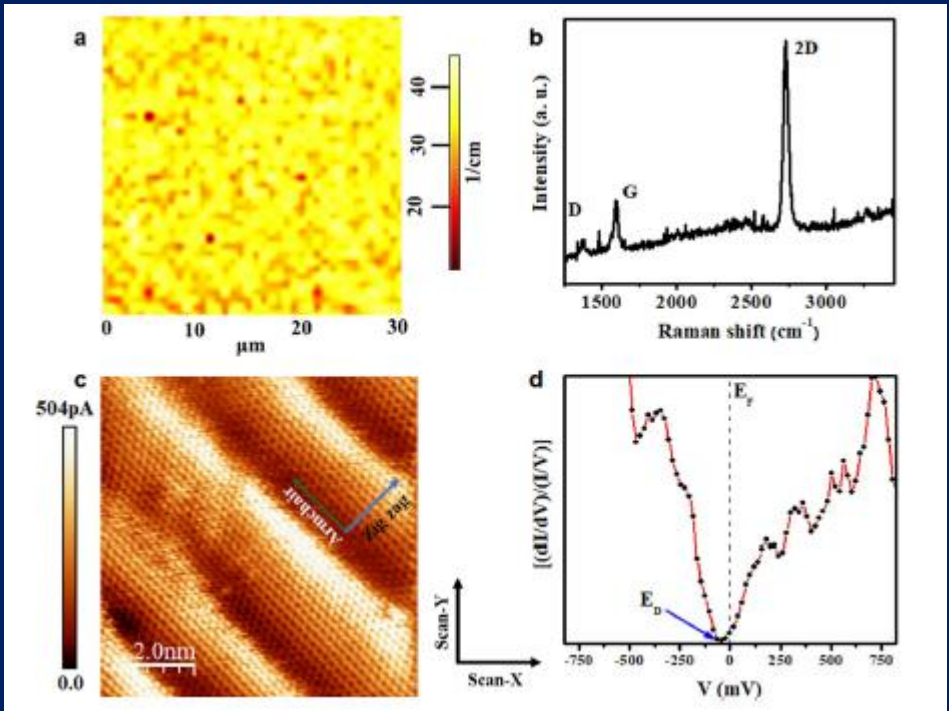
Pedro Grande (Institute of Physics) Richard A. Wilheim (Technical University of Viena)
Communications Physics, volume 2, Article number: 89 (2019)

Structuring of 2D materials and their heterostructures with ion beams is a challenging task,because typically low ion energies are needed to avoid damage to a substrate. In addition, atthe veryfirst monolayers of a material, ions are not yet in charge equilibrium, i.e. they mayeither charge up or neutralize depending on their velocity. The change in electronic structur eof the ion during scattering affects the energy, which can be transferred to the recoil and therefore the energy available for defect formation. In order to make reliable use of ion beams for defect engineering of 2D materials, we present here a model for charge state and charge exchange dependent kinetic energy transfer. Our model can be applied to all ion species, ion charge states, and energies. It is especially powerful for predicting charge state dependen tstopping of slow highly charged ions.

CVD graphene/Ge interface: morphological and electronic characterization of ripples

Cesar D. Mendoza, Neileth S. Figueroa, Marcelo E. H. Maia da Costa & Fernando L. Freire Jr.

Scientific Reports | *(2019) 9:12547*



Formation of human resources:

. 67 Doctors (PhD)

. 88 Masters (Msc)

. 70 Iniciação Cientifica

degrees in *Physics, Chemistry, Materials Science, Mechanical Engineering, Materials Engineering, Microelectronics, Petroleum Engineering and Chemical Engineering.*

Fellows of INES

Up 11/2019: CNPQ

DTI - A: 1 INPE, 1 UFERSA, 1 UNICAMP
Pos doc (PDJ): 2 UNICAMP , 1 UFRGS, 1 PUC-RIO, 1 UFSC/IBTeC, 1 UFERSA
AT-NM: 2 UFERSA
AT-NS: 1 PUC-Rio, 1 UFRGS

FAPERJ

Posdoc (PDJ): 1 UFRJ, 1 PUC-Rio

CAPES

PhD student: 1 PUC-RS
Pos-doc (PDJ): 2 UCS, 1 UNICAMP, 2 UFRGS, 1 INPE

How we selected the candidates? Call for proposals:

The advisor must present:

- CV Lattes of the candidate.
- Research project (only 3 pages).

Selection of the candidates was made by the Steering Board.

Former students:

Most of PhDs stay in the Academy:

Many new positions at traditional and new Federal Universities and Federal Institutes (mainly) in the last few years.

However, some students went to industries:

For exeample, Petrobras, SENAI Inovation Institute or small (spin-off)_Plasmar Tecnologia, Fineza (Caxias do Sul) and Clorovale Diamantes Indústria e Comércio S.A. (São José dos Campos)

Organization of scientific meeting in Brazil:

9th International Symposium on BioPIXE, Foz do Iguaçu, January 2018.
Chairs: Lívio Amaral and Johnny Ferraz Dias (UFRGS)

17th Annual Meeting of Brazilian Materials Research Society, Symposium T: Surface Engineering: from science to practice, Natal, September 2017.
Chairs: Carlos Figueroa (UCS), Felipe de Campos Carreri (Instituto SENAI de Inovação em Engenharia de Superfícies) and Fernando Lázaro Freire Jr. (PUC-Rio)

Technology forum coffee break at the 17th Annual Meeting of Brazil-MRS Meeting, Natal, September 2017
Chairs: Carlos Figueroa (UCS) and Felipe de Campos Carreri (Instituto SENAI de Inovação em Engenharia de Superfícies)

Transfer of knowledge to the society

- Diffusion of knowledge to the public in general using the web:
www.engenhariadesuperficies.com.br

Activities from initiatives of associated laboratories:

- Open lab days for high school students.

- Participation in the activities of the National Week of Science and Technology.

Web: www.engenhariadesuperficies.com.br

Papers and patents, technical presentations, videos, photos

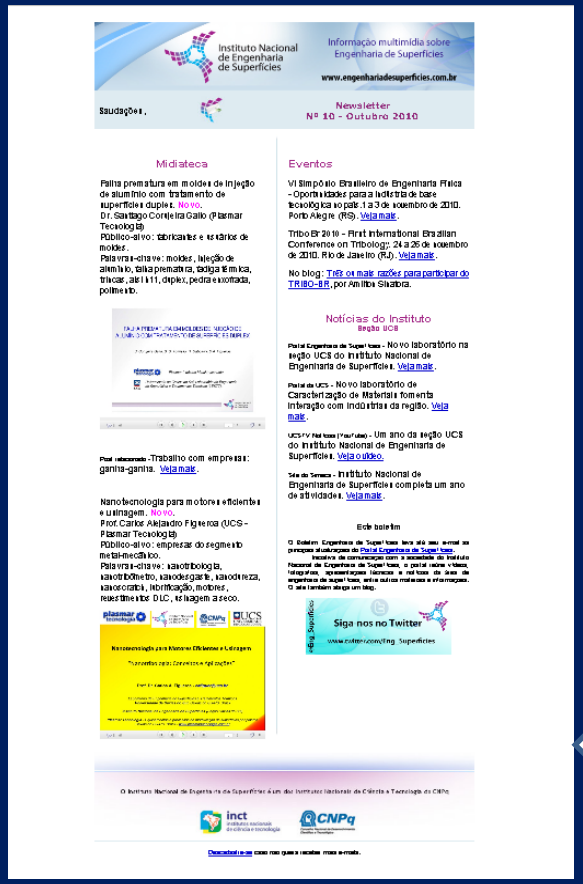
Contact form

250 page hits per month.

Web: how we reach the public

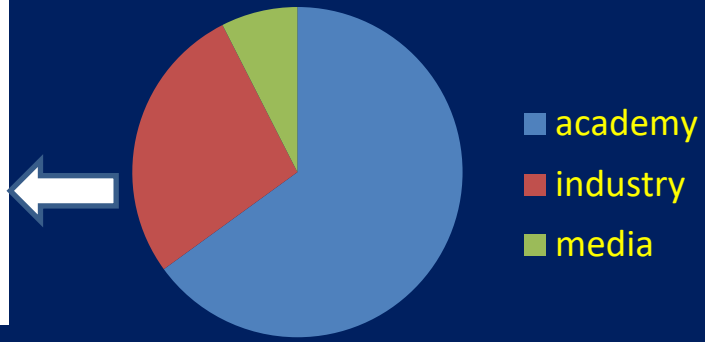
E-newsletter

bimonthly update



Twitter

600 subscribers



Statistics:

-Average of people reached on each post: 272.

- Average interaction (like, share, comment, click) on each post: 32.

Transfer of knowledge to the industrial sector

Professional equipment for depositing superhard diamond-like carbon (DLC) films with bactericidal, anticoagulant and other properties. The equipment uses a national technology that guarantees better properties to these films, based on a new deposition concept.

Transfer of knowledge to the industrial sector

DLC coatings: some products already in the market (INPE/Clorovale):

For Space

Oil & Gas

Dentistry

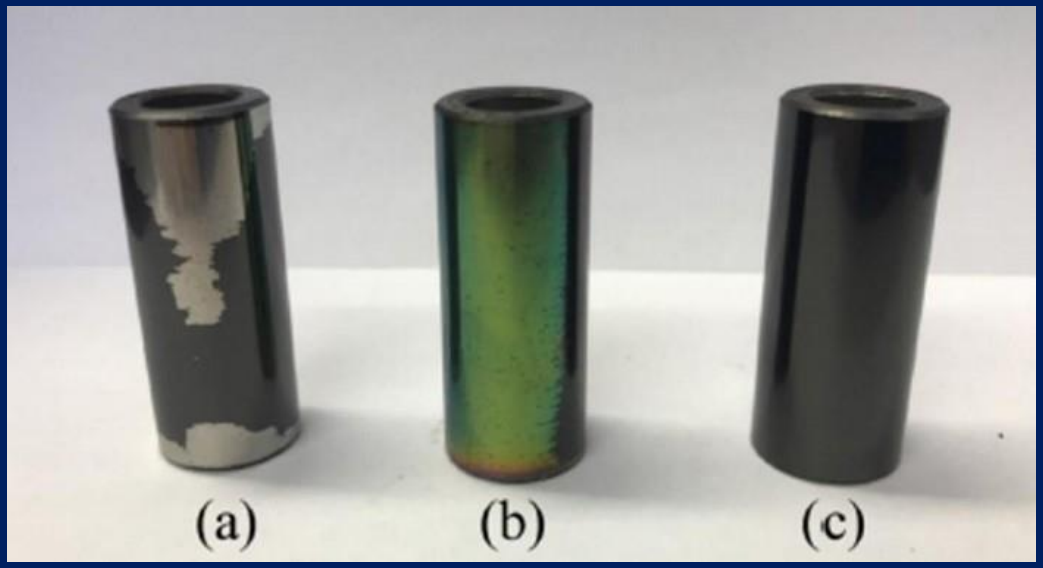
Medical

Engine parts

Cutelary & Others

Gold-colored coatings deposited by Physical Vapor Deposition (PVD) that can be applied to stainless steel (stainless) objects and other metallic materials for decorative purposes.

Process / treatment that improves adhesion of DLC coatings to parts to which they are applied: Deposition of the adhesion layer +hydrogen etching (reduces the process temperature)+ DLC coating by PECVD



DLC-coated automotive pins. The one on the right was previously treated with hydrogen etching.