National Institute for Research and Development in Microtecvhnologies
(IMT Bucharest)

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IMT-Bucharest is a non-budgetary public research unit supervised by the Romanian Ministry of National Education. IMT was set up in 1993 and became a national institute in 1996. The field of activity of IMT covers: micro and nano fabrication technologies, microsystems including MOEMS and RF MEMS.

IMT has coordinated or participated in 15 FP6 and 12 FP7 EC founded projects in the field of RF MEMS, photonics, micro & nano-technologies and microfluidics. Also IMT is involved in 12 FP7 related projects (ENIAC, MNT-ERA NET, COST, Leonardo da Vinci).

Relevant expertise of the groups which can be involved in the ESA projects (***Microphotonics Lab and Micromachined microwave and millimeter wave circuits Lab***) include: modeling and simulation of micro and nano photonics structures, passive and active micro-nano-photonics structures on silicon, graphene and organic semiconductors, hybrid or monolithically integrated photonics circuits and MOEMS (including heterogenous platforms) for sensors, micro-optics design and fabrication based on replication techniques, optical and electrical characterization of materials and devices, membrane supported millimeter wave circuits; *RF MEMS*: components, circuits design and modeling technologies, new generation of circuits devoted to the millimeter wave communications based on the semiconductor (Si, GaAs, GaN) micromachining and nanoprocessing, design and manufacturing of micromachined, passive circuits elements, monolithically and hybrid integrated receiver front-ends based on silicon and GaAs micromachining, acoustic devices (FBARs and SAWs) for applications in the GHz frequency range, based on micromachining and nanoprocessing of wide band gap semiconductors (GaN and AlN), UV photodetectors based on GaN/Si membranes, MEMS and NEMS technologies development, microwave devices based on carbon nanotubes and graphene.

IMT infrastructure for processing, characterization and simulation include:

1. Clean room: micro and nanolithography; nanoprinting; mask lithography system - DWL 66 fs, Heidelberg Instruments Mikrotechnik; Electron Beam Lithography and nanoengineering workstation - e_Line, Raith; Pattern Generator - Elphy Plus, Raith; Double Side Mask Aligner & UV NIL - MA6/BA6, Suss MicroTec; Dip Pen Nanolithography Writer - NSCRIPTOR, NanoInk; FC 2000 Evaporation System-Temescal; Electron Beam Evaporation an DC sputtering system - AUTO 500, BOC Edwards; PECVD - LPX-CVD, with LDS module, STS; LPCVD - LC100, AnnealSys; RIE Plasma Etcher - Etchlab, SENTECH Instruments; Rapid thermal processing/annealing - AS-One, AnnealSys; Micro-Nano Plotter - OmniGrid, Genomic Solution; DRIE - Plasmalab System 100ICP, Oxford Instruments Plasma Technology.

2. Characterization Tools: Vector Network Analyzer (VNA) up to 110 GHz and on wafer characterization system; spectrum analyzer up to110GHz; frequency generator synthesiser up to 110GHz; Semiconductor Characterization System & Wafer Probing Station - *4200-SCS*/Keithley/Suss MicroTec; Field Emission Gun Scanning Electron Microscope (FEG-SEM) - *Nova NanoSEM*, FEI Company; XRD; WLI; SNOM; SPM; High Resolution Raman Spectrometer; Nanoindenter.

3. Computation, Simulation and Design: high performance computing server **- IBM x3850 HPC server** - 32 cores XEON X7350 @ 2.93 GHz, RAM 200 GB, HDD 1.5 TB; **coupled analysis for MEMS** - **CoventorWare 2010.010** (COVENTOR, USA) - arhitect, designer, analyzer, MemElectro, MemMech, CoSolveEM, MemETherm, MemPZR, MemPZE, Damping MM, InertiaMM, MemHenry, MemCFD, Netflow, SwitchSim, ReactSim, MemFSI, BubbleSim, DropSim, SEMulator3D, EM3D; **Ansys Multiphysics 11.0** (ANSYS, USA) - structural, thermal, acoustic, electro magnetic and coupled field analyses; **COMSOL Multiphysics**; **Photonic components - simulation, modeling and design** - **Opti FDTD 8.1, Opti-HS, OptiBPM 9.0, OptiGrating** (Optiwave, Canada); **Microwave and millimeter wave circuits and microsystems: design and modeling** - **CST, IE3D & FIDELITY** (Mentor Graphics, USA); **Atomistic DFT calculations**: electronic structure calculations and ab initio molecular dynamics simulations of molecules and solids - **SIESTA** (ICMAB-SIESTA), Inelastica.

IMT has also a Reliability Lab equipped with last generation equipments and it is able to perform the following tests: *thermal cycling* - 2 chambers of 11 liters each: low temp. (-65...0ºC) and high temp. (+60…200ºC), temperature fluctuations: ±2°C, heating duration: 15 min (-65°C...150°C); *pressure & temperature* - capacity: 49 litres; temperature range: +5°C over ambient ...+200°C (±0.5°C), pressure range: 10...1100 mbar; temperature & humidity (damp heat) - temperature range: -40...+180ºC; Speed: 5ºC / min, humidity range: 20…95%RH, between +10ºC…+80ºC; *thermal (& electrical) stress* - capacity: 53 litres, temperature range: +5°C over ambient ...+220°C (± 0,5°C), electrical bias of sample; *vibrations & electrical stress & thermal stress & humidity* - frequency range: DC…3000 Hz, maximum moving

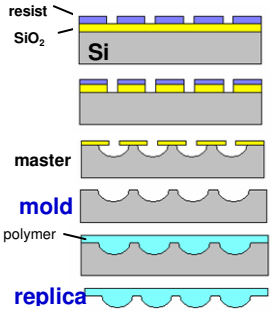
mass: 6.8 Kg, main resonance frequency: >3000 Hz, climatic system: 264 litres, temperature range: - 40ºC…+180ºC (±1ºC), heating speed: 2,5ºC/min, from -30ºC to +150ºC, cooling speed: 1,0ºC/min, from +150ºC to -30ºC, humidity range: +10%…+95% RH (±3%…±5% RH); *electrical stress & thermal stress & pressure & humidity* - Highly Accelerated Stress Test (HAST), 18 litres, temperature range: 105...142ºC, humidity range: 75%…100% RH, pressure range: 0.02…0.196 Mpa; *mechanical shock* - shock with free fall, maximum acceleration 4500 g, maximum height: 60 in, maximum speed at impact: 200 in/sec, minimum time duration: 0.3 ms; *mechanical ("tilting") & thermal stress* - functional testing for MEMS accelerometers, simulating the use in aero spatial and automotive applications, thermal stress superposed on tilting.

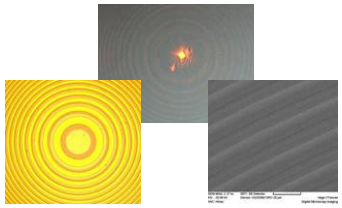
Also, IMT has a good experience in cooperation with industry: ***Honeywell Romania*** - agreement of co-operation (IMT offering scientific service), access to technology and host of equipments; ***INFINEON Technologies Romania*** - partner in ENIAC project: MOTORBRAIN - Nanoelectronics for Electric Vehicle Intelligent Failsafe Drive Train (coordinator: Infineon AG, Germany and IMT partner), organization of common actions in Romania - co-organizer of the European Semiconductor Device Research Conference (ESSDERC) and the European Conference on Semiconductor Circuits (ESSCIRC) 2013*;* ***Thales Research and Technology (TRT), Paris*** – common Projects: FP7 **-** SMARTPOWER**-IP**, NANOTEC**-IP**, NANORF-STREP, ENIAC **-** MERCURE, NANOCOM; ***NXP Semiconductor Netherlands BV (Philips)*** – common project ENIAC: SE2A; ***IMST GmbH, Germany*** **-** common project FP7 MEMS-4-MMIC.

Main results of ***Microphotonics Lab and Micromachined microwave and millimeter wave circuits Lab*** include:

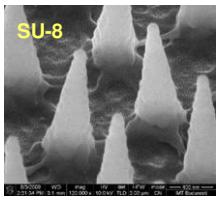
***1. Microphotonic Lab*:**

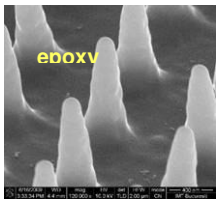
- Replication techniques for micro and nano-optical components





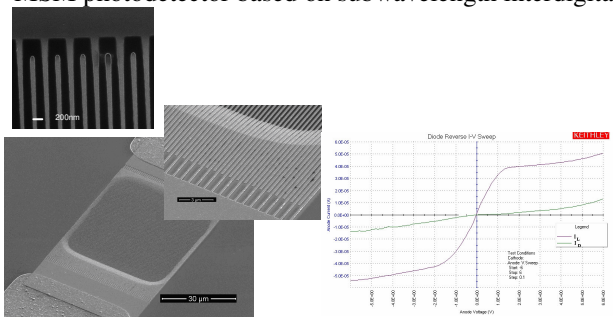
4-level Fresnel lens with focal length 6 cm





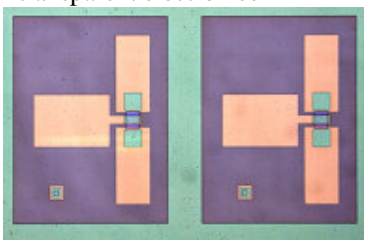
Antireflective layer in epoxy resin – replica (positive copy) of a SU-8 original- *4M Project*

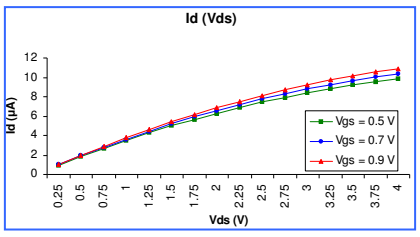
- MSM photodetector based on subwavelength interdigitated electrodes



- interdigitated Schottky contacts with fingers spacing of 80, 100, 200 nm, finger width of 80 nm , finger length of 100 µm.
- optically active area: 0.01 mm2
- efficient and ultrafast photodetection compared with conventional MSM device
- transit time < 5 ps ⇒ 100 GHz bandwidth
- capacitance < 2 pF

- transparent electronics

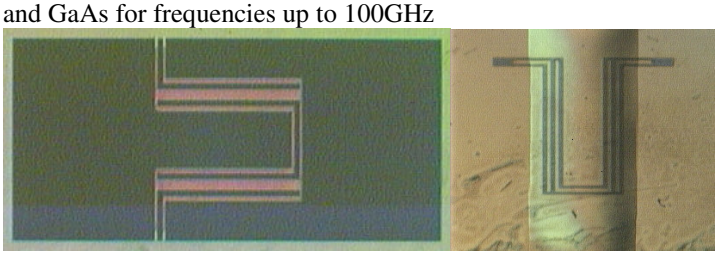




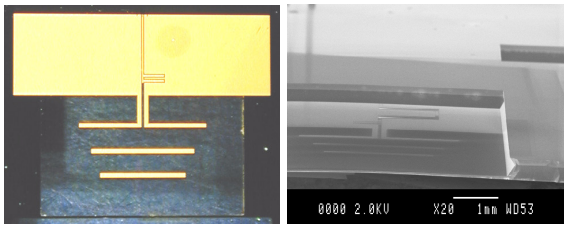
Transparent Thin Film Transistors (TTFT) on quartz substrate with *n-ZnO active channel*

2. *Micromachined microwave and millimeter wave circuits Lab* – *in cooperation with FORTH-IESL Heraklion, Greece, LAAS-CNRS Toulouse, France, FBK-irst Trento, Italy and CNR-M^{2}T Rome, Italy*

- band-pass and band stop filters supported on semiconductor and dielectric membranes on silicon and GaAs substrate for frequencies up to 100GHz
- doble folded slot anntenas and Yagi-Uda Anntenas supported on semiconductor and dielectric membranes on silicon and GaAs for frequencies up to 100GHz

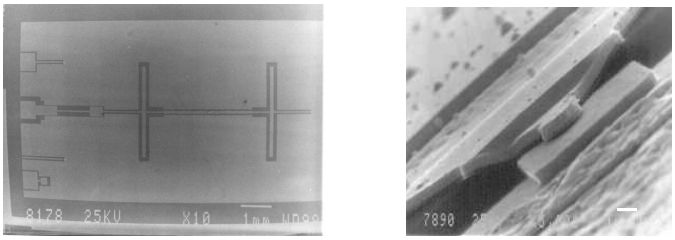


45GHz (left) and 35GHz (right) band pass filters manufactured on $SiO_2/Si_3N_4/SiO_2$ and GaAs membranes



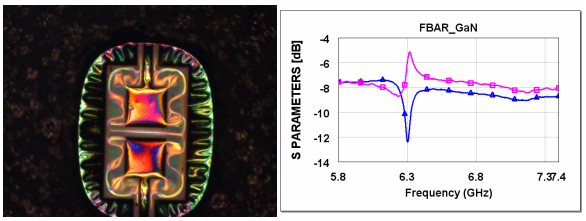
45GHz Yagi-Uda anntenas manufactured on dielectric membranes obtained by silicon micromachining

- monolithically integrated and hybrid integrated receiver modules supported on dielectric and semiconductor membranes manufactured on silicon and GaAs for frequencies up to 200GHz.

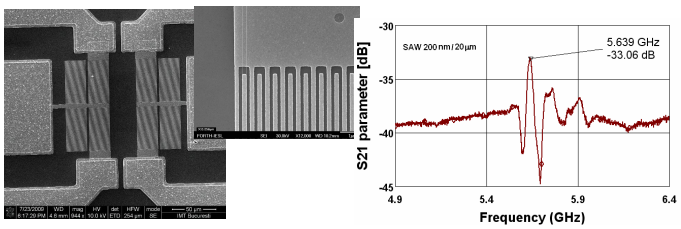


38GHz monolithically integrated receiver module mafactured on semiconductor membrane on GaAs substrate.

- FBAR and SAW structures on wide band gap semiconductors (GaN and AlN)

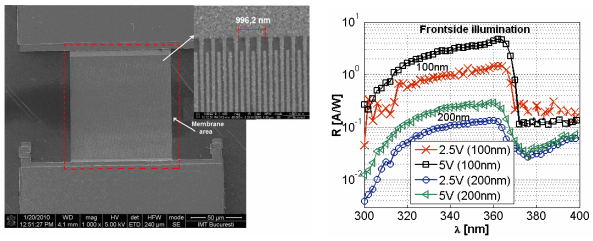


GaN FBAR – operating frequency 6.3GHz

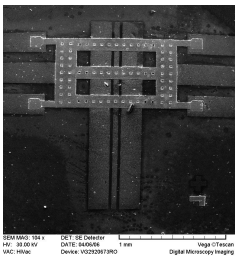


GaN/Si based structure – operating frequency 5.6GHz.

- UV photodetectors supported on GaN membrane
- MEMS switches for frequencies up to 60GHz



GaN membrane supported UV photodetector manufactured using EBL.



60GHz MEMS switch structures