RENATECH

French national nanofabrication network

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Newsletter

May 2015

Contents

RENATECH THESIS PRIZE

The second RENATECH prize will be awarded during the JNTE symposium
18-20 November 2015 at Ecole Centrale de Lyon

The RENATECH Technology prize will reward any outstanding work in micro-nanofabrication accomplished by a PhD student during his thesis work. The award consists of a tablet computer, a certificate, and invitation to talk at a regular session of the JNTE symposium which will take place at Ecole Central de Lyon.

Application Procedure

The thesis should have been defended in the two years before the JNTE symposium (2013 or 2014 for JNTE 2015). The work must have been carried out in an academic or industrial French laboratory. The thesis could have been done in collaboration with a partner, industrial or academic, French or foreign.

The application file consists of

A maximum summary in 3 pages including *(Fichier AAP-Prix Thèse RENATECH2015):*

- a short presentation of the PhD work
- one more detailed description of the technological achievement highlighting their originality and their impact in micro-nanofabricationand the technological gain
- presentation of the main results,
- publication list.

A letter by the supervisor of the PhD work or by a close collaborator,
in support of the application.

Calendar

The complete application file should be send by e-mail to Caroline BOISARD (caroline.boisard@cnrs-dir.fr) before 20th May 2015 before midnight.

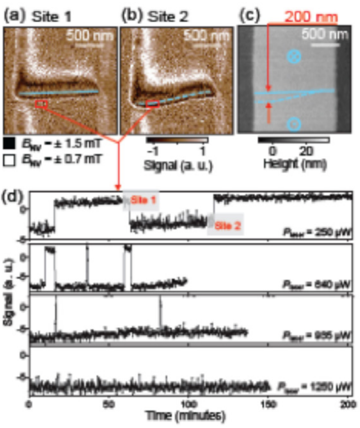
Please find the application on our website : www.renatech.org

The successful applicant will be elected and notify by the end of June 2015.

Nomination

The applications will be evaluated by a board of experts, taking into account the importance and novelty of the technological achievements. The evaluation is not focused on the scientific results later obtained from the fabricated device/material/instrument and their impact for the community.

Observation of domain wall motion at the nanoscale by scanning NV center microscopy



Of particular recent scientific and technological interest, is the control of domain wall (DW) motion in nanowires based on ultra-thin films with perpendicular anisotropy. One main challenge is to understand how narrow DWs (~10nm) interact with local pinning defects in magnetic wires. In order to better understand the underlying mechanism of DW motion, the direct observation of DWs at the nanoscale is a prerequisite. However, the relatively small number of spins makes the problem hard to tackle by direct magnetization imaging.

Very recently, an important step forward has been made by a partnership involving Institut d'Electronique Fondamentale in Orsay, Laboratoire de Physique des Solides in Orsay, ENS Cachan and Spintec Grenoble. They have used a scanning NV center microscope developped at ENS Cachan to non only directly observe (Fig. 1) thermally activated DW motion on a scale of less than 100nm but also determine the nature itself of a 10nm wide DW (Bloch vs Neel). The method have been applied to a single DW moving in nanowires based on Ta/CoFeB/MgO films with perpendicular anisotropy. Advanced nanodevices including very low edge roughness and multiple electrodes levels have been developped using the facilities available at the MINERVE (Orsay) and PTA (Grenoble) platforms.

FIG. 1 : Direct observation of a 10 nm wide domain wall hopping between two pinning sites in a magnetic wire. (a,b). Approximate DW profile (blue lines) extracted from (a) and (b), overlaid on the AFM image. (d) Telegraph signals obtained in the area indicated by red squares in (a) and (b), at various laser powers. Each data point corresponds to 10 s of integration

• PROJECT FP7 MAGWIRE (2010-2013) and ANR-NSF FRIENDS (2010-2014)
Paper under review in SCIENCE

New laser micromachining equipments

Fig. 1: Multiwavelength (IR,VIS, UV) ablation equipment using a femtosecond laser source. The insert provides details on the 300x300mm sample stage and shows the scanners for fast beam deflection.

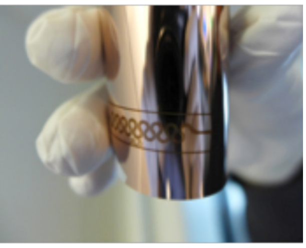


Fig. 2: Meandering coplanar transmission line obtained by local ablation of 1µm thick layer of copper without altering the plastic (PEN).

Within the frame of the LEAF EQUIPEX* project, IEMN has recently installed two laser micromachining equipments. Laser micro-structuring by photo-thermal ablation gathers in a single low temperature and chemical-free processing step what is commonly achieved in four steps (resist spin-coating, lithographic exposure, development and etching) with four conventional microtechnology equipments. The surface of objects processed by laser micromachining is therefore much less exposed to successive atmosphere and chamber contamination. Laser micromachining is emerging as an emerging key technology in the semiconductor research segment for structuring, ablating, scribing, cutting, drilling a wide range of materials as diverse as semiconductor crystals, metals and plastics. Among others, decisive advantages of ultra-short pulses laser is the reduced heat-affected zone as well as speed and versatility for fast prototyping loops. Ablation selectivity between materials can be achieved with a proper selection of wavelength, pulse duration, shot repetition rate and beam velocity. Two equipments are available (Fig. 1), operating in the nanosecond and femtosecond pulse regimes, respectively. The nanosecond source is principally used for steps cutting that involves stock removal of material and which necessitates, in turn, high power and large energy pulses at relatively low repetition rate. To address the broader range of materials, this source operates at UV wavelength. The femtosecond laser source is conversely devoted much finer micromachining work for which sub-picosecond pulses eliminate thermal stress and heat-affected zone. The newly installed femtosecond equipment features three wavelengths ranging from IR to UV (1030, 515 and 343nm), 300fs pulse duration and repetition up to 2MHz.

Major specs fs equipment	Major specs ns equipment
- multi-wavelength femtosecond (300fs) diode-pumped (DPSS) lasers source (UV343,GR515,IR1030nm) - average power up to 20W and pulse energy up to 100 µJoule in IR - repetition rate up to 2MHz - trepanning head	- UV nanosecond (35ns) diode-pumped (DPSS) lasers source (351 nm) - average power up to 8W and pulse energy up to 5 mJoule
- independent optical attenuation module - autofocus function - vector scanning mode without mask preparation - galvanometer deflection with extended field of 50×50mm2, high precision optical encoding and signal processor control - sample stage up to 300×300 mm2 with linear accuracy +/- 0.5 µm, repeatability +/- 0.2µm, flatness and straightness +/- 1µm - vision system and fast alignment capabilities - CAD software automation - vapor extraction - single equipment enclosure, CE certification, compliant with semicondutor industry standards (SEMI)	

For the sake of illustration, Fig. 2 shows a meandering coplanar transmission line obtained by local ablation of 1µm thick layer of copper without altering the plastic (PEN) over which it is deposited.

LEAF (Laser procEssing plAtform for multiFunctional electronics on Flex) is an EQUIPEX project (ANR-11-EQPX-0025). The partnership relies on the unified views of IEMN and LAAS for laser processing techniques devoted to advanced micromachining and lithography. LEAF has received the support of more than 20 industrial and academic associates and plays a major role in two common laboratories with STMicroelectronics and Essilor (http://leaf-equipex.iemn.univ-lille1.fr/). LEAF equipments are available through the RENATECH network.

Contact: Emmanuel Dubois (emmanuel.dubois@isen.iemn.univ-lille1.fr)

New equipment for stress measurement as function of temperature up to 500°C at FEMTO-ST

Mechanical properties of materials used in microelectromechanical system (MEMS) and in a micro-fabrication process, are of fundamental importance. Particularly, residual stress in deposited film always exists when a thin layer is used in device micro-fabrication. This residual stress is typically thought of as being composed of two components: intrinsic and extrinsic. Intrinsic stresses are typically associated with growth process deposition. Extrinsic stresses are a result of external influences after deposition such as temperature change in the presence of mismatched coefficients of thermal expansion. Residual and thermal stresses additionally cause deformation in the normally planar substrate, altering the anticipated static and dynamic response of devices. Under high stress conditions devices may even become inoperable. As a result, during microfabrication stresses should be minimized for optimum operation of a MEMS device. Thus, it is necessary to determine, and later control, film stress in MEMS-MOEMS for various purposes such as guarantying structural integrity and expected mechanical behavior. The FSM TC 500 is an integrated metrology system that can be used to measure residual stress and thermal expansion coefficient for deposited thin films on wafers (2", 3", 100 mm and 200 mm). This system computes global stress hysteresis in the film during a heat cycle at temperature up to 500°C. It works using a non-contact laser scanning techniques (using dual wavelength to overcome reflectivity issues) to obtain the radius of curvature of the tested wafer. This tool finds multiple applications in optoelectronics, microelectronics (low-k dielectrics) and microsystems.

Contact : Etienne Herth, (etienne.herth@femto-st.fr)

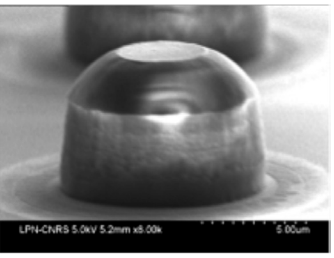
Industrial technological transfer of III-V oxidation oven for photonics devices manufacturing (Equipment in

The Laboratory of Analysis and Architecture of Systems (LAAS-CNRS) and the SME AET Technologies in Grenoble, have signed a partnership agreement for the development of a specific oxidation furnace, used in the manufacture of vertical cavity lasers (VCSEL). This innovating process equipment will help the semiconductor laser device manufacturers of the optoelectronic industry to improve their fabrication yield. In this partnership, the technology and know-how on the technique of selective wet thermal oxidation of III-V semiconductor materials will enable the development of a prototype equipment for commercialization. The LAAS Photonics team has developed an expertise in this area since the late 90s, in the RENATECH technology platform in Toulouse. This transfer of technology from the LAAS-CNRS laboratory and AET Technologies, a company specialized in the field of industrial electric furnaces, embodies a strategic action to conceive innovative industrial equipment based on academic research.

Oxidation furnace for III-V photonic devices installed in LAAS-CNRS

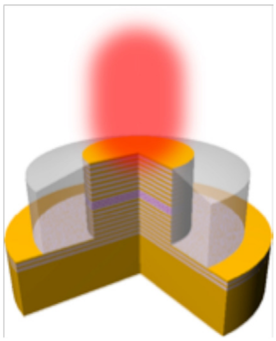
Contact:Guilhem Almuneau (almuneau@laas.fr)

Micropillar laser with integrated saturable absorber mimics biological neuronal response



It is well known that neurons are biological excitable systems possessing an absolute and a relative refractory period. These properties are partly responsible for the propagation of nerve impulse and for information processing in the brain. An excitable system is a system that possess a rest state and, if perturbed above a certain threshold (the excitable threshold) with a single perturbation, that emits a pulse with a characteristic shape (light pulse in optics, electrical pulse in neurons). The relative and absolute refractory periods reflect the response of the system under two consecutive perturbations.

We have fabricated a micropillar laser with integrated saturable absorber with an original design, that possess these three properties. In mimetic platform. particular we have shown for the first time the existence of a relative refractory period. This demonstrates that this system behaves analogously to a neuron but with much faster timescales (sub-nanosecond vs millisecond). The existence of a relative refractory period proves that the system keeps memory of its past state and that the excitable threshold is not a constant of the system. This has important consequences in view of utilizing these systems for neuro-mimetic optical processing of information, using spikes as logical bits. Moreover these micropillar lasers can be easily coupled. Moreover these micropillar lasers can be easily coupled opening the way to the fabrication of an optical neuro-mimetic platform.



1: Sketch and SEM image of a 4μm diameter micropillar laser with integrated SA coated with SiN.

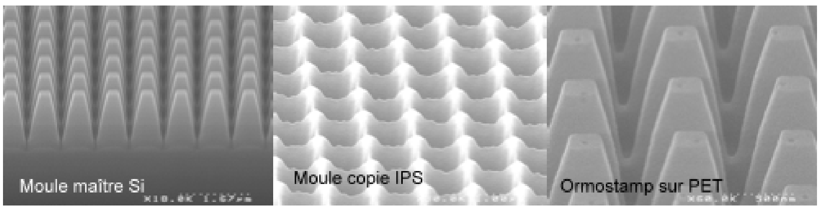
Further reading

«Relative Refractory Period in an Excitable Semiconductor Laser», F. Selmi, R. Braive, G. Beaudoin, I. Sagnes, R. Kuszelewicz, S. Barbay, Phys. Rev. Lett. 112, 183902 (2014), and «Semiconductor Lasers Get Nervy», Synopsis in Physics, (2014) http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.112.183902B.

•Laser mimics biological neurons using light, http://physicsworld.com/cws/article/news/2014/may/19/laser-mimics-biological-neurons-using-light

Projet ANAgRAM

Le projet ANAgRAM (FUI) a pour objectif de développer des systèmes de spectroscopie RAMAN à haute sensibilité, basés sur les innovations réalisées pour les spectrophotomètres SWIFTS dans le cadre d'un projet précédent réalisé à Grenoble, spectrophotomètres commercialisés aujourd'hui par la start-up RSS. L'augmentation de la sensibilité de la spectroscopie RAMAN passe par le développement de substrats SERS permettant d'exalter le signal RAMAN. Le LTM a réalisé des substrats spécifiques sur la Plateforme Technologique Amont (PTA) et développé les procédés technologiques associés. Ces substrats sur polymères flexibles sont constitués de réseaux de pyramides de dimensions sub-microniques, avec un fort rapport d'aspect. Leur obtention est basée sur des procédés de nanoimpression thermique ou UV. Le LTM a développé les procédés permettant de fabriquer les moules adéquats en silicium, avec contrôle de la pente des pyramides, de leur hauteur et de leur densité. Ces moules ont permis d'imprimer, par impression directe ou par inversion avec moule copie intermédiaire, des réseaux de pyramides dans un polymère souple qui est ensuite recouvert d'argent ou d'or afin d'obtenir l'exaltation du signal RAMAN attendue.



AWARD

CNRS SILVER MEDAL AT LPN

2014 CNRS silver medal was awarded to Pascale Senellart-Mardon (Nov. 2014) for her work on quantum optics with nano-emitters in micro-cavities.

Since 2002, P.Senellart-Mardon has studied the control of semi-conductor quantum dots spontaneous emission by including them in micro-cavities of several shapes. She has developed an in-situ lithography technology that allows controlling the position of a single emitter in a micro-cavity with nanometer accuracy (RENATECH newsletter feb.2011). Both optical studies and technological developments have allowed results such as the fabrication of ultra-bright solid state sources of indistinguishable single photons (Nature Communications 4, 1425 (2013), or electrically tuneable bright single photon sources (Nature Communications 5, 3240 (2014).

EVENTS

10-12 June, Riga, Latvia

The EuroNanoForum 2015 is a meeting point for industry, science and policy. Strengthening European competitiveness and supporting its re-industrialisation, it showcases innovation as driver for economic growth, presents new technologies arising from nanotechnologies and advanced materials, and discusses the new applications and commercialisation potential for these technologies.

Please joins us at our booth 13.

21-24 September 2015, The Hague, The Netherland

MNE 2015 is the 41st international conference on micro- and nanofabrication and manufacturing using lithography and related techniques. The conference brings together engineers and scientists from all over the world to discuss recent progress and future trends in the fabrication and application of micro- and nanostructures and devices. Applications in electronics, photonics, electromechanics, environment, life sciences and biology are also discussed.

The conference will be held at the World Forum in The Hague, The Netherlands

As usual, RENATECH will participate to this event.

To perform your project with RENATECH network

1. **Register** on www.renatech.org/projet/.
2. The application will be worked through and evaluated by the reception team.
3. **Realize** your project

For further information: renatech-accueil@cnrs-dir.fr