Editorial: Nanoscience in Rhône-Alpes

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Abstract: An overview of nanoscience research, its organisation and its relation with Rhône-Alpes nanotech industry is given. Nanoscience activities are organised and animated by the C'Nano national program, the Nanoscience foundation (Grenoble) and the Micro-Nano Rhône-Alpes cluster, each with a specific mission. The international training programs offered by the Rhône-Alpes institutions of higher education are also briefly described.

Keywords: C'nano; nanoscience; nanotechnology; Rhône-Alpes.

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Biographical notes: After his MSc Degree from the Ecole Centrale de Paris, Lévy got a PhD from the University of Michigan, Ann Arbor in 1982. He started his scientific carrier in the USA as a postdoctoral at Cornell University and stayed eight years as a research staff member at Bell Labs, New Jersey. He became a Professor at University Joseph Fourier in 1992, and joined the Institut Néel in 2007. He had a number of contributions to the magnetism of quantum fluids, low dimensional magnet and spin-glasses. His experimental observation of persistent currents in normal metals is considered as one of the pioneering contributions to nanophysics. He studied the spin and orbital magnetism of the 2D electron gas and other problems in low-dimensional systems. His current research focuses on graphene in high magnetic fields and superconducting quantum circuits. His coordinating efforts in the field of nanoscience started in 2000 with the Institut des Nanosciences in Grenoble and after 2005 as the C'Nano Rhône-Alpes director.

1 History

Rhône-Alpes with a current population of six millions [1] has always been a crossing region between France, Switzerland and Italy. Its growth through commerce, banking and broad range of industries has benefited from its geographical location as a crossing point between northern and southern Europe, fostering intellectual and business exchange which made this region a premium forum for Science and Innovation.

Lyon, the second largest French metropolitan area is one of the oldest European cities. The 'College la Trinité' founded by the Jesuits in 1519 was for a long time its only institution of higher education. It is only in 1835 that a University was founded with its Science College. This Science faculty was at the origin of today's Université Claude Bernard. The growth of the natural and physical sciences in Lyon dates from this period, with the notable contribution of André-Marie Ampère to electromagnetism. This was also a golden era for Engineering and saw the creation of several engineering schools under the patronage of private associations: the 'Ecole Centrale de Lyon' founded in 1857 only became a public engineering school in 1947. In the field of chemistry, the CPE (Ecole de chimie Physique et Electronique de Lyon) founded in 1888, got two Nobel laureates in chemistry (Victor Grignard, 1912 and Yves Chauvin 2005) and one for peace (Jean Jouzel, 2007). In Lyon, two other schools founded recently, INSA-Lyon (1957) and Ecole Normale de Lyon (1985), have also highly recognised nanoscience research groups whose contribution will be found in this volume.

The other Rhône-Alpes cities, Annecy, Chambery, Grenoble and St-Etienne were tiny centres dwarfed by the capital Lyon until the twentieth century. Grenoble University, founded in 1339, one of the oldest higher education centres was for a long time eclipsed by the University of Valence (now an antenna of Univ. Joseph Fourier, Grenoble) until the Napoleonic era when it became an imperial university and an academic centre. Individual figures like Joseph Fourier, mathematician, the Champollion brothers (Jean-François, Egyptologist and Jacques-Joseph archaeologist) contributed greatly to the University reputation. Today, Joseph Fourier is the Grenoble Science University. The industrial growth of Grenoble, originally driven by hydroelectricity and by the paper industry, attracted also several Engineering schools. Today, they form together the 'Institut Polytechnique de Grenoble' and cover most areas of Engineering, including nano-materials and nano-electronics.

To complete this historical overview of higher-education institution, there are two other Universities in Rhône-Alpes: The 'Université Jean-Monnet' in St Etienne (1969) has a nanophotonics program and the 'Université de Savoie' (Chambery-Annecy) (1979) a radiofrequency research centre.

The Rhône-Alpes region is today one of the major centres of research in nanoscience and nanotechnologies. This would not have happened without the creation of several research centres after WW2 by the two national research organisations 'Centre National de la Recherche Scientifique' (CNRS) and 'Commissariat à l'Énergie Atomique' (CEA) under the impulsion of Louis Néel (Nobel laureate 1970). In particular, the CEA opened in the 1980s an integration platform for high-tech industries in Grenoble. This increased the attractiveness of the region for international companies as the excellence in research and the quality of education was there for their use. As a consequence, a tremendous growth of the microelectronics industry took place around Grenoble: ST-microelectronics, Hewlett-Packard, Freescale, NXP, Schneider-Electric, Soitec, Atmel, Teem-photonics, Tronics etc. came and aggregated around them a number of other service and start-up companies. This represents more than 50,000 direct jobs. If one adds the student population (60,000) (all higher education institutions), the research and development laboratories and the indirect jobs, this has a huge socio-economic impact on the Grenoble metropolitan area (400,000) [1,2]. A similar evolution took place in Lyon around the life sciences, where a number of pharmaceutical laboratories (Bio-Merieux, Sanofi-Pasteur, Mérial, Bayer, Monsanto, Genzyme-Polyclonals, Genopïetic, Genoway, Flamel Technologies) took advantages of

the strength of the research and the availability of high level graduate in the life sciences. Because of the size of Lyon metropolitan area (2.9 million), their economic impact is more qualitative [1,2]. Considering the short distance separating Lyon from Grenoble (100 km), technological research also grew up in Lyon while major breakthrough in biotechnologies came from Grenoble by combining the life science expertise with the high-tech know-how. Two large European facilities were also built in Grenoble, the Institut Laue Langevin (ILL) and the European Synchrotron Radiation Facility (ESRF). They provide general investigation and characterisation tools of great use for nanoscience studies which are rarely available on the same site.

2 Nanoscience coordination and animation: the C'Nano story

2.1 Context

The growth of nanoscience and nanotechnologies was extremely rapid since the early 1990s. Today, it represents a good fraction of the activities of the laboratory studying dense media and their related engineering. This is best measured [3] by the fraction of PhDs produced in nanoscience compared to the total number of PhDs. In Grenoble, one-third of the PhDs produced by the graduate schools in Physics and EEATS (Electronics, Electrotechnics, Automation and Signal Processing) are in the field of nanoscience and nanotechnologies while it is close to a quarter for the Life Science graduate school. Since nanoscience involves cross-disciplinary expertise, research programs covering the same general areas were started in different laboratories. To optimise efficiency and saving resources, it is best to combine forces, through collaborative or any other appropriate aggregation of research expertises. Depending on the scientific issues of interest, these groups are rarely the same and need to be formed according the project needs. In a lab on chip project, Chemistry and Life Science groups may need to team up to get the desired functionalisation, while at the other end of the project, micro-fluidics and micro-fabrication groups can design and package the device. A group with all the cross-disciplinary expertise for one project would lack expertise for another.

We see how flexibility and connectivity between research groups are of prime importance in fields at the interface between disciplines. Today, laboratories are no longer organised within a single discipline. Nevertheless, for evaluation and many other reasons, they still have a strong focus in one general area (i.e., Chemistry, Engineering, Life Science, Physics). Sometimes, the appropriate expertise in a different discipline cannot even be found on a single scientific site, and it is necessary to outreach toward other regional, national or international sites. Because proximity has its value, a regional structure 'without walls', C'Nano (Centre de competence in Nanoscience) was created in 2005. The C'Nano provide the connectivity and the flexibility needed between different groups for a variety of projects and topics. Since such structure existed within the CNRS along thematic lines (Groupes de Recherche), the administrative structures were readily available. There are six such regional structures covering France.

Another consideration is the costs involved in all the Nanosciences initiatives. Fabrication and characterisation tools require not only state of the art machines but also trained personnel capable of maintaining and developing technological processes. For best efficiency and cost effectiveness, such tools should be concentrated in a

limited number of platforms with the appropriate resources to perform at the highest level. In practice, this requires some level of coordination in order to best satisfy the community's need with a limited number of platforms. At present, there a four such platforms in Rhône-Alpes, two with a national mission, i.e., the pre-industrial integration platform of the CEA-LETI and the PTA (plateforme de technologies amont) common to the CNRS and the CEA, with a mission oriented toward basic research. In addition, there are two smaller proximity platforms (NanoLyon and Nanofab-Grenoble). There are also state of the art resources devoted to teaching and training for nanotechnologies. A broad range of bottom-up tools are also available in both Lyon and Grenoble as local laboratory or inter-laboratory resources.

2.2 C'Nano within the national nanoscience program

The roadmap for science and technology involves the conception and the fabrication of nano-objects, the understanding of their science and operation, the manufacturing at an industrial scale of components which integrate these new building blocks. This task has been recognised as a key to present and future economic activity in USA by the National Nanotechnology Initiative (NNI) and in France by the 'Ministère de la recherche', the CNRS, the CEA and 'the Agence Nationale de la Recherche' (ANR). The C'Nano coordinated a broad survey indicating that 4200 full time researchers, postdocs, PhD students and staffs were presently devoted to nanoscience studies (1100 for Rhône-Alpes distributed in 25 laboratory-units).

A national coordination of the C'Nano program has been set up from the start around

- fabrication facilities, particularly proximity platforms
- national (J3N…) and international conferences
- school and training programs
- exhibits and high school outreachs

all part of the C'Nano missions.

2.3 The missions

The tasks assigned to the C'Nano network is to [4]

- Build the backbones of a national network for the nanoscience research community starting from a regional level.
- Create a scientific animation in nanoscience, through workshop and conferences. Their purpose is to create an immediate awareness to new and emerging trends in nanoscience. They also serve as an outreach tool for the regional laboratories toward neighbouring countries. Italy and Switzerland are our natural partners and have been drawn into TransAlpine conferences which first edition took place in Lyon in 2008, while the second will take place in Milan in 2010.
- Favour the emergence of interdisciplinary and cross-laboratories projects. These are also part of the mission of the Nanoscience foundation and the micro-nano cluster (see below).

- Facilitate the access to technology platforms: the goal is to concentrate the resources in a limited number of well equipped fabrication facilities and make the as open as possible.
- The C'Nano serves also as advisory council toward the national and regional organisms.
- Serve as the correspondents to their European partners within the European Network NanoSci-ERA.
- Organise and participate to the emergence of training programs.
- Help the diffusion of nanoscience toward the general public in partnership with museums and high schools. Participate to the reflection on the impact of the nanoscience and nanotechnologies within society.

All these missions are carried out with a very light 'Groupe de Recherche structure' involving a few people and a steering committee. The success of the C'Nano program hinges on its closeness to the research groups, with a good knowledge of their achievements and of their future projects.

3 The nanoscience foundation and the micro-nano cluster

Considering the rapid development of nanoscience, projects need often to be jump started with the help of world experts capable of bringing the knowledge and the know how to the community. This is best achieved through Chairs of Excellence for international scientists providing the means (postdocs and equipments) to start collaborations on the newest and hottest topics. The Nanoscience foundation was created in Grenoble [5] by four partners, the two academic institutions (Univ. Joseph Fourier and Institut National Polytechnique de Grenoble) and the two national research organisations (CNRS and CEA). The initial funding (26 M€) came from public sources, but as time goes on, private resources will be substituted to sustain the efforts of the nanoscience foundation. The foundation defined eight areas of excellence (Quantum nano-electronics, Spintronics, Nanophotonics, Molecular electronics, nano-materials, nano-characterisation, bio-chips and live sciences and nano-modelling) where all the Chairs are concentrated. In addition, funding for novel projects is also available through annual calls. There are also mechanisms to fund foreign student theses, which do not exist through other national or European channels. The foundation has also the flexibility to support local fabrication platform especially in their recurring costs, which are rarely provided through the national programs.

To complete this overview, the regional support to research and development is channelled through cluster networks, which tasks is to make the necessary bridges between research and applied projects relevant to companies. They cover 14 areas of socio-economic interest. One of them is micro and nanotechnologies [6]. The micro-nano cluster funds ~7 projects every year (mostly doctoral fellowhips). Several companies are represented in the steering committee which guarantees the socio-economic relevance of the project selected.

4 Education and training in nanoscience

Considering the large number of higher education institution in Rhône-Alpes, it is not possible to give a comprehensive picture of all the courses offered in nanoscience. On the other hand, a few programs have been integrated to international European networks, with courses in English. They are

- Master Nanotech [7], common to the Institut National Polytechnique de Grenoble, the EPFL (Lausanne) and the Polytechnico-Torino. This program hosts 20 students from each partner institution every year.
- The Master's in 'Nanoscience and Nanotechnology' [8] has seven partners, the Université Joseph Fourier, The Catholic University of Louvain (Belgium), Chalmers and Göteborg Universities (Sweden), TU-Dresden (Germany) with CEA-LETI and IMEC as technology partners. This is an Erasmus Mundus master of the EU.
- A 'Nanoscale-Engineering' Master's common to Ecole-Centrale de Lyon, INSA and Université Claude Bernard opened in the fall of 2009.

Finally, a European school in Nanoscience (ESONN) [9] offers every year an intense training in nanoscience including laboratory and clean-room practicals. It is only open to 60 graduate students and postdocs. It has two parallel sessions, one on nano-electronics, photonics and spintronics and the other on nano-biology and biotechnologies.

5 This volume

Throughout this paper we have stressed the interconnections between the high tech industries (nano-electronics, photonics, pharmaceutical and biotech companies) and the research activities in Rhône-Alpes. This is reflected in this volume where contributions in nano-electronics, nanophotonics, spintronics and biosciences take a large part. The relevance to local industries can also be measured in the contributions related to nanomaterials.

Not all the areas of excellence of Rhône-Alpes are present in this volume. Nanoparticles are also relevant to energy storage (Institut Néel, Institut des Nanotechnologies de Lyon) and to catalysis, where a strong research program is conducted by the 'Institut de la Catalyse' in Lyon. Also the engineering of intelligent and functional molecules, motors etc… constitutes a vibrant activity of the 'Département de Chimie Moleculaire de Grenoble'. Finally, applications to medicine, and particular to brain research and surgery have been developed at the 'Institut des Neurosciences'. Because of lack of time, it has not possible to include their contributions in this volume.

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