



**THE TECHNICAL
UNIVERSITY**
of CLUJ-NAPOCA

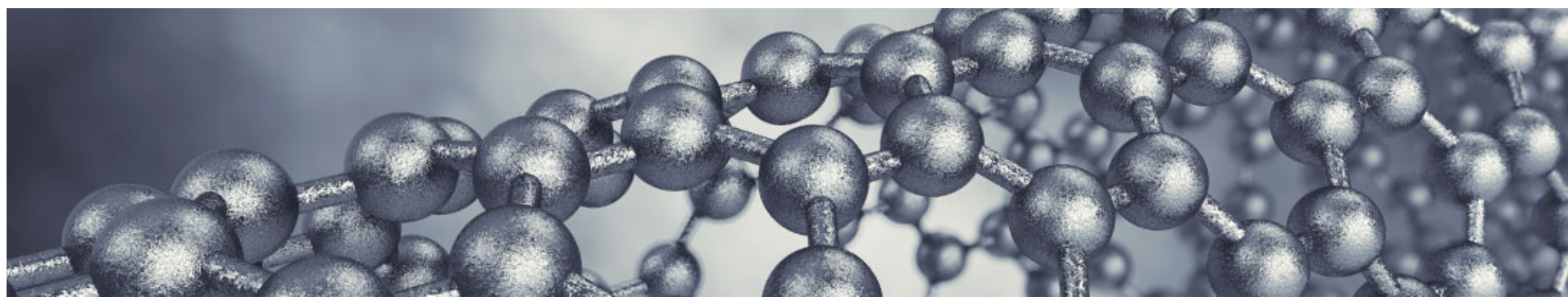
Research and development in Nanotechnologies at the Technical University of Cluj-Napoca

Prof. Phd. Eng. Phys. Coriolan TIUSAN

Department of Physics and Chemistry

Center of Superconductivity, Spintronics and Surface Science

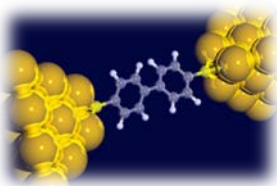
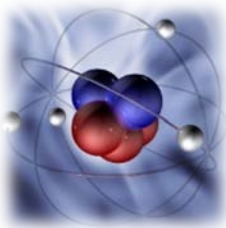
Faculty of Materials and Environmental Engineering



NANOTECHNOLOGIES

Incorporate an *assemble of technologies*:

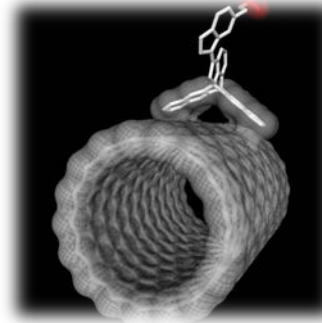
- At atomic, molecular, macro-molecular scale
- Based on **nanometric size** systems [1-100nm]
- Whose **functional properties derive from their dimensionality**



Intelligent assembling

Bottom-Up

Chemistry, Biology,...



PATTERNING

Top-Down

Physics,
Micro/Nano
electronics



Research strategy

Fundamental
research

Understanding: Basic phenomena

Technological
transfer

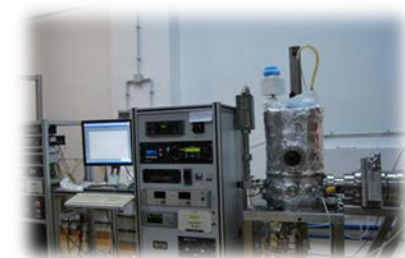
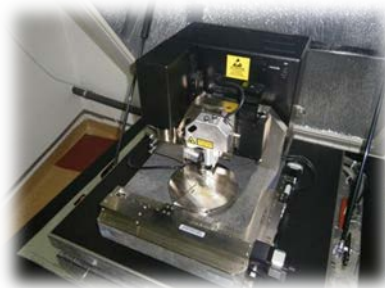
Elaboration: Materials, processes and
systems with tailored functional properties

TAILORING
of functional
properties via the
dimensionality

Applications

Integration:
in devices, systems and architectures, advanced and new
generation with innovative properties

TUCN
Research
centers

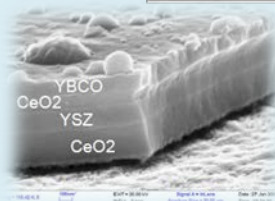


Prof. Phd. Phys. T. Petrișor

Prof. Phd. Eng. Chem. L. CIONTEA
Prof. Phd. Phys. I. ARDELEAN
Prof. Phd. Eng. Phys. C. TIUSAN
Assist. Prof. Phd. Dr. G. NEGREA
Assist. Prof. Phd. T. RISTOIU
Assoc. Prof. Phd. A. MESAROS
Assoc. Prof. Phd. M. GABOR
Assoc. Prof. Phd. T. PETRISOR Jr
Phd. M. NASUI
Phd. B. MOȘ
Tehn. R. MICLEA + Phd students...

**MAIN
RESEARCH
AXES**

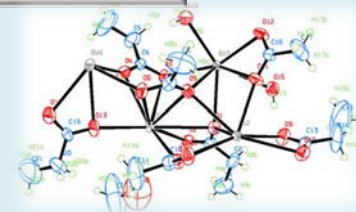
**High temperature
superconductors**



Prof. Traian Petrisor
Traian.Petrisor@phys.utcluj.ro

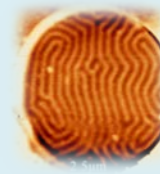
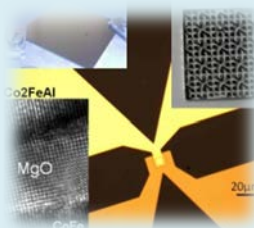
**Materials and
precursors chemistry**

Prof. Lelia Ciontea
Lelia.Ciontea@chem.utcluj.ro



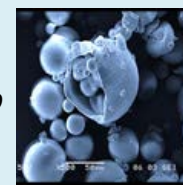
**Nanomagnetism and
Spintronics**

Prof. Coriolan Tiusan
coriolan.tiusan@phys.utcluj.ro

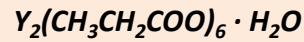
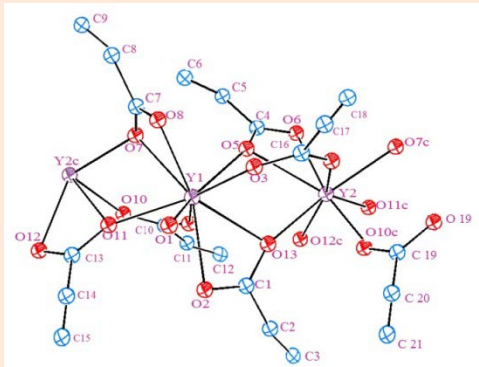


**NMR diffusometry and
relaxometry**

Prof. Ioan ARDELEAN
ioan.ardelean@phys.utcluj.ro

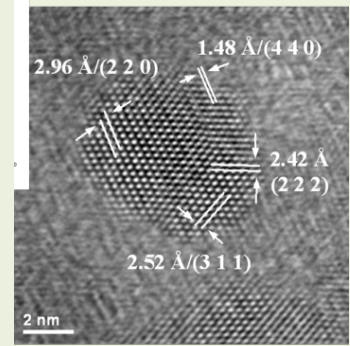
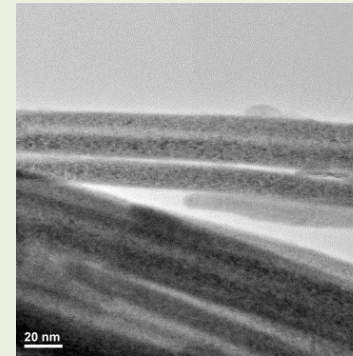


1. Molecular complex architectures: nano in 3D



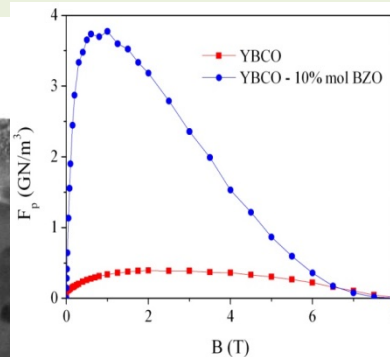
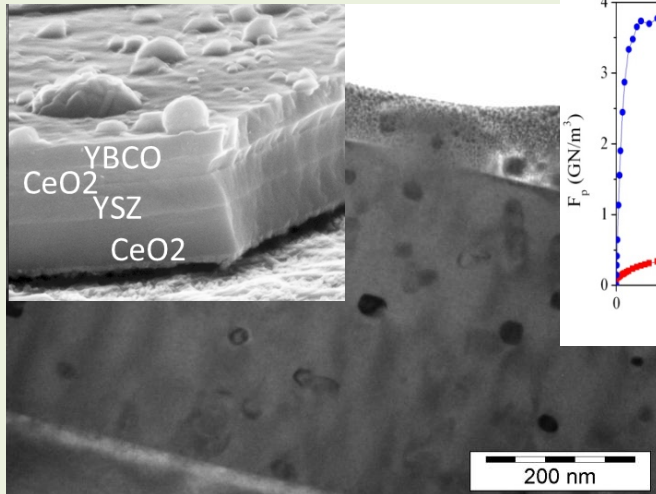
Precursors for thin films
with complex
composition and
architecture

2. Nanomaterials (1D, 2D, 3D)



Nanowires (e.g. Gd₂O₃) Nanopowders (GaFe₂O₄)

3. Thin films: nano in 1D

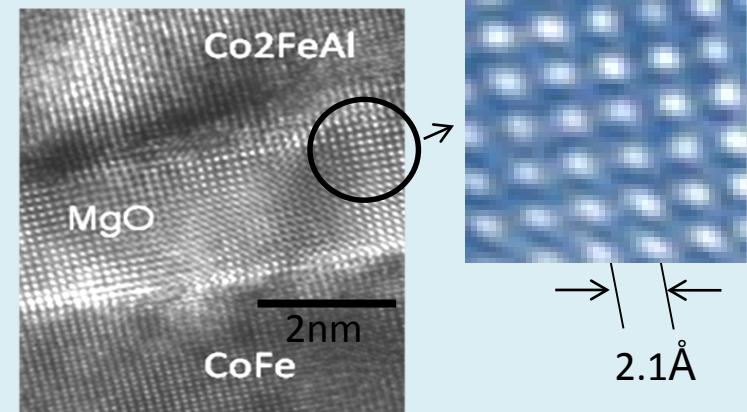


+
**Vortex pinning
nanocenters**
YBCO- BaZrO₃

Epitaxial superconducting architectures
Ni-W/CeO₂/YSZ/CeO₂/YBCO coated
conductors

- Energy transport without loss, producing giant magnetic fields, (fusion, NMR...)

Physical and functional properties modulated via
the thickness (nm)

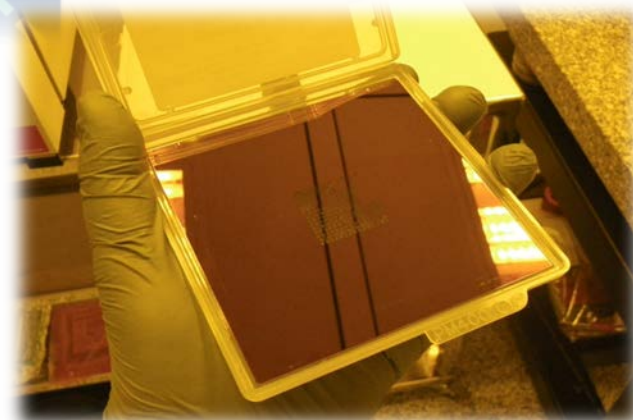


Multilayered spintronic architectures type
Magnetic Tunnel Junction

- **Spintronic devices:** Magnetoresistive sensors (field, position,...) (nonvolatile data storage, logic elements)

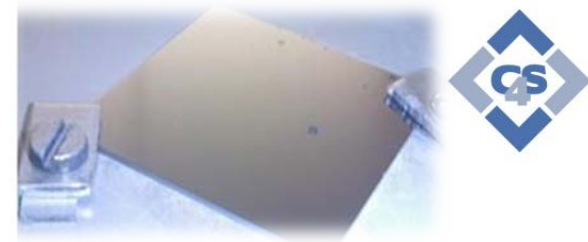
Clean room facilities (100 class)

- ☐ Optical lithography (MBJ4 SUSS mask aligner)
- ☐ Ion Beam Etching assisted by Auger spectroscopy
- ☐ Nanolithography facilities available in the chemistry lab

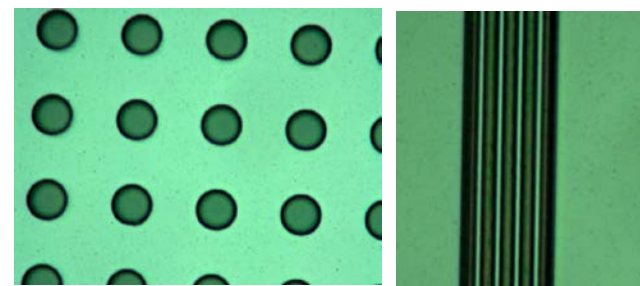


TOP-DOWN

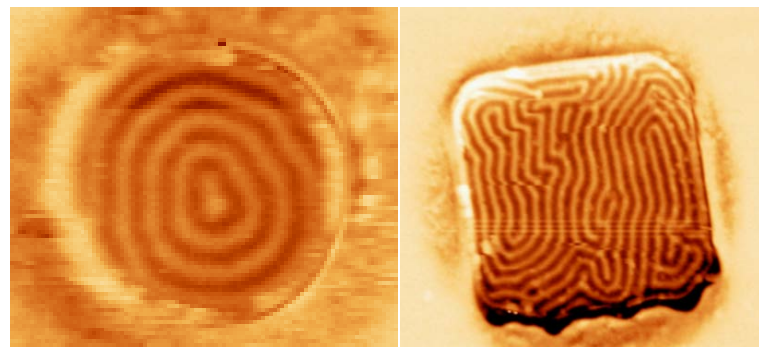
From continuous thin films to micro and nanostructures
3D (x, y, z) reducing of dimensionality



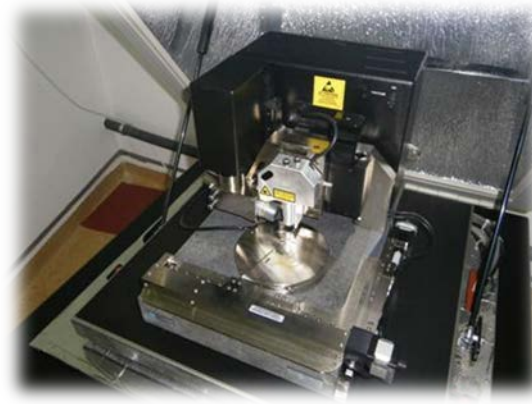
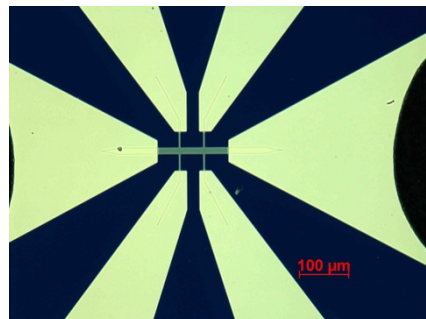
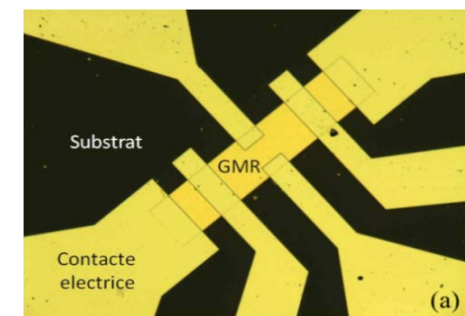
> 1 μm MICRO -LITHOGRAPHY



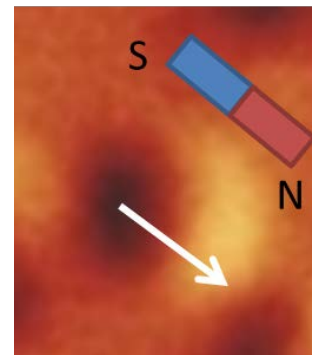
- Magnetic structures with tailored magnetic properties via shape and dimensionality



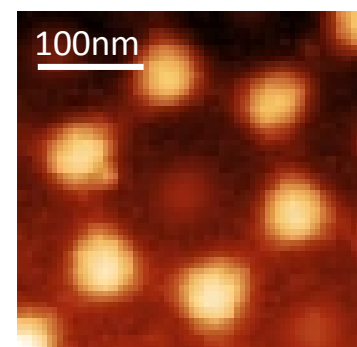
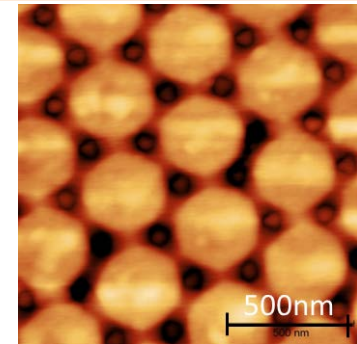
- Spintronic devices



Atomic/Magnetic Force Microscopy



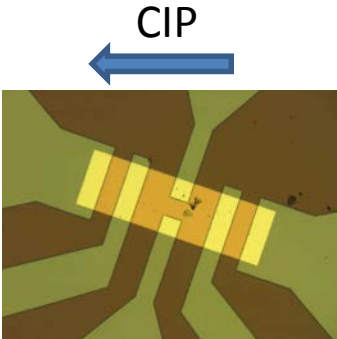
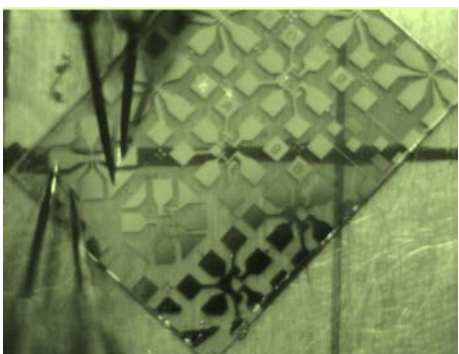
< 1 μm NANO -LITHOGRAPHY



Co nano- dots

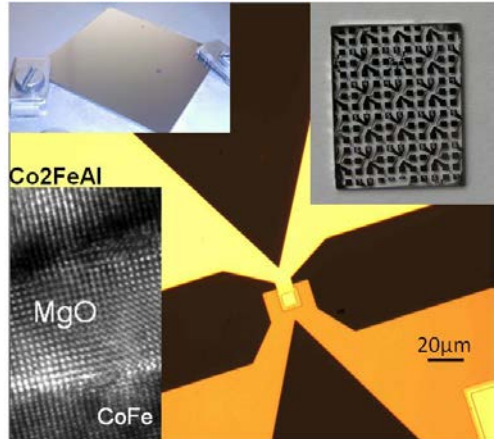
- Nano-engineering of magnetic properties
 - nonvolatile data storage
 - nano-oscilators with adjustable frequency
- Nano centers for vortex pinning in superconducting films

SPINTRONIC DEVICES

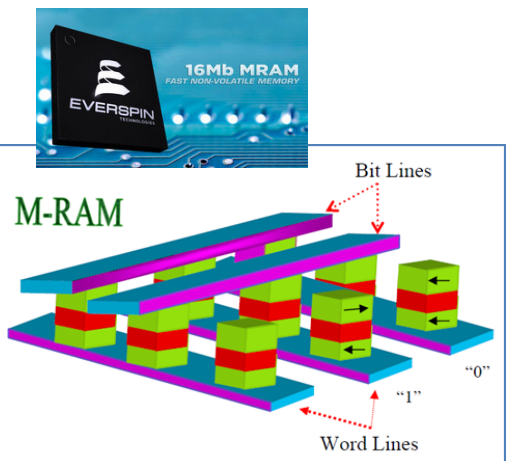
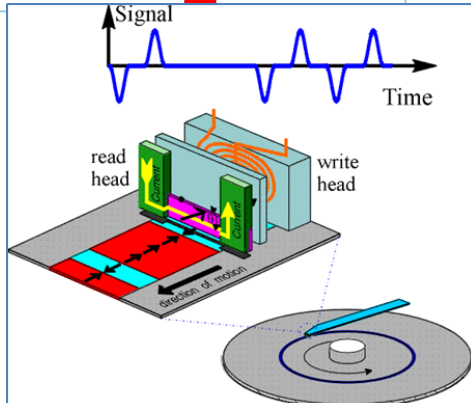
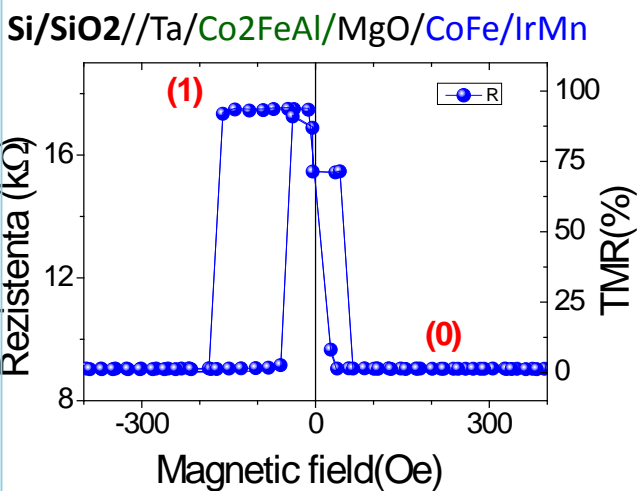
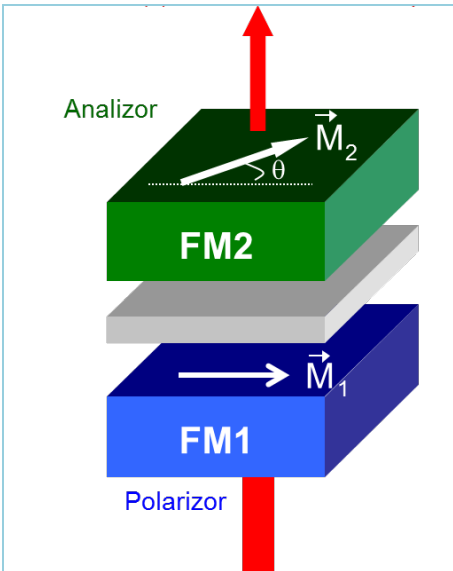
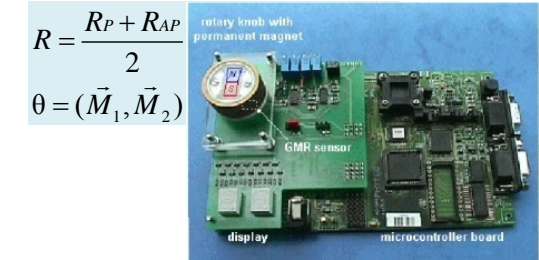
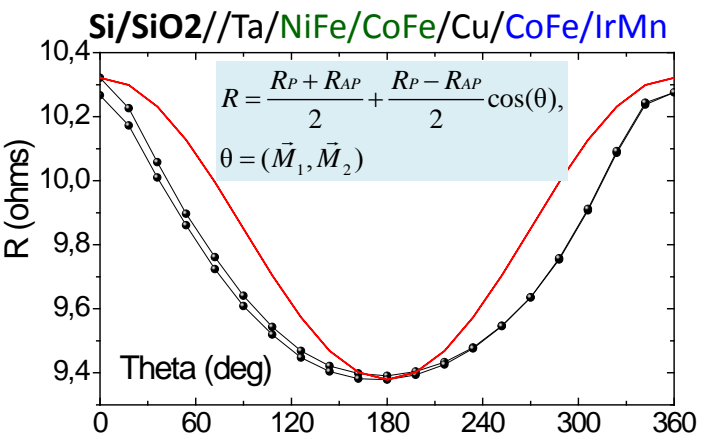


- Sensors : field, position (compass, ABS ,...)
- Read heads HDD
- Nonvolatile memories
- HF oscillators
- Logic elements...

CPP



Current $I=f(\theta)$ - spin valve effect



SPINTRONIC: POS CCE ID 574 Cod SMIS-CSNR: 12467

Prof. Phd. Eng. **Ionel Chicinaș**

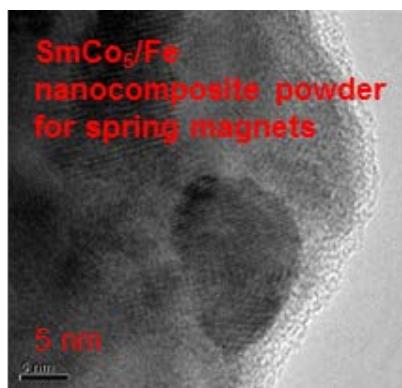
Assist. Prof. Phd. F. POPA • Assist. Prof. Phd. B.V. NEAMȚU • Phd. T.F. MARINCA • Phd. A.L. SORCOI •
Assist. Prof. Phd. C.V. PRICĂ, 2 Phd students • 2 Master students

Expertize areas

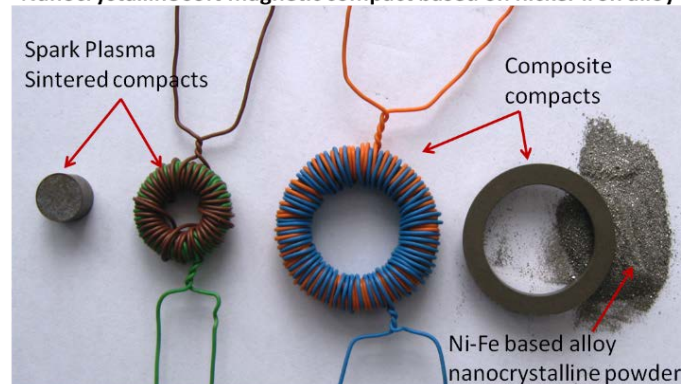
- ❑ Magnetic nanocrystalline, nanocomposite and amorphous materials (e.g. spring magnets)
- ❑ Magnetic nanoparticles, nanostructured powders pseudo “core-shell”
- ❑ Nanocrystalline compacts – synthesized and sintered in plasma (SPS)
- ❑ Material characterization

Nanocrystalline, nanocomposite, powder and compacted magnetic materials produced by MagMatNano

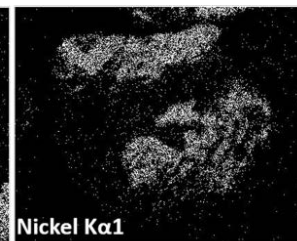
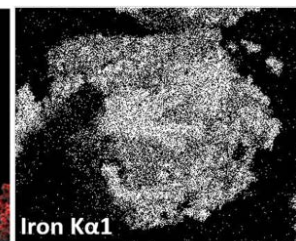
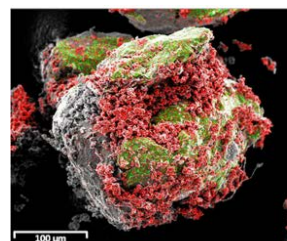
Nanocrystalline/nanocomposite powder and compacts based on soft magnetic ferrite



Nanocrystalline soft magnetic compact based on nickel-iron alloy



Plasma sintering setup
designed and produced
within the research
center- patent pending



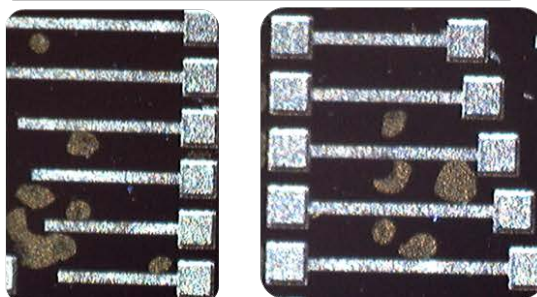
Prof. PhD. Eng. Marius Pustan

Prof. PhD. Eng. Corina BÎRLEANU , Prof. PhD. Eng. Cristian DUDESCU ,
Assist. Prof. PhD. Violeta MERIE, Lect. PhD. Mat. Florina RUSU, Assist. Prof. PhD. Radu CHIOREAN

Research topics:

- ☐ Reliability design of micro and nano systems (MEMS/NEMS)
- ☐ Materials nano-characterization MEMS/NEMS
- ☐ Nano-mechanics and Nano-tribology

Micro /Nano cantilevers



Multilayered cantilevers

SU8+Al
SU8+Au

Coated by a
nanofilm (Al and
Au)



Thermal switch

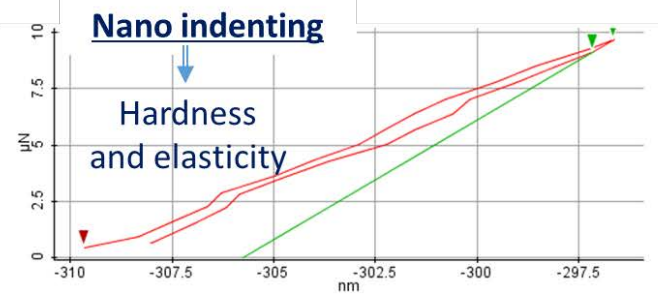
Characterization tools:

Cleanroom 1:1000

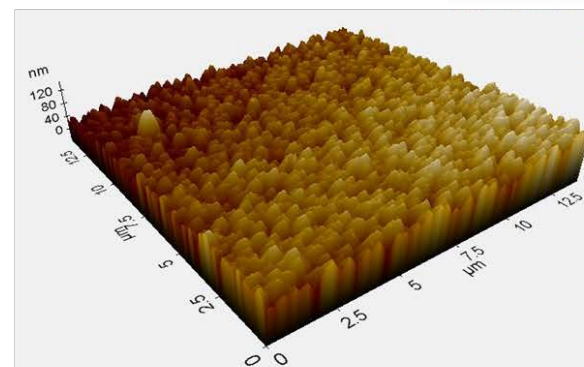
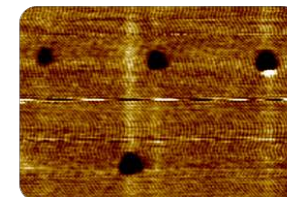
Atomic force Microscopy

Nanoindentation

Thermal stage (-10..160°C)



Slope Cursor Index 1 : 14
Slope Cursor Index 2 : 15
Contact Depth : 6.48nm
Tip Shape : Berkovich
Poisson's ratio of the tip : 0.07
Poisson's ratio of the sample : 0.25
Hardness : 9GPa



Nano-tribology

topography
adhesion
Nano friction
Nano wearing

Prof. Phd. Phys. E. Culea

1 . The research group on advanced vitreous materials (GCSMVA)

Prof. Phd. Phys. E.Culea, Assoc. Prof. Phd. P. Pascuta, Assoc. Prof. Chem. S.Rada

- ☐ ***Elaboration and characterization*** of structure and properties of systems vitreous doped with rare earth ions and co-doped with nanoparticles of rare metals with applications in the development of telecom equipment (lasers, laser amplifiers , optical fiber) → obtain vitreous materials based on metal oxides heavy (TeO₂ , GeO₂ , BiO₂) doped Eu³⁺ , ER³⁺ Nd³⁺ , Sm³⁺ and Gd³⁺ co-doped with Ag nanoparticles
 - ☐ **Doping with Eu³⁺ + codoping with Ag nanoparticles** producing *amplification of 10-15 times emission in the visible through the mechanism of " plasmon resonance".*
 - ☐ **Doping with Er³⁺ + codoping with Ag nanoparticles** produces the effect of emission « *freezing* » of light in the visible range.
- ☐ ***Getting vitreous materials by recycling waste***
- ☐ ***Storage of waste through immobilization in vitreous matrix .***

2. The research group for the study of advanced materials by means of NMR (NMR GCSMA) –

Prof. Phd. Phys. R.Fechete

- ☐ ***Study of the relationship between the dynamic structure and the properties of nanocomposite membranes used in PEM fuel cells .***
- ☐ ***Studies of the nanostructure of materials with nanoparticles fillers and polymer additives .***
- ☐ ***The study of nano - biomaterials by NMR spectroscopy and NMR relaxometry .***

3. The research group for the study of advanced polymeric materials (GCSMPA)

Prof. Phd. Eng. V. Popescu, Phd.Eng.G. Popescu

- ☐ ***Nanopowders based on TiO₂ , Cu₂S , Fe₂O₃ , ZnO with photocatalytic properties***
- ☐ ***Nanostructured films based on PbS , Cu₂S , CdS , Fe₂O₃ , TiO₂ (photosensitive in different ranges) .***
- ☐ ***Biomaterials based on composite materials with organic matrix and fillings made of glass, hydroxyapatite and TiO₂ or ZnO nanopowders .***

RESEARCH IMPACT

☐ International collaboration

France

Lorraine University (IJL Nancy)
Strasbourg University (IPCMS)
Grenoble University (Neel Institute, SPINTEC laboratory)
Paris XIII Sorbona University
Rouen University
CEA-LETI, MINATEC, Grenoble

Belgium

Liege University
Open Engineering SA
IMEC Leuven

United Kingdom

Imperial College London

Portugal

Aveiro University

Spain

ICMAB Barcelona
Madrid University

Italy

ENEA Frascati, Parma University
Salerno University
Torino University

Germany

Osnabruck University
Aachen Rheinisch-Westfälische Technische Hochschule (RWTH)
Technical University Ilmenau

Poland

University of Technology from Warsaw

Slovakia

Inst. of Physics, P.J. Šafarik University, Kosice



University of Alaska

South Korea
Park System Co.

☐ National collaboration

- UBB, INCDTIM, UMF, UIAC, ICPE-CA ...

❑ National and international research projects

- ❑ 1995-2015 over 30 international projects

- ❑ 2010-2015 over 10 national projects IDEEAS, Complex IDEEAS, Young Teams

❑ Research dissemination

- ❑ 2005-2015 Over 350 ISI ranked papers

- ❑ 2005-2015 over 75 oral and poster presentations and conferences and workshops

- ❑ 2010-2015 over 5 workshops, summer schools and conferences organizing

❑ Pending patents

- ❑ 2010-2015 over 5

❑ Research facilities investment

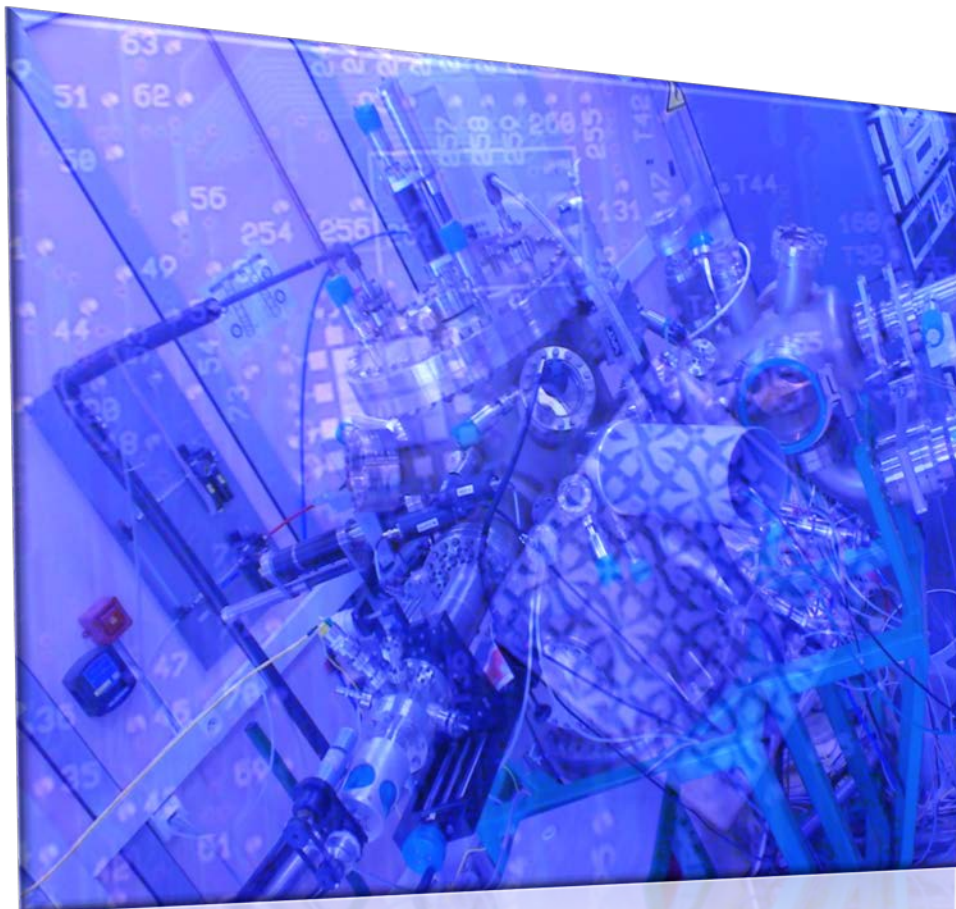
- ❑ 2000-2015 over 3 millions Euros

❑ Significant contribution to academic teaching

Research lab integrate Master and Phd. students (over 20 - 2010-2015)



ADMATECH Cluster (2015) : **Advanced Materials, Micro and nano technologies**



Competitiveness and competence pole, reference at Regional, National and European level

Academic partners (Universities):

UTCN, UBB, UMF, USAMV, U Oradea, SRF

Research Centers (NIRD):

INCD-TIM, ICPE-CA, INCDO-INOE (ICIA)

Industrial partners:

SINTEROM, NAPOSINT, MINESA, PURTECH, BETAK, PROPLANTA, PROCEMA, REMED

President TUCN (Prof. Phd. Eng. C. Popa)

VP: TUCN: (Prof. Phd. Eng. C. Tiusan) – responsible on Competitiveness and competence poles

NANOTEHNOLOGIIES: Convergence areas of Sciences and Technologies

