Infrastructure for excellence

Dr Nikos Glezos and **Professor Dimitris Tsoukalas** discuss how the use of state-of-the-art tools and expertise is leading to the creation of a nanotechnology centre of excellence

Can you begin by outlining the main objectives of the project Micro and Nano Systems Centre of Excellence (MiNaSys-CoE)?

Our main objective is to upgrade the research infrastructure and research portfolio of the Department of Microelectronics at the National Center for Scientific Research "Demokritos" in a way that would enable it to be competitive worldwide in the coming decade and maintain its role and influence in Greece as the reference centre in the field of fabrication of micro/nano systems. The objectives will be implemented by transnational two-way exchange of research staff between the Department and the selected centres, hosting experienced researchers with relevant expertise from all over Europe.

As a National CoE in nanofabrication, nanoelectronics and microelectromechanical systems (MEMS), what are some of the greatest discoveries the Department has made?

To mention a few, we have explored integrated optical or mechanical silicon transducers with integrated readout; plasma-etched smart microfluidics with controlled wetting properties; lab-on-a-chip system integrating electronics and microfluidics suitable for point-of-care diagnostics and analysis; sensors able to recognise a variety of gases operating similarly to an electronic nose; energy harvesting devices; and new concepts for the realisation of low-power electronic memories made either from silicon or organic materials. These achievements pave the way for future developments in the Department, where autonomous microsystems harvesting energy from different sources will be developed.

How will a dedicated electron beam lithography tool facilitate the work of the Department? What possibilities will the tool open?

Due to the different fields of research that were being pursued in our Department, we had some very special demands for the new patterning system. It not only had to be capable of operating in a multi-user environment, but also had to provide high-class and efficient nanolithography in all areas of our activities, spanning nanoelectronic devices, sensors, MEMS and nanofluidics.

The EBPG5000plusES is the perfect match for these requirements and it will allow the Department to further improve its position at the forefront of nanotechnology. Moreover, the system incorporates an interactive graphical user interface (GUI) that provides ease of use for diverse 'multi-user environments'. The tool will not only enable the Department to maintain its leading role in national nano-research, but also to participate in European research projects, networks of excellence and technology platforms at the highest level.

How important has EU funding through the Seventh Framework Programme (FP7) been to the project, particularly given Greece's current economic situation?

FP7 funding to MiNaSys-CoE has been particularly important as it has promoted the development of unique research infrastructures in Greece, with long-term benefits in technology-driven sectors that may have significant impacts on economic growth. EU funding has also reinforced the presence of the Department at the national and European levels and its collaboration with major R&D centres and industry.

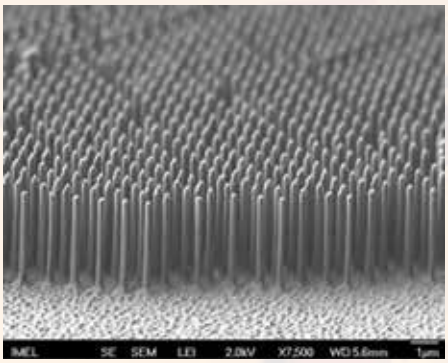
We hope that MiNaSys-CoE's technological development will be further sustained by innovative Greek programmes in science and technology in order for Greece to ensure the development, as much as possible, of a competitive economy based on its own technological capabilities.

Would you say that research at the nanoscale is sufficiently well-reported in the media?

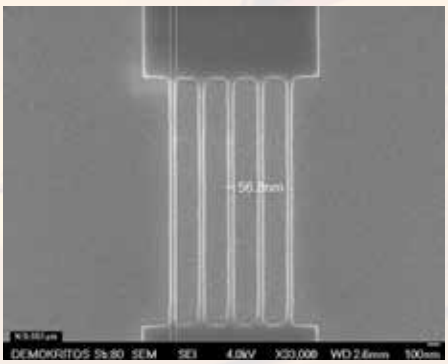
In the Greek media reports on nanoscale research are scarce. Even in the few cases where such information is highlighted, it is mostly either a translation of reports, transmitted by international news agencies, or a simplistic exposition of the activities of some individual Greek professors. We believe that researchers working in the area should make it a priority to inform members of the broader scientific and industrial community of the specific opportunities for exploitation offered by the nanoscale research they are involved in.

What dissemination and networking activities will be organised by MiNaSys-CoE and who will they target?

We are organising four international workshops to attract leading scientists in the field from around the world. This will allow us to exchange views with external scientists who can evaluate the progress of our project, give advice for overcoming any difficulties or even enlighten our research with new innovative ideas. Furthermore, we will invite representatives from selected small- and medium-sized enterprises and large industrial laboratories in Europe, as well as other specialists that can provide valuable advice for the further improvement of our techniques.



FOREST OF SILICON NANOPILLARS



SILICON NANOWIRES

Giant leaps in microscopic technologies

The establishment of the **Micro and Nano Systems Centre of Excellence** in Greece is offering social and economic rewards through the advancement of micro- and nanotechnologies

THE RELATIVELY NEW field of microelectronics has played a central role in the technological revolution that has reshaped how people live their lives. As the name suggests, microelectronics relates to the microfabrication of extremely small electronic designs and components, made from a semiconductive material, traditionally silicon. With innovations in microscopy, scientists are now able to work at previously unimaginable scales. Typically ranging between 1-100 nanometres (nm), this rapidly advancing field is opening up novel technologies, processes and high-value products that are finding surprisingly diverse applications.

INVESTING IN THE FUTURE

Perhaps most commonly recognised in the development of the microchip, which forms the basis of modern computing power and is utilised in all of the modern electronic devices we have become accustomed to, the microchip allows for an ever-increasing amount of components to be integrated onto a single chip. Previous to its invention in the early 1960s, separate large transistors, resistors, capacitors and of the associated connective wiring were required to complete even a basic circuit system. While these micro- and nanotechnologies have graced the computer and telecommunications industries with a staggering pace of advancement, nanotechnology is now being utilised in many sectors of industry and research, including energy, environmental science, medicine and food safety, with new applications that benefit society being pioneered every day.

Representing one of the fastest growing technologies, it is perhaps not surprising that governments and financial institutions around the world are investing heavily in micro- and nanotechnology. Indeed, it is estimated that in 2008 the US assigned over $1 billion to the new science. In an increasingly competitive global market, it is clear that investment in state-of-the-art facilities required for R&D in this field will be vital to enable nations to reap the social and economic rewards on offer.

A NEW CENTRE OF EXCELLENCE

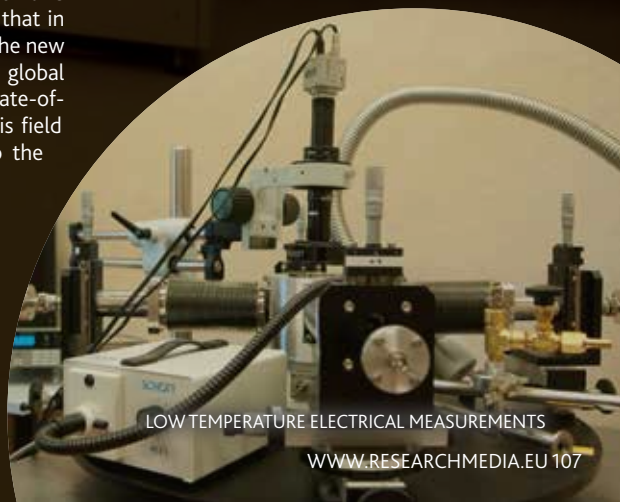
To this end, Professor Dimitris Tsoukalas and Dr Nikos Glezos of the Department of Microelectronics (D-MEL) in Athens, Greece are leading a project to establish the Micro and Nano Systems Centre of Excellence (MiNaSys-CoE). The main goal of the programme is to enhance and improve the capabilities of the Department so that it can act as a reference centre in the field of fabrication of micro and nano systems, building on its already considerable success. Glezos wants to reinvigorate the research infrastructure in order that D-MEL maintains and expands its position as a leader in micro- and nanotechnologies. "Innovative and competitive research in micro- and nanotechnologies requires advanced technological equipment which is, in principle, expensive and needs to be continuously upgraded," explains Tsoukalas.

Established in 1986 as one of eight independent research institutes associated with the National Centre of Research (NCSR) "Demokritos", the mission of D-MEL is to perform medium- to long-term research into nanotechnology. Running for over 25 years, the Department has cemented itself as the primary organisation in Greece to go to for its comprehensive capability in micro and nano system fabrication and testing, while simultaneously acting to support related educational activities, alongside crucial collaborative efforts with industrial partners.

NEW SYNERGIES

The Department is particularly well-positioned to foster young scientists entering the field: "D-MEL participates very actively in educational programmes by providing special courses and laboratory training," Glezos highlights. "The important expertise and know-how of its researchers play a crucial role in postgraduate education, preparing the next generation of researchers in the country." Moreover, recognising the

THE NEW ELECTRON BEAM LITHOGRAPHY SYSTEM WITH WRITING CAPABILITY DOWN TO 8 NM



LOW TEMPERATURE ELECTRICAL MEASUREMENTS

INTELLIGENCE

MiNaSys-CoE

OBJECTIVES

- To extend and improve the existing facilities and know-how at the Department of Microelectronics (D-MEL) of the National Centre for Scientific Research (NCSR) "Demokritos", Greece
- To organise and coordinate access to the infrastructure at regional, national and EU levels
- To conduct dissemination and networking activities in order to foster collaborations with countries in southeastern Europe in the field of nanofabrication, nanodevices and sensors

KEY COLLABORATORS

École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Institut de Microelectronique et de Nanotechnologies, Lille, France

Tyndall Research Center, Cork, Ireland

CNR-Instituto di Fotonica e Nanotechnologie, Rome, Italy

Electron Microscopy for Materials Science, Antwerp, Belgium

Centre d'Elaboration de Materiaux et des Etudes Structurales, Toulouse, France

IMEP-LAHC, **MINATEC**, Grenoble, France

FUNDING

EU Seventh Framework Programme (FP7)

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PROFESSOR DIMITRIS TSOUKALAS coordinates the MiNaSys-CoE project. He is currently Professor at the National Technical University of Athens (NTUA), where his research focuses on electronic materials and devices. He holds an Electrical Engineering diploma from NTUA and a PhD from Grenoble Institute of Technology.

DR NIKOS GLEZOS is the Research Director currently in charge of D-MEL. He is active in the fields of electron beam lithography process and simulation, molecular electronics and organic electronics.

diversity of applications, they have forged long-lasting alliances with other Departments of the NCSR "Demokritos", creating a synergistic approach that is fundamental to their success.

At the European level, D-MEL is regarded as one of the most competitive organisations in its field on the continent, regularly opening its doors to researchers from across the EU and sharing its facilities, which include a 300 m^2 clean room equipped with patterning, doping and thin film depositing instruments capable of producing and exploring microscopic devices. Their central position in Europe is underlined by their status as one of the founding members of the European Silicon-based nanostructures and nanodevices (SiNANO) Institute, which was established in 2007. Furthermore, the Department is a key contributor to the EU Seventh Framework Programme (FP7), which aims to meet nanoscale needs in ICT, materials and production processes (NMP), health, environment and energy sectors. D-MEL's involvement in FP7 reflects its world-class standing, having important research findings reported in high-impact journals, and being issued with related patents.

STATE-OF-THE-ART TOOLS

EU funding has been instrumental in the creation of the MiNaSys-CoE project, having received a three-year grant from the REGPOT (Research Potential) stream. The funding has enabled D-MEL to purchase a state-of-the-art electron beam (e-beam) nanolithography tool with lithographic capabilities down to 8 nm. This device provides the team with the critical capabilities to carry out some of the most advanced work within the sphere of nanotechnology, including the exploration of nanoscale devices such as nanowires – which constitute the building blocks of future nano systems.

Tsoukalas and his collaborators hope to integrate further high-class tools into the CoE to enable them to maintain and increase their status in the nanotechnology world, including a new plasma etching system for creating high aspect ratio features in silicon for microelectromechanical systems (MEMS) and atomic layer disposition equipment for making nanoscale insulating materials, which are critical for modern semiconductor devices.

CVD THIN FILM DEPOSITION

THE RIGHT PERSONNEL

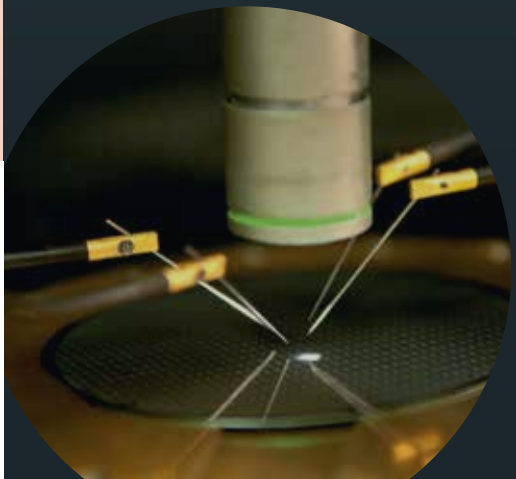
Beyond its emphasis on state-of-the-art tools, the MiNaSys-CoE team intends to grow in terms of human resources. The recruitment and training of experienced researchers with expertise in e-beam tool operations and nanostructure imaging, alongside the secondment of staff to well-recognised research centres in order to exchange know-how and to further collaborative efforts, is a high priority: "Our visits to these centres are intended for us to become acquainted with sophisticated nanofabrication techniques and apply the experience acquired in our laboratories," outlines Tsoukalas.

Additionally, the researchers intend to continue an open door policy, inviting collaborative institutions with the desire to 'tune-up' their basic e-beam processes to the new CoE, allowing the exchange of knowledge to be used as a basis for future research.

ECONOMIES OF SCALE

It is clear that the experience forged from decades of working at the forefront of integrated circuit R&D leaves the Department poised to take a lead in a world of miniaturised computers, personalised healthcare devices and complex telecommunications. Moreover, as Greece has no history of traditional manufacturing, the new industries centred around microelectronics offer a fresh source of revenue for a country in particular need of financial growth: "Greece faces unprecedented economic challenges that can benefit from innovation in many areas of science and technology for which the country possesses strong institutions and human potential," expounds Tsoukalas.

With a wealth of talented young researchers potentially benefiting from the work at D-MEL, MiNaSys-CoE is offering real hope for greater regional development both at national level and within southern Europe.



DEVICES UNDER TEST