Simpozion

Institutul de Fizică Atomică

ANCS
AUTORITATEA NAŢIONALĂ PENTRU CERCETARE ŞTIINŢIFICĂ

POSIBILITĂȚI DE COOPERARE A CERCETĂRII CU INDUSTRIA

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Organizat la inițiativa Autorității Naționale pentru Cercetare Științifică (ANCS), evenimentul îşi propune o întâlnire a reprezentanţilor INFINEON TECHNOLOGIES şi HONEYWELL din România cu reprezentanți ai instituțiilor de cercetare de pe Platforma Măgurele şi Institutul de Microtehnologie Bucureşti, în scopul stimulării unor proiecte comune cu puternic caracter aplicativ. În prima parte a simpozionului vor fi prezentate propuneri concrete de colaborare din partea cercetării, iar partea a doua a întâlnirii se va focaliza pe cristalizarea unor inițiative realiste de proiecte comune care vor beneficia şi de susținerea ANCS.

Miercuri 29.02.2012, ora 11^{30}, Sala de Consiliu, Bloc Turn, etaj 9

Proposals of the National R&D Institutes for Cooperation with Industry

- February 29, 2012 -

National Institute for Laser, Plasma and Radiation Physics (www.inflpr.ro)

1. Maria DINESCU (dinescum@nipne.ro)
   Laser Induced Forward Transfer (LIFT): applications in sensor printing and medicine

2. Cristian LUNGU (cristian.lungu@inflpr.ro)
   Technology for antireflective and protective coatings „Diamond Like Carbon" (DLC) on optical elements.

3. Cristian RUSET (rusetcristian@yahoo.co.uk) and Eduard GRIGORE
   From scientific research to industrial production – a few examples in surface engineering

4. Cristina SURDU-BOB (cristina.surdubob@plasmacoatings.ro)
   Plasma coatings research

5. Ion TISEANU (tiseanu@infim.ro, http://tomography.inflpr.ro/)
   X-ray microtomography and image processing

6. Marian ZAMFIRESCU (marian.zamfirescu@inflpr.ro)
   Direct laser writing of materials by ultrafast laser pulses

National Institute for Materials Physics (www.infim.ro)

7. Monica ENCULESCU (mdatcu@infim.ro), E. Matei, C. Florica, N. Preda, I. Enculescu
   Nanowire-based devices for applications

8. Aurelian Cătălin GÂLCĂ (ac_galca@infim.ro)
   Optical, structural and electrical properties of transparent conductive oxides

9. Corneliu GHICA (cghica@infim.ro)
   Opportunities for highest level microstructural characterization by high-resolution analytical electron microscopy

10. Liviu NEDELCU (nedelcu@infim.ro) and Marian Gabriel BANCIU
    Advanced Dielectric Materials for Microwave and Millimeter Wave Applications

11. George E. STAN (george_stan@infim.ro)
    Highly c-axis textured AlN films for MEMS technology. Biofunctional thin films for medical applications

Horia Hulubei National Institute of Physics and Nuclear Engineering (www.nipne.ro)

12. Ion BURDUCEA (bion@nipne.ro) and Marius DOGARU
    Hydrogen, Deuterium and Tritium profiling in thin layers by Resonant Nuclear Reaction (RNR) and Accelerator Mass Spectrometry (AMS)

13. Marin Marius GUGIU (gmarius@tandem.nipne.ro)
    Materials characterization by Ion Beam Analysis techniques

14. Ioan Valentin MOISE (vmoise@nipne.ro), Corneliu Catalin PONTA
    Radiation processing for automotive industry

15. Carmen PAVEL (cnico@nipne.ro)
    Micro-PET based on planar detectors and columnar cesium iodine scintillators

16. Mihai STRATICIUC (mstrat@nipne.ro)
    Slow positron facility for thin layer analysis

National Institute of Research & Development for Optoelectronics (www.inoe.ro)

17. Mihail ELIŞA (astatin18@yahoo.com)
    Temperature sensors based on vitreous materials doped with semiconductors of type II-VI

18. Ileana Cristina VASILIU (icvasiliu@inoe.ro)
    Sensitive organic/inorganic structures for electrolytic media monitoring

National Institute for Earth Physics (www.infp.ro/en)

19. Mircea RADULIAN (mircea@infp.ro)
    Seismic hazard assessment in sites of national interest

National Institute of Research & Development in Microtechnologies (www.imt.ro)

20. Alexandru MULLER (alexandru.muller@imt.ro)
    IMT- Bucharest presentation

PROPOSAL # 1

Laser Induced Forward Transfer (LIFT): applications in sensor printing and medicine

Maria Dinescu-INFLPR (National Institute for Laser, Plasma and Radiation Physics)

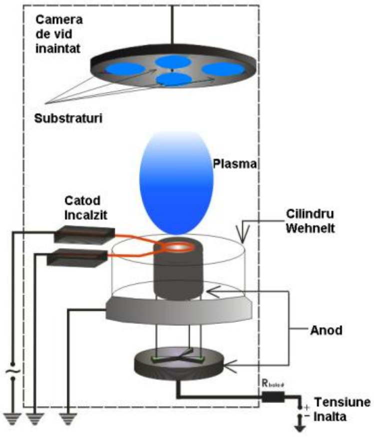
Laser Induced Forward Transfer (LIFT) is used as technique for printing active micrometric membranes (polymers, metals, nanoparticles, multilayers, biological materials) on different sensor matrices for Volatile Organic Compounds (VOC's) detection. The same technique can be successfully applied for cells, proteins, blends of polymers/proteins/nanoparticles printing for medical applications as drug delivery and tissue engineering.

PROPOSAL # 2

Technology for antireflective and protective coatings „Diamond Like Carbon" (DLC) on optical elements

Lungu Petrica Cristian, Corneliu Porosnicu, Jepu Ionut, Petrica Chiru, Ana Mihaela Lungu, Valer Zaroschi, (National Institute for Laser, Plasma and Radiation Physics)

1. Characteristics:



This technology will ensure the production of Diamond Like Carbon films having the following characteristics: reflexivity: less than 40%, in the range of 2-25 µm, nanohardness: 40+/-5 GPa; the refractive index: 1,9 - 2,9; chemical bonding of sp^3 type: larger than 60%; deposition rate: 0.1-5 nm/sec; the films thickness: 10 - 200 nm.

The principle of the technological setup is presented in the figure: a W heated cathode produces thermoelectrons focused by a Wehnelt cylinder toward a carbon rod, the anode. The W cathode is heated until the electron beam emitted evaporates the carbon anode. A positive voltage of 1-5 kV applied on the anode accelerates the electrons producing bright plasma in pure carbon vapors. The carbon atoms as neutrals and positive ions are deposited on the substrate fixed at tens of cm far away from plasma source.

2. Novelty

The absolute novelty of this technology consists in the deposition conditions: the coatings are performed in ultra high vacuum in the absence of any buffer gas used in all other technologies for thin film preparation.

The coatings are performed in the conditions when the growing layer is strongly bombarded with genuine carbon ions having the same composition like the layer. The controlled ion energy in the range of 100-2000 eV confers to the layer to have a majority of sp^3 bindings, diamond type. The high ion energy ensures a high adherence and compact layer formation.

The proposed technology is protected by a patent request registered at OSIM with the nr. A/00951/20.11.2009: „Hard carbon antireflexive layer with diamond like carbon (DLC) bindings obtained using thermionic vacuum arc method", authors: INFLPR: Lungu Petrica Cristian, Mustata Ion, Zaroschi Valer Nicolae, OPTICOAT: Sobetkii Arcadie, Cirstoiu Florentina, IPA: Vlăduț Gabriel Cătălin, Matei Virginia

3. Competitively level:

At the European level, in agreement with the scientific publications, was concluded that the coatings of the order of 60 nm prepared using 0.2 – 0.3 nm/s led to an efficient conversion of the solar energy in the electric energy, starting from 3.7% without DLC coating up to 5.4% in the case of DLC coating between 40 and 54 nm.

The proposed technology will ensure the realization of amorphous DLC coatings with sp^3 bindings concentrations higher than 60%.

Due to the usage of W cathodes and low current discharges the ion sputtering will be lower compared with other technologies and the layers will be not unpurified. The evaporating material will be bombarded with electrons not with ions, like in other technologies. Connecting this fact with the high plasma energy, the cluster formation will be avoided and the coating quality will be higher than of other methods.

PROPOSAL # 3

From scientific research to industrial production – a few examples in surface engineering

C.Ruset, E.Grigore
National Institute for Laser, Plasma and Radiation Physics

At the moment in INFLPR there is processing and analyzing equipment which is currently in use for industrial applications in surface engineering.

Equipment includes a plasma nitriding unit of 70 kW for diffusional treatments (case depth up to 0.5 mm), a CMSII (Combined Magnetron Sputtering and Ion Implantation) coating unit of 25 kW (coatings with thickness of 1-30 μm), a GDOS (Glow Discharge Optical Spectrometer) for depth profiling of the concentrations for surface constituents, microhardness testers, metallographic microscopes, mechanical and metallographic workshops.

The main applications developed during the last years are:

- Tungsten coating (10-25 μm) of the carbon based materials (CFC-Carbon Fiber Composite and FGG-Fine Grain Graphite) for the first wall in nuclear fusion devices where the surface temperature can reach 2,000 °C. CMSII was proved to be the best European technology for this application. More than 3,000 tiles of different shapes and dimensions were coated and installed in JET (Joint European Torus) and ASDEX Upgrade tokamaks. JET, Culham Center for Fusion Energy, UK is the biggest operational tokamak in world and ASDEX Upgrade, Garching, Germany is one of the biggest. Value of the contracts on this subject: more than 1 M€.
- Plasma Anti-sticking - is applied in rubber industry for components which are in the contact with non-vulcanized rubber during the tyre manufacturing process. Main beneficiary: Michelin Company. The anti-sticking layers were qualified by MARK laboratories, USA.
- Plasma nitriding of various components for forging, mould and plastic industries.

Next technologies which are envisaged:

- Laser alloying and laser cladding in combination with plasma nitriding and CMSII coating. Application area: forging dies, moulds for aluminium injection, etc.
- Carbon based coatings with high wear resistance and low friction coefficient. Application area: automotive industry.

Personnel: 8 people specialized in plasma physics, material science, mechanical engineering and electronics. The CMSII technology was developed in INFLPR from laboratory to industrial scale in 2 years. Qualification of technology for tungsten coating of carbon materials and coating production for 3,000 tiles took about 2 years too.

PROPOSAL # 4

Plasma coatings research

Cristina Surdu-Bob, PhD
Head of Plasma Coatings Research Group Low Temperature Plasma Laboratory, National Institute for Laser, Plasma and Radiation Physics

The Plasma Coatings Research Group of INFLPR has contributed to the development of an original low-temperature plasma source and is active on demand-based-plasma-technologies for thin film deposition of any metal in the Periodic Table including refractory metals, non-metals, as well as nitrides, DLC and combinations at a nanometric level of any two of these materials. Our experience comprises deposition of hard films, anti-corrosive films, low friction films, anti-microbial films and bio-compatible films. Substrates typically used: steels, optical glass, Si, as well as temperature sensitive materials like textiles and plastics. Current research focus: tuning of optical band-gap. We have also developed a technique for the synthesis of ultra-thin metal and DLC foils (thickness 1.5 microns and a few square centimeters area). Another achievement is the development of a system for the synthesis of spherical particles of micrometric diameter. The infrastructure comprises an original plasma source in vacuum for the deposition of thin films, planetary motion rotation of samples (holder for 24 pieces), medium scale textile metallization system (approx. 10m per load), Spherical microparticles production system (50-800 microns diameter). Staff: 1 PhD graduated in the UK (physics), 1 PhD co-supervised with Germany (physics), 2 PhD. med., 1 PhD Std.
www.plasmacoatings.ro

PROPOSAL # 5

X-ray microtomography and image processing

Team Leader: Dr. Ion TISEANU National Institute for Laser, Plasma and Radiation Physics

Team structure

The team is composed of 2 researchers (1 senior researcher Ist rank, 1 senior researcher IInd rank), 2 scientific researchers and 1 technician.

Dynamic of research directions and subjects

Since 2000 our group has been responsible for the design and fabrication of a prototype of an X-ray microtomography facility suitable for operation in the (*International Fusion Materials Irradiation Facility)* IFMIF test cell environment. This task was successfully accomplished: *(*EFDA Fusion Newsletter, *3-D X-ray Microtomography at MEC Romania, Vol. 2003/6, December 15, 2003).*
Currently the microtomography group operate two X-ray imaging facilities which were completely designed and constructed within our laboratory:

A. **NanoCT** – an X-ray submicron resolution computer tomograph

Upgraded and commissioned during 2007-2008, the system is equipped with a high performance Nanofocus X-Ray source for non-destructive inspection. The source is operational in micro- or nano-focus regime in which case it is capable of sub-micron feature recognition, at a tube voltage up to 225 kV and a maximum power of 10÷20 W. X-Ray images can be acquired by using three different high resolution detector types: Image Intensifier (768x576 pixels of 132x132 µm2) for rapid non-destructive examinations and two CMOS flat panels (pitch size 48 and 75 µm) as very high resolution 2D imaging detectors. A high energy, line detector (pitch size 400 µm) is employed for the slice by slice scanning of high density samples. Positioning and turning around of the sample are ensured by a set of seven high precision motorized micrometric manipulators. Automation, control and data acquisition were obtained by means of an in-house software package. The tomographic reconstruction for the cone-beam scanning is based on an optimized implementation of the modified cone beam filtered back-projection algorithm. Using a parallelization technique on multiprocessors workstations, experimental data consisting of several hundreds of large radiographic images (1220x1216 pixels) are processed for building the 3D reconstructions of typically 1024x1024x1024 voxels in less than 10 min.

B. **Tomo-Analytic** – a combined X-ray microbeam transmission/fluorescence system for 3D morphology characterization and composition mapping Tomo-Analytic (commissioned in 2008) is an innovative concept of 3D morphology and composition mapping instrument completely developed by our group. The 3D-CT component is configured to take several hundred highly resolved (48 μm) radiographic views of the object in order to build a 3D model of its internal structure. 2D slices through this volume can be viewed as images, or the 3D volume may be rendered, sliced, and measured directly. For the NDT inspection of miniaturized samples the microtomography analysis is guaranteed for feature recognition better than 15 μm. The key element of the XRF component is a policapillary lens which provides a focal spot size around 15-20 micrometers. Also a significant increase of X-ray intensity (up to three orders of magnitudes) is obtained. This guaranties higher detection sensitivity and shorter measurement time. The main limitation consists in the possibility to investigate relatively thin samples. The implementation of a confocal geometry realized with the attachment of a polycapillary conic collimator to the X-ray detector further allows the extension of capabilities of the instrument towards fluorescence tomography (3D composition mapping).

Main applications of our X-ray imaging techniques

I. Non-destructive analysis in fusion technology

- Assessment of the structural integrity of a prototypical instrumented IFMIF high flux test module rig. 3-D tomography is accepted as the official inspection procedure.
- Tomography measurements with very high space resolution (up to 2.5 microns/voxel) on relatively large sample volumes (up to 5x5x5 mm3) were performed at the NanoCT facility
- A new procedure for the quantitative evaluation of the CFC porosity factor by post-processing of the 3-D computed tomography images has been applied. Porosity factors for all fusion technology relevant CFC materials and multilayer SiC were evaluated.
- Non-destructive analysis of bonding technologies for CFC and SiC/SiC materials to heat sink components (ex. brazing of N11 CFC to Cu in the Tore Supra tokamak)
- Non-destructive analysis of metal coated/impregnated composite materials. The 3D reconstructed model of the infiltrated metal can be used as input data for the evaluation of the thermal properties of the CFC – heat sink assembly.
- Our combined absorption/fluorescence X-ray technique offers a fast and nondestructive method which allows the quantitative determination of the thickness of a tungsten coating on a carbon material on large areas. The method is currently used to determine 2D erosion mapping of metal coated graphite/CFC tiles from ASDEX Upgrade and JET tokamaks.

II. Microtomography on superconductor materials: bulk, wires and cables

Another relevant topic concerns the tomographic analysis of superconducting wire and cables (Nb3Sn, NbTi and MgB2).

- We proved that X-ray micro-tomography permit the non-destructive reconstruction of the 3D image of the Nb3Sn ITER-type multifilamentary wire enabling the determination of the number of inter-filament contacts on unite lengths well as the twist-pitch parameter.
- We applied microtomography visualization to MgB_2 bulks, tapes and wires. This provides powerful and unmatched information by the conventional microscopy techniques on the local 3D density uniformity and distribution, connectivity, search and identification of the macrodefects, 3D-shape details of the macro defects and of the components from the composite MgB_2 wires or tapes, on the roughness and perfection of the interfaces between the components.
- Our group has won a Fusion for Energy cotract to perform the quality control monitoring of NbTi strands and conductors for JT 60 SA tokamak.

Most important achievements

- Development of the X-ray advanced imaging instruments operated in our laboratory.
- Development of the official inspection procedure for the assessment of the structural integrity of an instrumented IFMIF high flux test module rig.
- Consistent evaluation of porosity factors for all fusion technology relevant CFC materials and multilayer SiC.
- Development and application of a high productivity method for the 2D erosion mapping of metal coated graphite/CFC tiles from ASDEX Upgrade and JET tokamaks.
- Novel image processing methods for fusion plasma diagnosis: An optical flow method was developed for and is applied of several fusion plasma relevant issues, including plasma wall interactions.

Interdisciplinary research

Our work involves close cooperation with material scientists, surface engineering experts as well as geologists or more recently medical engineering and biology specialists.
A short list of interdisciplinary topics:

- Complete morphology and mineral composition characterization of granite samples of the candidate nuclear waste repository by X-ray tomography and microbeam fluorescence.
- Reverse Engineering of Cardiovascular Devices: mechanical valves and carotid stents were scanned by X-ray microtomography in order to provide the accurate 3D CAD model necessary in numerical modeling and simulations
- Treatment of Acid Mine Drainage: Column experiments and X-ray microtomography for determination of variation in porosity and secondary mineral precipitation.

Our strategy is to introduce X-ray imaging methods to new fields like chemical engineering, geology of biomedical. In this regard we have combined our forces with a leading institute of biology in order to construct a “*High-resolution, small animal radiation research platform with fully 3D X-ray tomographic and microbeam fluorescence/luminescence guidance capabilities*”. The main objective is to deliver to the Romanian biomedical community involved in oncology and radiobiology research, an open access platform for in vivo 3D investigation of tumors in animal models and nanoparticles (NPs) enhanced radiation therapy. Irradiation of high-Z NPs targeted and delivered to tumor cells results in physical and biological processes that may be exploited efficiently for both imaging and therapy (theranostics).

Evolution of human resources

The core members of our team have an experience of almost 30 years between them in the field of tomography algorithms, scaning configurations and image processing. Recently, we’ve hired two young engineers to support the continuous upgrading activity but also to offer high value added services to research and industry. We estimate the need for an additional physicist in the next years.

International cooperation

Collaborations with research institutes and universities

- Max-Planck-Institut fuer Plasmaphysik, Garching, Germany
- Institut fuer Energie und Klimaforschung – Plasmaphysik, Forschungszentrum Juelich GmbH, Germany
- JET Culham, UK
- Forschungszentrum Karlsruhe, Germany
- National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan
- ENEA - Frascati Research Center, Italy
- CEA Cadarache, France
- Institute of Nuclear Technology and Radiation Protection, N.C.S.R. "Demokritos", Athens, Greece
- Institute of Environmental Assessment and Water Research, IDAEA, CSIC, Barcelona, Spain

Collaboration with industry

- Hans Wälischmiller GmbH (HWM), Germany: as scientific advisor I. Tiseanu has assisted the company in all areas related to radiation physics, tomography scanning configurations, reconstruction software design and implementation. Among numerous projects implemented are the X-ray tomographs of : Audi AG Neckarsulm, Eurocopter and EADS Munechen, Toyota Poland, Kytek Corea and FH Wels, Austria.

- Uni-Hite System Corporation, (UHS) Japan: in UHS I. Tiseanu have participated at the development of a new image reconstruction method and device by oblique view cone beam tomography (OVCB-CT). Based on these inovations protected by two patents, tens of eucentric OVCB systems were sold to major japanese companies: Japan Texus Instruments, Toshiba, Mitsubishi Electric, Kawasaki Electronics, Hitachi, Pioneer, Pentax, Mitsubishi Motors, Nissan, Sony, Fuji Electrics, Yazaki, Canon, Matsushita AVC, Matsushita Kotobuki, Senju Metalics.
- RayScan GmbH, Germany is the succesor of HWM company. One of the main project I. Tiseanu have participated in RayScan was the design and construction of a mobile CT-System for in-situ inspection in the LHC at CERN. The key role is played by the limited angle scanning and tomography reconstruction.

Entrepreneurial initiatives

- Recently, we have hired two young engineers to support our offer of high value added services to research and industry.
- We conduct a service contract with Fusion for Energy for the performance of quality controls in support of an in-dept monitoring of the NbTi TF strand and TF conductor production for JT-60SA.
- We offer training services for laboratory CT.

PROPOSAL # 6

Direct laser writing of materials by ultrafast laser pulses

Marian Zamfirescu (marian.zamfirescu@inflpr.ro), *National Institute for Laser, Plasma and Radiation Physics - Magurele*

Recently, at INFLPR was developed a platform for ultrashort pulsed laser structuring at micro- and nanoscale, as well as setups for spectroscopic characterization techniques with high spatial and temporal resolution by femtosecond lasers.

A laser processing installation was designed and built for Direct Laser Writing (DLW) of materials by laser ablation, Laser Induced Forward Transfer (LIFT), Two-Photon Photopolymerisation (TPP), and for nanoscale processing of materials by optical near-field enhancement. 2D and 3D micro- and nano-structures were produced in various materials such as metallic films, photopolymers, semi-conductors and ceramics, with implications in sensing, photonics and tissue engineering. The DLW method was utilized for fabrication of interdigitated microstructures on gold thin films for metamaterials, working at frequency range of tens to hundred of GHz. By TPP technique, photopolymerized biocompatible microstructures were also produced. The self-organization of nanostructures by laser induced periodical surface structuring effect is proposed as fast nanotexturing method of large surfaces for bio-mimetic surfaces, plasmonic applications, and security marking against counterfeiting.

PROPOSAL # 7

Nanowire-based devices for applications

M. Enculescu, E. Matei, C. Florica, N. Preda, I. Enculescu
INCD Fizica Materialelor, Magurele (National Institute of Materials Physics – NIMP)

During the last years the weight-center of research in the field of nanotechnology shifted from the discovery of new nanostructures and methods of preparation of such nanostructures to the development of application targeted nanoobjects. The first key element of the process is to control the parameters (e.g. morphology, composition, and structure, electric and optic properties) of these low dimensional building blocks directly from the preparation step. The second key element is to manipulate and integrate precisely tailored nanostructures into various functional devices.

By template based fabrication approaches one can finely tune the morphological and dimensional properties of the nanostructures, this leading to new potential functionalities generated by their size.

The lecture will review the concept of template fabrication and its potential in obtaining nanostructures or nanostructured materials with controlled morphology and/or high aspect ratio. Several types of templates will be discussed including the most important characteristics in terms of material, geometry and obtaining method. There will be presented our results in the preparation of metallic, semiconductor and complex structure nanowires. The presentation will point out the possibilities of fine tuning properties such as magnetic, optical emission or electronic transport directly from fabrication step. In Figure A an example of multisegment metal –semiconductor – metal nanowires prepared by our group using a sequential deposition algorithm is presented.

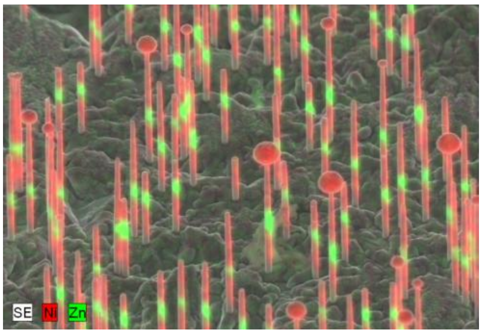


Figure A. Multisegment metal-semiconductor-metal nanowires prepared by sequential deposition

Further we will focus on nanowire-based devices ranging from giant magnetoresistance magnetic field sensors to photodiodes or ultraminiaturized light sources. Our results in nanowire manipulation using external magnetic or electric fields and integration in electronic circuits by lithographic methods (photo- and electron-lithography or focus ion beam induced metallization) will represent the next step in the presentation. In Figure B an electronic circuit containing a magnetic nanowire contacted by means of focused ion beam induced metallization is presented.

As an example finally the presentation will be dedicated to the potential of such nanowires in fabricating high sensitivity biosensing devices (EUROCORES contract 5 EUROC/2011).

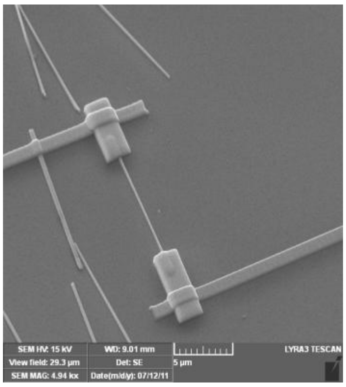


Figure B. Metallic nanowire contacted by FIB IM employing the clean room facility from NIMP

PROPOSAL # 8

Optical, structural and electrical properties of transparent conductive oxides

dr. Aurelian-Catalin Galca
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The industry using transparent conductive oxides (TCO) is actively searching for a replacement of indium tin oxide because of high costs and shortage of resources. The perfect candidate should be a large band gap semiconductor, which is in other words a dielectric (E_g>3eV), with a high conductivity provided by dopants (free carriers). Such a material will have a low resistivity and a high optical transparency in the visible range.

Aluminum and zinc are among most abundant elements in the Earth crust and therefore aluminum doped zinc oxide, a highly conductive and transparent n-type semiconductor, has been promoted as a potential replacement. Also, recent studies revealed that oxygen deficient ZnO and silicon doped ZnO are good transparent conductive oxides. However, these polycrystalline materials are inadequate for most flexible substrate applications. Moreover, since the substrate roughness is preserved or increases, electrical contact problems might appear. The polycrystalline oxide shows a grain size dependence of conductivity, while the absence of crystallinity could result in the lowest resistivity value. Therefore, amorphous oxide semiconductors (AOS) have lately received important attention, with a special focus on developing flexible thin-film transistors and other optoelectronic devices. In the case of depositions from a single target (pulsed laser deposition, magnetron sputtering), amorphous materials may presents a compositional in depth gradient, while for polycrystalline materials one should take into account the grain size distribution. These nonhomogeneities can lead to a considerable difference between surface conductivity and the one through the corresponding TCO.

Along with the electrical properties (resistivity, charge carrier mobilities), the optical properties are important parameters of a TCO. The transparency spectral range, the refractive index dispersion in the corresponding spectrum as well as the absorption coefficient (or extinction coefficient) define the optical properties, and together with TCO thickness could be used to estimate the amount of light that reaches the core p-n junction. It will be presented the properties of indium zinc oxide (IZO) and indium gallium zinc oxide (IGZO) thin films with variable cations composition, which were grown by pulsed laser deposition technique. The agreement between thickness values estimated from\ spectroscopic ellipsometry (SE) and X-ray reflectivity (XRR) data confirms the validity of the physical models used to extract the optical coefficients. Both characterization techniques are non-destructive and can be used as in-situ controllers.

NIMP has the necessary infrastructure for target preparation, thin film deposition by PLD or magnetron sputtering, advanced structural characterization (XRD, SEM, TEM and HR-TEM), optical and electrical characterization, as well as processing in clean room environment (photo and e-beam lithography). NIMP has also human resources with expertise in the field of oxide materials with conducting, semiconductor or ferroelectric properties (5 senior researchers, 2 junior researchers and 5 post-docs, PhD students and master students).

PROPOSAL # 9

Opportunities for highest level microstructural characterization by high-resolution analytical electron microscopy

Corneliu Ghica, PhD
National Institute of Materials Physics, Bucharest-Magurele
Head of the Laboratory of Atomic Structures and Defects in Advanced Materials

Electron microscopy and, especially, the transmission electron microscopy has always represented an essential tool for microstructural characterization in the semiconductor industry. NIMP holds state-of-the-art facilities for analytical electron microscopy investigations including 2 TEMs, a SEM-FIB dual system installed in a class 1000 cleanroom and a fully equipped and fully operational lab for TEM specimen preparation (http://lab50.infim.ro/tem.php).

One of the 2 TEMs is the latest generation high-resolution analytical transmission electron microscope JEOL ARM 200F. Installed at NIMP in 2011, it is provided with probe C_s corrector (0.8 Angstrom resolution in HAADF-STEM mode, 1.9 Angstrom point resolution in HRTEM mode), EDS unit for analytical investigations and EELS unit for analytical investigations and energy filtered imaging (EFTEM). The instrument reaches the highest technical characteristics available today in terms of space resolution (sub-Angstrom resolution) and it is the only instrument of this level installed in Eastern Europe. At least 10 working modes are available on this instrument: CTEM, HRTEM, STEM BF, STEM ADF/ HAADF, SAED, nano-ED, CBED, EDS, EELS, EFTEM, EELS-SI.

The second TEM is a standard analytical TEM, JEOL 200CX, equipped with CCD camera and EDS unit. The instrument is used for conventional TEM (CTEM) and analytical investigations.

The SEM-FIB dual system Tescan Lyra 3 XMU has been installed in 2011 in the NIMP cleanroom. The instrument has been configured for TEM lamella preparation (SEM, FIB, GIS, nanomanipulator), surface analytical investigations (SEM, EDS), and surface structural investigations (SEM, EBSD).

A fully equipped and fully operational lab for TEM specimen preparation has been developed in NIMP, including dicing and lapping machines, ion milling installations (two Gatan PIPS machines), electrochemical polishing installation, carbon coating and surface metallization. The available equipments and know-how enable us to prepare the whole range of TEM specimens, from powder samples to plan-view and cross-section specimens of thin films, metallic alloys, ceramics etc.

A number of 10 highly qualified personnel operate the mentioned installations, cumulating the highest expertise in electron microscopy at the national level certified by hundreds of ISI publications. Five are senior scientists with a rich expertise accumulated during long term positions as PhD students or visiting researchers in famous TEM laboratories such as EMAT – University of Antwerp, Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS), Claude Bernard University of Lyon, etc. One is a post-doc level researcher, with a recently obtained PhD degree at Claude Bernard University of Lyon. Two young researchers (PhD student and MSc student) have been recently recruited.

Beside a brief presentation of the available infrastructure and human resource, my talk will include a few examples of TEM results obtained with the newly acquired equipments or throughout the last 10 years in projects developed in cooperation with partners from Western Europe such as IMEC Leuven, EMAT – University of Antwerp, Claude Bernard University of Lyon, IPCMS on subjects related to semiconductor technology (smart cut for SOI – silicon-on-insulator, SiGe epitaxial layers), TCO thin films growth&processing for OLED fabrication (thermal and laser treatments).

PROPOSAL # 10

Advanced dielectric materials for microwave and millimeter wave applications

Liviu Nedelcu and Marian Gabriel Banciu
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Dielectric materials continue to have a decisive influence on the evolution of the electrical and electronic engineering, communications and information technology. These materials, which exhibit high dielectric constant, low dielectric loss, and good temperature stability, are required to reduce the equipment size and weight, enhance its reliability, and lower the manufacturing and operational costs. Ceramics are from far the most utilized as they offer cost-effective solutions for applications.

Four types of microwave dielectrics are presented in this report. The $Ba_{1-x}Pb_xNd_2Ti_5O_{14}$ materials show the highest dielectric constant (ε_r ~ 85). A very small controllable temperature coefficient of the resonance frequency τ_f in the range (-2 ÷ +4) ppm/^{o}C can be achieved by using dielectric resonators Mg doped $(Zr_{0.8}Sn_{0.2})TiO_4$. On the other hand, $BaX_{1/3}Ta_{2/3}O_3$ (X=Mg, Zn) complex perovskite exhibit the highest values for the Q x f product, ranging from 100,000 to 200,000 GHz, which make them attractive for millimeter wave applications.

Such ferroelectric materials as $Ba_{1-x}Sr_xTiO_3$ (x = 0.25 – 0.90) were developed bulk and thin film for tunable devices (ferroelectric capacitors). It was showed that the Sr content decreases considerably the ferroelectric cubic to tetragonal transition temperature, decreases substantially the microwave dielectric permittivity and losses, decreases the unit cell volume and reduces the effect of grain segregation. Moreover, our experiments revealed that the sintering conditions lead to important changes in the polymorphic diagram, which we have built for $Ba_{1-x}Sr_xTiO_3$.

Investigations on microstrip resonators manufactured on temperature-stable $(Zr_{0.8}Sn_{0.2})TiO_4$ substrates (ε_r ~ 36) showed an outstanding small thermal variation of the resonance frequency of less than 1 ppm/ ^{o}C. Cross-coupled microstrip filters and dielectric resonator oscillator for microwave communication systems were developed. The proposed metamaterial four-ports are planar devices which provide very high coupling values not possible in other planar configurations and are very attractive for diplexing applications.

Antennas with improved characteristics were developed and characterized in anechoic chamber (working range 900 MHz-40 GHz). On one side, the patch antenna and dielectric resonator antenna offer size reduction required by mobile communications. On the other side, the zero order resonance metamaterial antennas allow frequency bands independent of antenna size.

The characterization facilities for microwaves and millimeter waves include the Agilent E8361A PNA Vector Network Analyzer, Probe Stations for miniaturized devices (CPX-HF Probe Station from Lake Shore Cryotronics and Microtech Cascade Summit 11000-B up to 67 GHz), Spectrum analyzer MS2724B from Anritsu etc.

The research infrastructure of the NIMP was continuously modernized in the last years by projects funded by National Authority of Scientific Research and European Union. In the frame of these projects, 2 new equipments, state of the art in the field, were purchased: Agilent PNA-X N5245A Vector Network Analyze with millimeter-wave modules (10 MHz – 500 GHz) and Aispec pulse IRS 2000 pro THz time-domain spectrometer (0.1 - 7 THz). Accurate full wave electromagnetic analysis is carried out by using high performance simulation software as CST Studio Suite 2012, Ansoft HFSS 13. At the same time, facilities for material's synthesis and characterization were acquired. Moreover, there are clean room facilities ISO 1000 (45 m^2) with nanolithography facilities (E-beam, FEG-SEM-FIB), two metalizing facilities; an extra 15 m^2 ISO 100 clean room with a new photolithography facility (EV Group).

PROPOSAL # 11

Highly *c*-axis textured AlN films for MEMS technology. Biofunctional thin films for medical applications

G.E. STAN - National Institute of Materials Physics (NIMP)

Radio Frequency–Magnetron Sputtering (RF–MS) has emerged as a promising alternative method for producing high quality films due to its tailoring possibilities and due to some other advantages: low pressure operation, low substrate temperature, high purity of the films, ease of automation, and excellent uniformity on large area substrates. A key advantage of RF-MS is easiness of technology transfer to industrial scale. Furthermore, RF-MS is a "green" and low-cost method for thin films' synthesis.

The micro- and nano-electromechanical (MEMS, NEMS) resonators are regarded as promising technologies for many hi-tech applications: telecommunications, electrometry, chemical and biological sensing, and scanning probe techniques. The recent developments in semiconductor nanoprocessing technologies has opened the perspective of manufacturing surface acoustic wave (SAW) and film bulk acoustic resonator (FBAR) devices for application in the GHz frequency range. Among the wide band gap (WBG) materials, the aluminum nitride (AlN) has attracted a great technological interest due to exceptional properties such as piezoelectricity, wide energy band gap (6.2 eV), high breakdown voltage, high electrical resistivity (~1015 Ωcm), high hardness (11−15 GPa), good thermal stability, high thermal conductivity, high surface acoustic velocity (up to 6000 m/s). The full compatibility with the current microelectronics requires a low temperature deposition process. However, the synthesis of highly *c-axis* textured AlN films at low temperature is still challenging. Reactive RF-MS presents the advantage of low deposition temperatures (preferentially bellow 100°C), and could allow the synthesis AlN films with the preferred crystal orientations and reduced roughness at low pressure.

Recently, in collaboration with *IMT-Bucharest (Dr. A Muller)*, efforts have been made for obtaining high quality AlN films onto high resistivity silicon (100) by reactive RF-MS, which lead to the successfully development of FBAR and SAW devices with excellent performances. Resonance frequencies of about 10 GHz for FBAR structures and of about 5 GHz for the SAW devices have been obtained. The best previous result found in literature was a SAW on AlN (deposited on diamond and not on silicon) operating around 5 GHz.

NIMP is one of the initiators of the research for the study and implementation of a new generation of osteointegrative implants functionalized with thin highly bioactive films with superior mechanical properties, synthesized by RF-MS technology. Switching to a new generation of implants, better accepted by the body, which will not require revision surgeries, involve the fulfillment of well-defined objectives regarding the implant - living tissue interaction: the creation of strong implant – tissue chemical bonds, the compatibilization of the implant – bone elastic modulus, and the elimination of residual ionic diffusions from the metallic implant into the surrounding biological media.

By own efforts and synergistic collaboration with *Institute of Biochemistry (Dr. S.M. Petrescu)* and *U.M.F. „Gr. T. Popa" Iaşi (Dr. I. Poeată)* we succeded in finding innovative and viable technologic algorithms for producing highly performing implants biofunctionalized with thin (hundreds of nanometers) adherent hydroxyapatite, carbonated hydroxyapatite or bioglass films with varying degrees of resorbability / bioactivity. The preparation of carbonated hydroxyapatite and bioglass coatings by RF-MS is a worldwide premiere, opening new research and application perspectives. Presently NIMP aims to obtain the approvals of clinical use for the optimized architectural implant models and to identify industry partners interested in developing and producing performant implants.

PROPOSAL # 12

Hydrogen, Deuterium and Tritium profiling in thin layers by Resonant Nuclear Reaction (RNR) and Accelerator Mass Spectrometry (AMS)

Ion Burducea, Marius Dogaru, IFIN-HH

For resonant nuclear reactions, ^{19}F projectiles impinging on a solid target containing Hydrogen triggers a threshold nuclear reaction above 16.44 MeV. Varying the incident energy for the ^{19}F projectiles above the threshold a depth profile of hydrogen can be established by high energy gamma ray (6.13 MeV) measurements.

AMS presumes the sputtering of a target, accelerating the ions and magnetic separation; deuterium and tritium are atom by atom numbered at different depth from the sputtered target.
The project's goal is to build the experimental chamber, setup the methodology for online measurements for nuclear resonant reactions and developing the AMS methodology.

The project requires the access at an accelerator able to deliver ^{19}F projectiles above 16 MeV. The setup will be an easy transportable one including a large volume gamma ray detector, a fully equipped high vacuum target chamber and an acquisition system.

For the AMS experiments the setup and methodology will be available at a designated location (IFIN-HH).

PROPOSAL # 13

Materials characterization by Ion Beam Analysis techniques

Marin Marius Gugiu, IFIN-HH

Accelerated ion beams are often used for analysis and materials characterization by IBA (Ion Beam Analysis) techniques, such as PIXE (Particle Induced X-ray Emission) and micro-PIXE, PIGE (Particle Induces Gamma Ray Emission), ERDA (Elastic Recoil Detection Analysis) and RBS (Rutherford Backscattering).

The most important feature of IFIN-HH is the 8.5 MV Tandem Van De Graff linear accelerator, dedicated to basic research and applied Atomic and Nuclear Physics with accelerated ion beams. The Tandem accelerator provides a broad spectrum of ion species with a wide range of energies, charge states and fluences, such as: protons (max: 10 MeV, 300 nA), alpha particles (max: 18, 6 MeV, 500 nA) and ^{12}C ions (max: 32 nA, 250 MeV).

Two other accelerating facilities are under construction now: “Center of radiocarbon for environment and biosciences – Tandiment” and "Nuclear spectrometry center for energy, environment, materials and health – EMMAS”.

Considering these aspects, we invite you to lay the fundation for further studies of physical, chemical and structural materials changes, using analytical atomic and nuclear techniques, or irradiations. We have a long experience in using these techniques, such as PIXE and PIGE, on characterization of different types of samples of medical and environmental pollution. Using ion beam analysis methods, we have already obtained interesting experimental results concerning the involvement of oligoelements, enzymatic activity and free radicals in cutaneous cancer and other human diseases.

PROPOSAL # 14

Radiation processing for automotive industry

Ioan Valentin Moise, Corneliu Catalin Ponta
"Horia Hulubei" National Institute for Physics and Nuclear Engineering, Romania

Radiation processing is a technique for modifying the properties of materials by irradiation with gamma rays or electron beams. Although this technique is applied mainly for the sterilization of medical devices, there are important applications for the cross-linking of polymers. The purpose of this paper is to show the potential of radiation processing for the automotive industry in Romania, with a description of the Multipurpose Irradiation Facility belonging to "Horia Hulubei" National Institute for Nuclear Physics and Engineering, with some examples of plastic or composite parts improved through radiation processing worldwide and with new ideas connected to the recycling trends.

PROPOSAL # 15

Micro-PET based on planar detectors and columnar cesium iodine scintillators

Carmen Pavel, IFIN-HH

Microcolumnar CsI:Tl as scintillator screen coupled with planar detectors (Varian Paxscan detectors) can be the fundament of a new type of 3D micro tomograph with positron emission.

A rectangular structure (box) of large dimensions (40 x 40 x 30 cm^3) will be the detecting chamber for small animals under examining. The thick columnar CsI:Tl screen must have at least 10% efficiency in 511 keV gamma detection. The paired gamma rays impact will be recorded by planar imaging detectors and streamed to computing unit.

The proposed model eliminates the complicated coincidence setup for pairing the emitted gamma rays and also delivers a 3D structure for gamma rays with a greatly increased geometrical efficiency.

PROPOSAL # 16

Slow positron facility for thin layer analysis

Mihai Straticiuc, IFIN-HH

Positron Annihilation Spectroscopy (PAS) is a spectroscopic technique which enables materials research. PAS is a nondestructive, noncontact method that in some cases provides higher sensitivity than electron microscopy.

The project goal is to develop an electrostatic positron accelerator in the tens of keV range with the possibility of fine kinematic parameters tunability: positron beam on/off switch, positrons selection by velocity and control of the positron beam flux.

By using a slow positron beam defects depth profile, up to few microns can be determined. The 511 keV coincidence gamma rays are collected and used in various techniques as Doppler Broadening Spectroscopy or Positron Lifetime Spectroscopy. The forthcoming device will have a mobility feature and will practically be able to produce real-time results. Primary positron source can be a radioisotope (^{22}Na the most common, with a fair production cost) or a small accelerator.

PROPOSAL # 17

Temperature sensors based on vitreous materials doped with semiconductors of type II-VI

Dr. Elisa Mihail, Departament "Optospintronica", INOE 2000, Magurele

The main concept of the present proposal is based on investigation of luminescent properties of thin films based on II-VI (CdS, CdSe, CdTe) semiconductors passivated by wide band gap semiconductor (ZnS), all imbedded in inorganic vitreous matrices, applied as temperature sensors. The novelty of the proposal consists of the study of the influence of the vitreous matrix on the luminescent properties of the passivated semiconductors. The composite films semiconductor-inorganic vitreous matrix type will be prepared by sol-gel method and by pulsed laser deposition. The sol-gel method allows a homogeneity at molecular level of the system components and a processing at relative lower temperatures. The materials investigated in the present proposal are basic elements for relative low costs temperature sensors.

PROPOSAL # 18

Sensitive organic/inorganic structures for electrolytic media monitoring

Ileana Cristina VASILIU, INOE 2000, Magurele

***Market needs*:** The pH and relative humidity (RH) (electrolytic media) are important parameters that need to be measured or monitored in various chemical processes, such as in the food, electronics, textile, chemicals and pharmaceutical industries, in the ambient environment and recently in construction industry. Even there are commercially available humidity and pH sensors they cannot be easily modified/adapted and do not have the characteristics required to, for example, monitoring of carbonization of concrete in buildings and construction industry. The relative humidity for civil engineering works is a very important parameters for concrete structure as well for structural health monitoring to allow the corrosion prevent and its negative effects. If the humidity dangerous effects is analyzed for heritage buildings or artefacts, museums, historical vestiges, painting operas etc, the humidity of environment monitoring needs is very high due to irremediable and devastating efects against of works placed inside of high humidity environment. So the posssibility to receive very early an advertising signal is a necessity for immediate reaction and welcomed intervent for damage prevention and effects limitation. So the humidity and pH monitoring and preventing actions are of stringent as well as of urgent necessity.

The overall objectives of the proposed cooperation project are to develop **high sensitive, resistant,** and l**ow cost** materials by designing them at micro and nano level. These sensing materials allow for better-specialized sensors for environment monitoring when the composition of electrolytic aerosol media contains, for example, H_2O, CO_2, NO, NO_2, SO_2. These new functionalised structures can be used as prepared (membranes) or integrated in sensors (placed on optical fibre for instance). Inorganic and/or organic surfaces will be functionalised with metal organic complexes. The organic moiety is based on azo derivatives and the metals are selected from (Cu, Zn, Ru, Er, Eu). These are achieved by: (i) developing technology for preparation of highly sensitive metal-organic compounds based on azo dyes; (ii) developing innovative functionalised structures/sensing material by encapsulation of the most promising organic moieties in silica matrices; (iii) exploring the optical properties of the metal-cromophore entrapped in the silica matrix for utilization in sensors or other applications; (iv) providing new knowledge obtained from functionalised structures/interfaces for sensing applications.

Targeted innovation: The originality of the project proposal is the specific technology used in obtaining superior sensing materials/surfaces such as: (i)new compounds with higher sensitivity as compared with the market homologues; (ii)the synthesis routes for the compounds are special designed to improve the characteristics of the materials; (iii)the syntheses are economically advantageous.

PROPOSAL # 19

Seismic hazard assessment in sites of national interest

Mircea Radulian, National Institute for Earth Physics, Magurele

The seismic hazard evaluation is the fundamental input for designing and protecting the important infrastructures and critical facilities in case of earthquakes. The National Institute for Earth Physics has high-level expertise and infrastructure to carry out research for site qualification in case of earthquake effects. Therefore, it provided site investigation for critical facilities (like nuclear power plants, dams, bridges, nuclear reactors, hospitals etc.) and contributed to the elaboration of seismic standards in Romania.

PROPOSAL # 20

IMT- Bucharest presentation

Alexandru MULLER

IMT- the Institute of Microtechnology was founded in 1993, being the first institute with this profile in Eastern Europe. Since 1994, microtechnologies have been included in EU programs. Since 1996 became **National Institute for Research and Development in Microtechnologies - IMT Bucharest** (merging with ICCE)
Mission: **Integrating R&D with education and training and with support for industry** (**services, technology transfer**)**; networking at national and international level** (including interaction with European Technological Platforms), **innovation, in the field of micro-nanotechnologies** (RF-MEMS, photonics, sensors, bio-nano-info technologies, CNT and graphene based sensors and nanodevices).

Employers: 181 Technical and scientific personnel: **110**
Researchers: **74** (52% PhDs, 20% PhD students etc),
Starting with 2009: Accommodating a new generation of scientists - 9 young people getting their **PhD abroad** in: EU, Japan, Singapore and SUA

In the period 2003-2012 IMT was involved in national and European projects: **15 FP6,** projects**, 11 FP7** projects and 10 FP7 related projects: **5 ENIAC, 5 ERANET**. In the landscape of the new member states of UE, IMT is an active actor in RTD. IMT houses an European Centre of Excellence financed by the EC (2008-2011) through the project **MIMOMEMS (RF and Opto MEMS).** In December 2009, the European Associated Laboratory (LEA) was inaugurated, with IMT - Bucharest, LAAS/CNRS Toulouse and FORTH, Heraklion. This lab is acting in the field of RF MEMS/NEMS.
3 Projects – Structural funds- a new Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials - **CENASIC**- under construction.

The investments in equipment (7 millions of Euro in 2006-2009) provide an excellent support for the experimental work. Through the Centre for Micro- and Nanofabrication (IMT-MINAFAB) these facilities are available to customers from industry, research and education (www.imt.ro/MINAFAB).

- **Main facilities:**
  - A **class 1000 clean room** (220 sqm) for the **mask shop** and the most demanding technological processes (in use since September 2008);
  - A class **100,000 clean room**, the so called "**Grey Area**" (200 sqm), mostly for the **characterization equipments** (in use since September 2008);
  - A class **10,000 clean room** (105 sqm) for thin layer deposition by CVD techniques, DRIE, RTP, etc
  - CAD and simulation for microsystems and microelectronics: COVENTOR, ANSYS, COMSOL, IE3D Zeeland, CST, OPTI-FDTD,OPTI- HS, Solidworks and **Dual IBM 3750 Server**
  - Microphysiscal characterization: XRD, Raman, FEG-SEM, WLI, SNOM, SPM, Nanoindentation, including nanoscale structuring using EBL nanoengeneering-work station from RAITH and Dip-pen nanolithography, microwave characterization facilities up to 110 GHz
  - A centre for education and training, equipped with computer network

Brief presentation of experimental results.
Developing cooperation with multinational companies active in Romania and EU: Honeywell Romania, Infineon Technologies Romania, Thales TRT Paris, NXP Nijmegen (through FP7 and ENIAC projects)**.**