"Institut d'Électronique du Solide et des Systèmes"

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CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

ulp UNIVERSITÉ LOUIS PASTEUR STRASBOURG

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InESS ("**In**stitut d'**É**lectronique du **S**olide et des **S**ystèmes") is a joint laboratory (Laboratoire Commun, UMR 7163) of the Louis Pasteur University (Université Louis Pasteur, ULP) and of the National Center for Scientific Research (Centre National de la Recherche Scientifique, CNRS) where it is associated with the departments of Engineering and of MIPPU ("Mathématiques, Informatique, Physique, Planète et Univers"). InESS also belongs to the Doctoral School of Mathematics, Information and Engineering Sciences (École Doctorale MSII, Mathématiques, Sciences de l'Information et de l'Ingénieur), and accommodates the Strasbourg section of the MIGREST branch (MIcroélectronique GRand EST) of the organisation for the National Coordination of Microelectronics Training (Coordination Nationale de la Formation en Microélectronique, CNFM).

The research activities of the Laboratory span various topics, extending from solid state electronics to electronics of systems. The different themes are thus concerned with materials and nanotechnologies for electronics, materials and concepts for photovoltaics, optoelectronic instrumental systems and microsystems, and integrated instrumental systems.

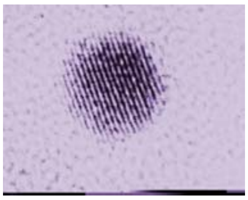
All of the research work is handled by about ten researchers and thirty teaching researchers from four units of the University (UFR de Sciences Physiques, École Nationale Supérieure de Physique de Strasbourg, IUT Louis Pasteur de Schiltigheim, and IUT de Haguenau). These permanently attached researchers are supported by about twenty temporary researchers, mostly PhD students, and as many Engineers, Technicians and Administrative staff (Ingénieurs, Techniciens et Administratifs, ITA).

Finally, research projects benefit from many collaborations, with public laboratories as well as with industry. At a national level, InESS is involved in several CNRS Research Groups (Groupements De Recherche, GDR) and research programs of the CNRS and of the Ministry of Research. At an international level, the Laboratory is a partner in several European and cross-border projects. As regards collaboration with industrial world, this takes different forms, from mere scientific and technical assistance to contracts lasting several years, for example in the case of CIFRE grants, or national or European programs. With certain members of the Laboratory being Consultants, InESS also has privileged relationships with certain companies.

Specialised technical resources

- **Fabrication technology**
  Materials synthesis (metallisation, laser processes, plasma deposition…); fabrication of electronic devices (class 10,000 clean room of 100 m²).
- **Characterisation technology**
  Characterisation by several methods of microscopy and spectroscopy, some of which are time resolved; measurement of electrical characteristics.
- **Ion beam implantation and analysis**
  Implantation of many types of ions; analysis by various methods, some of which can be implemented during implantation.
- **CAD tools for microelectronics**
  Technological simulations, CAD of mixed-signal integrated circuits, characterisation of digital and analogue integrated circuits.

Materials and nanotechnologies for electronics



◂ *Si nanocrystal in SiO_2*

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This axis groups together studies related to materials familiar to electronics. **Nanostructuration with ion beams** enables the growth of nanometrically sized precipitates for use with standed microelectronic technology. Their peculiar properties have significant potentials for new application but require further investigations concerning the self-organisation phenomena within the matrix under irradiation, that is, out of equilibrium. As for **nanostructuration with laser beams**, it has two kinds of uses: local modification of the electronic behaviour of semiconductors (Si, Ge, C) and growth of networks of carbon nanotubes which are well adapted for making efficient sources of electrons. Depending on the considerated material (Si, SiC, Ge, alloys...), researches in **nanoengineering of junctions** and **defect engineering** in semiconductors concern as well microelectronics as power electronics and detectors. Accurate modelling of diffusion processes, characterisation of bulk defects, and examination of properties of point defects in alloys aim at improving cristallogenesis and at optimising procedures so as to increase performances of both ultrashallow junctions and X ray detectors. Work also has to do with **transport at the nanometric scale**, and especially with effects of quantum confinement because it introduces discrete levels and disturbs the electric transport in nanodevices (for example, semiconducting nanocrystals in a quantum Flash memory).

Optoelectronic instrumental systems and microsystems

◂ *System for interference microscopy*

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Research on the development of new materials and devices requires progress in new instrumentation for characterisation. Work carries more particularly on imagers and on systems for implementing interference microscopy. **High speed imagers** are ultrafast optical systems (with resolutions of less than one picosecond to several milliseconds) such as streak cameras, high-speed video imagers and optical imagers. Streak cameras are perfected by the use of CMOS technology and by extending their range of sensitivity towards wavelengths that prevail for the analysis of optoelectronical devices dedicated to future high speed telecommunications. In high speed video, emphasis is placed on the replacement of the digital processor by an optical processor which has a much higher processing speed. Concerning **instrumentation for interference microscopy**, the first challenge is to improve equipment for the characterisation of material surfaces (rugosity, homogeneity, adhesion, pattern shape...) by Coherence Probe Microscopy (CPM). The objective is to increase vertical and lateral dynamics in order to be able to analyse difficult surfaces like those that are very rough, buried under transparent layers, or inhomogeneous, as well as those that change with time. Finally, resolution and sensitivity towards the blue part of the visible spectrum have to be raised. Interest for the applications of these systems in other fields (medicine, astronomy, environment) is also taken into account.

Materials and concepts for photovoltaics

◂ *Si layer (20 µm) on ceramics*

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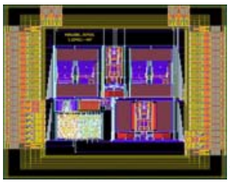
Research pursued in the field of photovoltaic conversion aims at increasing the conversion efficiency while reducing the cost of solar cells. In this way electricity of solar origin will become competitive compared to other sources of electric power. Several directions are explored. **Advanced concepts for photovoltaic solar cells based on thinned silicon wafers** (< 200 µm) are implemented by various processes such as selective emitter deposition by plasma etching, generation of localised repulsive fields, and deposition of rear surface contacts. Work on **thin layer silicon materials on foreign substrates** (ceramics or glass) concerns as well the growth of thin layers (< 10 µm) as the study of their structural (grain size, morphology, orientation...) and optoelectronical (carrier lifetime, reflectance...) properties, and manufacturing of trial solar cells. Lastly, growing interest is devoted to **inorganic and organic nanostructured materials for photovoltaics**. Inorganic materials under consideration are, on the one hand, nitride or oxide matrices containing silicon or germanium nanocristals which convert blue photons into red photons by photoluminescence and, on the other hand, silicon cells that encompass a buried layer of nanoscopic structures made up of nanodots. Organic materials are on their part used for the production of organic photovoltaic cells achieved by self-assembling of functionalised semiconducting polymers.

Integrated instrumental systems



◂ *Microelectronic circuit*

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This axis addresses the integration of sensors in system-on-chip. **Physical study and compact modelling of advanced devices** are essential to develop the devices that will replace conventional MOSFET. Besides, **integrated sensors** will have to process various signals (electrical, optical, magnetical...) and to remain compatible with CMOS technologies in order to take advantage of on-chip electronics. Such an approach is used in our reaserch on magnetic sensors (Hall-effect sensors, and sensors that use ferromagnetic thin films or spin electronics devices). The need for data preprocessing inside the chip stimulates studies on downstream structures that give some intelligence to the **instrumental chains**. Special effort is directed towards the conception of very low noise and low consumption basic devices, optimisation of routines taking into account the architecture of the surrounding electronics, and the implementation of adaptative analogue systems able to process signal flows coming from a matrix of sensors. Finally, **conception technology** is an approach that allows the integration of multidisciplinary complex systems from theoretical considerations, in a simple and sure way, and from the microscopic to the human scale (cars, planes, telephones...). Its validation on industrial examples already showed some benefits (reduction of the time needed to formulate the models, absence of syntax errors...).