IEMN - Institut d'électronique, de micro-électronique et de nanotechnologie

Rapport Hcéres

agence d'évaluation de la recherche
et de l'enseignement supérieur

Section des Unités de recherche

Evaluation Report

Research unit :

Institute of Electronics, Microelectronics and Nanotechnology (IEMN) – UMR 8520

University and school :

USTL : University of Sciences and Technologies of Lille

UVHC : University of Valenciennes and Hainaut Cambresis

ISEN : Institut Supérieur d'Electronique et du Numérique

February 2008

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Le Président
de l'AERES

Jean-François Dhainaut

Section des unités
de recherche

Le Directeur

Pierre Glorieux

mars 2009

Evaluation Report

The research unit :

Name of the research unit : IEMN

Requested label : UMR

N° in case of renewal : UMR 8520

Head of the research unit : Prof. Alain CAPPY

University or school :

USTL : University of Sciences and Technologies of Lille

UVHC : University of Valenciennes and Hainaut Cambresis

ISEN : Institut Supérieur d'Electronique et du Numérique

Other institutions and research organization:

CNRS

Date(s) of the visit :

November 4, 5 and 6th, 2009

Members of the visiting committee

Chairman of the commitee :

Mr André TOUBOUL – IMS – University of Bordeaux

Other committee members :

Mr Olivier JOUBERT – Director of LTM - Grenoble

Mr Walter LAURIKS – KU Leuven - B

Mr Dominique MAILLY – LPN - Marcoussis

Mr Franck MURRAY – NXP - Caen

Mr Francesc PEREZ-MURANO – CNM – CSIC – Barcelona - E

Mr Raymond QUERE – XLIM – University of Limoges

Mr Huub SALEMINK – University of Delft - NL

Mr Michael SCHLECHTWEG – Fraunhofer Institute – Freiburg - D

Mr Luc VANDENDORPE – UCL – Louvain - B

CNU, CoNRS, CSS INSERM, représentant INRA, INRIA, IRD.....) representatives :

CNU : Mr Bernard CRETIN – FEMTO – ST - Besançon

CoNRS : Mr Jean-Louis SANCHEZ – LAAS – Toulouse

Observers

AERES scientific representative :

Mr Michel ROBERT

Research organization representative (s) :

Mr Sylvain ALLANO – deputy director of ST2I Dept

Mr Giancarlo FAINI – MPPU Dept

1 • Short presentation of the research unit

Numbers of lab members including researchers with teaching duties, full time researchers, engineers, PhD-students, technicians and administrative assistants : **450**

- *Number of associate professors and professors : 111*
- *Number of researchers (scientists and senior scientists of CNRS) : 45*
- *Administrative and technical staff : 74 (42 CNRS, 25 USTL, 6 UVHC, 1 INSERM)*
- *30 engineers and technicians hired on contracts*

Number of HDR and of HDR who are PhD students avisors : **78**

- Number of PhD students who have obtained their PhD : **32 / year**
- Number of PhD students currently present in the research unit : **147**
- Number of PhD students with fellowships : **147**
- Number of lab members who have been granted a PEDR : **45**
- Number of "publishing" lab members : **142**

2 • Preparation and execution of the visit

The visiting committee has been organized from Tuesday, November 4th to Thursday, November 6th 2008. Oral presentations have been given by the director of the lab, by the leaders of the five axis, by the researchers in charge of the different groups and the new direction team (which will start on January, 2010) has presented their project for the lab direction. Two subcommittees respectively for Axes 1 and 3 and for Axes 2, 4 and 6 have been organized. Visit: clean room, characterization center, Near Field Microscopy and Telecom platform. Other meeting : Regional organization of ICT domain : IRCICA (report, Project). Meeting with IEMN personnel and parent organization representatives.

3 • Overall appreciation of the activity of the research unit, of its links with local, national and international partners

IEMN has been created in 1992 and it is supported by four institutions : USTL, UVHC, ISEN and CNRS. This lab is located on five different sites. The research is organized on the basis of five main scientific topics :

1. Physics of Nanostructures
2. Micro- and Nanosystems
3. Micro- Nano- and Optoelectronics
4. Communication Systems and Application of Microwaves
5. Acoustics

Each scientific area is divided into groups, varying from 3 to 7 according to the size of the axes. Among them, four groups belong to two different axes.

IEMN is characterized by two main features :

- A very high level research performed on these five topics which can easily be compared to the state of the art at the european and international level. This can be seen on the basis of international relations, the participation to FP6 and FP7 programs and solid industrial collaborations which have given rise to the creation of two joint labs.

A good equilibrium has been found in research by having 30% dedicated to long term research, 50% to mid term and 20% to short term, covering the whole range from the most innovative topics to the answer to industrial topics.

- Clean room and measurement facilities at micro and nanometer size with the most updated equipments and high frequency device characterization, near field Microscopy platform for nano scale characterization and telecom platform for communication system analysis.

Among the three basic missions of a research institution, the staff of the lab is involved in education and innovation. IEMN is seen as a real actor of the regional economic life, involved in three clusters ("Pôles de compétitivité") and since 2006, IEMN received the "Carnot Institute label" that is a tool to increase professionnalism in industrial relationships and to build a real IP policy for the lab.

As a spin-off of research at IEMN, three start-ups have been created mainly devoted to microwaves and RF MEMS technologies.

The scientific production of IEMN (from 2004 to 2007) is characterized by an increase, which is respectively 45% for invited talks, 50% for papers and 57% for communications in international conferences, which gives a mean value of respectively 1.2 paper, 1 conference and 0.27 invited communication per researcher and per year.

It will be seen further in the report that these mean values appear to be rather different when considering the average per researcher and per scientific axis. The number of patents is around 10 per year for IEMN. It is important to stress that this increase in the production is also a qualitative increase which can be seen through the high impact factors of journals in which papers of IEMN are published and the front covers of international journals which present IEMN works.

4 • Specific appreciation team by team and/or project by project

- **Axis 1 : Physics of nanostructures**

The axis I "Physics of nanostructures" is mainly focused in the following fields of research :

-III- V heterostructures and self assembled semiconductor nanostructures

- Dynamics of organic or biomolecular molecules in interaction with surfaces

- Phononics and photonics

- Active nanostructures and films for MEMs.

The research topics are addressed thanks to strong skills in the field of

1) Material growth (MBE, CVD)

2) Elaboration and characterization capabilities of molecular nanostructures

3) Strong competences in the field of near field microscopy

4) Theory / simulation capabilities

The research activities of axis I are addressed by three different teams :

- Physics
- Epiphy (Epitaxy and physics of nanostructures)
- NCM (Nanostructures and Molecular Devices).

Axis I is composed of 30 permanent researchers (26.8 equivalent full time researchers that is about 20% of the total research potential of IEMN) and 29 non permanent researchers (PhD students represent 13% of the total number of IEMN PhD students). The scientific production of Axis I is much higher than the average scientific performance of IEMN (204 papers in per review international journals, i.e. 1.9 papers per researcher per year).

The contractual activity of Axis I is very good (19 ANR projects, 6 EU contracts…). Interactions between Axis I and other axes are good mainly with Axis 2 (Micro and Nano systems) and Axis 3 (Micro/Nano & Optoelectronics).

Overall evaluation of Axis 1 is excellent and is detailed by teams as follows :

The **Physics** team is composed of 15 permanent researchers (among them 10 are from CNRS), 15 non permanents researchers (among them 10 PhD students) and organized in four different groups. The scientific production is excellent [129 papers published in per review international journals, average of 2.4 per researcher per year) and 22 invited communications] and the team has a world wide reputation. The quality of the research is excellent and the integration within IEMN is good and brings a lot of added value to the laboratory. The cooperation with more applied research groups has been strongly improved in the last four years. The scientific results are clearly presented and well documented, the future directions of work are clear in photonics, quantum devices, and electrostatic and physics of nanostructures.

The **"theory"** group seems to live its own life without strong connection with the Physics team. This situation could be improved. The work in the field of "Physics" within Axis I is strong, well organized and relevant.

The committee believes such a team could take even more risks and originate new topics while today the thematics addressed are also widely studied elsewhere. Another interesting direction would be to use even more intensively the clean room potential to intensify the work on nanowires-based devices or on more generally very innovative devices in cooperation with other groups at IEMN.

In the field of **Epitaxy and Physics of semiconductors**, an impressive panel of tools is dedicated to the growth of new materials. The main topics addressed are the growth of As, P and Sb based III-V semiconductors, the CVD of Si/Ge nanowires.

Full real-time flux measurement set up has been demonstrated during MBE growth which is suitable for all elements III. The team has a strong expertise on the growth of III-V semi-conductors with the objective to generate low electron effective mass and low power consumption HEMT's devices. State of the art electron mobilities are obtained with AlSb/InAs structures.

The scientific production of the team is somewhat weaker than other groups working in the field of growth by MBE and the number of students working on such powerful experimental systems could be higher (3 PhD students only for 10 permanent people).

In the work dedicated to the growth of III-V based materials, a clear distinction should be made between the "production" of III-V heterostructures directly correlated to device studies and the more exploratory work.

Pioneer work has been started on the annealing of SiC thin films to generate thin graphene layers. A more promising way will be addressed by using MBE to generate graphene layers. This topic is very attractive and could give a new breath to the team. A strong effort should be dedicated to this project in order to obtain a worldwide leading edge position and generate high quality graphene layers to boost IEMN graphene-based device studies. Inorganic semiconductor nanowires growth studies are also seriously considered and could constitute interesting new topics for the epitaxy team.

The same team is also involved in optoelectronic generation and detection of terahertz signals. Impressive time domain THz experiments are installed in the clean room. *The scientific production of this activity is below expectations and the THz source work is not really original with respect to other research groups in Europe*. The group has to find more original topics or a niche and maybe find a more appropriate place within IEMN.

Studies on **Molecular nanostructures and devices** are also performed in Axis I in the so-called "**NCM"** team whose main goal is to explore concepts and limits for molecular scale electronics and nanoscale organic electronics. The team (5 permanents and 7 non permanents) generates an impressive scientific production and more particularly a large number of invited talks (25 in four years). Large numbers of topics are addressed: role of fluctuations, noises and vibronic effects on electron transport in molecular junction, local probe studies of organic structures, molecular self-assembled transistors, organic devices with nano-objects and organic materials for smart textile. Many excellent groups are working on similar topics even though the general interest in this field seems to decrease. A focus on a smaller number of specific topics would help to propose long term perspectives and to set up a clear strategy. The committee wonders how this impressive know-how could be used to build up an expertise in an application topic in which functional organic materials are involved.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A	A+

- **Axis 2 : Micro and Nano Systems**

The "**Micro and Nano Systems"** Axis federates four research groups and seeks the integration of activities of two new groups (FILMS, GEPIFREM) to reinforce the BioMEMS group. Two of these groups (MITEC and AIMAN) share their activities with respectively Axis 4 and Axis 5. The scientific production and quality are good and well in line with the average of the lab. This axis has a very good visibility in the national and international environments. The integration in the research community is very good on the basis of the participation to many national and international projects and the set-up of a spinoff company "DelfMEMS" which could have been presented in more details to the committee. The attractivity of this axis is important as it is able to federate new activities on plasma processes and fluidics. The strategy adopted is fully coherent with the potential of the axis and the collaboration with others labs in the frame of LEMAC for instance. For the development of BioMEMS, the interdisciplinarity is very important to allow pertinent scientific activities. Therefore the link with bio-physics activities should be carefully followed and structured through collaborations with IRI in the next future.

This axis has a high potential for developing a coherent scientific project for the 2009-2013 period. It has been, notably, validated through an ERC grant for the development of probes for Atomic Force Microscopy. The activity on micro-sensors and micro-sources appears very promising as well as the coupled multiphysics approaches for micro- and nano-systems.

Globally, the committee has a very positive view on the activities of the Micro and Nano Systems Axis which appears as a very dynamic axis with good research projects and a high scientific level. However, as the activities of this axis combine different topics in various scientific domains, emphasis must be put on the management of strong relations with bio- scientists. This management will also be necessary to keep track of the integration of new activities.

Finally the committee encourages this axis to continue in this successful way and to fully take advantage of its scientific environment: IEMN technology platform and collaboration with the new IRI institute.

NAM6 group is mainly oriented towards the development of technology for the fabrication of MEMS /NEMS devices, focused to several applications. The group is very well focused, well balanced in terms of permanent, post-doctoral and students, with a good leadership and good management strategies. The main strengths of the group are its expertise in MEMS/NEMS technology and in taking full advantage of the facilities of IEMN, which can place the group at the leading edge of European research in MEMS/NEMS.

The split per projects rather than per team or techniques has been appreciated during the oral presentations . The group has several sources of funding, including national (ANR) and European (ERC starting grant) and industrial contracts. The ERC starting grant achieved by one of the members is an indication as well of the good health and level of the group works.

The number and quality of publications are very good. The average number of publications per researcher is in line with the IEMN. The group has published in relevant international journals for the MEMS/NEMS community, and their communications are accepted for the IEEE-MEMS conference in every edition, which is a sign of quality and relevance of the work. The number of priority patents is very high as well, which is another indication of high industrial relevance.

The directions that the group proposes for the next years (2009-2013) are found to be very adequate for the IEMN environment and facilities, and take advantage of the group expertise. Directions 1-3 (resonators for AFM, Strain transducers based on surface effects and GaN resonators) represent a natural continuation of the group and are hot research topics at this present moment. Direction 1 (resonators for AFM) is found to be specially promising, innovative and challenging. Direction 4 (Bio-inspired systems) is more risky and a little bit apart from the main trajectory of the group. The group is aware of it, and that its successful development will deserve close collaboration with other groups from biology and/or medical science. The commission encourages to take this risk but in a controlled way.

In summary, *the overall impression of NAM6 is very positive*. It is expected a successful activity during the next period. The main two recommendations by the commission are:

- to improve the visualization of the group at the European Level, for example, by increasing its participation in working groups and networks
- To push for getting even more relevant results that could increase the number of publications in high ranking journals (Nanoletters, PRL, Science). The group has the potentiality to achieve it.

MITEC group has been created very recently (2007) with researchers coming from 4 different groups. This explains the collaboration of the group with Axis 2 (Micro and nanosystems) and with Axis 4 (Communication systems and application of microwaves). *Globally, the thematic coherence of the group seems weak*: the different topics (thermal micro sensors microwave instrumentation, interconnections and thin film materials characterization) are in different domains and it is difficult to find any obvious link between them. Moreover, the global number of papers in international journal (19) is rather low for a group including 2 CNRS researchers and 8 assistant professors or professors.

Nevertheless, the global level of the research is good. On one hand, the integrated micro sensors developed for heat flux and infrared sensing, connected with Axis 2, are on the first level of the state of the art and will probably highly enhance the reputation of the group. On the other hand, microwave and mm-wave instrumentation, connected to Axis 4, seems to be spread in different frequency ranges and application fields: free-space techniques, slotted waveguides, near-field microscopy and radiometry are covered. Presented industrial applications are promising but the level of the research compared with the state of the art is not always clear. The third subgroup (Interconnections – Thin films characterization), which is the smallest, has high level skills in electromagnetic modeling and should complete well the instrumentation activity in the future.

About the group strategy for the future, the projects are pertinent and not too dispersed; the aim of the group to contribute to the creation of an international-leading energy research cluster has been appreciated positively. A recommendation for the "MITEC" group is to increase the level of publications (especially about papers in international journals). It remains difficult to understand the structure and the strategy of this group, especially for the links between the various teams which are very difficult to understand. It rather looks like an assembly of people with their own competences and projects. Nevertheless there is a strong expertise in instrumentation which could be the basis of the merging with another characterization group.

The **BIOMEMS** in its current configuration was founded in 2007 and gathers 9 permanent researchers. Two topics are addressed by this group and deal with the cellular BioMEMS and the THz MEMS. The scientific production of the group is good while situating just below the average of the whole IEMN lab in the various categories (journals, conferences). The involvement in research programs is good with 3ANR programs and various international collaborations. The cellular BioMEMS team is engaged in hot research topics such as real time monitoring of cellular systems using Digital Micro Fluidic for elemental operations on droplets. THz MEMS activities are well recognized by the scientific community with numerous citations of the work performed.

This activity is well fitted with IEMN skills and would take full advantage of the technology platform on nanostructures fabrication in the lab. The impression during the presentation was that this coupling (between research activities and the existence of the technology centre) was too weak and needed to be strengthened.

GEPIFREM is a group of 4 permanent researchers who are involved in plasma processes and materials. The scientific level of this group is definitely good. They are willing to join the BioMEMS group in order to develop new processes and materials to solve BioMEMS problems. While they are well formulated, it is not clear which concrete projects will be undertaken in the framework of this integration.

The strategy of this group can still be improved with a better integration of bio scientists and a better definition of the contribution of the GEPIFREM group in concrete projects. The research project is coherent and this group should take the opportunity of the vicinity of IRI close to IEMN in the next future. Finally the scientific activity of this group would benefit of a reinforcement of its human potential with permanent researchers. An additional suggestion would also be to structure in depth the group in the direction of projects.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A	A

- **Axis 3 : "Micro-Nano-and Optoelectronics"**

Axis 3 "**Micro-Nano-and Optoelectronics**" is mainly focused in the following fields of research :

- High frequency low power devices (III-V, Carbon, Silicon)
- Power devices (GaN …)
- Alternative silicon devices
- Metamaterials
- Optomicrowave
- Nano-photonics
- THz sources and detectors
- Electronic device modelling
- Modeling for advanced Technology

These research topics are addressed within 6 teams: Dome, Anode, Puissance, Microelectronique silicium (shared with Axis IV), Opto, Silphyde and Epiphy (shared with Axis I). These 6 teams are composed of 40 permanent researchers representing 30 full time researchers and 70 non permanents (post-docs and PhDs).

Within the last four years, 254 papers have been produced in peer review international journals which represent 2.11 papers per researcher per year, *twice the IEMN average*. Axis III also generates a large number of invited conferences, 66 in four years, i.e. 0.55 invited talk per researcher per year. Axis III has also produced an important number of patents (20 patents in the last four years, mainly in cooperation with industrial partners).

Axis III is funded by many projects, at the National and European levels (31 European contracts and 34 French contracts) and benefits from the support of IEMN /ST Microelectronics and IEMN / Thales common laboratories.

Most of the research projects of Axis III are extensive users of the technological facility of IEMN and of the powerful characterization platforms (electrical HF, near field microscopy).

The overall evaluation of Axis 3 is excellent.

In the field of **"Dispositif Opto-et-Micro-Electronique quantique"**, a large part of the electromagnetic spectrum from microwave to infrared via the Terahertz spectral regions is addressed. Significant and impressive breakthroughs are performed which concerns the demonstration of negative refraction in composite metal dielectric metamaterials operating at microwave frequencies and a novel approach for clocking at Terahertz frequencies in *high-k* BST ferroelectrics. These interesting research topics are driven by a dynamic team with clear perspectives (moving towards applications at microwaves frequencies using metamaterials and PC cloacking devices). Numerous collaborations at the regional, national, european and international level are also sustained. The scientific production is clearly high (3.1 papers per researcher per year). The performance of the team strongly relies on the access to the technological facility. A reinforcement of this strong team to improve the access to technology and increase the number of industrial projects would be very beneficial for IEMN.

In **Silicon microelectronics**, three fields of research are addressed by 4 permanent researchers and 7 PhD students and post-docs: development of non conventional MOS architectures, multiscale simulation of nanodevice processing and digital circuits and communications. Major breakthroughs have been achieved such as the design and fabrication of metallic source/drain 25 nm gate length MOSFETs with state of the art current drive performance (Ion = 530 µA/µm at Vg=Vd = -1.1 V) and with successful integration of complementary silicides (PtSi, $ErSi_{1.7}$). A new spacer first damascene metal gate FinFET architecture based on hydrogen silsesquioxane (HSQ) engineering has also been developed which allows suppression of stringer formation and provides no interdependency on fins, gate, spacer and S/D dimension. This work clearly demonstrates that significant contributions and new concepts in the field of silicon microelectronics can be demonstrated without working on a 300 mm state of the art technological platform. The team is involved in many European projects (3 STREPs, 2 Networks of Excellence, 2 Integrated Projects), and also coordinates 2 themes out of 5 of the ST Microelectronics-IEMN common Lab and has a good scientific production. The new strategy of STMicroelectronics (research for the 32 and 22 nm technological nodes performed in partnership with IBM) may impact the research topics of IEMN–ST Microelectronics common lab. Even with this new situation, IEMN team can maintain a strong collaboration with STMicroelectronics. New perspectives announced by the team, working on generic device architecture based on networks of vertical nanowires, seem quite promising. IEMN is the right place to work on such topics and will have a greater impact if enough resources are dedicated to this type of project.

In the field of "**Advanced nanometric devices for high frequency, low noise, low power applications"** a team (5 professors, 2 assistant professors, 1 CNRS, 22 PhD students, 6 post-docs) works on narrow bandgap based-HF electronics, carbon based-HF electronics and advanced silicon based-HF electronics.

Excellent results are obtained with double-gate HEMT with separated commands, plasma wave transistor for THz applications and antimonide based HEMTs. The work benefits from the experience of the MBE team for the growth of III-V semiconductors and of the potential of the technological platform.

Excellent work on the HF potentialities of carbon nanotubes based MOSFETs has also been achieved. An intrinsic current gain cutoff frequency of 30 GHz, new state of the art frequency of CNTFETs, has been obtained. The scientific production is high (2.4 reviewed papers in average per researcher per year), the participation to research contracts is excellent (9 European projects and 8 National projects), the number of PhD students involved in this research is very high. *This team is exemplary, very well positioned in its field, very well driven* (with collaborations and clear mid-term perspectives with its own internal roadmap), internal fruitful collaborations with other IEMN teams and particularly with EPIPHI group on carbon HF electronics.

The **Optoelectronic group** addresses topics related to Nano-photonics and Microwave photonics. The group is composed of 10 permanents and 10 non-permanents. Scientific production of the group is in the average (1.3 reviewed papers in average per researcher per year, few invited conferences) while the group is involved in different contracts with EU (4 contracts), 2 ANR, 2 industrial contracts.

The group is working on high speed optical switches and also demonstrated the first integrated optical switch using nanophotonics.

In general, this group addresses too many topics without clear goals and priorities. The strategy seems somewhat unclear and the group should try to concentrate on very clear and limited objectives.

The group **"Puissance"** is composed of 7 permanents researchers and 18 non permanent researchers. This very dynamic group has an excellent scientific production (2.5 reviewed papers per researcher per year) and is involved in many contracts with EU (4), National agencies (7), and is part of the common laboratory between IEMN and Thales.

The group works mainly with wide band gap semiconductors to generate microwave power transistors on SiC and Si. State of the art results are obtained on both substrates. The group also works on wide band gap semiconductors photodetectors (state of the art results) and solid state tunable THz detectors and emitters. In the very highly aggressive field of power devices, the competition is now extremely intense and public research laboratories, such as IEMN, may face hard times in competing with respect to the best industrial teams.

This group should try to clarify its position with respect to industry and possibly find new topics and niche areas where they could use and develop their own expertise.

In the field of **"Simulation Physique des dispositifs électroniques et optoélectroniques"**, the team is mainly working on Monte Carlo simulation codes, "Macroscopic" hydrodynamic-like models and modelling of low dimensional ferroelectric systems. This team seems in fact poorly connected with the real work on devices addressed by IEMN. Are home-made models developed by the team relevant with respect to existing models? In order to strengthen the scientific output, the team should select one or two relevant topics. In addition, the scientific performance is weak, and no PhD students are involved in this effort.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A+	A+

- **Axis 4 : Communications systems and Applications of Microwaves**

Axis 4 gathers four groups, among which one (Microelec Si) is mainly involved in Axis 3. The size of this axis is correct with an interesting range of skills related to microwave wireless systems. The researches developed by this axis are well fitted with the IST European framework and in line with the "More than Moore" roadmap of the electronic industry.

Its scientific production is of good quality as well as scientific and technological realizations. Due to the applicative nature of the researches of this axis, emerging subjects appear not as visible as more fundamental topics. However the definition of relations with the economic world is pertinent with a lot of fruitful collaborations with academic and industrial partners; this is particularly true for the CSAM group. Members of this axis are well integrated in the scientific community through their participation to national and international committees. Moreover they are also very active in the education activity at the Master level and doctoral studies.

Because of the scattering of the locations of the different groups of this axis, and the existence of an activity that seems to decline in electromagnetic compatibility, care must be taken in the management of this axis to maintain a high level of coherence between the various activities. The scientific potential of this axis is high with well recognized activities covering the whole spectrum of telecommunications including propagation problems in harsh environments linked to transportation systems and indoor communications.

The research projects for the next period address well chosen topics but the risks inherent to the development of a new thematic have to be carefully analyzed. Provided a management plan which will allow taking full advantage of the various skills of the groups and of the strategic technological facilities of IEMN, the research project proposed by this axis has very good chances of success. Finally the committee have noticed the quality of the presentations and the consistency between the thematic presented and the experiments shown during the visit. Moreover the committee appreciates the dynamism of this axis.

The **TELICE** group (Telecommunications, Interferences and Electromagnetic Compatibility) (located at Villeneuve d'Ascq but outside the IEMN building) gathers 8 permanent researchers in the field of telecommunications and 3 (including the head of the group who will retire soon) in electromagnetic compatibility. This group can rely on the collaboration of 4 engineers and one technician.

This group is strongly supported in the framework of the CPER and by the regional competitivity cluster "Transportation and Systems". The average number of papers published is below the lab level while the number of communications is above. It would be wise to equilibrate those numbers. The sub-group "Telecommunications" is dynamic and well recognized at the international level. It has developed strong skills in the propagation of waves inside tunnels and more generally in transportation systems. *However, the future of the EMC activity is questionable.*

One research topic of the group "Telecommunications" is UWB which is shared among other groups like CSAM and COMNUM. It is clear that synergies could be found on that topic. It is crucial to overcome the difficulties linked to the geographic scattering of these three teams. Some tools should be explored to solve the related difficulties.

It would be wise to ask to the concerned teams which tools and measures can be implemented to address this issue and to give rise to effective collaborations and dialogues.

The **"COMNUM**" group (Systèmes de communication avancés), located in Valenciennes is constituted of 9 permanent researchers and 12 PhD students. No technician is working in this group. This team works on advanced communication domain, wired and wireless. Activity in image processing has been stopped. Works are supported through ANR, the CPER and participates to European projects as "INTERREG". The project of this group seems clear and its strategy has been refined. The average number of papers is slightly below the IEMN average while the number of communications is above. It would be wise to equilibrate those numbers. Moreover, a priority topic of this group deals with the UWB domain. *Efforts in this field should be coordinated with other teams as TELICE and CSAM .*

In addition, it would be worth that all the groups fully use the important and strategic facilities that have been set up at IEMN (clean rooms, platforms)

CSAM is a group of 10 permanent people (7 researchers, 3 staff) and 18 PhDs and Post Doc. The scientific production is very good, with papers and communications. The group is also very well represented in various committees and European programs, like the interesting example of "MEMS - 4 – MMIC". The presentation was very clear and well introduced. In particular, the introduction showing the network of the team was appreciated. The research carried out is of high interest and the group seems to have brought some original and interesting solutions in the field of MEMS switches. There is a good combination of experimental and theoretical work, like the work done in the modeling and simulation of RF propagation. In addition, the experimental work combines research in the fields of design architecture, IC design and physical experimentation. This is a well-balanced combination and overview between short term and longer term projects.

Nevertheless, several remarks have to be made with regard to future projects: the risks seem to be underestimated, especially in the field of micro-batteries. A suggestion is here to carry out an extensive state-of-the-art and benchmark study, which was not clear during the presentation. *The overall impression was very good* as the group seems to be well managed.

The **Microelec Si group** which is working in this axis represents only a part (one third) of the Microelec group. Three permanent researchers associated with 5 post doctoral researchers and 5 PhD students are involved in the topics related to reconfigurable analog baseband filters, tunable BAW filters and digital generation of RF signals.

Globally the scientific production of this group is very good but the number of papers in journals could be improved when regarding this activity in the group. Perhaps is it due to the difficulty to separate the activities related to Axis 4 and 3. It must be noted that the number of patents is rather high. The group has a strong involvement in collaborative programs through the common lab with ST Microelectronics and through many European projects.

The strategy of this group appears well in line with topics complementary of those addressed by the CSAM group. They have assets to address important subjects such as cognitive radio or digital interface to UWB millimeter waves radio, both from the point of view of the design and simulation of subsystems.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A	A	A+	A	B

- **Axis 5 : Acoustics**

The axis "Acoustics" is constituted of three groups of very different sizes. Two of them (ACOUSTIC and AIMAN) are rather small while very active and the later (ULTRASONS) is much bigger but with five subgroups. The activities of the AIMAN group are split between Axis 2 and Axis 5 and those related to the present axis are more oriented on material elaboration and modeling. This axis will integrate the "FILMS" group.

Globally the level of the scientific production is very good (above the lab average) on innovative interesting topics with a good balance between journal papers and communications. The integration in the industrial world is good with some success stories in the creation of spin-off companies and diffusion of software. However industrial relationships of the Ultrasons group should be reinforced.

The topics addressed by this axis are numerous and interesting but it would be wise to extract some priority in those topics in order to emphasize the consistency of the research activities.

The committee has noted the good scientific quality of this research theme, its strong implication in educational tasks and an appealing research project. However the cooperation between the different groups seems too weak, being probably due to the geographic scattering of these groups. This research theme would benefit from a management plan that would reinforce the links between the different groups and place the whole axis in the IEMN mainstream. Moreover some hierarchy in research projects should be found especially for smaller groups. The integration of the FILMS group appears positive and should bring useful skills to the scientific activity of the axis.

The **"Acoustic"** group is small (the staff composition is not clear because the general presentation has shown 3 permanent positions and 6 persons were listed in the group). But it is very dynamic and recognized for its high scientific skills on both national (one bronze medal of CNRS 2008) and international (23 papers in international journals in the period 2005-2008, participation in 4 scientific committees of congress, and organization of 2 conferences) levels. The investigated fields include acoustic microsystems for telecommunications and health engineering, and ultrafast acoustics. In the presented research, both theoretical approaches and high level experiments seem very promising. The link with industry is also very strong: a spin-off ("Microsonics company") has been created in 2007 for the industrialization of a software for acoustic micro-system modeling. The software "ATILA" has been sold worldwide (more than 100 licenses). About the prospects, the number of short and middle terms projects is impressive (9 different projects, some including sub-projects). The policy of the group should determine which orientation to be decided.

The **"Aiman"** (Nonlinear magneto acoustics) group belongs to Axis 2, Micro and Nano systems, and Axis 5 (Acoustics). The activity within Axis 5 has a stronger component of materials elaboration, modeling and characterization. The oral presentation was felt very good . Activity within Axis 2 is more applied and it stands out for the development of magnetically actuated microvalves. Also, the activity within Axis 2 could take more advantage of the IEMN technological facilities. While the activity in both axes is different, it is positive that the group remains unique because there is a clear benefit of the multidisciplinary skills and know-how. The group is small, well balanced in terms of permanent and students, but low in terms of post-docs. In this sense, it will benefit from the incorporation of the FILMS team that, in addition, will provide new know-how (fluidics) and will allow to address new objectives and applications. The number and quality of publications is very good. The average number of publications per researcher is well above the average of the IEMN. Publications are in the main international journals of the area, and the group is regularly attending international conferences with a pretty high number of invited talks. The lack of priority patents issued during the last years is surprising when taking into account the industrial relevance of the research and the high number of industrial contacts. The group is well aware of it and it seems that there is the intention to change this situation in the near future. The group receives funding from different sources, including European projects, national and industrial contracts. National funding is in comparison lower than for other groups. European funding is also reflected by the important number of international collaborations. It has also strong links with the RAS from Russia in the framework of LEMAC, a joint European laboratory. There are no major concerns about the proposed research directions for next years that are found to be innovative and relevant, and well balanced in terms of fundamental and applied research. The incorporation of the "FILMS" team is positively evaluated, as mentioned before.

The "**Ultrasons**" group gathers a large group of researchers with different backgrounds.The scientific production is in agreement with the average of IEMN, despite of a heavy involvement of some members in teaching and administration (direction of 2 masters and of one department) and the very small number of CNRS researchers. Research topics are found challenging. Attention should be paid to the scientific production which is lower than for the Acoustic and

AIMAN groups. Moreover, some research topics may not be in the mainstream of IEMN. A lack of patents and a poor number of invited talks (below average of the lab) might weaken the scientific impact of this group. It has also been noticed that industrial relationships are not at the expected level. Some research topics in acoustics are very important for IEMN: e.g. characterization of thin layers, testing of MEMS but some important topics seems to lack: ultrasonic cleaning and auralisation . The latter seems crucial for the IRCICA project: the acoustic part of the virtual reality project is not very sophisticated at the moment. The committee recommends an increased collaboration with ACOUSTIC and AIMAN groups on the basis of regular meetings, applications for common projects, joint PhD's. Future vacant position should be offered to international competition and group members should be stimulated to spend some time in international labs. The number of research topics should be limited but the group should try to reach excellence in some topics. An organisation of the group with modelling, simulation and test on one side and materials on the other side could improve the clarity of the organisation.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
B	A	B	B	B

5 • Appreciation of resources and of the life of the research unit

The annual support of the lab (from the four institutions) has seen a decrease of about 12% in 2007. Fundings from the CPER and BTR have also decreased whereas a significant increase (about 69%) is found in the funding by the National Research Agency (ANR).

The important participation of IEMN researchers to European projects is the most important contribution on the 2004-2008 period, before ANR and French Ministry of Defense fundings.

Fundings from industrial contracts have decreased into 2007 but remains at the same level as it was in 2005.The overall effect of this variation in 2007 leads to a total amount of resources of 10,13 M€ which remains absolutely necessary to cover the infrastructure costs (1,45 M€ / year) and to keep the investment at their best level (5 M€ / year). Funds of research contracts are used to cover the salaries of non-permanent staff (technical, administrative ans post-doc).

About the permanent and non-permanent staff of the lab, some points must be underlined :

From 2004 to 2008, a significant increase (+21%)of CNRS positions have been obtained by the lab. In the same time, only 2% increase is found in permanent engineers and technicians whereas a 53% increase is found for non-permanent positions. On the same period, a slight increase of the PhD students (+15%) must be compared to the 100% variation of post-docs, mainly due to the fundings of ANR. Nevetheless, the Director of the lab underlines the difficulties to attract high level PhD students. Both, researchers, engineers, technicians and administrative staff, PhD students and post-docs have stated that IEMN is a good place to work. This shows on the basis of their presentations that the direction staff of the lab has created a real and pleasant work environment in which all the members of the lab find their place and appreciate the way they work. A very interesting presentation has been provided by the representatives of administrative and technical staff. From their "SWOT" analysis, it appears that attention should be paid to the ratio of permanent staff / equipment, their will to maintain the lab at its best level and the rate of increase of contractual staff (53%).

6 • Recommendations and advice

- **Strong points :**

The alliance between fundamental research and applied research is very powerful within IEMN. As an example, IEMN is one of the few places where :

- both fundamental properties of nano-materials and integration of nano-materials to create innovative devices are addressed simultaneously,
- mid/long term research programs (30 / 50%) are combined with applied and short term research (20%)
- new interdisciplinary fields which connect nano-objects and biological aspects, hardware and software in telecommunications systems are explored .

Equipment and technical teams of the technological platform are at the highest level. The clean room appears to be well organized. In the future, IEMN should try to hire technological researchers in order to remain a driving force in terms of technology developments. Some technologies such as nano-imprint technologies are becoming generic in the world of micro and nanotechnologies; IEMN should be ready to address such new techniques and challenges.

Level of expertise is exemplary leading to national and international recognition in several research fields : III/V HF devices, MEMS devices, HF and analog electronics.

IEMN appears to be a *reference institute* at the national and at the European levels, and for some fields, teams involved are at the international state of the art, especially when developing studies starting from new materials, innovative elementary devices to systems (in biotech and telecommunications) .

All these works have generated an outstanding scientific production on the basis of :

- the published papers in journals with a high ranking,
- the communications at international conferences,
- the remarkable number of invited talks .

Researches are lead on the basis of a lot of cooperative research, yielding significant funding through national and European programs. It concerns also an important cooperation with ST-Microelectronics and several other industrial partners, including start-ups like DELFMEMS, MC2…

As a summary, the committee recognizes the high quality of :

- the management of IEMN , involving not only its director but also the leaders of the five axes,
- the relevance of the prospective as well for the evolution of research topics as in the equipment of clean rooms and the characterisation lab.
- the technological facilities implemented in the lab and their high potential,
- the successful integration of IEMN in the regional activities of research and development (regional clusters – " pôles de compétitivité")
- the excellent and efficient network of international exchanges (with Belgium, Russia , Japan) for which a dedicated position has been created at IEMN .

Finally, the committee has favourably noticed the presentation by the future management team of the lab of their project and their will to maintain and reinforce the skills of the lab.

- **Weak points to be improved :**

- IEMN has a very nice and well equipped facility, including clean rooms, tools, characterization labs…A concern for the coming years might be found both in the cost of the technological equipments which is still growing and in the hiring of technological engineers.

- It seems that the culture of cooperative research has been strongly developed with other academic institutes but less with the industry. In the field of microelectronics, it is a very important axis.
- The split into axis seems to be coherent but is not strongly felt during the teams' presentations: some of them appearing as "independent". Are there probably too many teams in IEMN?
- Works on Ultra Wide Band (UWB) which are performed within three teams of Axis 4 need to be clarified and probably gathered in a single team, even if different aspects are considered in the three teams.
- In general, the number of topics addressed in many teams of IEMN is rather large: focusing towards a more limited number of topics should be considered. Concentrating the potential of each team on fewer topics can help in targeting an international visibility and in defining a clearer strategy.
- The over-all evaluation of Axis 5 "Acoustics" shows some difficulties related to its management , an heterogeneous level between the three teams (which is much less the case for the other 4 axis) and a scientific production to be globally improved (in numbers and quality) .
- Many groups have their own simulation capabilities whereas a specific group is dedicated only to simulation. A better organization of the simulation capabilities of IEMN could be very beneficial for the lab.

- **Recommendations :**

A better benchmarking of each team in the international context would have been helpful to clearly position the efforts and the strategy of each team. It should be stressed more on the added value of the local technology facilities. Attention should be paid to the number of projects per team. In some fields a team represents less than 10 people. If small teams can be identified in emerging fields, they have no real added value in "mainstream" fields of the lab. In this case, the conditions of merging teams should be considered.

Projects for 2010 : a new team will be in charge of the direction of the lab. They are willing to keep the scientific organization on the 5 existing axis. They are aware of the fact that about 2 professors and two engineers and technicians will leave, for retirements, IEMN each year. Their priority will remain to keep IEMN attractive for high level PhD students and post-docs.

Note de l'unité	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A+	A

Université Lille1
Sciences et Technologies

Villeneuve d'Ascq, vendredi 27 mars 2009

Philippe ROLLET, Président de l'Université Lille1
Marie-Pierre MAIRESSE, Présidente de l'Université de Valenciennes et du Hainaut-Cambrésis
Thérèse LEBRUN, Président-Recteur de la Fédération Universitaire Polytechnique de Lille

A l'attention de Jean-François DHAINAUT, président de l'AERES

Objet : Réponse au Rapport du Comité de Visite de
L'Institut d'Electronique, de Micro-électronique et de Nanotechnologies (IEMN, UMR 8520).

Monsieur le Président et Cher collègue,

Nous tenons à remercier le comité de visite pour l'analyse du bilan et du projet de l'Institut d'Electronique, de Micro-électronique et de Nanotechnologies (IEMN, UMR 8520).

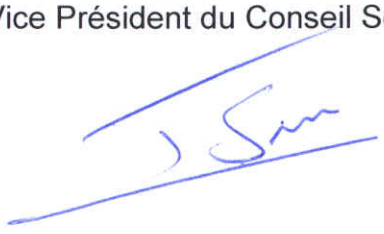
Vous trouverez ci-joint la réponse de l'unité à ce rapport. Elle comporte :

- des demandes de correction d'erreurs factuelles ;
- des observations et commentaires sur le rapport d'évaluation.

Les établissements partagent la réponse de l'institut, en particulier sur le caractère hétérogène de l'évaluation des équipes et l'absence d'une évaluation de l'Institut IRCICA qui constitue un élément majeur de la structuration de la recherche dans le secteur « STIC ».

Nous vous prions d'agréer, cher collègue, l'expression de nos sincères salutations.

P.O. Isam SHAHROUR
Vice Président du Conseil Scientifique



Comments of IEMN to the visiting committee report

General comments

IEMN staff thanks the visiting committee for its recommendations and remarks given in the report. These recommendations will be taken into consideration by the direction.

However IEMN would like to add the following remarks:

1. The group evaluations are strongly heterogeneous. Some groups have only general observations despite a significant number of scientists and many scientific projects.
2. The evaluation of the scientific production is mainly quantitative (number of scientific papers and conferences per person of the group compared with IEMN average). This quantitative analysis does not take enough into account the quality of the production (journal impact factor, selectivity of the conference) as well as the variety of IEMN activities that cover domains ranging from theoretical physics to industrial demonstrators.
3. The second 'weak point' in page 15 mentions that '*the culture of cooperative research has been strongly developed with other academic institutes but less with the industry'*. IEMN does not understand this remark that is not in agreement with the *'overall appreciation'* section indicating *'solid industrial collaborations' (p. 6)* while *'an important collaboration with ST-Microelectronics and several other industrial partners'* is noted in the *'strong point section'* of the report. It should also be noted that the quality of IEMN industrial partnership was awarded through the 'Carnot Institute' label attribution by the ministry of research in 2006.
4. No comment on the report concerns the structuring of the ICT domain on the Lille1 campus (IRCICA federation project) despite it was presented in details to the committee.
5. The remark of the committee *In general, the number of topics addressed in many teams of IEMN is rather large: focusing towards a more limited number of topics should be considered* is shared by IEMN. This results from the funding of almost all the research activity by projects (EU, ANR …). The improvement of this situation would require more funds directly given to the laboratory from its parent organizations.

More specific remarks are made below for each research axis.

Axis 1

Theoretical physics

Concerning the comment that the theory team is "*living its own life*", we would like to mention that this is not at all the case: two EU projects and seven papers were published in the period 2004-2007 involving both IEMN experimentalists and theoreticians of the physics group. In addition, about 50% of our papers are written with experimentalists from different national and international laboratories.

Epiphy

We strongly contest the sentences about the scientific production of the EPIPHY group. The group has published **78 papers in international peer-reviewed journals** for an average number of seven researchers over the period. We want to stress that the main part of the growth activity is devoted to the epitaxy of high quality heterostructures for innovative

devices with state of the art results, as it is noted in other sections such as the ANODE group report (p 10) and the strong IEMN points in the '*recommendation and advice*' section (p 14). The THz activity has grown significantly over the last four years starting with only one researcher in 2004 to reach four permanent positions in 2008. This corresponds to almost 2 full-time researchers who published **21 papers** over the period including **11 Applied Physics Letters.** These 11 APL clearly demonstrate the international level and the originality of the research carried out. We also want to point out that this group:

- has deposited an international patent concerning a new THz 3D horn antenna
- obtained a world record efficiency for a 1.55 µm THz photomixer (Electronics Letters 44, 1320 (2008))
- is partner of MITEPHO, a European Marie Curie Network dealing with THz photomixing recently launched.

Axis 2

Mitec

MITEC being a recent group gathering scientists having a broad range of skills, it intends to federate this rich know-how toward joint projects for the next term. So far, the industrial relevance of the research achieved in the group is illustrated through numerous industrial contracts. Accordingly, several patents balance the publication figure.

Axis 3

Silphyde

The comments about Silphyde group are somehow excessive. The difficulty to hire students and PhD on this topic partially explains the weak scientific production. Nevertheless, the group will consider the advice of the committee to focus on a smaller number of activities.

Axis 4

Telice

Two remarks to answer the report comment '*the average number of papers published is below the lab level'* can be made*:*

- Only four researchers were working in Telecom team over the 2004-2007 period and 5 from the 2007-2008 one instead of 8 as mentioned in the report.
- the EMC team is strongly application oriented and most of the results are presented at EMC symposia

Concerning the *'the future of EMC'* comment, the head of the EMC team (and not of the TELICE group) is now retired. As already discussed during the oral presentation, EMC activities will be strongly oriented toward noise measurements and modelling and to the development of new test bench. Consequently, EMC and telecom teams will merge.

Ultra wide band (UWB) activity

Ultra Wide Band (UWB) is a generic terminology which covers various techniques.
COMNUM, CSAM and TELICE groups have different approaches of this concept (frequencies, architectures, data rate, channel modelling, applications …).
However we will take into account your recommendation and will increase the sharing and gathering of our competences and facilities through transversal projects.

Axis 5

Ultrasonics

The ultrasonic group not only contributes to research themes that are in the IEMN mainstream but also to specific programs like CISIT (International Campus for Safety and Inter-modality in Transportation) on new aspects linked to acoustic sensors for biomechanics and non-destructive testing. The ultrasonic group regrets that the reorientation already engaged since two years as well as some internationally recognized activities (for example the growth of piezoelectric and ferroelectric materials) were not mentioned by the committee. Finally, IEMN believes that the suggested novel research topics (ultrasonic cleaning, auralisation) are already widely investigated in other laboratories and would increase the dispersion of research topics.