

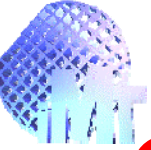
OFERTA DE SERVICII

NanoScaleLab

**INCD-Microtehnologie
(IMT-Bucuresti)**

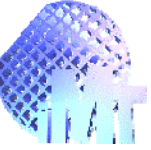
**Dan Dascalu
Raluca Muller**

www.imt.ro



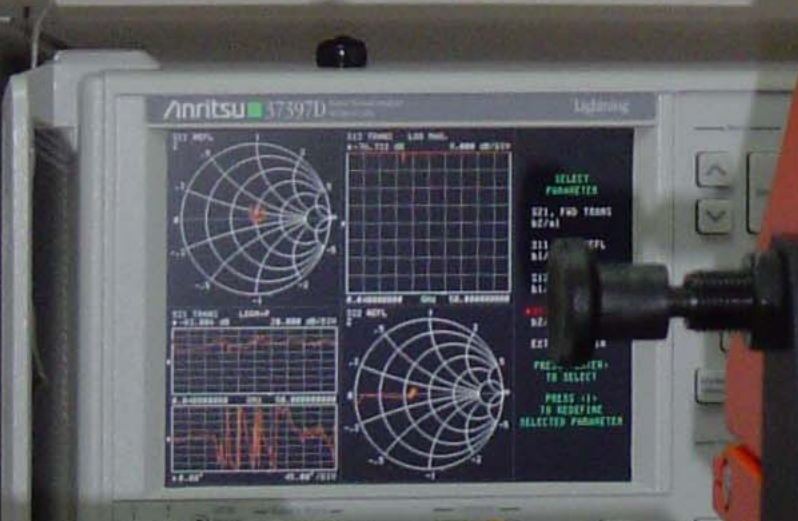
Ce contine aceasta prezentare?

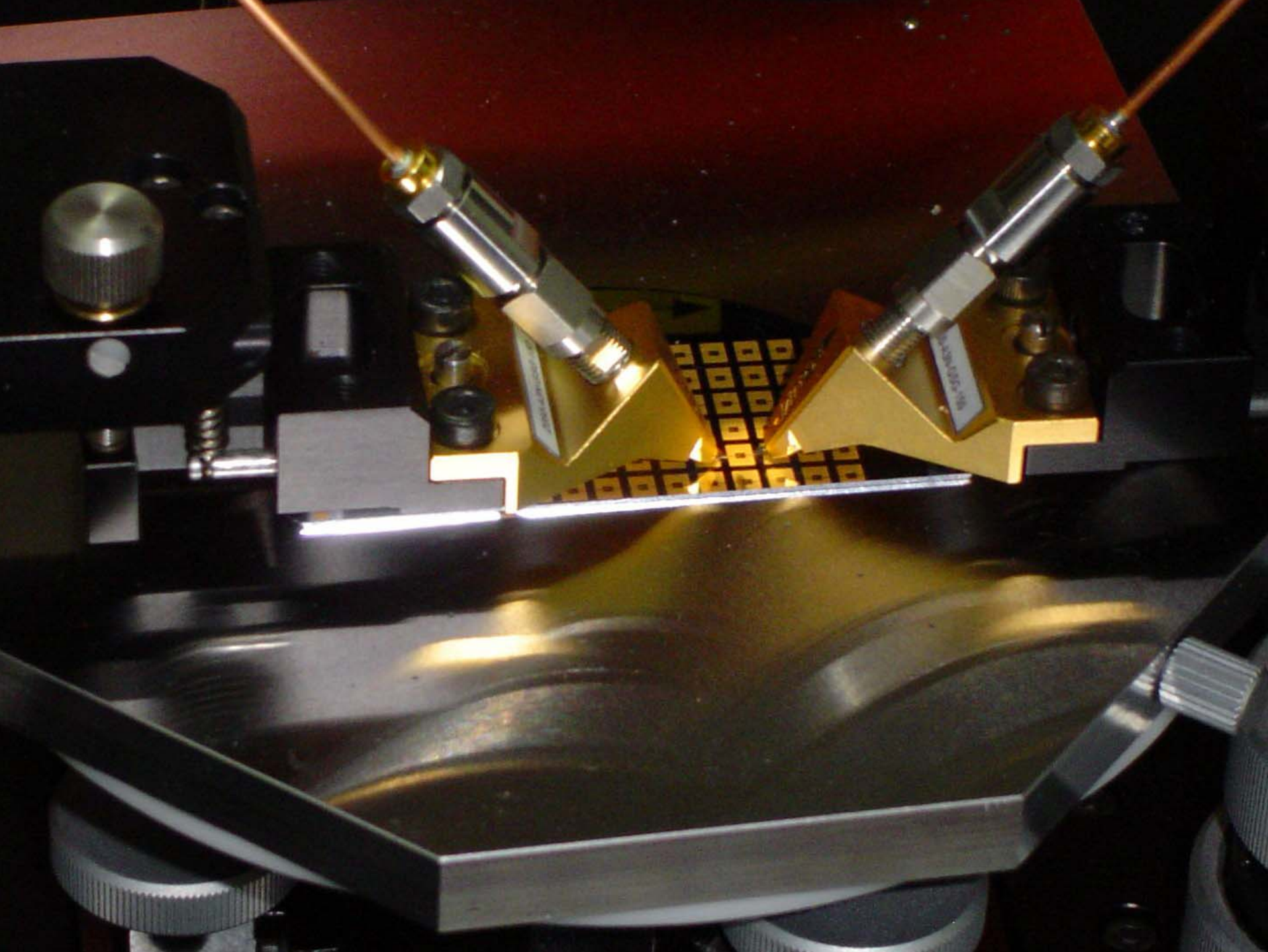
- Este axata pe **NanoScaleLab**, un laborator destinat caracterizarii si structurarii la scara “nano”.
- Reflecta “ambitia” IMT de a fi competitiv in nanostructurare, combinand litografia cu fascicul de electroni cu cea “traditionala” (optica, cu laser) si cu alte tehnici (nanoprint etc.)
- Prezinta ultimile realizari ale NanoScaleLab in contextul mai general al politicii IMT de asigurare a unei “platforme tehnologice” de micro si nanotehnologie care sa asigure integrarea activitatilor de cercetare, educatie, inovare.

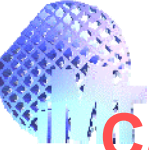


IMT – repere in timp

- **INCD pentru Microtehnologie (IMT-Bucuresti) infiintat in 1993, sub denumirea de IMT (Institutul de Microtehnologie): primul institut cu acest profil din Europa de est (www.imt.ro)**
 - **Domeniu principal: micro- si nanotehnologii**
- **Institut national din 1996 (fuziune cu ICCE)**
 - Din 1996 – laborator de nanotehnologie
- **Camere albe (curate): incepand din 2005**
- **Laboratoare deschise (de retea) NanoBioLab, NanoScaleLab: incepand din 2005**
- **Parc stiintific si tehnologic: incepand din 2006**
- **Convergenta tehnologiilor (micro-nano-bio): incepand din 2006**
- **Integrarea micro- si nanotehnologiilor: incepand din 2008**
- **Facilitate de micro- si nanofabricatie IMT - MINAFAM: incepand din 2008 (in curs de organizare). Corelare cu facilitati similare din UE**
- **Centru european de excelenta, finantat de UE (MIMOMES – RF and opto MEMS): incepand din 2008 (contract in vigoare; primul centru de excelenta finantat dupa ce Romania a devenit membra a UE).**







Cat de important este domeniul in care lucreaza IMT?

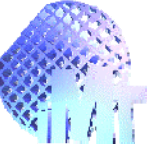
Tematica din PC 7

Convergenta > integrarea tehnologiilor (micro-nano-bio-info):

- In ICT (Information and Communication Technologies)
- In NMP (Nanotechnologies, Materials, Production)
- Aplicatii in sanatate, agricultura, energie, constructii etc.

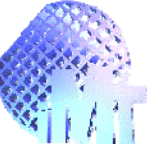
Platforme tehnologice europene:

- MINAM (micro- si nanotehnologii, 2008)
- Nanomedicina
 - *“ERA-NET nanomedicine” – in pregatire*
- PHOTONICS21 (fotonica)
- EPoSS (integrarea sistemelor inteligente)
- ENIAC (nanoelectronica)
 - > ENIAC Joint Undertaking, competitie mai 2008.



De ce servicii?

- **General:** Triunghiul cunoasterii (cercetare – educatie – inovare)
 - Un centru de cercetare puternic pune baza materiala si cunoasterea de care dispune pentru activitati de educatie si de inovare
 - Serviciile nu sunt un scop in sine, ele reprezinta “deschiderea” cercetarii catre celelalte educatie si inovare
- **Specific:** Facilitati tip camera alba (camera curata), pentru micro si nanofabricatie
 - Caracterizare la scara micro- nano, dar si simulare si proiectare asistata de calculator
 - Cercetare multidisciplinara, accesul la dotari al colectivelor de cercetatori > servicii!
- **Concret:** Cum se asigura servicii:
 - Colaborare in contracte din PN II (programele de Parteneriate, Inovare etc.)
 - Colaborare europeana (EUROPRACTICE, retea de facilitati tip Camera alba etc.)
 - Fonduri structurale (cercetare de firma in colaborare cu IMT)
 - Comercial?



Platforma tehnologica, pentru micro - nanotehnologii

- **Micro-nanofabricatie:**

- camera curata echipamente de procesare tehnologica, micro si nanolitografie

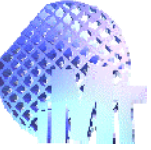
- **Echipamente de caracterizare microfizica si testare functionala**

- **Software dedicate proiectarii si simularii micro si nano-sistemelor**

- **Expertiza multidisciplinara**

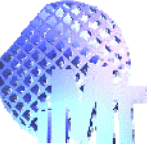
Extindere si upgradare continua din diferite surse de finantare

Colaborare si acces la facilitati prin proiecte comune, multidisciplinare cu diferite institute, universitati, SME-uri



Cum se asigura baza materiala?

- **Surse variate de finantare a dotarilor, eventual a amenajarilor corespunzatoare. Situatia din Romania.**
 - De la buget (dotari din fonduri centralizate)
 - Din finantarea nucleu
 - Din proiecte de infrastructura (CEEX, modul IV; programul “Capacitati” din PN II, fonduri structurale, REGPOT din PC 7)
 - Din proiecte tip retea tehnologica (CEEX)
 - Din proiecte de cercetare din diverse programe (dotari independente; CEEX, PN II)
- **Cum se asigura exploatarea dotarilor respective?**
 - In majoritatea cazurilor dotarile sunt obtinute din “proiecte”, propuse si rulate de catre cercetatori (laboratoare de cercetare);
 - Dotarile sunt gestionate de catre laboratoarele care le-au castigat;
 - *Dotarile centralizate (care asigura baza experimentală in alte tari) sunt practic inexistente;*
 - Exploatarea echipamentelor complexe la adevaratul potential nu se poate face decat de catre cercetatori.
 - Care este solutia? In special pentru o “platforma” cu facilitati extrem de diferite?

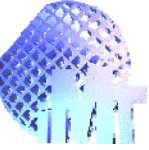


Caracterizare microfizica si functionala

CEEX Modul IV-

Laboratoare acreditate sau in curs de acreditare

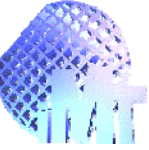
1. **NANOMORPH** - Dezvoltarea capacitatilor de analiza topografica si compositionala la scara nanometrica ale Laboratorului de Caracterizare Microfizica al IMT Bucuresti **CEEX- Modul 4 (2006-2008)** - Director de proiect: Phys. Raluca Gavrilă
2. **OPTOLAB**- Dezvoltarea unui laborator de masurari si Testari optice si opto-electrice in acord cu cerintele directivelor si normativelor Europene - **CEEX- Modul 4 (2006-2008)** Director de proiect: Dr. Munizer Purica
3. **MICROLAB**- Laborator de caracterizare avansata a componentelor si circuitelor de microunde si unde milimetrice - **CEEX- Modul 4 (2006-2008)** – Director de proiect: Dr. Mircea Dragoman
4. **LIMIT** - Dezvoltarea laboratorului de evaluare a conformitatii produselor microtehnologiilor in acord cu cerintele Uniunii Europene, Director de proiect: Ing. Virgil Ilian



Caracterizare si structurare la scara “nano”

Proiecte din programul de Capacitati (PN II)

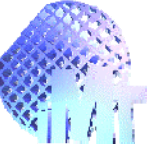
Dezvoltarea capacitatilor de analiza topografica si compozitionala la scara nanometrica ale Laboratorului de Caracterizare Microfizica al IMT Bucuresti (NANOSCAN)	A Dinescu
Extinderea functionalitatii Laboratorului NANOSCALE-LAB de structurare si caracterizare la scara nanometrica (NANOSERV)	D.Dascalu
Sistem de caracterizare microfizica si in unde milimetrice a componentelor si circuitelor pentru comunicatii avansate (SIMMCA)	A. Muller
Laborator de difractometrie de raze X de Inalta rezolutie (LADRIX)	M. Danila



De la simulare, la fabricatie si testare

Proiecte din programul de Capacitati (PN II)

Laborator de modelare-simulare pentru micro sisteme (LAMSYS)	O.Nedelcu
Laborator integrat de tehnologii avansate Pentru micro si nanosisteme (MICRONANOLAB)	G. Moagar
Modernizare laborator de depuneri straturi Subtiri dielectrice si conductoare pentru Micro si nanofabricatie(DDC-LAB)	C. Moldovan
Dezvoltarea infrastructurii pentru cercetarea de fiabilitate in domeniul micro-nanosistemelor integrate (FIAB-MICROSIS)	L. Galateanu



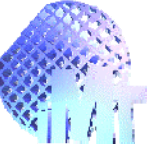
NANOSCALE-LAB

2005- CEEEX (2005-2008)- Program CALIST: Proiect “Rețea de servicii științifice de structurare și caracterizare la scară nanometrică, cu aplicații în dezvoltarea de tehnologii convergente” (Nanoscale-Conv)

Coordonator: IMT București (Dr. Raluca Müller) - 11 parteneri

▶ **Achiziția unui echipament “*state of the art*”**

- ▶ utilizarea în comun a echipamentelor costisitoare; cercetări noi, inovative
- ▶ dezvoltare de servicii și cercetări complexe care să corespundă cerințelor europene
- ▶ acces pentru studenții- masteranzi și doctoranzi
- ▶ accesul companiilor industriale la acest echipament și cunoștințe noi
- ▶ dezvoltare de tehnici noi
- ▶ realizare demonstratoare de nanodispozitive



NANOSCALE-LAB

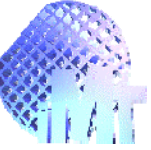
Echipamentul pentru nanolitografie- EBL

este compus din:

- ▶ SEM –**VEGA II LMU** de la firma **TESCAN** si
- ▶ **Pattern Generator** de la firma **RAITH**

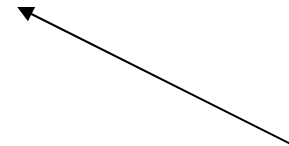
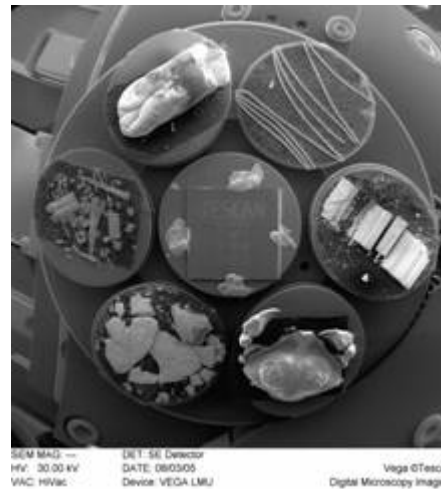
Echipamentul este dedicat cercetarii intr-un domeniu de varf, cel al *nanostiintelor si nanoelectronicii*, avand un spectru larg de **aplicatii in domenii cum ar fi:**

- ▶ micro si nanosisteme,
- ▶ circuite integrate de ultima generatie cu dimensiuni submicronice,
- ▶ tranzitoare cu un singur electron (SET),
- ▶ circuite fotonice, retele de difractie, cristale fotonice



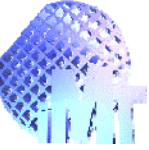
NANOSCALE-LAB

• **SEM- ul** poate fi utilizat si **independent**, cu ajutorul lui fiind oferite servicii de caracterizare (**analize topografice si compositionale**) institutelor de cercetare, de invatamanat superior si utilizatorilor industriali din domenii cum ar fi: **micro si nanotehnologii, biotehnologii, aplicatii medicale, aplicatii industriale: auto, metalurgie, textile, otel, energetica si electronica.**

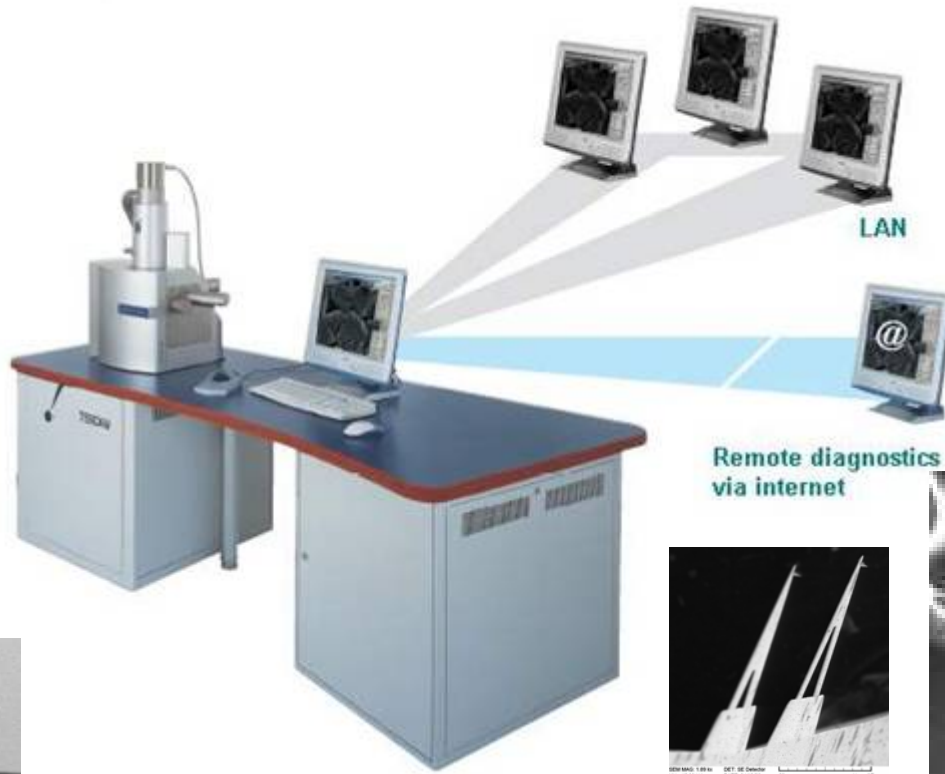


Pot fi vizualizate
7 probe simultan

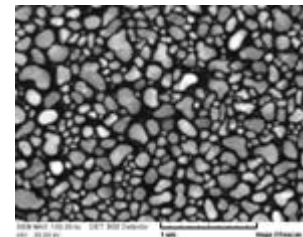
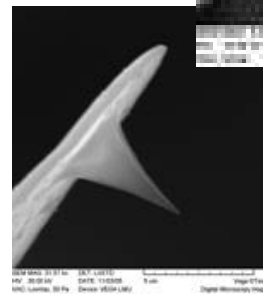
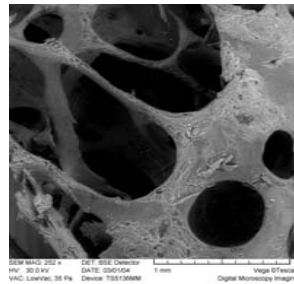
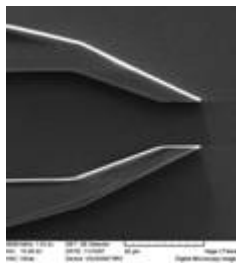
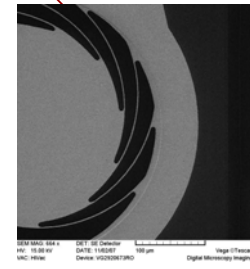
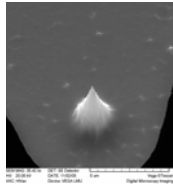
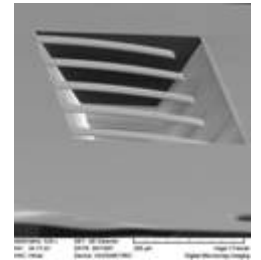
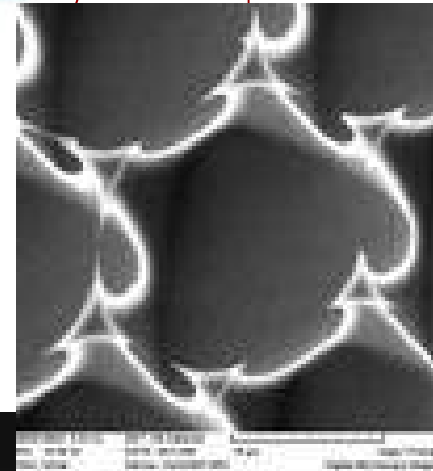
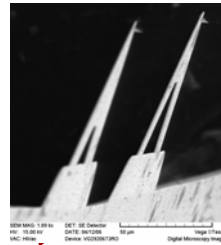
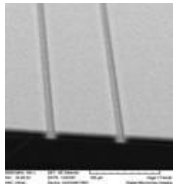
Rezolutia echipamentului: pentru SEM este de 3 nm (viteza de scanare 200 ns-10ms/pixel) pentru o tensiune de accelerare de 200 V, la 30 kV

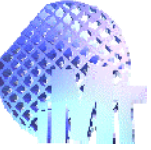


► **Sistemul SEM+EBL poate fi culplat in retea interna a institutului, iar prin intermediul unui server si la parteneri**



Exemple de imagini SEM





2006:

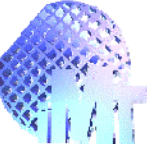
Primul echipament pentru nanolitografie din tara

ELPHY Plus – Advanced SEM/FIB System for Nanolithography- RAITH

Modulul pentru nanolitografie rezolutie: de 50 nm.



- 6 MHz high-speed pattern generation hardware (19" DSP Unit decoupled from PC)
- Fast, noise-reduced, deglitched and high performance 16 bit DAC vector scan beam deflection
- 16 bit DAC vector scan beam deflection
- 2 ns writing speed resolution
- TTL and 100 V blanking signal drivers
- 12 bit AD channel for reading detector signal (image acquisition)
- TTL signal for FIB/SEM external beam control request
- 3 additional DAC per channel for scaling, rotation / orthogonality and shift (for hardware alignment and hardware calibration)
- Decoupling from PC electronics and thermocontrol for main and calibration DACs



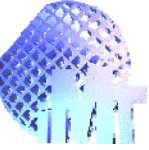
NANOSCALE-LAB



Instalare si teste PG Elphy Plus
Mai 2006

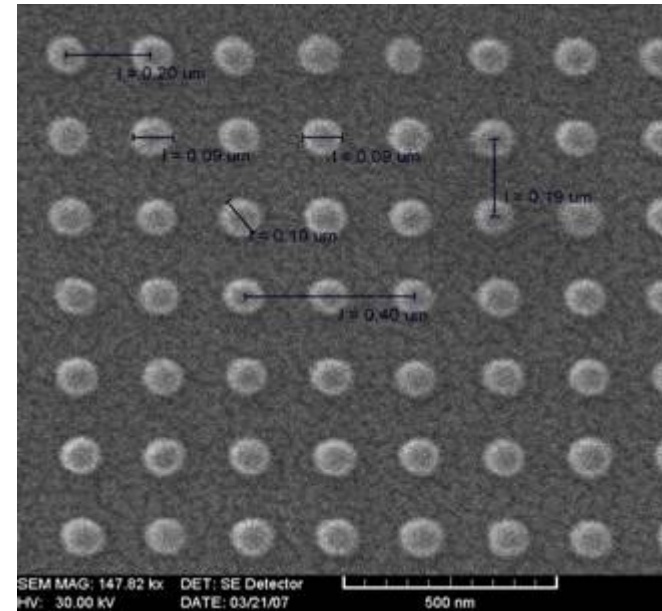
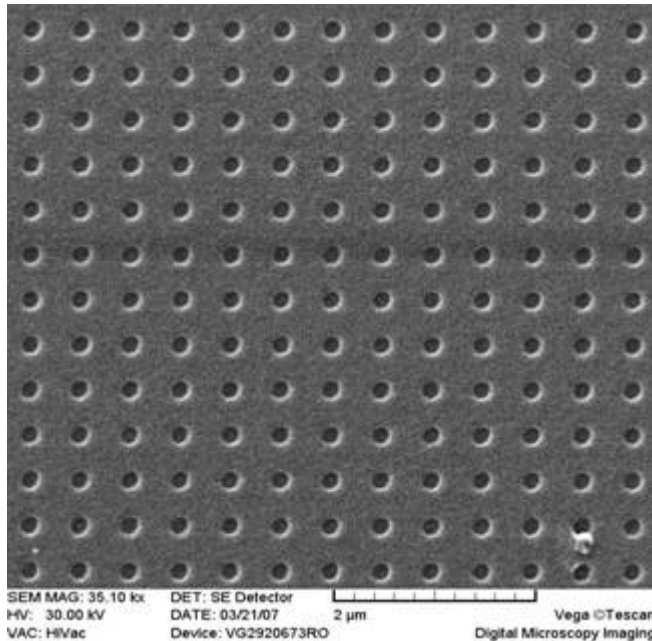


Colaborare bilaterala cu
CNRS- LAAS Toulouse
Decembrie 2006

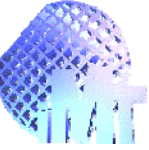


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Exemple pentru diferite investigatii utilizand echipamentul pentru Nanolitografie- EBL

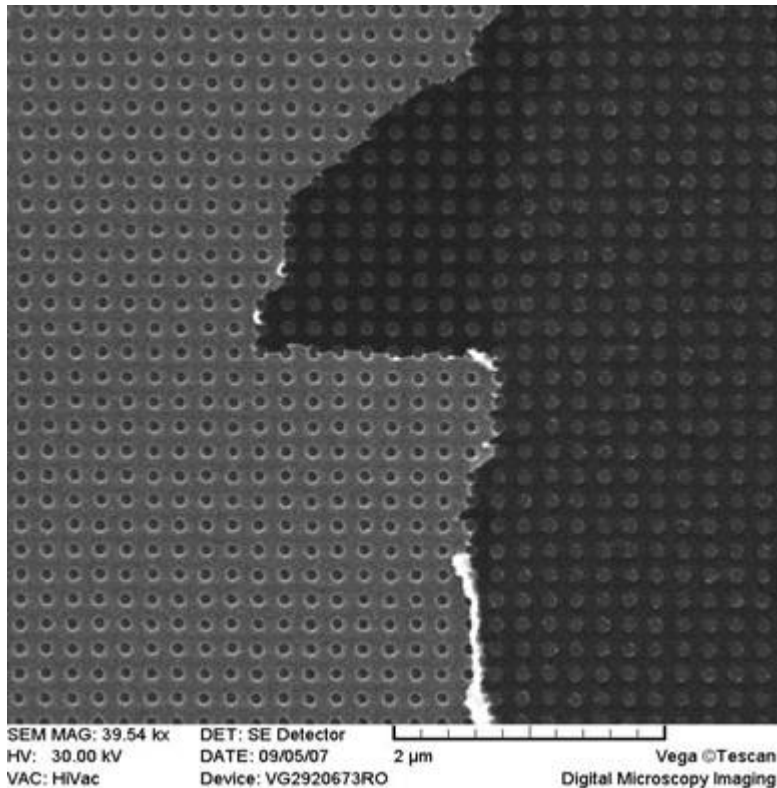


Teste pentru nanolitografie: arie de puncte-90-nm obtinute in PMMA, pentru cristale fotonice, realizate pentru Laboratorul de Fotonica al IMT- Bucuresti

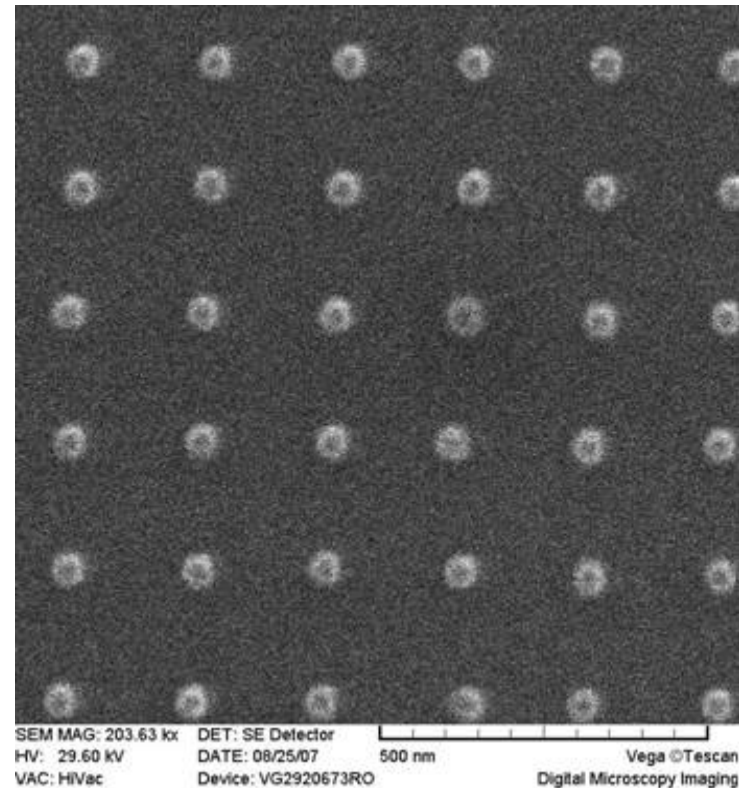


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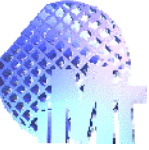
Exemple pentru diferite investigatii utilizand echipamentul pentru Nanolitografie- EBL



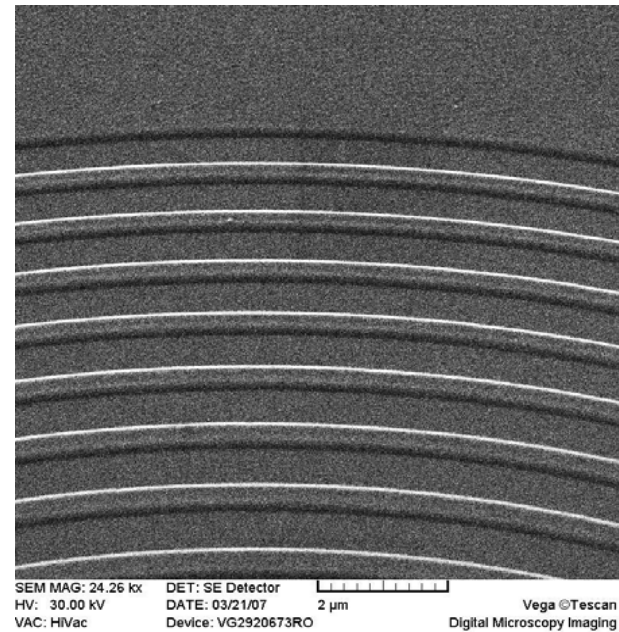
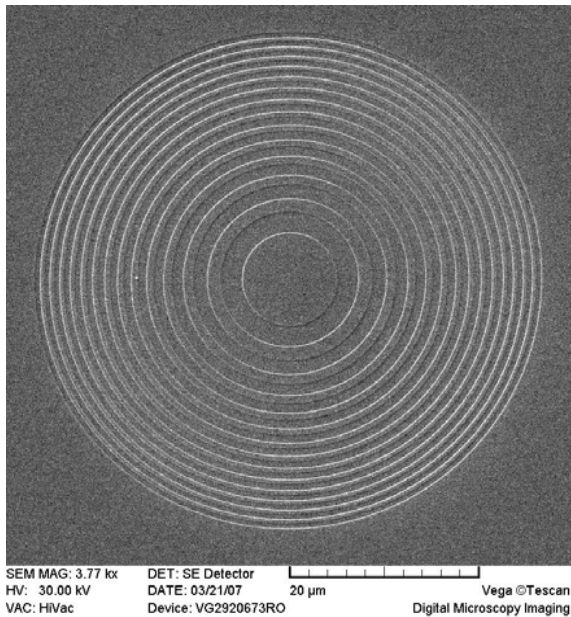
Nanopuncte (Au pe siliciu)



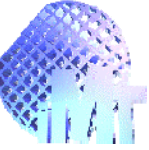
Puncte de Au pe sticla, 50 nm diametru pentru aplicatii in domeniul fotonicii



Exemple pentru diferite investigatii utilizand echipamentul pentru Nanolitografie- EBL

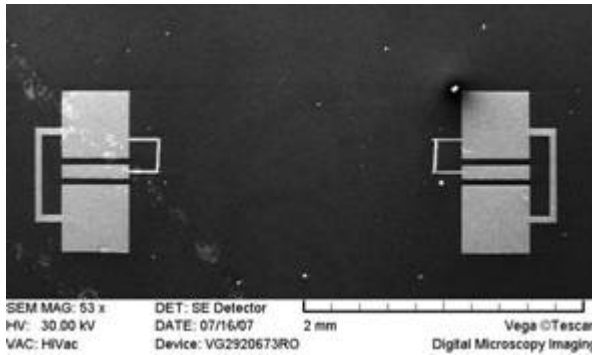
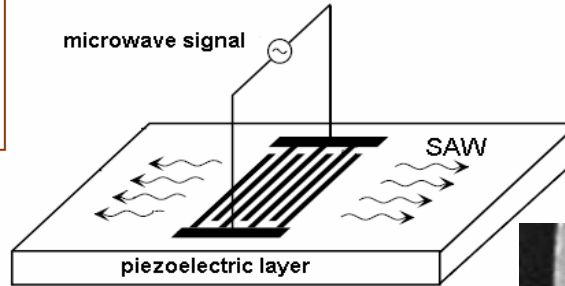


Diferite configuratii in PMMA pentru obtinerea unor lentile Fresnel lens,



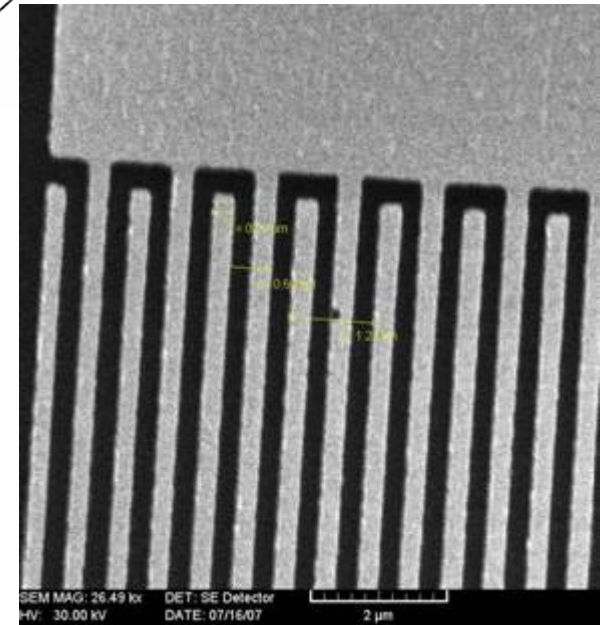
Examples TiAu nanostructures obtained by EBL and lift off process , obtained by RF-MEMS Lab of IMT- Bucharest

Structuri SAW pentru domeniul GHz . Experimente realizate pe straturi subtiri de AlN si GaN cu linii nanometrice pentru digiti

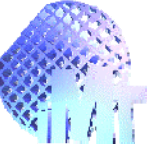


2 structuri SAW interdigitale pozitionate "face to face"

2007

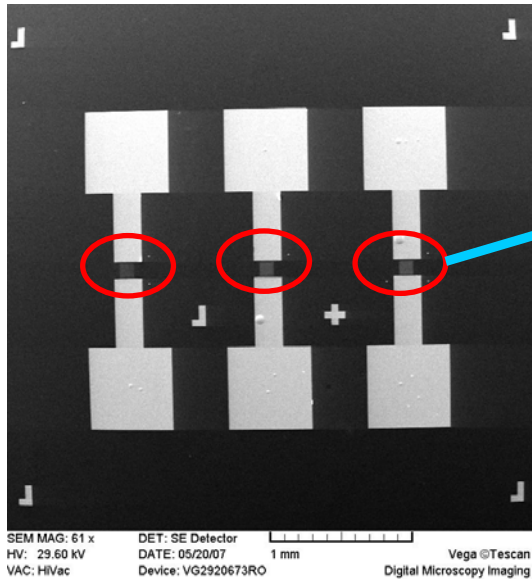


Structura metalica de **TiAu** interdigitala, cu digiti de 300 nm latime si 200 nm inaltime **obtinuta prin tehnica "lift off"**- laboratorul RF-MEMS din IMT- Bucuresti

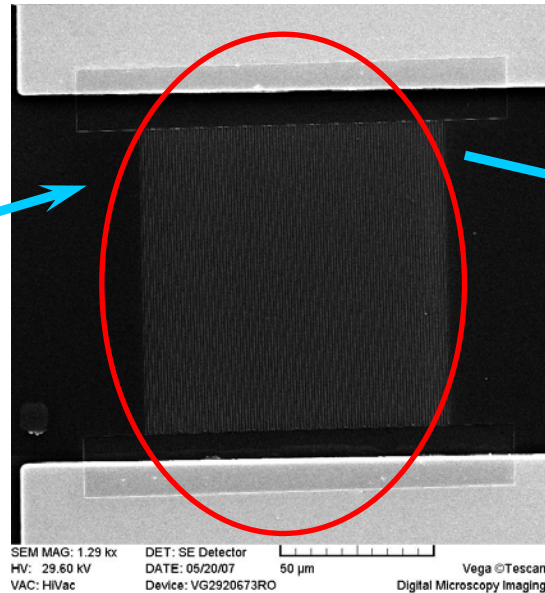


Exemple de nanostructuri experimentale obtinute cu ajutorul nanolitografiei- EBL

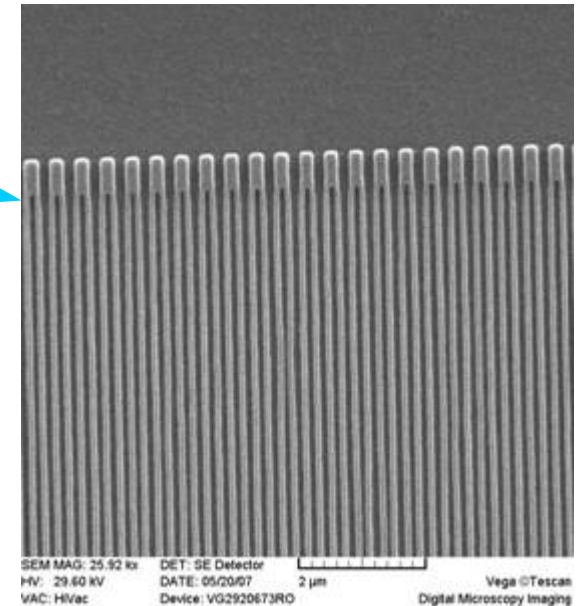
Structuri obtinute prin
litografie optica clasica



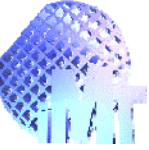
Structuri obtinute prin
EBL



Detalii ale structurii
prin **EBL**



**Exemple de litografie mix and match : clasica si EBL.
NanoScaleLab si laboratorul RF MEMS (IMT),
cooperare cu IESL-FORTH, Grecia**



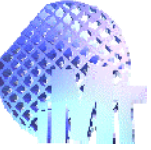
2006

Alaturi de proiectul **NANOSCALE-CONV**, un nou proiect de retea

► **RTN-NANOEL**: Romanian Technological Network for integration in the European Platform for NANOELectronics (**ENIAC**) (2006-2008)- CEEEX- INFOSOC-
Coordonator: Prof. Dan Dascalu – 10 parteneri

Contribuie la dotarea acestui laborator cu **noi module** pentru procesarea mastilor la scara nanometrica si pentru caracterizarea microfizica

Din 2007: alte dotari – din proiecte de “Capacitati”



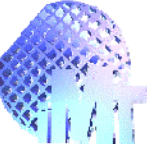
NANOSCALE-LAB

Misiune:

- ▶ Caracterizare si structurare la scara nanometrica
- ▶ **Laboratorul este in acest moment primul si singurul** din Romania care dezvolta cercetari si ofera **servicii pentru nanolitografie**, utilizand tehnica EBL

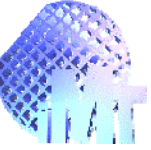
Principalele domenii de expertiza in acest moment (situatia evolueaza rapid):

Microscopie de forta atomica (**AFM**), Microscopie electronica de baleaj (**SEM**), Nanolitografie cu fascicol de electroni (**EBL**) pentru nanodispozitive; Microscopie optica, Caracterizare electrica: materiale si dispozitive



NANOSCALE-LAB

- ▶ Laboratorul **NANOSCALE-LAB** este positionat intr-o asa numita **zona "GRI"** a IMT- Bucuresti, plasata in hala tehnologica – in vecinatatea facilitatilor tehnologice propriu-zise: zona “curate” (camera alba).
- ▶ **Avantajul:** In zona “GRI”, amenajata cu fonduri din proiectele de **Capacitati** (fonduri prevazute special in acest scop), vor fi amplasate pana la sfarsitul anului **2008 inceputul lui 2009**, o serie de **echipamente performante**, in special **dedicate caracterizarilor microfizice**, achizitionate prin aceste proiecte: raze X, SNOM, WLI etc. care le completeaza prin cele din NanoScaleLab
- ▶ Zona “GRI” este amenajata in paralel cu o noua zona de camera alba care va dezvolta facilitatile actuale de litografie (masti realizate cu laser pana la scara submicronica) cu echipamente “rapid prototyping” tip “nanoindenter), precum si cele ale “NanoBioLab”

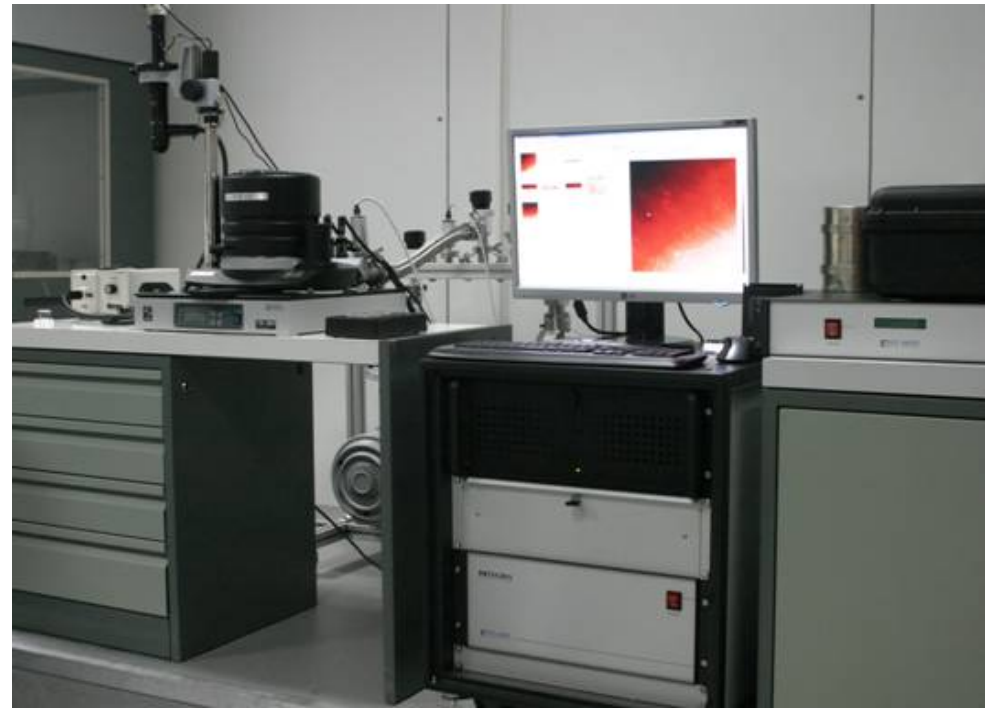


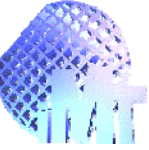
In aceeași zona “GRI” este poziționat deja noul echipament al laboratorului **NANOSCALE-LAB**– (dotare CEEEX- Modul IV):
SPM - Multifunctional Scanning Probe Microscope NTEGRA
Aura (NT-MDT)

!

Characteristici

- ▶ Maximum scan range: : 100x100x10 μm (up to 150x150x15 μm in DualScan™ mode)
 - ▶ Min Control Resolution XY: 0.0004 nm
 - ▶ x, y: Nonlinearity, with closed-loop sensors 0.15%
 - ▶ z: Noise level, with sensors: 0.04 nm (typically)
 - ▶ Thermal stability to $\pm 0.005^\circ\text{C}$ (typically).
-
- ▶ Moduri de operare: in aer: STM Scanning Tunneling Microscopy/ STS Scanning Tunneling Spectroscopy/contact AFM/ LFM/ ResonantMode (semicontact + noncontact AFM)/ Phase Imaging/ Force Modulation (viscoelasticity)/ MFM/ EFM/ Adhesion Force Imaging/AFM Lithography-Force/Spreading Resistance Imaging (SRI)/AFM Lithography-Voltage/Scanning Capacitance Imaging (SCI)/Scanning Kelvin probe microscopy(SKM)

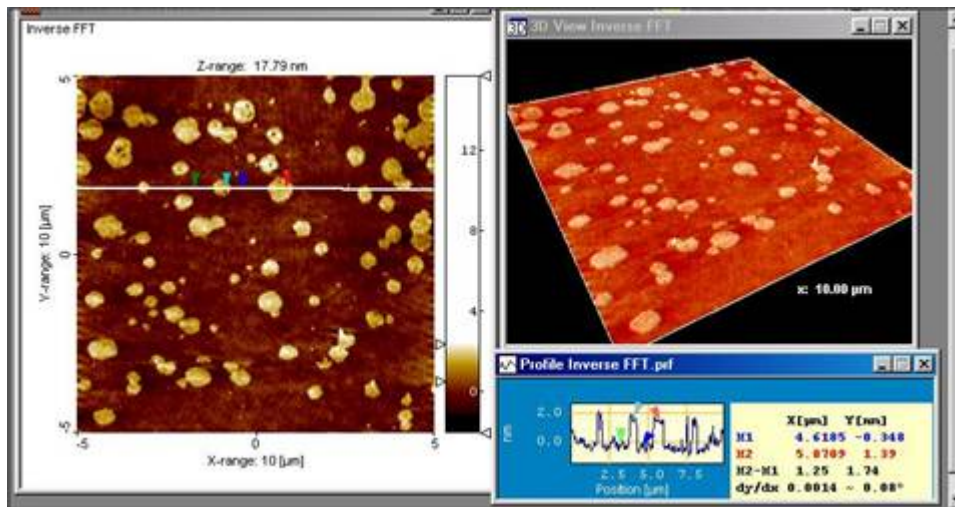




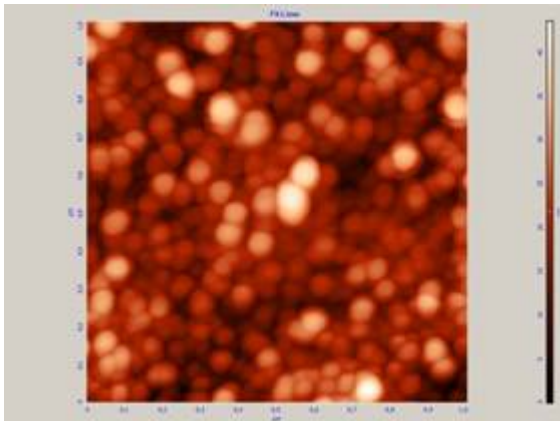
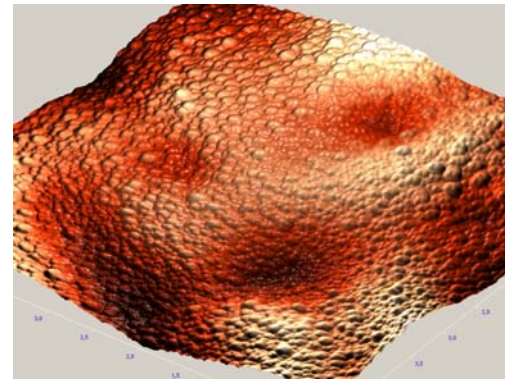
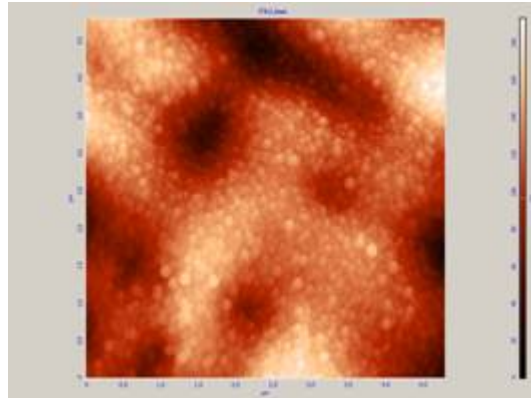
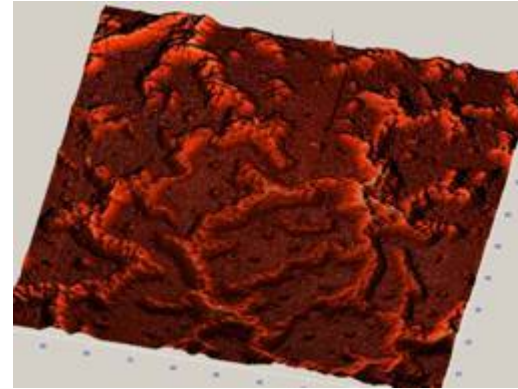
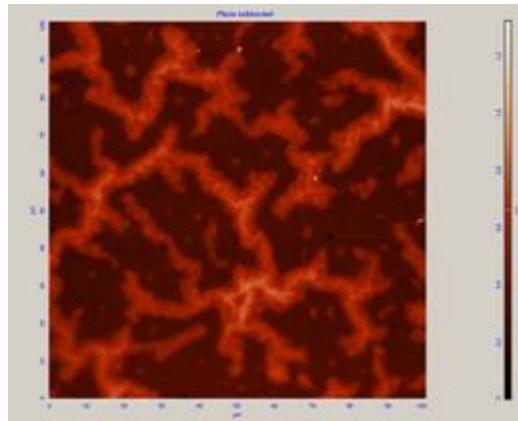
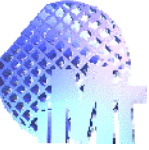
► SPM - Multifunctional Scanning Probe Microscope

NTEGRA Aura (NT-MDT) a fost recent instalat

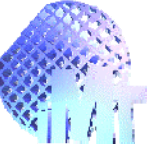
- Opereaza in aer, lichid, vid (10⁻² torr) si in atmosfera controlata de gaze
- Se pot utiliza cateva tehnici pentru captarea imaginii si masuratori ale suprafetelor, pentru domeniulmicronilor pan a la cel nanometric (molecular)
- Temperatura probei poate fi controlata pana la 200°C



Imagine AFM de control a morfologiei unei lamele de sticla utilizata pentru incubare de celule biologice, evidentiind “insule” de contaminare cu inaltimea de 1,7 nm



Imagini AFM la arii reduse succesiv (100x100, 5x5 si 1x1 micrometri, respectiv) ale morfologiei unor straturi multiple (Ag-Au) folosite ca suport pentru depunere proteine - Imagini 2D si 3D



NANOSCALE-LAB

Prin proiectul **RTN-NANOEL** s-au achizitionat urmatoarele echipamente:

▶ Modul **Laser interferometer stage pentru nanolitografie** with 100 mm by 100 mm traverange and 2 nm resolution achieved by closed-loop piezo-positioning

▶ **EDX- Energy dispersive X-ray microanalysis in SEM- system QUANTAX (Bruker AXS)- liquid nitrogen free XFlash® silicon drift detector, 135eV resolution, boron detection- analyses of composition of different materials- care va fi instalata in curand!**

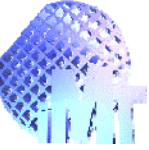
■De asemea proiectul **RTN-NANOEL**, impreuna cu alt proiect - Finantare Nucleu - **a contribuit la achizitonarea unui nou echipament:**

e-LiNE Nanoengineering System
Litografie cu fascicol de electroni de rezolutie foarte ridicata, de la firma RAITH

RM1

preuna

RalucaM; 04.05.2008



2008 !! e-LiNE Nanoengineering System

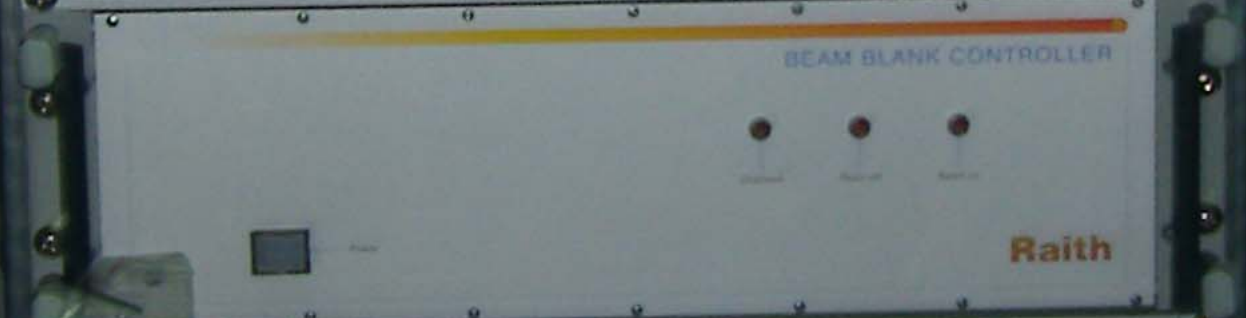
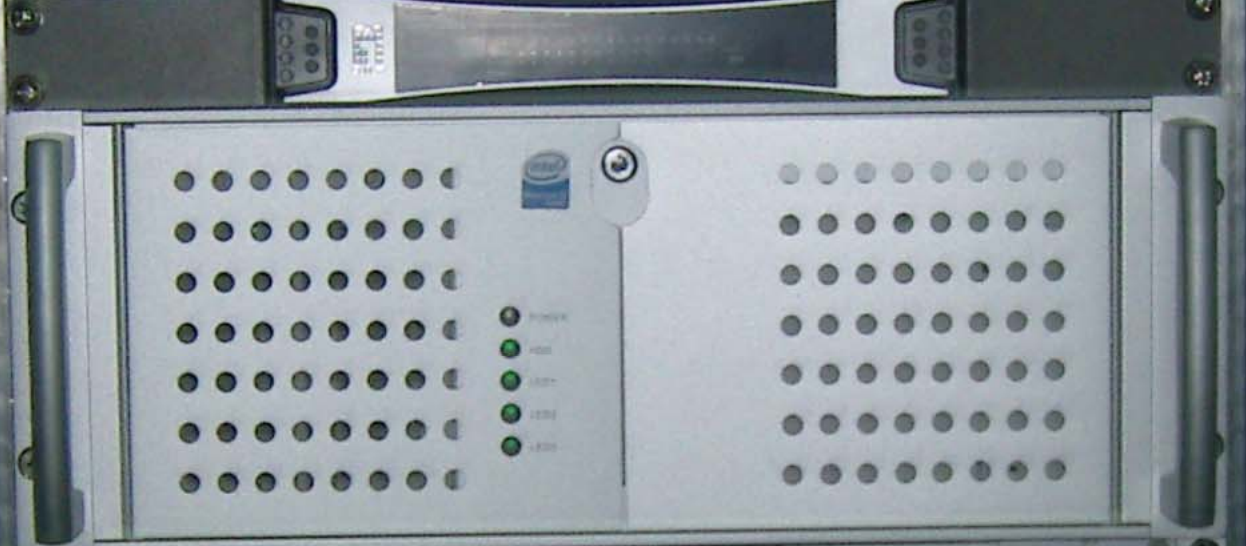
- tun electronic cu emisie in camp
- generator de configuratii (timp dwell min 100 ns - viteza de scriere_

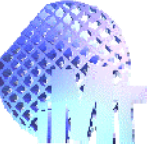


Raith









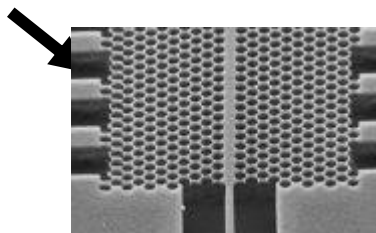
e-LiNE Nanoengineering System

Sistemul este un echipament performant pentru **nanolitografie de rezolutie ridicata si un workstation pentru nanoinginerie**

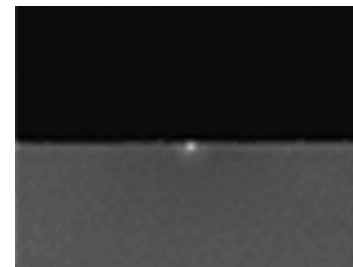
Exemple

Aplicatii:

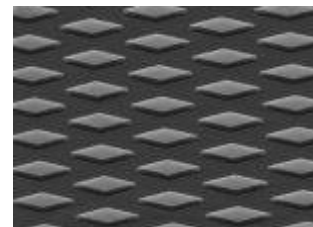
- CNT
- Ingineria straturilor subtiri
- Cristale fotonice, retele de difractie, SAW
- Structuri tridimensionale, holograme, microlentile
- EBID (Electron Beam Induced Deposition)
- EBIE (Electron Beam Induced Etching)



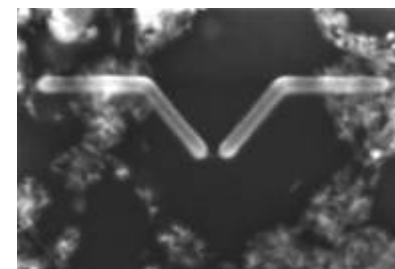
Photonic crystal structure in membrane (underetched) University of St Andrews, United Kingdom



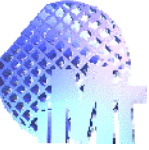
Electrical nm-contact fingers for Carbon Nanotube transport Measurement University of Basel, Switzerland



Nanostructure array for Magneto-electronics Technical University of Aachen, Germany



EBID-Contacting of Nanorods Raith GmbH, Germany



e-LiNE Nanoengineering System

Sistemul achizitionat constine:

▶ **Generatorul de configuratii - masti** (rezolutie sub 20 nm), arie de lucru 100 mm, x 100 mm

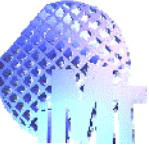
▶ **2 injectoare de gaz cu urmatorul rol:**

- **EBID- Depunere indusa prin E-Beam** (precursori incalziti peste presiunea de vapori ajung printr-un sistem injector de gaze, deasupra probei. EB ajuta la depunerea moleculelor de gaz pe proba. Se pot depune: Platina, Wolfram, SiO_x)

- **EBIE - Coroadre indusa prin E-Beam** (Materialul poate fi indepartat, in apropierea punctului unde fascicolul de electroni patrunde in substrat, prin controlul unui flux de gaz)

▶ **2 nanomanipulatoare**

Acestea sunt utilizate pentru realizarea contactelor electrice pentru structuri nanometrice si de asemenea pentru testarea mecanica a nanostructurilor.



Va multumim pentru atentie!

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Info: www.imt.ro