RENATECH

French national nanofabrication network

Newsletter

November 2011

In this issue

- RENATECH open to international cooperation
- Specific technological tools
- Recent technological realisations
- Events
- Realize your project with RENATECH network

RENATECH open to international cooperation

RENATECH – the French national nanofabrication network – welcomes at its facilities international academic and industrial users providing the open, interdisciplinary, hands-on environment that enables them to use the advanced instruments of nanotechnology to bring their ideas to fruition. Offering to international partners the top level infrastructure, RENATECH is promoting its activities via participation at major European scientific and technological events and creation of international research partnerships.

In 2011 RENATECH successfully participated at three leading European events – Compound Semiconductor Week (CSW) and Micro- Nano-Engineering Conference (MNE), both held in Berlin, as well as presented its activities at SEMICON Europa in Dresden. Those were the excellent and particularly effective opportunities for the network to transmit information and establish contacts with the interested partners.

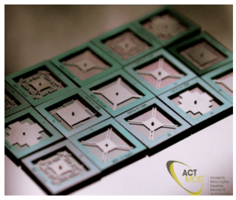
Another significant step towards the development of international cooperation has been done by RENATECH in 2011 – participation in the creation of an international laboratory between **France and Canada: LN2.**

The scientific and technological cooperation in nanotechnologies between France and Canada will be strongly enhanced thanks to the new international laboratory LN2 (UMI-LN2) involving CNRS, RENATECH, University of Sherbrooke and French universities (INSA Lyon, Ecole Centrale de Lyon, CPE Lyon and UJF Grenoble). The UMI-LN2 researches will be focused on 3 main technological activities: 3D integration and packaging, BioMEMs, Energy management on chip.

The UMI-LN2 is a bilateral laboratory with Canadian and French sites. In 2012, a staff of about 45 people will be located in the Interdisciplinary Institute of Technological Innovations (3IT) at University of Sherbrooke, Quebec, Canada. Strong collaborations will be developed with the MiQro Innovation Collaborative Centre (C2MI) which is an international centre of excellence for electronic assembly research. In France, the research activities will be mainly developed within the national nanofabrication network RENATECH. Two first projects with RENATECH are already planned for 2012 in the field of GaN and Single Electron devices.

Strengthening its cooperation with industrial partners, one of RENATECH laboratories, FEMTO-ST, is actively participating in **ACTMOST consortium for micro-photonic technologies.** Launched on 1 September 2010, ACTMOST (Access Centre to Micro-Optics Expertise, Services and Technologies) is a new industry support model that aims to lower the technological barriers associated with producing micro-photonics solutions by promoting European industry and encouraging product innovation. Financially supported by the European Commission (EC), ACTMOST is a joint effort between 14 high-tech research institutes and university laboratories from six European countries, and strives to provide complete solutions for companies through focused collaborations and the hands-on training of industry staff.

Micro-optical components mounts micromachined at FEMTO-ST



ACTMOST aims to provide technology support throughout the entire chain of product development, ranging from the optical design, measurement, prototyping, replication and packaging stages, through to proof-of-concept demonstrations, reliability tests and pre-production level fabrication.

In the consortium, FEMTO-ST expertise is more specially used in projects needing silicon microsystems (actuators) and glass microlenses fabrication that are conducted in the Mimento platform – but a full range of expertise in optics and photonics is available through the other partners and can seen at www.actmost.eu.

For further information concerning LN2, contact:
A. Souifi, Director UMI-LN2: abdelkader.souifi@insa-lyon.fr
V. Aimez, Vice-Director UMI-LN2: Vincent.aimez@usherbrooke.ca
Website: www.labn2.ca
For further information concerning FEMTO-ST in ACTMOST, contact: Christophe Gorecki, christophe.gorecki@femto-st.fr

Specific technological tools

Nanobeam NB4 system, a new 100 kV ebeam lithography machine at IEF facility

The Nanobeam NB4 system.

The ebeam lithography is a key step for the fabrication of nanometric scale devices. The «printing» of a pattern is made by exposing to an electronic beam a substrate covered by an electro-sensitive resist. For a 100 kV exposure, the beam size is below 10 nm and remains nearly unchanged all along the resist. The high energy exposure allows to reduce the impact of proximity effects so that it becomes possible to realize nanometric and dense structures.

The Nanobeam NB4 system is the new 100 kV ebeam lithography machine installed in the technologies facility CTU-MINERVE of the IEF since the beginning of May 2010.

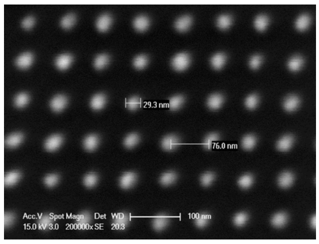
The machine uses an acceleration voltage from 30 kV up to 100 kV with a theoretical beam size of 2.3 nm at 100kV and a guaranteed writing beam size < 8nm for a current of 3 nA at 100 kV. The usable current can vary from 2 nA to 50 nA. The beam has a dynamic position drift below 150 nm per hour (this value includes the contributions for the blanking, stage move, and deflections). The stitching error and the overlay error are below 25 nm (~ 21 nm during the acceptance tests).

The beam deflection combines two kinds of fields: the mainfield which implies a move from the stage and the subfields which use the deflection of the beam. The mainfield specifications are the following: a 1000 µm maximum size, an address resolution of 1 nm and the use of a 20bit DAC. For the subfield, the properties are: a 20 µm maximum size, an address resolution of 1 nm and a clock rate of the system of 55 MHz.

The NB4 admits different size of samples from 5 mm² up to 5 inch glass masks used for UV lithography with a cassette holding up to 10 chucks. Each of them can hold from one sample (4 inches wafer) to several (0.5 mm x 0.5 mm to 2 inches wafers).

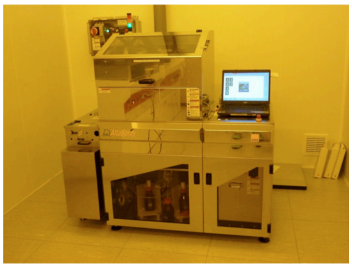
The system has shown already its capability of automatic location of alignment marks, automatic beam focus and writing of a second level lithography with different kind of resists (PMMA, ZEP, MaN).

Contact: ctu.ief@u-psud.fr



Array of gold pillars with a 76 nm period on a silicon substrate. The pattern is made with a 200 nm-thick PMMA resist.

New equipment for photosensitive resist spray coating at LAAS facility



Since June 2011, the LAAS optical lithography area accommodates new equipment for photosensitive resist spray coating: Delta AltaSpray from Suss Microtec.

This technique allows depositing in a uniform and conforming way a photosensitive resist (especially validated for the positive resist) on substrates presenting important patterns topography.

The equipment treats substrates from 10mm to 150mm in diameter. It is equipped with 2 resist lines (positive and negative), each one having its own head of spray.

The first results obtained are:

- a positive resist, novolak chemistry: thickness 7µm, 2µm resolution on the top of the substrate. Possibility to achieve a network of line with 10µm broad in a cavity of 250µm with addition of an optical lens on the mask aliner
- a standard SU8 resist: thickness of 10µm and resolution of 10µm.

All the micro and nano components prototyping fields could be addressed by such equipment.

Contact : conedera@laas.fr

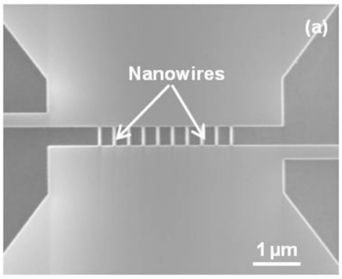
Recent technological realizations

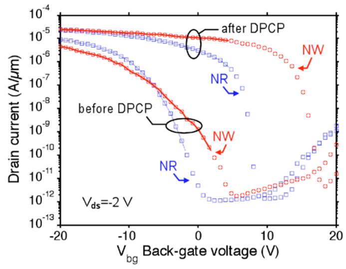
IEMN High Gain and Fast Detection of Warfare Agent using Back-Gated Silicon Nanowires MOSFETs

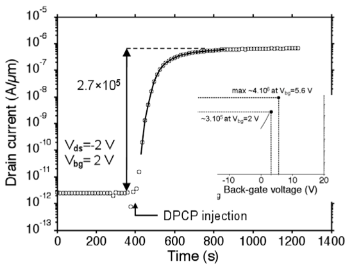
The use of silicon nanowires (NWs) as nerve agent/organo-phosphorus detectors is here reported, where NWs are grafted with 3-(4-ethynylbenzyl)-1, 5, 7-Trimethyl-3-AzaBIcyclo [3.3.1] Nonane-7-methanOL hereafter referred to as TABINOL and exposed to diphenylchlorophosphate (DPCP), used as a simulant of nerve agents, thus forming aza-adamantane quaternary ammonium salt. Devices realized with arrays of silicon nanowires (NWs) are especially fascinating for sensing applications as they increase the surface-to-volume ratio of the detector. A current gain of 4×106 is obtained upon detection of sub-ppm concentration of a nerve agent simulant. This represents a four decades improvement over previous demonstration based on nanoribbons, proving better sensing capabilities of nanowires. When compared to their nanoribbon counterpart, NW sensors feature both enhanced threshold voltage shift (ΔVT) and larger relative change in current (ΔI/I)peak upon exposure to DPCP resulting in much larger detection margins. This demonstration has been performed within the frame of a collaboration between IEMN-Lille (F), LITEN-Grenoble (F) and UCL-Louvain (B).

V.Passi et al., 'High Gain and Fast Detection of Warfare Agent using Back-Gated Silicon Nanowires MOSFETs', IEEE Electron Dev. Lett. 32, pp 976-978, July 2011.

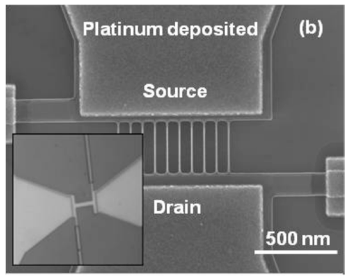
Contact : emmanuel.dubois@isen.iemn.univ-lille1.fr







(a) Measured Ids-Vbg characteristics of nanowires (NWs) and nanoribbon (NR) based devices before and after DPCP exposure. (b) Measured time dependent steep increase of current in NWs during the injection of DPCP with an amplification factor larger than 3×106. The static current gain after exposure to DPCP presented in the inset shows that the Vbg = 2 V bias condition for time-dependent measurement is slightly below the maximum gain of 4×106 obtained at Vbg = 5.6 V.



Top-view SEM image of silicon nanowires: (a) after resist development, (b) after lift-off of platinum on the source and drain pads. Inset of (b) shows a nanoribbon with metal contacts. The width of the nanowires is 25 nm, while the nanoribbon is 1 µm-wide.

Integrated LC Filter on Silicon for DC–DC Converter Applications

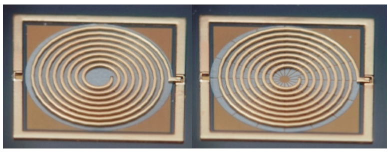


fig.1: Optical pictures of micro-inductor with magnetic shield (a) plain; (b) laminated. Total filter area is 3 mm x 3 mm.

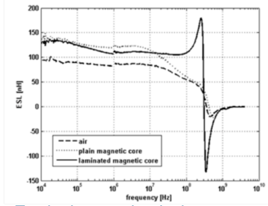
The integration of passive components on silicon for future DC-DC converters applications is still a challenging area of research. Within the framework of the PRIIM project (OSEO funded, lead by IPDIA), the objective is to realize integrated passive components (capacitors, inductors, filters) with high performance : low losses and high specific values. In 2011, we realized the microfabrication of a fully integrated filter containing a spiral inductor on top of a 3D capacitor[1].

The technology of 3D capacitor relies on high aspect ratio pores etched by Deep Reactive Ion Etching (DRIE), filled with a dielectric bilayer of Si_3N_4/SiO_2 and polysilicon for the electrodes. The spiral-type micro-inductor, with thick electroplated copper windings (50 µm) is realized on top of the capacitor. For this step a thick photoresist mould was developed. A thin magnetic shielding layer (electroplated CoNiFe, 2 µm thick) is introduced between the two components to reduce losses caused by the inductor in the capacitor area.

The fabricated filter that contains a 3D capacitor (brown area) and a spiral inductor separated with a magnetic shield is shown in figure 1. Two configurations of the magnetic shield were tested: a plain one and a laminated one. This filter was characterized with an impedance analyzer. Beyond the challenge of technological steps successions, precise impedance measurement in a wide range of frequencies (10 kHz to 4 GHz) proved the double interest of realizing a thin magnetic material layer between the inductor and the capacitor: the inductor value is modestly increased and the magnetic layer provides an excellent shielding against magnetic coupling with the substrate/capacitor. Lamination helps keeping the eddy currents low in the magnetic material. As a result the inductance stays constant up to 110 MHz.

The component was characterized with waveforms typically found in DC-DC converters and a loss analysis was conducted at 5 MHz. The filter presents absolute values of inductance (110 nH) and capacitance (560 nF) that are well suited for DC-DC converters with switching operation in the range of several MHz.

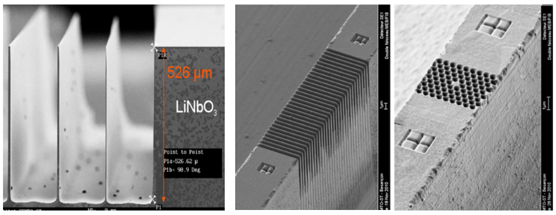
Contact : Magali Brunet, mbrunet@laas.fr



Equivalent series inductance measured with impedance analyzer below 1MHz and with network analyzer above 1MHz

[1] P. Artillan, M. Brunet, D. Bourrier, J.P. Laur, N. Mauran, L. Bary, M. Dilhan, B. Estibals, C. Alonso, J.L. Sanchez, Integrated LC filter on silicon for DC-DC converter applications, IEEE Transactions on Power Electronics, vol. 26, No. 8, August 2011, pp. 2319-2325.

High aspect ratio tunable photonic crystal-based sensors on lithium niobate



SEM views of LiNbO3 ridge waveguides fabricated by Ti-indiffusion followed by optical grade dicing. Bragg gratings and photonic crystals are fabricated by FIB milling

The purpose of this work is the development of LiNbO3 nanostructures with high reflectivity. The nanostructures are implemented on both ends of a LiNbO3 optical waveguide for fabricating an integrated optical Fabry-Perot. The high electro-optic coefficients of lithium niobate materials associated with the Fabry-Perot structure would enable the development of sensitive and compact electric field sensors.

We have been exploring this technology with FIB milling to integrate Bragg mirrors and photonic crystals on Ti-diffused lithium niobate waveguides. Currently a maximum reflectivity of 80% has been reached. We have also explored a new technology in the view of improving the confinement of light within the waveguides. We developed an optical grade dicing method producing smooth ridges with an aspect ratio larger than 500, enhancing the electro-optic interaction in the device. This quite unique technology is the latest outcome of years of development in polishing-while-dicing technology, and it is fostering a fall-out of new research projects in photonics and in acoustics. New investment in dicing equipment is currently underway to further develop this technology.

Contact: Nadege Courjal, nadege.bodin@univ-fcomte.fr
Gwenn Ulliac, gwenn.ulliac@femto-st.fr

λ^3 /1000 Plasmonic Nanocavities for Biosensing Fabricated by Soft UV Nanoimprint Lithography

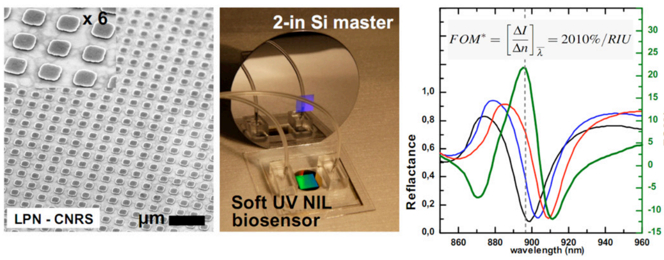
Surface plasmon polariton and related phenomena in metallic nanostructures are currently being exploited for a variety of applications including molecular sensing, focusing of light, near-field optical microscopy, subwavelength photonics and optical metamaterial.

Arrays of plasmonic nanocavities with very low volumes, down to λ^3/1000, have been fabricated at LPN by Soft UV Nanoimprint Lithography. Nearly perfect omnidirectional absorption (30° - 70°) is demonstrated for the fundamental mode of the cavity (λ = 1.15 µm). The second-order mode exhibits a sharper resonance with strong angular dependence and total optical absorption when the critical coupling condition is fulfilled. It leads to high refractive index sensitivity and state of the art figure of merit ($\Delta I/\Delta n$~20) and offers new perspectives for efficient biosensing experiments in ultralow volumes [1].

Moreover, the wavelength and width of the broad fundamental resonance can be tuned by carefully designing the resonant nanoantenna array, and for 2D arrays, the total omnidirectional absorption obtained is independent of the polarization of light, making this structure ideal for the design of efficient photovoltaic devices in which the absorbed light leads to electron-hole pair generation in an ultrathin inorganic or organic semiconductor layer placed in the ultrasmall cavity volume.

[1] Cattoni et al., Nano Letters 11, 3557 (2011)

Contact: Stéphane Collin, stephane.collin@lpn.cnrs.fr
Andrea Cattoni, andrea.cattoni@lpn.cnrs.fr



Left: SEM image of the 2D nanocavities fabricated by SoftUV NIL. Center: picture of the biosensor based on 2D plasmonic nanocavities fabricated by Soft UV Nanoimprint Lithography using an hard-PDMS/PDMS stamp replicated from a silicon master mold fabricated by Electron Beam Lithography. Right: spectral shift of the second-order mode for different refractive index solutions and the corresponding Figure of Merit (green line).

Events

RENATECH at MEMS 2012 in Paris

RENATECH will be present as an exhibitor at the 25th International Conference on Micro Electro Mechanical Systems (MEMS 2012) which will be held from 30 January - 2 February 2012 in Paris.

RENATECH will welcome its existing and potential users during a special **presentation and cocktail event** which will be held in the evening on **Tuesday, 31 January**. This moment of conviviality will provide an excellent venue for researchers and engineers to exchange about new results and advanced capabilities in nanoscale science research and in particular in MEMS field, to inform about the latest technological competencies and equipment, as well as to overview the procedures of project submission and its realisation at RENATECH network.
For more information contact Elena Hoffert: Elena.Hoffert@cnrs-dir.fr

Inauguration workshop of UMI-LN2

The inauguration workshop of the international laboratory UMI-LN2 is scheduled from 14 to 18 July 2012 in Quebec. More information concerning this event could be found on the website www.labn2.ca starting from January 2012. For further information contact:
A. Souifi, Director UMI-LN2: abdelkader.souifi@insa-lyon.fr
V. Aimez, Vice-Director UMI-LN2: Vincent.aimez@usherbrooke.ca

Realize your project with RENATECH network

1.Contact RENATECH network via:

common entrance point: renatech-accueil@cnrs-dir.fr
or contact directly one of RENATECH facilities to discuss your application:

IEMN technological facility
Contact: plateforme@iemn.univ-lille1.fr

FEMTO-ST technological facility
Contact: mimento@femto-st.fr

IEF technological facility
Contact: ctu@ief.u-psud.fr

LAAS technological facility
Contact: plateformertb@laas.fr

LPN technological facility
Contact: centrale-techno@lpn.cnrs.fr

PTA technological facility
Contact: accueil@pta-grenoble.com

2.The application will be worked through and evaluated by the reception team at each facility.

3. Realize your project

For further information concerning RENATECH newsletter contact: Elena.Hoffert@cnrs-dir.fr