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Nanotechnology in Argentina

CIA map of Argentina

Report of a Fact Finding Mission to San Carlos de Bariloche and Buenos Aires, 19-23 November 2007

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1. Introduction

The emerging nanotechnology research community in Argentina represents an untapped potential due to several factors including lack of international visibility. Argentinean researchers are interested in participating in international research cooperation, including under the European 7th Framework programme for Research and Technological Development FP7. The present report aims at stimulating such cooperation by highlighting the activities, human resources, research infrastructure and policies in the area of nanotechnology in Argentina. It is based on a visit to Bariloche and Buenos Aires from 19 until 23 November 2007. The visit is a follow-up of the EU funded NanoforumEULA project, and the report will be published online at www.nanoforumeula.eu and disseminated among interested parties in Europe and elsewhere.
The nanotechnology research community in Argentina is well connected and has good political contacts. They have personal relations to the new Minister for Science and Technology, Dr. Lino Baranao. Most of the research is still mono-disciplinary, but there are some initiatives for interdisciplinary collaboration. Many research groups have extensive collaborations with partners in Europe in their own scientific field or for access to expensive research infrastructure (e.g. synchrotrons). These projects are funded by the Argentinean government or bilateral cooperation programmes (e.g. DAAD – Germany, France, UK, etc). There is intensive nanotechnology cooperation between Argentina and Brazil.
EU funded collaboration is rare, because of paper work and less favourable conditions for Argentinean participants than other programmes. There appears to be a gap between science and engineering, which starts in education. There are no nano-engineers, only mono-disciplinary nanoscientists.

2. Nanotechnology policy and networks

According to Ernesto Calvo (2007), the American company Motorola SPS (Arizona) initiated nanotechnology research in Argentina through a fact finding mission in 2000, visiting the Balseiro Institute and Centre for Atomic Energy Bariloche in San Carlos de Bariloche and Universities of La Plata and Buenos Aires. They also went to the universities of Campinas and Sao Paolo in Brazil during that same mission.

In 2005, the Argentinean President Kirchner launched the Argentinean Nanotechnology Foundation (FAN) by decree 380/2005 on 29 April 2005, which created a lot of political and public debate, including in congress, the Argentine Physics Association and the National Committee on Ethics in Science and Technology (Foladori, 2006). The main issues were political, including fear of foreign military funding, and economic. The FAN was launched without the need for approval by the congress. The government announced an investment of $10 million in it.
In June 2005, the congress discussed a ten year nanotechnology development plan proposed by the technology commission headed by Mrs. Lilia Puig de Stubrin. (Sametband, 2005) Several congress delegates have proposed “proyectos de ley” (legislative projects in 2005 and 2006) which indicates that there is still a lot of political interest in nanotechnology and its implications for the Argentinean economy and society. On 31 March 2005, Jorge Raul Giorgetti proposed creating the “Argentinean Institute of Nanotechnology,” before the Presidential decree which was issued a month later. On 13 May 2005, the congress adopted a resolution asking the executive for information about the objectives of science policy and the

creation of the FAN. On 2 June 2005, Lilia Puig de Stubrin and colleagues proposed the abovementioned "ten year strategic plan for developing micro and nanotechnologies." One and a half years later, Miguel Dante Dovena and Jorge Raul Giorgetti tabled a proposal entitled: "Nanotechnology, regime for its industry," on 7 December 2006. The parliamentarians participating in the debate demonstrate concerns about how to ensure that Argentinean companies and the economy and society at large can benefit from the investment in nanotechnology. They cite several articles by international scholars about applications of nanotechnology for developing countries. Puig de Stubrin and colleagues propose to collaborate with Brazil, Chile and Mexico in funding joint nanotechnology facilities. Dovena and Giorgetti propose to install the Argentinean Nanotechnology Institute IANATEC, which should develop and manage a national nanotechnology development plan with annual government funding of 0.05% of the budget of the national administration. The main aim is to enhance the productivity of the Argentinean economy, by enhancing the access of the Argentinean public and private sector to key technologies including nanotechnology. This should contribute indirectly to poverty reduction and the existing disparities in the Argentinean society. (Source: Argentinean Congress website)

In the mean time, other initiatives have been taken in consultation with the scientific community in Argentina. The FAN has been reformed into a revolving fund for stimulating early stage investment in Argentinean nanotechnology start-ups. Since 10 December 2007, FAN is part of the new Ministry of Science, Technology and Innovation. Within the objectives of the new ministry, the development of Biotechnology, Nanotechnology and Information Technology (TICs) will be a priority. Special sector funds will be provided by World Bank to fund these three areas. The Nanotechnology Fund will be administered by FAN, according to Ernesto Calvo.

2.1 MINCyT

Since 10 December 2007, Argentina has a Ministry of Science, Technology and Productive Innovation MINCyT in the government of President Cristina Kirchner. Dr Lino Baranao is the Minister.
In the past, this has been a Secretariat of State for Science, Technology, and Productive Innovation (SECyT) of the Ministry of Education, Science and Technology of Argentina. In 2005, SECyT has developed a Strategic plan for science, technology and innovation (2005-2015). This plan is oriented towards the global millennium development goals (UN General Assembly, 2000) and includes plans for societal as well as economic and technological development. Nanotechnology is explicitly included as one of five key technologies (along with biotechnology, ICT, space technology and nuclear technology). The plan has been developed in consultation with interested parties. These actors have emphasised the responsibility of the Argentinean State for establishing thematic priorities, regulating scientific activity and fixing ethical codes for research. Among the specific objectives proposed for nanotechnology are fostering research, educating human resources for nanotechnology, international collaboration with Brazil, other Latin American countries (in MERCOSUR), Europe and the USA, as well as "promoting an ethical, responsible attitude in use of nano-objects in habitat, science and education, taking into account its social implications." (SECYT, 2005) (www.mincyt.gov.ar)

MINCyT has an office for stimulating participation of Argentinean researchers in EU funded projects: ABEST. (http://www.abest.secyt.gov.ar/)

2.2 CONICET

CONICET is the national research council. They stimulate and fund research projects, networking, human resources development and mobility and have installed a number of CONICET research centres in four areas of research:

- Agriculture, engineering and materials
- Biological sciences and health
- Exact and natural sciences
- Social sciences and humanities

CONICET funds most of the scholarships to pay doctoral and postdoctoral students. It has a structure of Institutes like CNRS in France. (www.conicet.gov.ar)

2.3 Redes Argentinas de Nanociencia y Nanotecnologia

After a call for proposals in 2004 by the National Agency for the Promotion of Science and Technology ANPCYT, there are four research networks in nanoscience and nanotechnology in Argentina:

- Argentinean Network for Molecular, Supramolecular and Interface Nanoscience and Nanotechnology, including UBA (Buenos Aires), INIFTA (La Plata), UNC (Cordoba), UNRC (Rio Cuarto), UNSL (San Luis) and CAB CNEA (Bariloche), coordinated by Dr Roberto Salvarezza at INIFTA
- Argentinean Network for Nanoscience and Nanotechnology: nanostructured materials and nanosystems, including CNEA and UBA (Buenos Aires), UNC (Cordoba), UNSL (San Luis) and CAB CNEA (Bariloche), coordinated by Dr Carlos Balseiro at CAB-CNEA
- Self-organisation of bionanostructures for transmission of molecular information in neurobiology and biological processes, including UNC and CONICET (Cordoba), UNT (Tucuman), UNSL (San Luis) and CAB CNEA (Bariloche), coordinated by Dr Bruno Maggio
- Virtual Laboratory for design, simulation and fabrication of nano and micro samples, prototypes and devices, including CNEA, UBA, CITEFA, UNSM (Buenos Aires), INTEC (Santa Fe), IMBECU (Mendoza), UNNE (Corrientes), UNER (Entre Rios) and CAB CNEA in Bariloche, coordinated by Dr. Alberto Lamagna

2.4 Centro Binacional con Brasil

The Binational Argentinean-Brazilian Nanotechnology Centre (CABNN) was created by an agreement of the governments of Argentina and Brazil on 30 November 2005. (www.cabnn.secyt.gov.ar)
The aim is to stimulate nanotechnology research collaboration between the two countries by joint projects and events. The coordinators are:
Argentina (currently):

- Dr Roberto C. Salvarezza
- Dr Alfredo Boselli

Argentina (2005-2006):

- Dr Ernesto Calvo

- Dr Alberto Lamagna

Brazil:

- Dr José de Albuquerque e Castro
- Dr Jairton Dupont

2.5 Centro Interdisciplinario de Nanociencia y Nanotecnologia (CINN)

The Interdisciplinary Centre for Nanoscience and Nanotechnology CINN **(Start date?)** comprises about 100 scientists in Bariloche, Buenos Aires and La Plata working in UBA, CNEA and CONICET institutes. It is supported by five companies: the high tech engineering company INVAP, TENARIS, NANOTEK, the chemical products supplier DARMEX and B&W. The board is comprised of four senior and four new generation researchers:

- **Dr Ernesto J. Calvo (responsible scientist) (UBA-CONICET)**
- **Dr Carlos Balseiro (responsible administrator) (CNEA-CONICET)**
- **Dr Roberto Salvarezza (UNLP-CONICET)**
- **Dr Oscar E. Martinez (UBA-CONICET)**
- Dr Alejandro Fainstein (CNEA-CONICET)
- Dr Federico Williams (UBA-CONICET)
- Dr Galo Soler Illia (CNEA-CONICET)
- Dr Felix Requejo (UNLP-CONICET)

The budget for four years is US$2.4 million for instrumentation, US$1.2 million for two projects with industry and **(xx)** for a postgraduate school in nanoscience and nanotechnology, repatriating 12 young scientists and educating 60 PhD students.

3. San Carlos de Bariloche

The city of San Carlos de Bariloche is home to the National Commission for Atomic Energy – Atomic Energy Centre Bariloche CNEA-CAB and the prestigious Institute Balseiro for educating the best physics students. The high tech company INVAP is a 30 year old spin-off from CNEA, formerly the centre's Applied Research department. All these are located in a beautiful ski and tourist resort on a lakeside on the edge between the flat dry plains and the mountains in Patagonia.

3.1 CNEA

The National Commission for Atomic Energy CNEA was founded in 1950. It is responsible for nuclear energy research for peaceful purposes, in three research centres. They are forming a virtual nanoscience centre within CNEA consisting of 40 people, aiming to stimulate networking inside and outside CNEA. The work comprises basic and oriented research. They also intend to invest in a new clean room and other research infrastructure. Human resources will also be developed. The focus is on Nanophysics (magnetism, electronic transport, superconductivity, optics, surface physics and chemistry, nanomaterial fabrication, etc.), as well as Nanochemistry, oxides, micromachines and simulation of nanostructures. The network will be coordinated from CAB in Bariloche and link to institutes in Brazil and Europe.

The first Atomic Energy research centre is located in Bariloche: CAB. This research centre includes an experimental reactor and basic and applied research laboratories.
According to Dr Alejandro Fainstein, human resources include 120 physicists, 70 nuclear engineers, 90 PhD students and 15 MSc students.

Several fundamental research departments are engaged in basic experimental nanotechnology research projects:

- Low Temperature Physics
- Optical properties
- Metal physics
- Atomic physics
- Surface Physics
- MEMS
- Engineering group on Computational Mechanics (MEMS collaboration)

Several groups are working on theoretical physics of nanotechnology:

- Condensed Matter
- Statistics and Complex Systems

Key staff:

- Dr. Carlos Balseiro (member Argentinean Academy of Sciences)
- Dr. Alejandro Fainstein, Optics Group
- Dr Hernan Pastoriza, MEMS
- Dr Roberto D. Zysler, Magnetic Resonance Lab
- Dr Hugo Ascolani & Dr Esteban Sanchez, Surface Physics Group

3.1.1 Optical properties group

The Optical Properties group led by **Alejandro Fainstein** includes 1 permanent researcher, 1 technician, 5 PhD students and 1 MSc student. They specialise in Raman spectroscopy, and have procured fast optics equipment in 2007. The research is organised in 2 lines:

- Semiconductor nanostructures: The group studies the interaction of light in optical micro cavities. The light is enhanced and confined with ultrasound waves in the THz frequency. The purpose is to make monochromic ultrasound, in a phonon or sound THz laser. The group collaborates with partners in France, Spain, USA and Japan and has published 40-50 publications, including 3 in Physics Review Letters in the last year as well as other reputable journals. The research is fundamental. samples cannot be fabricated in Argentina, because the layers must be produced with MBE (Molecular Beam Epitaxy), which is not available in the country. International cooperation, including the INSP (Institute of Nanoscience of Paris), France, is thus strong. A LIA (Associated International Laboratory) between groups from CAB and the INSP is being established with funding expected to come from CNRS and the MINCyT.
- Surface enhanced Raman scattering and molecular nanostructures: This research deals with ultrasensitive detection of molecules in nanoengineered plasmonic metallic structures, including nanovoid substrates of nanocavities of gold or silver (300-900 nm in diameter). Gold is used as a substrate for a monolayer of Latex nanospheres, grown by controlled evaporation. The layer, which is almost perfectly organized, serves as a template for the metal nanocavities which are grown by electrochemistry, followed by a chemical removal of the latex nanospheres. The surface plasmons are studied, with varying characteristics, depending on the thickness, angle of incoming laser light,

colour of the laser etc. The group studies the surface enhanced Raman scattering, to investigate the amplification. They see a quite large amplification, and have performed several studies of molecules and electrochemistry of molecules on surfaces using this method. The amount of amplification is not yet well established, but is estimated to be around 10^5-10^7. They are investigating electrochemical and biomimetic properties. Together with Ernesto Calvo, the system is being applied in glucose detectors. In this collaboration, Alejandro Fainstein's contribution is more in the fundamental questions, the chemists are more into applications, e.g. for detection of agricultural contaminants. They are developing collaborations with groups in Southampton, Cambridge and Barcelona in this subject.

The group has a state of the art Raman lab with near infrared, visible and ultraviolet lasers. They also have cryostats and microscopes for experiments. The experiments include photoluminescence experiments and fast optics. In March/April 2008, they will start with time resolved femto-second spectroscopy. A variable angle ellipsometer is used for determining optical and dielectrical properties between 1200 and 30 nm. The optical response depends on the angle and colour. This enables precise determination of layer thickness and optical properties of ultrathin layers. In an adjacent chemistry lab, controlled formation of the latex balls takes place with electrochemistry and pure water. In 2008, a general facility for CAB will be built, in which the optical properties group will also move their fabrication part.

The Optics group is collaborating extensively with France including the Nanoscience institute of Paris, and the Photonics and Nanostructures Lab (LPN) in Marcoussi (South of Paris). The groups visit each other annually. Two Argentinean doctoral students are co-supervised. With the ICMAB institute in Barcelona, Spain, they are collaborating in Raman studies of Germanium and Silver. This is a follow-up of an earlier collaboration with the Technical University of Berlin. The Argentineans use the SNOM which is available in Barcelona for experiments with nanosurfaces.

The funding is project based. The sources include SECYT and several binational programmes with European countries including DAAD (Germany), CSIC (Spain), ECOS (France). ECOS has funded 2 projects in 3 years, which can't be extended. A new activity is the LIA, a French instrument for bilateral cooperation, funded by CNRS. It is almost certain that the first LIA in Argentina will be approved, for €20,000 for each partner per year for travelling of researchers and students.

The ALBAN programme is funding 2 students.

The group has not participated in the EU Framework Programmes. It appeared too complicated, and the partners they worked with in Europe had national rather than European funding. The US Office of Naval Research ONR stimulates Argentina-USA research cooperations, but they fund travel and investment in equipment for the Argentinean groups enabling them to start the collaboration. The Max Planck Society has a similar scheme. If the EC wants Argentinean groups to join FP7, they must fund them to help them join consortia and give incentives to European groups to work with Argentineans.

3.1.2 MEMS group

Dr. Hernan Pastoriza is responsible for the **MEMS group, SEM and low temperature physics**. They have a clean room with different rooms (fabrication, characterisation, lithography and MEMS development and testing). They are collaborating with INVAP and aim to get closer to industry. The group studies nanostructured conductors and the behaviour of small particles, including periodic phenomena. A major task is fabrication of samples.

They have a lithographic system, a SEM down to 50 nm, and microscopes. They investigate the structures and properties of Josephson Junctions, depending on geometry and distance. Biological motors are simulated with Pb-Cu-Pb junctions to study their movements and characteristics. The magnetic properties of small particles are also investigated. The group is attempting to make cantilevers and serpentine wires, as thin as possible to make them more sensitive.
There is collaboration with the company MEMSCAP (USA). They don't have good MEMS fabrications facilities, but there are good facilities for educating the students.
Nanotubes are placed between electrodes to measure electrical resistance, depending on the electromagnetic field. This is done in collaboration with a group in Buenos Aires, who want to know the electrical resistance. The nanotubes of 0.5 to 9 microns are made in CNEA in Buenos Aires, and the MEMS group at CAB is studying the properties.
The microscopes are not only used in the group's own research, but also for characterising samples of many other research groups. There is e.g. collaboration with Barcelona for characterising lines on semiconductor surfaces and Raman spectroscopy. The pattern is made more or less dense and varied in other ways.
The group also studies high TC films with 100 nm thin lines and structures, to determine electron transport.
Lithography instruments are used for making oxide and magnetic thin films. The magnetic and non-magnetic layers are deposited by sputtering in argon plasma. A thermic evaporation machine is used for depositing submicrometric particles of Noble metals. They also have a reactive material plasma etching machine, attacking the surface chemically and physically.

The low temperature lab studies properties at the nanoscale. A magnetometer is used to determine magnetic properties. Ovens are available for making ceramic materials and very pure small particles. A PhD student work on this. The cryogenic equipment is working at Liquid Helium temperatures, and other techniques are available for reducing the temperature further. All equipment has been made by the technicians in the CAB, except the magnetometer. The liquid Helium and Nitrogen is produced for CAB and INVAP researchers.

The MEMS group has collaborated with INVAP in an infrared system, for which patent is pending.

3.1.3 Magnetic Materials

Dr Roberto Zysler is responsible for the lab on **Magnetic Properties of Materials.** www.cabrem4.cnea.gov.ar The group consists of 14 senior and junior researchers, plus post-docs and PhD students. 25-30 papers are published annually, mainly in Resonancia Magneticas. The research is divided in 2 areas:

- Bulk magnetic systems (Perovskites) and
- Magnetic nanosystems (nanoparticles, wires, tubes, films and multilayers). They study basic phenomena of transport properties, Hall effects, etc. for future applications.

The research on magnetic nanoparticles focuses on magnetic order and anisotropy of surfaces. They also study secondary aspects including the magnetoresistance of Perovskites. The group is collaborating with biologists for biomedical applications and is looking for chemical partners. They aim for acquiring good quality particles. The magnetic nanowires studied are both metallic and general. The nanotubes are manganites. The films include granular, metallic, manganite, magnetoresistant, pillars and magnetic semiconductors.
The labs facilities include:

- Sample preparation, needed to control the properties of the samples. Most samples are self-made. They don't offer sample preparation to others except as part of collaboration. They collaborate with other departments in CAB, Argentina, Spain, France, Italy and Germany in bilateral projects, not in the EC Framework programme;
- Magnetic Properties: determining the complete scope of properties in well equipped labs for studying microscopic systems and the specialisation magnetic resonance. They look for partners with equipment they lack themselves, e.g. for access to synchrotrons in Argentina, Brazil (Campinas), Sweden and Trieste, Italy.

The equipment is being expanded.
A new chemistry lab is being built, which will open next year. This will be used for chemical synthesis of antiferromagnetic and ferromagnetic nanoparticles. Another group makes perovskite nanotubes and nanowires. The magnetic transport properties and magnetoresistance are being measured. The properties of Vanadium oxide nanotubes are also being determined. Of multilayer structures, anisotropy and Mossbauer Effect are being studied and films are prepared in the low temperature lab. The group has a lot of experience in Electromagnetic resonance spectroscopy, determining coexistence of paramagnetic and ferromagnetic phases in nanoparticulate materials. Most of the instruments used are imported.
In collaboration with an Italian group in Rome, the basic properties including surface effects and internal organisation of NiO particles are studied, which may be applied in magnetic read/write heads. There is collaboration with Spain on Nickel Nanowires, with France on spintronics, and with the USA on MnO and Perovskite oxides. The funding is from national and bilateral research funds in Italy, France and Germany, not from the EU. The conditions are hard, because the European partner must justify the participation of the third country participant.

3.1.4 Surface Physics

Dr Hugo Ascolani and Dr Esteban Sanchez are responsible for the **Surface Physics Group** in the Laboratory for Atomic Collisions. They do fundamental research on absorption of atoms on surfaces. The materials are organic Thiols. The group collaborates in a research network in Argentina, where they share samples and study complementary properties. The chemical-physics group of Patrito in Cordoba prepare samples of thiols and seneloles. The Physical chemistry group of Salvanezze in La Plata studies physico-chemical properties of the Thiols. The physics group in Rosario studies the theory of absorption of molecules and the Surface Physics group in Bariloche studies UHV photoemission spectroscopy etc.
The group also collaborates internationally with synchrotrons in Paris, Trieste, and with groups in Aarhus (Denmark), Madrid and the UK.
The themes they work on include:

- absorption of atoms and molecules
- formation of superstructures
- Tiols, metals and semiconductors
- Sulfur / Au (111) (basic research which receives much interest)
- Phase transitions crystallography on surfaces. Sulfur is very mobile on gold. They freeze it and look what happens. Will it form a layer or a structure?

Since the 1980s they have commercial equipment for vacuum research of materials properties, which they use to prepare samples. They collaborate with synchrotrons for characterisation. They have built their own beamlines with intermediary energies (1-100 KeV) for shear studies of the electromagnetic field to characterise surfaces. They use a VG chamber for electron

spectroscopy at varying angles. This enables good determination of the electron structure at very low current.

3.2 Institute Balseiro

According to Dr Alejandro Fainstein, the Balseiro Institute was founded in 1954. Undergraduate students have to study the first two years in another university. After this, they can participate in an annual national concourse with examinations in five or six cities throughout Argentina. The best 60 students are interviewed in Buenos Aires, leading to a selection of 35-40 students who are granted a fellowship for full-time studies at the Balseiro Institute (IB). These students will have to pass all examinations to be allowed to stay in IB. Each year, 15 physicists, 15 nuclear engineers and 10 mechanical engineers are being trained.

3.3 INVAP

Dr. Marcelo Basigalup is Deputy VP projects of the Aerospace and Government Division of INVAP. He presents his company. The high tech engineering company INVAP started 31 years ago as a spin off from the Atomic Centre in Bariloche CAB, to use research results in commercial products. The first few years INVAP stayed on the CNEA premises, and later, during the economic crisis, they bought former hotels in residential areas in different parts of Bariloche. Currently they are building R&D and assembly plants and other facilities on a central location out of town. Among these is a large clean room of class 100,000 for assembling three satellites of several metres high in the next four years. In this hall, there will be tents of class 10,000. The clean room should be finished in February / March 2008.

The company is 100% dependent on commercial projects, but owned by the government of the state of Rio Negro, which offer financial guarantees for their projects. They are also obliged to remain a publicly owned company, because they also do government and defence projects. The company works on a project basis and currently develops nuclear reactors, satellites and radar systems. They are planning to diversify in order to reduce their dependency on individual clients. They are not limited to one sector, but can work in telecommunications, energy and other sectors. 80% of employees have a technical background. They are highly flexible and able to gain expertise in new fields rapidly, e.g. nuclear engineers can also become experts in radar systems.
Dr. Pablo Abbate is Design Manager of the Nuclear Division. He explains the general structure of INVAP. The company started in 1976, and has annual sales ranging between US$30 and 70 million. Currently there are 600 employees, including ~ 350 professionals (14 PhD (incl. 9 in physics), 176 engineers, 32 scientific licensees and 140 technicians). It is an unspecialised high tech company, with expertise in optics, mechanics, nuclear technology etc. They are also advanced in simulation and computer modelling including thermal and chemical models and combustibles. The combination of many different disciplines is hard to find in one single company. They can rapidly shift from nuclear to satellite projects, because there are many overlaps in the technologies. The main clients are governments or large companies.
INVAP doesn't have own funding for R&D. If development is necessary, the client must pay for it. INVAPs advantages are the technical skills they offer at competitive prices. They don't engage in serial production, but make unique prototypes and specific solutions. The markets

they cover are nuclear, space, medical and scientific equipment, services and industrial products, government / security / defence and small projects.

3.3.1 Aerospace

INVAP designs and fabricates scientific satellites (1500 kg) since 1990. They are also going into communication satellites. For assembling the satellites they need large clean rooms. One of these halls, mainly for conventional industrial projects is already operational; a larger one for non-conventional (aerospace) projects is under construction. For the aerospace projects they need a vacuum chamber and an ageing chamber for testing materials and equipment under outer space and environmental conditions. Currently two scientific satellites are being built. The first together with NASA, the other is a national project to bring a radar system into space.

The Argentinean government has a Space plan. (See www.conae.gov.ar) They have contracted INVAP to develop Argentinean Scientific Satellites (SAC). These satellites are used for studying space radiation (SAC-B, the first one), a technological satellite to learn how to build one (SAC-A), and an optical mission incorporating instruments from other countries (Denmark, UK, France). INVAP also develops and includes photographic cameras for earth observation of water, vegetation and chlorophyll in trees in infrared and the visible spectrum, together with scientists. The mechanical, electronic and thermal design of the satellites is tested separately. A new satellite, SAC-D, is under construction and will be launched 25 May 2010, for the celebration of the 200th anniversary of the Republic of Argentina. It is a US$200 million project putting a NASA-radar for measuring ocean salinity built by the Joint Physics Lab JPL into orbit. The radar is intended for studying gulf stream paths and effects of climate change. They were looking for suppliers of platform technologies outside the USA and started cooperation with the Argentinean CONEA.

In the SAOCOM project, 2 satellites are being built for launch in 2012 for bringing an area radar system into space which can make a “photo” in another frequency range of a whole area rather than identify one specific target, e.g. for studying clouds. The ARSAT communication satellite system is in the first stage of engineering. All governments are entitled to a communication satellite. Argentina lost its satellite and has decided to bring 2 home made satellites into space. ARSAT is the company which is having it built and will exploit it. The expected launch is in 2012-13.

3.3.2 Radar

Argentina needs to build up a national radar infrastructure for civil aviation as well as controlling smuggling. INVAP is developing and building 10 secondary radars for civil aviation, to identify flights with a transponder and check their position. Afterwards they will also develop and build 10 primary radars for autonomous detection of non-declared aviation for military applications.

Five years ago, the Argentinean government gave INVAP an order to develop an Argentinean secondary radar system. In October 2007, they acquired the certification of the International Association of Civil Aviation after testing by a Belgian enterprise. The first INVAP radar is currently installed in Buenos Aires, and they are currently constructing the second. One year ago they started developing the first primary radar for controlling the Argentinean-Brazilian border, which is scheduled to be finished in four years.

According to Ernesto Calvo, INVAP and INQUIMAE are considering a collaboration project to develop ultra-hydrophobic layers on the radar system using nanotechnology.

3.3.3 Nuclear Reactors

INVAP just finished a scientific nuclear reactor for Australia. Currently they are one of three companies invited to tender for a reactor in the Energy Centre Netherlands in Petten, for producing medical radio-isotopes.
According to Pablo Abbate, the first experimental nuclear reactor of 0.5 MW was built for Argentina in 1982, followed by reactors for Peru, Algeria, Egypt and Australia. The last one cost US$180 million. They have developed a method for delivering complex projects in other countries including not only technical aspects but also organisational logistics, transport of goods and people.

3.3.4 Economic aspects

INVAP aims to compete on international markets, where competition is tough. Their disadvantage is that Argentina is not known for high technology, and suffers economic instability. The economic crisis in 2001 came in the middle of the Australian reactor project. It was difficult to work in a country without banks. The provincial government of Rio Negro and the Federal government support INVAP with financial guarantees in the absence of bank guarantees. There is a lack of bank or other private finance for investing in high tech companies in Argentina. Multinationals don't invest in R&D in Argentina, only in their own home country. Repsol bought the petrol company IPF and moved R&D out of Argentina. Cargill and Shell also don't invest in R&D here. INVAP is funded by publicly owned banks and some private banks working with states and the federal government. The rates are higher than international rates, and most financing is limited to other economic sectors. Finance is the company's main problem. Finding qualified employees is not, because they work with universities and support students in their final part of their studies, e.g. by offering internships at INVAP.

4. Buenos Aires

From 20-22 November 2007, the 2nd Max Planck Society sponsored German-Argentine Workshop on Multiparametric probes and agents of cellular function was organised at the Faculty of Exact and Natural Sciences at the University of Buenos Aires. The aim is to stimulate German researchers to come to Argentina and find out they are doing first world science in this country. On 20 November, the director of the Max Planck Society signed an agreement to establish a Max Planck Institute in Argentina, directed by Thomas Jovin.

4.1 UBA - INQUIMAE

A discussion on nanotechnology research and policies took place in Buenos Aires at the INQUIMAE Institute on Chemistry of Materials, Environment and Energy, which is part of

UBA and CONICET on 22 November 2007. The Dean of the **Faculty Exact & Natural Sciences Jorge Aliaga** is concerned about education of graduate students. European universities need human resources, and for nanotechnology, complementarity is important. Argentina is marginal in nanotechnology research.
The political situation in Argentina is uncertain. The policy goes into one direction for five years and another for the next five years. Argentina needs 30 years stability like in Brazil. Many problems are caused by the economic instability of the country. For companies, a five years perspective may be suitable, but universities aim at the long term, doing scientific research and training students. The UBA needs a technology transfer unit and an incubator in the faculty of exact and natural sciences. Currently, advanced students will focus on an academic career. A change in the academic culture is necessary, incorporating entrepreneurial skills. The faculty already has a few spin-off projects. The scientists must not manage the spin-offs, but hire a professional manager. Advanced students should work on the technology. In Santa Fe, the university also has an incubator.
Beginning of the 1970s there were a lot of science students. This fell to a minimum in 1987, and now it is still not recovered. In the past, most engineering students aimed to start their own business. Now they look forward to being employed by a big company.

4.1.1 Equipment

At the University of Buenos Aires, **Dr. Lia Pietrasanta** leads a centralised **Microscopy Lab** including 2nd hand DSM 982 Gemini X-ray microscope, Scanning Electron Microscope (SEM), 30 years old Transmission Electron Microscope (TEM) and 2 AFMs which were donations. There is a pressing need for funding research equipment and a lack of well trained staff.
The **Electrochemistry** department led by **Ernesto Calvo** includes a spectroscopy lab for in situ chemistry experiments with infrared spectroscopy instruments (SNIFTIRS). Here the lack of funding for equipment is a major bottleneck.

4.1.2 INQUIMAE

INQUIMAE is the Institute of UBA and CONICET on Chemistry of Materials, Environment and Energy. It has 30 Research Fellows and 60 students. Activities on Nanoscience:

- Molecular Electrochemistry group (E. Calvo),
- Nanostructured films (S. Bilmes),
- Fuel Cells (H. Corti),
- Biosensors (F. Battaglini),
- Nanoclusters (E. Marceca),
- Coordination Compounds (L. Baraldo),
- DFT modelling of nanomaterials (D. Scherlis),
- Surfaces, nanostructures and catalysis (F. Williams), etc.

INQUIMAE: (http://www.inquimae.fcen.uba.ar/)

4.2 Fundacion Argentina de Nanotecnologia (FAN)

The Argentinean Nanotechnology Foundation was founded in 2005 by presidential decree. It is now part of the Ministry of Science, Technology and Innovation of Argentina MINCyT and

aims to promote nanotechnology for industrial needs through innovation. This should help improve the productivity of the Argentinean economy. FAN is a private revolving fund for early stage investment in nanotechnology with a capital of $10 million. By investing in nanotechnology start-ups, FAN intends to attract other investors such as Banco Santander and Meryl Lynch. They intend to develop a good reputation in selecting promising investment opportunities, to be seen as a quality mark. The investment should contribute to Argentinean nanotechnology based products in the next few years. They also work on nanopatents, norms and standards for nanotechnology and ethics and health implications. FAN will be in charge of administration of a special new sector fund for Nanotechnology in 2008.
The contact person is Ms. Lidia Rodriguez, (lrodriguez@mincyt.gov.ar). FAN (http://www.fan.org.ar/).

4.3 Companies interested in nanotechnology

Five companies are interested in participating in a platform for nanotechnology development together with the Argentinean nanotechnology researchers: INVAP (especially for medical implants), TENARIS, DARMEX, NANOTEK and B&W.

4.3.1 DARMEX

According to **Paulo Porta**, the industrial supplier of chemical products DARMEX started in-company R&D in 2002 aimed at innovation. Clients may ask specific solutions. In 2005, they started a nanotechnology research project with four researchers: a chemist, a rubber specialist, an engineer specialising in numerical simulations and a mathematician.

4.3.2 Nanotek

An entrepreneur from the petroleum sector and the academic **Gerardo Lopez** started Nanotek in 2006 as a spin-off from an academic group which had been developing a catalytic process since 2000. The aim of the enterprise is to identify potential applications: ‘Nanosolutions to megaproblems’. 2007 is the first year they have a turnover, in 2006 they were just spending money on marketing without generating income. Currently three people are working in the company. They match with a user company, such as a paint company for developing paint with nanosilver, and then develop a market assessment and business plan.
The company has developed a nanocatalysed remediation process nanoCatox ® based on Fenton reactions. It is validated for removing wastes from cellulosis pulp, food processing, petrol and petrochemical, photographic wastes, etc. They build a pilot scale process of 3 litres and the client must upscale it. The process takes place inside an industrial reactor. They are extending the use of the process to contaminated sites, it is already approved for PCBs. They see no reason why it can’t be useful for removing other hydrocarbons in soil and subsurface water. The reaction products are Carbon Dioxide, Water and Ferric Oxide. The catalyst is nanometallic iron.
One project is aimed at treatment of contaminants including PCBs with iron-oxide nanoparticles in Paraguay. The Acaray power plant in Paraguay has contracted them to clean soil contaminated with PCBs due to a condenser explosion. They also see a large home market, because under Argentinean law, all PCB contaminated soil must be cleaned before 2010. Currently, nobody has the technology in Argentina, so the soil is shipped to France. Greenpeace opposes the alternative developed by Nanotek. The equipment comes in a container, into which the soil is introduced and separated from the pollutant. Nanotek aims to enter the market for cleaning condensators, with a higher concentration of PCBs.

They also want to develop a method for selective entrapment of heavy metals including lead at very low concentrations (<1 ppb, 5 times less than usual). This is required due to local regulations in a mining company.
The company is also working on advanced development for future products. They study nanoparticles to determine the properties, in collaboration with an association for research. There are opportunities for nanobusiness.
Nanosilver can be applied in antimicrobial paint. They cooperate with a university and the development takes place in Nanotek's lab. A manufacturer of industrial and specialty Paint Company is interested in it. The product's performance is currently being assessed under current environmental standards including ASTM standards.
In another project they develop a nanoproduction method in a textile for continuously generating nanosilver particles. This is collaboration between Nanotek, INQUIMAE and a manufacturer of specialty textiles. It is preliminary work at lab scale. They have applied for funding including a doctorate fellowship.
Nanotek is collaborating with Marta Litter of CNEA (Comision Nacional de Energia Atomica) on removing Arsenic from water. It is a problem in North West Argentina, the USA and Africa. They will present a paper in March 2008 about it. The project is 3-5 years to market.
The company is also starting collaboration with the Autonomous University of Barcelona UAB in sensor research. The aim is to enhance the response of biosensors with nanometals such as Copper, Silver and Iron. They are considering a project proposal.
Furthermore, they are starting work on nanozinc and zinc oxide for non-toxic UV barriers in cosmetics. They have done some initial lab tests to determine the properties and are looking for funding for an R&D project and an industrial partner. They also intend to apply nanosilver in polymeric blends as biocide and fungicide for food preservation. They are applying for funding for developing a business plan and seeking an industrial partner. The problem is technical: homogeneous distribution of the nanoparticles in the polymer. The advantage is that they can produce the nanosilver at half the world market price ($2800-$3000). They also have an initial agreement for a project incorporating nanosilver in filters for airconditioners together with a Spanish partner. Finally, they have an initial agreement to enhance the mechanical properties by adding nanoiron to mortar blends, together with a Colombian industrial partner.

4.4 Applied research organisations

Nanotechnology is also taking place at two national applied research organisations, the Industrial Research institute INTI and the Agricultural Research institute INTA.
According to Mr Sébastien Garnier of the Dutch embassy, a group of researchers including Daniel Lupi at INTI is interested in international cooperation in Nanotoxicology.

5. Conclusions

A number of trends in nanotechnology in Argentina spring to mind after meeting and interviewing several researchers and entrepreneurs in San Carlos de Bariloche and Buenos Aires from 19 to 23 November 2007 and studying some background materials.

Education

The new nanotechnology research network intends to educate 60 researchers. This is enough for filling the academic posts, but would not be sufficient to address a potential industrial need for trained staff.

Equipment
The CNEA Atomic Energy Centre in Bariloche is well equipped for fundamental research. The Balseiro Institute there trains 35-40 excellent physicists, nuclear and mechanical engineers each year.
The University of Buenos Aires has a pressing need for funding equipment and infrastructure.

Finance
The weak economy and lack of capital for investing in high tech enterprises hampers the development and export of Argentinean high tech companies including INVAP.

Multidisciplinary collaboration
There is little experience in multidisciplinary research collaboration. The first projects involving chemists, physicists and biologists are ongoing. There is a gap between natural sciences and engineering. Education is not aimed at multidisciplinary or entrepreneurial skills development.

International cooperation
Researchers are collaborating a lot with partners in other parts of the world including Europe. This is mostly basic science, with partners in the same field or to have access to synchrotrons or other expensive infrastructure. The funding is mostly from bilateral programmes funded by SECYT or national funds of the cooperation countries. Most (senior) researchers have made a career in science abroad and have recently returned to Argentina. The German Max Planck Institute has signed an agreement to start an affiliated institute in Buenos Aires, probably inside the new Ministry of Science and Technology.

EU funded projects
Some researchers and entrepreneurs are interested in collaborating in EU funded projects. Many are scared off by the bureaucracy and dependence on European partners who must invite them to join consortia. Their chances of success are low because the Argentinean nanoscience community is not visible in Europe. There are few contacts with complementary groups needed for multidisciplinary cooperation under FP7.

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