Swiss Research Program Nano-Tera .ch

Engineering Multi-Scale Systems for Health, Security, Energy and the Environment

Activity Report 2015

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NANO-TERA.CH: FUNDING RESEARCH IN SYSTEMS ENGINEERING

Prof. Giovanni De Micheli
Nano-Tera.ch Program Leader,
Executive Committee Chair

Nano-Tera.ch is a national funding program supporting research in engineering of complex (tera-scale) systems for health and the environment using nanotechnologies. Energy and security issues are also investigated as crucial transversal themes for system design.

Nano-Tera.ch funding is open to all Swiss research institutions according to the corresponding legislation and its mission includes research, development and technology transfer, as well as education and dissemination. In particular, Nano-Tera.ch puts a special focus on PhD students by providing them with a specific training, the Nano-Tera.ch NextStep program, targeting collaborative research and the economic exploitation of scientific results.

Moreover, Nano-Tera.ch fosters collaboration among researchers and industries that are partners or supporters of the research projects. In this perspective, Nano-Tera.ch strongly contributed to the design of Bridge, a new concept for jointly funding research and pre-competitive technological innovation that will be deployed by the Swiss National Science Foundation (SNSF) and the Swiss Commission for Technology and Innovation (CTI) in the form a novel common funding instrument for the period 2017-2020.

The Swiss National Science Foundation (SNSF) also contributes to the Nano-Tera.ch program by evaluating and monitoring the large research projects through an international panel of experts, thus ensuring the high scientific quality of the program.

Nano-Tera.ch strives to enable mechanisms that can map the high productivity of research ideas, publications and patents of the Swiss community into a significant momentum in terms of industrial growth as well as job and enterprise creation. To further strengthen its contribution to this goal, Nano-Tera.ch has joined efforts with CSEM and EMPA and created a specific funding instrument, the Gateway program, intrinsically positioned at the frontier between research and innovation. Gateway aims at the translation of research results obtained within Nano-Tera.ch projects into industrial demonstrators directly exploitable by the industrial partners involved in the Gateway projects.

NANO-TERA.CH: SWISS EXCELLENCE IN RESEARCH

Prof. Heinrich Meyr
Nano-Tera.ch
Scientific Advisory Board Chair

The Scientific Advisory Board reviews the Nano-Tera.ch program as a whole and provides criticisms and suggestions for its future growth. The Board regards the Nano-Tera.ch program as a unique blend of technology exploration and system design. The scientific and industrial challenges studied in the program are related to exploiting micro and nano components within complex systems whose added value is much larger than the sum of their parts. A notable example is networked sensors for medical and environmental applications. Networking boosts the intrinsic power of local measurements, and allows us to reach new standards in health and environment management, with positive fallout on security of individuals and communities.

Smart and diversified energy generation, such as harvesting and low-power system design are of the utmost importance to society and the economy. Truly innovative approaches are needed, that can only be found by massively investing in engineering research. Thus the Board lauds the extension of the Nano-Tera.ch scope to include energy as an application area.

The upcoming scientific and engineering challenges are too heterogeneous and complex to be solved within a single scientific domain. They require a truly collaborative and crossdisciplinary approach. The Nano-Tera.ch program brings together excellent researchers in various fields from many Swiss institutions with outstanding reputation.

The program is not only of high scientific value but also of eminent economic importance for the industrial sector of Switzerland. The program serves as the seed for truly innovative products and industries. It also fosters the education of highly-qualified engineers and researchers who are the most valuable and indispensable resource of this country.

EXECUTIVE SUMMARY

Nano-Tera.ch is a Swiss national program supporting research in multi-scale system engineering for health, security, energy and the environment. The broad objectives of the program are to improve quality of life and security of people and to create innovative products, technologies and manufacturing methods, thus resulting in job and revenue creation.

Launched in 2008, Nano-Tera.ch is one of the largest federal programs funding research in engineering sciences. It is a strongly established program which has been supporting about 140 projects for a total budget of more than 250 MCHF. The 1200+ staff members active in Nano-Tera.ch projects represent 50 research institutions which constitute an almost exhaustive coverage of the Swiss scientific community in the program's fields.

The research funded resulted in more than 1000 peer-reviewed publications (40% of which in established journals) and numerous prototypes and demonstrators, a tangible sign that the program focuses on concrete collaborative research leading to potentially exploitable results.

Building upon this success, the program is further pursuing its main objectives: excellence in collaborative research in engineering disciplines, educational programs, design of applied demonstrators, and transfer of acquired research results to the Swiss industry.

There are currently 25 large (3- or 4-year) research projects running, complemented by 9 focused (2-year) projects and 24 educational activities.

The research carried out in the program explores various key thematic areas. Smart prosthetics and body repair covers topics ranging from image-guided micro surgery for hearing aid implantation, to tactile prosthetics as well as spinal cord neuroprosthesis for restoration of locomotion. Health monitoring addresses the use of smart textiles for monitoring long-term obesity, smart bandages, newborn care, and personalized therapeutic drug monitoring. Innovative medical platforms include flexible MRI detectors, cancer diagnostic using cantilever sensors, or high-performance portable 3D ultrasound platforms, among others. In addition to these health-related challenges, Nano-Tera.ch also tackles important issues in environmental monitoring, with technologies such as distributed sensor networks for air quality monitoring or natural hazard detection, multi-color lasers analyzing greenhouse gases or aquatic robots tracking water pollutants. Finally, Nano-Tera.ch has been focusing on the crucial theme of smart energy, with projects addressing ultra-high performance photovoltaic cells, economically viable renewable energy production through solar-hydrogen generators, or smart power grid monitoring and management.

To strengthen its impact on the training of highly skilled staff for the Swiss research and economy, Nano-Tera.ch is running a specific 'NextStep' action, designed to help PhD students explore possible ways to exploit their scientific skills. In particular, Nano-Tera.ch is providing coaching to PhD students to incite them to consider economic exploitation of their scientific results, has opened research grants to fund collaborative research exclusively involving PhD students, and is organizing a "My Thesis in 180 Seconds" contest to train PhD students to present their research to a larger audience outside their field.

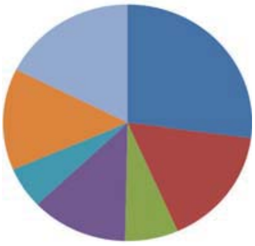
From an industrial perspective, most of the running RTD projects receive support from industrial partners and hospital end-users: in total, 44 industrial partners are involved in the Nano-Tera.ch RTD projects, for a total of 3'753'001 CHF of in-cash and in-kind contributions and 15 hospital partners are contributing 5'212'812 CHF to the projects. Furthermore, 19 patent applications have already been filed so far in the new projects.

The impact on the Swiss industry has been further strengthened by the latest Nano-Tera.ch action, the Gateway pilot program, initiated in order to transfer research results toward the Swiss industry. Concretely, 4 projects have been launched, involving laboratories, institutions specialized in technology transfer (EMPA and CSEM) as well as industrial partners. The goal of these projects is to convert the laboratory prototypes resulting from Nano-Tera.ch research projects into industrial demonstrators with high economic potential directly exploitable by the involved industrial partners.

Detailed information about Nano-Tera.ch can be obtained on the Nano-Tera website (www.nano-tera.ch), which represents one of the main dissemination channels for the program, with over 100,000 page views from more than 140 countries.

INTRODUCTION

Partner distribution by institution



Partner distribution by discipline

The objective of the Nano-Tera.ch program is to support research, design and engineering of complex systems and networks using micro/nano-technologies. More precisely, the program aims at identifying and fostering potential synergies between micro/nano component technology (the "nano" part) and large-scale system design (the "tera" part) to meet the growing need for complex engineered solutions to socially relevant issues related to Health, Security, Environment, and Energy. Examples of such issues are detecting in real time different health risks and conditions through integrated bio probing, revealing security risks through smart buildings and environments, continuous ambient sensing through low/zero-power electronics, or detecting and monitoring environmental hazards such as floods or avalanches. Embodiments of such solutions will typically take the form of lightweight, mobile and personalized products embedded in the environment and on/in the human body.

To meet these objectives, Nano-Tera.ch supports three main types of projects:

Research, Technology and Development (RTD) projects, representing about 80% of the Nano-Tera.ch activities, are large integrated, interdisciplinary research projects involving a collaboration between two (or more) research groups, preferably from different institutions. RTD projects typically focus either on the in-depth study of a particular vertical technology or on the development and implementation of a horizontal application area. The expected duration of RTD projects is 3 or 4 years, with total budgets in the range of 1-2 MCHF/year.

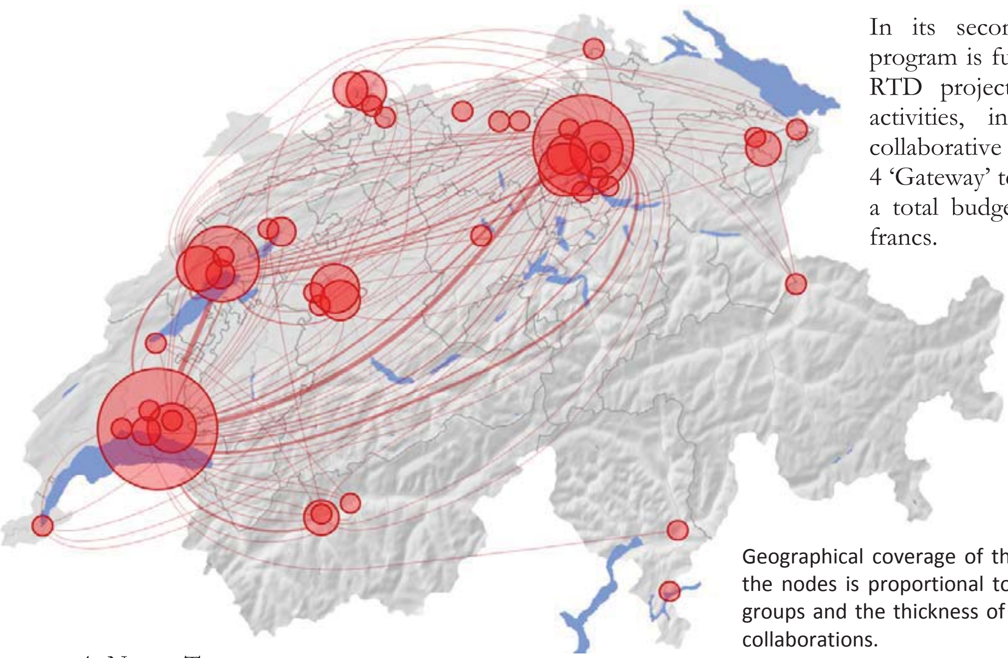
Nano-Tera Focused (NTF) projects are small-scale research projects addressing specific scientific/technical issues and needs. Their typical duration ranges from one to two years, with total funding of around 100-200 kCHF.

Education and Dissemination (ED) activities correspond to actions aiming at supporting short courses, workshops, mini-conferences, and developing new curricula in domains covered by Nano-Tera.ch that are not provided by Swiss Universities or Polytechnics. ED activities may address the in-depth study of a technology or interdisciplinary horizontal activities, and their typical funding level is in the range of 15-30 kCHF.

The Nano-Tera.ch program is funded by the Swiss Polytechnic and University Boards (ETH Board and CUS), under the supervision of the Swiss Secretary of Education and Research (SER). The Swiss National Science Foundation (SNSF) evaluates and monitors Nano-Tera.ch research projects through an international panel of experts.

Overall Results, Phase II (2013-2016)

In its second phase, the Nano-Tera.ch program is funding 62 research projects: 25 RTD projects, 9 NTF projects, 17 ED activities, in addition to 7 'NextStep' collaborative projects for PhD students and 4 'Gateway' technology transfer projects, for a total budget of about 134 million Swiss francs.



Geographical coverage of the Nano-Tera program. The size of the nodes is proportional to the number of involved research groups and the thickness of the links measures the number of collaborations.

These projects are carried out by consortia of 3 to 10 research groups, building a network of 37 Swiss research institutions, involving more than 600 staff members. As illustrated by the map, this network represents a very dense geographical coverage of Swiss research institutions.

Scientific Dissemination

Publications

In terms of scientific dissemination, the funded research has generated about **195 new publications** in the past year, bringing the total number of publications of Nano-Tera's second phase to **315**. The distribution of the publications by publication type (journals or conference proceedings) is given below.

Journal and book publications	111
Conference proceedings	204
Total	315

Conferences and workshops

Almost **600 presentations** at conferences and workshops have been given (about 40% of which were invited oral presentations, the rest being other oral presentations or posters), and the projects have led to several presentations in the media (television, radio, press).

Awards

This year, **11 awards** have been received by Nano-Tera researchers, for best presentations, thesis or paper, bringing the total for Phase 2 to **17 awards**.

Collaboration with the industry and patents

Most RTD and Gateway projects receive support from various industrial partners and hospital end-users. In total, **44** industrial partners are involved in the Nano-Tera.ch RTD projects, for a total of 3.8 million CHF of in-cash and in-kind contributions and **15** hospital partners are contributing 5.2 million CHF to the projects.

	Industrial partners	Hospital end-users
Number of partners	44	15
Number of projects with partners (of 29)	22	10
Contributions (MCHF)	3.8	5.2

Furthermore, **11 patent applications** have been filed for results related to the Nano-Tera.ch projects this year, bringing the total for Phase 2 to **19 patents**.

MAIN SCIENTIFIC ACHIEVEMENTS

Nano-Tera.ch supports 25 collaborative 3- and 4-year 'RTD' projects, uniting teams right across the country. Health-related themes feature strongly among the research subjects selected, with strong participation from university hospitals and doctors. The themes related to environmental monitoring and energy are also taking pride of place.

As with previous calls for proposals, the key domains of Nano-Tera.ch (Bioengineering and Electronics) are well represented in this selection. What is new compared to the earlier phase of the program is the arrival of research topics combining engineering with life sciences, medicine and energy.

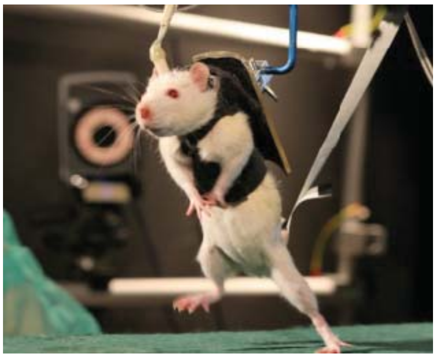
A STRONG FOCUS ON HEALTH APPLICATIONS

The university hospitals and the specialists that thrive there, such as specialized surgeons, neurologists and cardiologists, represent about a fifth of all co-investigators involved. The CHUV, the InselSpital of Bern, the University Children's Hospital in Zurich, the University Hospitals of Basel and Zurich and the Hospitals of Schaffhausen are all bringing their knowledge and expertise to the research of the Nano-Tera program. Research with health-related applications can be loosely arranged in three distinct thematic clusters:

SMART PROSTHETICS AND BODY REPAIR

Smart prosthetics and body repair is an integral part of the program, with projects addressing tactile prosthetics and other sensorimotor functions (in particular after spinal cord injury), smart muscles for incontinence treatment or micro surgery.

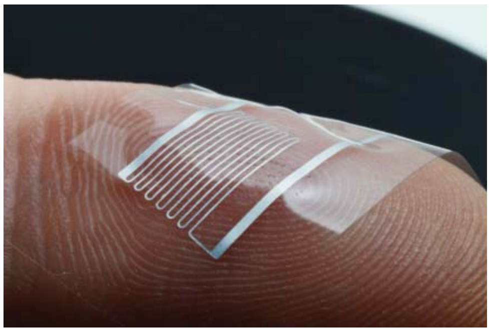
Image-guided micro surgery for hearing aid implantation. The project HearRestore is developing novel robotic technologies to drastically reduce the invasiveness and improve the outcome of cochlear implant surgery. The project specifically aims to increase the safety of the procedure through the implementation of advanced surgical planning/image analysis, non-invasive registration, modeling/prediction of bone drilling, neuromonitoring, and nanometer tracking. The major highlight of the project is the successful transfer of the base technology to clinical use. The project has obtained regulatory clearance for a first in man clinical trial. Additionally, a live animal study was launched in collaboration with all four partner institutions, which offered a unique opportunity for each of the project partners to make individual in-vivo measurements with direct impact on their individual sub-tasks. Extensive electromyography measurements were conducted with varying and controlled stimulation protocols along with both in-situ impedance measurements and drilling temperature measurements.



High-performance spinal cord neuroprosthesis for restoration of locomotion after spinal cord injury. The goal of the SpineRepair project is to develop and optimize the enabling technologies to implement a cutting-edge spinal cord neuroprosthesis, allowing victims of paraplegia to recover partial mobility. Prototypes of the novel integrated devices are evaluated in animal models. So far, the team has demonstrated the first biointegrated spinal implant capable of concurrent delivery of biochemical and electrical stimulation of the spinal cord, and so without damaging the underlying delicate tissue of the spinal cord. The implant, called electronic dura mater, matches mechanically the response of the native dura mater, the protective skin of the spinal and cord and the brain. The implant is so compliant that it was surgically positioned below the natural dura mater and enabled efficient neurostimulation of the spinal cord after weeks of implantation. Using e-dura, the SpineRepair team was able to restore leg motor control in paralyzed rats. In view of the final spinal neuroprosthetic system, the team has also designed and tested the first generation of a customized CMOS chip to transmit, adjust and control precise stimulation patterns to the spinal implant electrodes. Upcoming experiments will aim at integrating the electronic hardware with the spinal electrode arrays.

Use of superparamagnetic nanoparticles for the detection and treatment of cancer. Indeed, such particles are used as contrast agent for MRI, especially for the liver, and as heat sources for the treatment of tumors (magnetic hyperthermia). The goal of the project MagnetoTheranostics is to combine both applications using optimized particles for imaging and heating in an alternate magnetic field. So far, the team has been developing the unique synthesis method which enables the manufacturing of superparamagnetic iron oxide nanoparticles in a very reproducible way. The particles, which show a narrow size distribution, were successfully used for the preparation of injectable formulation foreseen for the treatment of primary tumors. On the biological and medical side, the animal model was determined and the most promising antibodies/epitopes for a high specificity of particle adsorption tested in vitro. The results showed that the functionalization of the nanoparticles with the selected antibodies is successful. On the engineering side, the construction of the magnetic field generator is well advanced, a second prototype is under construction.

Cutting-edge technology for the next-generation of artificial muscles. SmartSphincter is studying smart muscles for incontinence treatment and involves hundreds of thousands of low-voltage, dielectric, electrically activated nanometer-thick polymer layers. Already, the researchers have found two promising alternatives to conventional stiff metal electrodes for the polymer actuators and shown that they are able to power them for 10 days without recharge from available lithium ion cells. The team has also successfully applied to their local ethical committee for a full pilot study involving 10 male and 10 female participants. By summer 2015, several participants had signed up for the study from which seven male subjects have been assessed. The analysis of the data has proven the conclusion drawn based on the pre-pilot study. Looking towards the future, the team has designed a system for fabricating multiple layers of nanometer-thin actuators using physical vapor deposition in ultra-high vacuum, and are currently proceeding with its realization.



Wise skin for tactile prosthetics. Amputation of a hand or limb is a catastrophic event resulting in significant disability with major consequences for daily activities and quality of life. A sense of tactility is needed for providing feedback for control of prosthetic limbs and to perceive the prosthesis as a real part of the body, inducing a sense of "body ownership" and a natural sensation of touch. The idea of the WiseSkin project is to provide a non-invasive solution for restoration of a natural sensation of touch by embedding miniature tactility sensors into the cosmetic silicone coating of prostheses, which acts like a sensory "skin". Already, a first sample of the artificial skin was developed. Regarding the stimulation and sensor feedback concept, the team has investigated algorithms to achieve intuitive and versatile control of hand prostheses by detecting hand movement intentions by real-time recording and processing of surface electromyography signals.

HEALTH MONITORING

Nano-Tera focuses on personalized health management through the use of implanted devices, smart textiles and intelligent drug monitoring systems. Application targets are in the fields of monitoring of obesity and neonatology, among others. Like in the initial phase of Nano-Tera, the area of health monitoring and personalized health management is well covered, with several projects addressing different research avenues, such as:

Monitoring the consequences of obesity. ObeSense is combining innovative and non-invasive sensors into single monitoring systems integrated in smart textiles for the long-term monitoring of overweigh/obese patients. The physiological sensors include respiratory rate and volume, energy expenditure, blood pressure and cardiac output and are to be integrated into stand-alone comfortable systems using both low power electronics and smart textiles. Regarding the monitoring of the respiratory rate and volume, transparent flexible polymer-optical fibers have been integrated in a smart T-shirt and successfully tested. Near infrared spectroscopy is being developed to measure the arterial and venous oxygen saturation, important parameters to determine energy expenditure. An application for cell phones and tablets has been developed, which communicates with the sensors and shows the physiological parameters. A non-occlusive blood pressure sensor setup has been designed: verification of the prototype and validation over 10 healthy subjects has been completed

Monitoring of the healing of chronic wounds. The research consortium of FlusiTex is fabricating a sensing wound pad that can be used for non-invasive wound monitoring based on integrated fluorescence coupled biosensors, and which is likely to find broad applications in strongly growing fields such as health care and medtech. The metabolites playing a key role in wound healing have been identified, and the team has designed a strategy to integrate those markers into commercially available wound pads. A compact optical setup for real-time wide-field fluorescence lifetime imaging in the nano- to microsecond range was developed.

A system on a chip to make medical devices wearable. For both in- and outpatient applications, the electronic interface to typical sensors and electrodes still has a size and weight that prevents it from being used in the convenient and flexible way. Integration of the plethora of functionalities required in a wearable medical monitor, including the management of wireless connectivity, holds the key to the breakthrough required for clinical and user acceptance. This is why WearMeSoC is developing a chip that will enable very small wearable medical monitors with wireless connectivity to small phones and tablets. So far, a modular and multi-functional hardware prototype has been evaluated successfully and a miniaturization of the multi-functional device has been targeted. A first prototype of a medical monitoring SoC based on a parallel ultra-low power (PULP) multi-core processor has been developed and successfully evaluated. Finally, a first prototype of a battery-operated biomedical implant device including a wireless link with the dimensions below 1cm^3 has been realized.

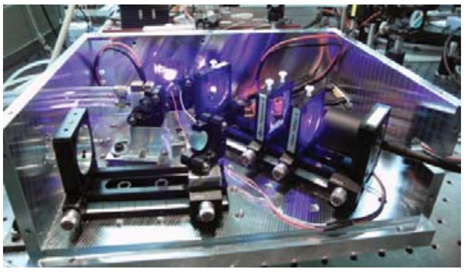
MAIN SCIENTIFIC ACHIEVEMENTS

Newborn monitoring based on multiple vision sensors. The increasing number of parameters to monitor and the sensitivity of current sensors to body movement are responsible for unacceptably high rates of false alarms in new born monitoring. NewbornCare seeks to drastically reduce the false positive alarms by using a computer vision-based approach to estimate accurately the heart and respiratory rates in a contactless fashion. First prototypes of sensors have been created, that translate the intensity of travelled-through-tissue, near-infrared light to create and visualize information on the brain tissue oxygenation in real time. The sensors are attached to the head of a newborn by a proprietary headband.

Therapeutic drug monitoring for personalized medicine. The ISyPeM II project is developing a technological platform to improve medical practice by enabling personalized medicine via therapeutic drug monitoring, while reducing healthcare costs. It is exploring new sensor technologies, hardware and software data processing means, and drug release mechanisms based on silicon membranes. This will provide a comprehensive integrated approach to Therapeutic Drug Monitoring which combines innovative point-of-care compatible assays, prescription decision support and interoperability in a complex data-sharing scenario. The software user-interface for therapeutic drug monitoring, which features the possibility to visualize the concentration curve, percentiles for population data and patient specific parameters has been validated for several drugs and it currently employed by pharmacologists at CHUV.

MEDICAL PLATFORMS

In this new phase, Nano-Tera.ch is developing several medical platforms, notably a next-generation, high-quality, mobile ultrasound imaging device and elastic, lightweight MRI detectors that patients can wear like a piece of clothing. The research covers several fields of medicine, such as oncology.

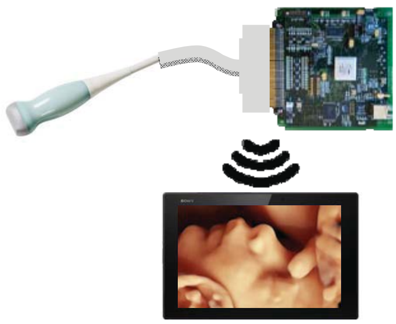


Novel semiconductor disk lasers for biomedical and metrology applications. In a follow-up to the original MIXSEL project, MIXSEL II is consolidating its high-power ultrafast semiconductor laser technology. The goal is to develop prototype demonstrators for end-user demonstration in biomedical imaging, compact efficient white light generation for general high brightness illumination and frequency metrology applications. So far, the project has reduced the pulse duration of MIXSELs to 253 fs in 235 mW of average output power at 3.35 GHz repetition rate. The first biomedical imaging experiments were performed.

Wearable ICT for zero power medical applications. Keep your friends close, but keep your medical sensors closer: such could be the motto of the BodyPoweredSenSE project, which aims to demonstrate that smart medical diagnostics can be performed using ergonomic, efficient, energy harvesting based sensors. Specifically, the scientists are developing smart, energy aware, user friendly wearable sensors and associated medical algorithms for the early diagnosis of Alzheimer's disease and childhood epilepsy, where the sensors derive power from the user's body energy (heat and motion) as well as from ambient light. The energy harvesting work has resulted in several prototypes being tested in the laboratory. Thermoelectric generators have been integrated into headwear and the stretching piezo composite materials are being evaluated. Design of the embedded clinical applications for ECG and EEG has begun as well as the design of a test hardware platform so that real time energy consumption can be evaluated. At the clinical level, the set of epilepsy detection algorithms are being finalized and EEG algorithms are being tested.

Rapid sensing of cancer. PATLiSci II is developing a measurement module for a scanning force microscope to perform parallel force spectroscopy for identification of cancer cells by their elastic properties and chemical recognition of related biomarkers by nanomechanical sensing. A cantilever array approach reduces diagnosis times from 3 hours to minutes, allowing faster decision on the appropriate therapy. Rapid biomarker tests based on cantilever sensors complement information on the status of the tumor. The project profits from its predecessor PATLiSci where basic concepts of parallel force spectroscopy and nanomechanical biomarker sensing have been validated. Here, optimized cantilever arrays are fabricated for both parallel force spectroscopy and nanomechanical sensing. First conclusive results on discrimination of breast cancer cells from unaffected cells in tissue using a single cantilever have already been demonstrated. Investigation of RNA in melanoma and wild type cells shows clear difference in nanomechanical bending response of functionalized cantilevers, in particular the BRAF mutation which is essential for selection of appropriate treatment measures. The BRAF mutation has been successfully detected in biopsy samples. Synthetic oligonucleotide as well as biopsy samples have been investigated successfully to detect the HER2 gene relevant in breast cancer diagnosis.

High performance portable 3D ultrasound platform. While ultrasound imaging is ubiquitous in medicine due to its low cost compared to other imaging techniques such as MRI – whose own challenges are addressed below – its image quality is usually poorer, and the high-quality devices that exist are expensive and aimed at hospital operation only. This is the reason why UltraSoundToGo is developing a prototype of next-generation, high-quality, mobile ultrasound imaging device, while operating at a level of power consumption compatible with battery-powered operation on the field. So far, UltrasoundToGo has achieved significant breakthroughs in the design of innovative ultrasound imagers. This was achieved with a blend of expertise in electronic design, software methods, and image processing techniques, and the feedback of hospital and external experts of medical ultrasound. New image processing techniques have been devised to achieve the same or better contrast than traditional methods of imaging, using up to 30 times fewer insonifications. This translates into the possibility of improving frame rates or designing lower-power transducers.

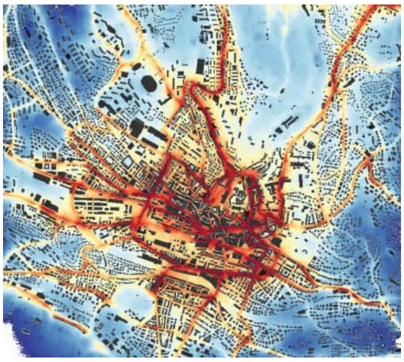


On the hardware side, the team has completed the architectural design for a breakthrough chip to reconstruct 3D volumes with unprecedented quality at 15 fps with just 30W of power. Software techniques have been developed to allow for the automatic mapping of software parts of the imager onto the hardware infrastructure.

Wearable MRI detector and sensor arrays. Magnetic resonance imaging (MRI) is another widely used imaging technique in medical diagnostics and basic research. The project WearableMRI seeks to advance the technique by introducing flexible, lightweight signal detectors that patients can wear like a piece of clothing. What renders this project unique in this field is the radical step from rigid, cage-like detectors to wearable assemblies that conform to the patient. To master this transition, the project is tackling unique challenges of mechanical and electronic adaptability along with those of miniaturization. At this point, the system design for a demonstrator has been completed. The most eminent step recently completed is the fabrication and deployment of the integrated receiver, which, at a size of just a few mm, performs MR signal digitization and decimation for subsequent optical transmission. The chip has been successfully tested and its specifications have been verified. Meanwhile, the remainder of in-magnet electronics and the evaluation platform have been advanced to the point of enabling full operation in a basic system configuration. With this configuration, a first MRI experiment has been successfully performed, yielding the project's first actual MR image.

A NEW LOOK AT ENVIRONMENTAL MONITORING WITH FURTHER CHALLENGES

Given the importance of environmental monitoring, several projects from Nano-Tera's initial phase are extended into the second phase with new directions. Projects address both air and water pollution monitoring, as well as environmental sensing in mountainous areas, as detailed below:



Crowdsourcing high-resolution air quality sensing. A major issue for obtaining accurate and high-resolution air pollution maps is the tradeoff between the cost of the measurement device and its accuracy. To address this problem, the OpenSense II consortium is integrating all available data sources starting from the infrastructure developed in the original OpenSense project, together with the high-end static stations of the National Air Pollution Monitoring Network and crowd-sourced data. In addition, the team is studying the impact of exposure to air pollution on human health and evaluating the potential of crowdsourcing for providing feedback to users. This involvement of private citizens as both providers of data and users of health recommendations is a novel contribution and will effectively close the loop between data gathering and the end-user.

An aquatic robot which can "smell" polluting substances in water. Envirobot is developing an anguilliform robot equipped with physical, chemical and biological sensors to automatically survey surface water quality. Environmental contamination is usually measured by sampling at defined locations and time intervals with subsequent off-site analysis of the collected sample, but rarely in a continuous manner along a trajectory by a moving vehicle or vessel. Not only will the aquatic robot sample, measure and communicate water quality parameters autonomously, but the robotic system will ultimately be able to guide its movement along a pollution gradient towards the pollution source. So far, a new version of the anguilliform robot was fabricated with larger modules and improved swimming capacity. Data communication between modules and sensors was established and physico-chemical sensors were tested and implemented in individual robot modules. A method for automated movement detection from Daphnia individuals captured in microfluidic cages was developed, that can be used to monitor distress upon pollutant exposure. Finally, bacterial bioreporters sensitive to pollutants were constructed and calibrated in miniaturized fluidic systems, ready for implementation in the robot module.

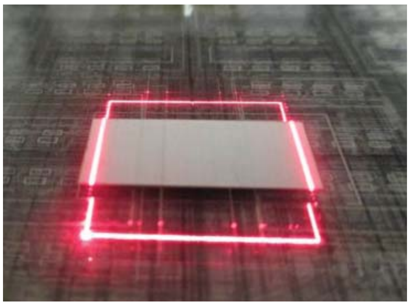
MAIN SCIENTIFIC ACHIEVEMENTS

MEMS acoustic detectors for natural hazard warning systems. Understanding, controlling and minimizing the risk associated with changes in our natural environment is of major societal interest, and there is an increasing need for risk-reduction methods and technology. The alpine monitoring system developed in X-Sense is extended with its X-Sense II to contribute to the reduction of this growing gap by technological development and scientific advance. It is investigating a complete data chain from custom designed sensor technology over networking, data-based storage and processing towards new discoveries in environmental sciences and new, more effective technologies for early warning. So far, the field site for pilot experiments has been identified and pilot deployments of acoustic and micro-seismic measurements undertaken and analyzed. A continuous GPS pilot program has been successfully launched. The sensor technology and data evaluation methodology has been applied to a number of natural hazard sites in Valais, Switzerland.

An all-in-one detection platform for air pollutants and greenhouse gases. The environmental dimension can also be a new direction added to a past project. While IrSens developed a sensing platform for liquid and gases using near and mid-infrared spectroscopy to measure cocaine concentration in saliva and CO_2 isotope ratios in air, IrSens II is going several steps further by realizing new tools for gas monitoring, specifically analyzing nitrogen dioxide as well as major air pollutants and greenhouse gases. The main difference between this project and others in the field is the use of multi-color distributed feedback lasers, with which several wavelength sources coming out of the same laser can be obtained. This considerably decreases the complexity of the optical setup of the sensor. The team has already developed a new geometry for the multi-color distributed feedback laser giving a better yield of independent single mode lasers and improving the dynamical range usable for spectroscopy, as well as a quantum cascade laser driver for the NO_2 platform.

A CRUCIAL MATTER: THE MANAGEMENT OF ENERGY

The theme of energy has taken on a whole new dimension in this phase of Nano-Tera.ch. In the past, the research being funded related mostly to ultra-low power microchip or systems. Energy is a central theme that affects system design, society and the economy, and now takes center stage: Nano-Tera.ch addresses various high relevance application areas such as low-power trustable electronics, smart grids, green data centers and environmentally friendly energy harvesting systems:



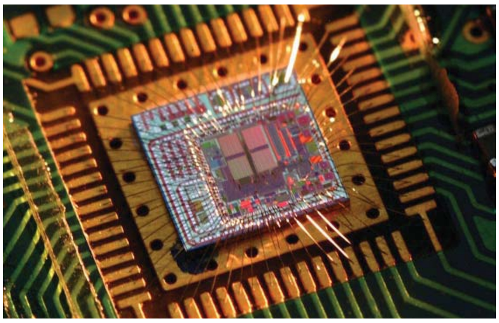
Cost-effective and integrated solar-hydrogen generator. The development of economically viable technologies to produce fuels such as hydrogen, solely based on sunlight and water is one of many potential solutions, on a global scale, to transition from a fossil fuel economy to a renewable energy economy. SHINE's goal is to develop the design principles and experimentally demonstrate a continuously-operating solar-hydrogen generation system with an optimal working point in terms of fuel production cost. In the first years of the project, SHINE has developed the foundations to achieve viable solar-hydrogen generations. In particular, the team has demonstrated the first membrane-less water electrolyzers that produces pure hydrogen streams.

Real time monitoring and management of smart grids. The project SmartGrid seeks to optimize the power grid through a hierarchical vision, from the individually monitored power consumption of electrical appliances, across the mid-scale "Microgrid" that optimizes small pools of consumers and at high level with high speed electronics for power system dynamic emulation. The team is developing new technologies dedicated to the real-time monitoring and secure management of electricity distribution using specific microelectronics ICs and real time ICT. The architecture of the smart building management platform has been designed and tested. The team is using the EPFL campus for validation: already, a preliminary version of the EPFL active distribution network process is successfully running. Moreover, SmartGrid has designed and tested the architecture of the smart building management platform, done in order to integrate the demand side management of buildings within the active distribution network.

Systems for ultra-high performance photovoltaic energy harvesting. The Swiss energy landscape will have to undergo fundamental changes to compensate for the massive losses in electricity production capacity resulting from the phase-out of nuclear power plants. At the same time, electronic devices have become more mobile, demanding for ubiquitous energy scavenging to power them while providing minimal surface area that could be used for solar cells. The Synergy project is addressing both issues by developing low-cost photovoltaic energy harvesting systems with ultra-high efficiencies. These systems have the potential to revolutionize the PV market, and, as a consequence, also the Swiss energy landscape.

Thermal storage control. With increasing penetration of renewable energy sources, power forecast errors increase, threatening grid reliability. To manage the real-time grid energy imbalances, HeatReserves seeks to develop control schemes for thermal loads of an aggregation of office buildings and residential households as an economically and environmentally attractive approach to provide additional ancillary services for the Swiss power grid. Already, an integrated building modeling and simulation environment has been built to serve as a testbed for the control schemes being developed. In collaboration with Swissgrid, ancillary service requirements and the market structure have been explored. The first round of the market study was conducted, aiming to determine factors influencing user acceptance of thermal load demand response schemes.

Green servers and datacenters. Energy-efficient datacenters are of strategic importance to Switzerland, as 75% of the Swiss economy is service-based and depends on the IT datacenter infrastructure cost. In YINS, the researchers are developing a radically new thermal-aware design approach for next generation energy-efficient datacenters. This new approach integrates the cooling infrastructure definition with system-level power, performance and thermal management, and energy recovery strategies for the complete datacenter. The research carried out is very interdisciplinary: it integrates innovations in several research areas, namely, computer engineering and cooling design, large-scale computing system simulation, software generation and optimization, statistical network modeling and model predictive control theory. A new system developed to monitor wirelessly energy consumption, temperature and humidity in racks and servers, called Power Monitor System and Management, was transferred to the Wispes Sàrl start-up to start commercializing it in the area of energy-efficient datacenter monitoring, and it is in the process of consolidating a maintenance and extra purchase contract to expand its use in datacenters.



Inexact sub-near-threshold systems for ultra-low power devices. As any portable device today consumes too much energy, the goal of the project IcySoC is to reduce significantly the energy used for performing different applications required by customers. Letting microchips make a few mistakes here and there could make them much faster and more energy-efficient: such is the core idea behind the project. It is developing an ultra-low-power platform based on an integrated circuit operated at very low supply voltage ("near- or sub-threshold") and using inexact computation blocks that provide approximate results tolerated by many applications like video or audio. The team is very close to tapeout a complete platform with 4 cores, memories, exact and inexact hardware accelerators in ALP180 (180 nm from EM Microelectronics). Inexact arithmetic adders and multipliers have been designed. Dynamic RAMs and low-voltage standard-cell based memories based on latches in different technologies have been developed. IcySoC has also developed techniques and circuits for timing error detection and for highly dynamic clock-frequency adjustment of microprocessors that adjust their clock period on a cycle-by-cycle basis based on current instructions.

NANO-TERA FOCUSED PROJECTS COMPLETE THE PICTURE

In addition to these 25 large-scale multi-disciplinary RTD projects, Nano-Tera also funds the smaller NTF projects (Nano-Tera Focused) addressing specific aspects. Some projects involve smart textiles (3D large-scale integration into smart textiles, or novel textiles for non-invasive monitoring of pressure and oxygenation of tissue), others address different aspects of health monitoring, from night monitoring of blood pressure, to diabetes non-invasive activity monitoring, among others.

PHASE II RTD PROJECTS, 2013-2017

BodyPoweredSenSE	Wearable ICT for Zero Power medical Applications	Prof. Pierre-André Farine EPFL
Envirobot	Automated surveying of surface water quality by a physical, chemical and biological sensor equipped anguilliform robot	Prof. Jan van der Meer UNIL
FlusiTex	Fabrication of fluorescence sensors integrated into a textile dressing for non-invasive lifetime based wound monitoring	Prof. Bradley Nelson ETHZ
HearRestore	Image-guided micro surgery for hearing aid implantation	Prof. Stefan Weber UniBE
HeatReserves	Demand Response for Ancillary Services: Thermal Storage Control	Prof. John Lygeros ETHZ
IcySoC	Inexact Sub-Near-threshold System for Ultra-Low Power Devices	Prof. Andreas Burg EPFL
IrSens II *	A multi-component sensor for air pollutants and greenhouse gases	Prof. Jérôme Faist ETHZ
ISyPeM II *	Therapeutic drug monitoring for Personalized medicine	Prof. Carlotta Guiducci EPFL
MagnetoTheranostics	From Superparamagnetic Nano-particles until Tools for Detection and Treatment of cancer	Prof. Heinrich Hofmann EPFL
MIXSEL II *	Novel semiconductor disk lasers for biomedical and metrology applications	Prof. Ursula Keller ETHZ
NewbornCare	Newborn Monitoring based on multiple vision sensors	Prof. Pierre Vandergheynst EPFL
ObeSense	Monitoring the Consequences of Obesity	Prof. Jean-Philippe Thiran EPFL
OpenSense II *	Crowdsourcing High-Resolution Air Quality Sensing	Prof. Alcherio Martinoli EPFL
PATLiSci II *	Rapid Sensing of Cancer	Prof. Ernst Meyer UniBas
SHINE	Solar Hydrogen Integrated Nano Electrolysis	Prof. Christophe Moser EPFL
SmartGrid	Smart grids, Smart buildings and Smart sensors for Optimized and Secure Management of Electricity Distribution using dedicated microelectronic ICs and real time ICT	Prof. Maher Kayal EPFL
SmartSphincter	Smart muscles for incontinence treatment	Prof. Bert Müller UniBas
SpineRepair	Hybrid CMOS-polymer neural interfaces for restoration of sensorimotor functions after spinal cord injury	Prof. Stéphanie Lacour EPFL
Synergy	Systems for ultra-high performance photovoltaic energy harvesting	Prof. Christophe Ballif EPFL
UltraSoundToGo	High performance portable 3D ultrasound platform	Prof. Giovanni De Micheli EPFL
WearableMRI	Wearable MRI detector and sensor arrays	Prof. Klaas Prüssmann ETHZ
WearMeSoC	Multi Functional Wearable Wireless Medical Monitoring Based on A Multi Channel Data Acquisition and Communication Management System on a Chip	Prof. Qiuting Huang ETHZ
WiseSkin	Wise Skin for tactile prosthetics	Dr. John Farserotu CSEM
X-Sense II *	MEMS acoustic detectors for natural hazard warning systems	Prof. Lothar Thiele ETHZ
YINS	Energy-and thermal-aware design of many-core heterogeneous datacenters	Prof. David Atienza EPFL

* Follow-ups of Phase I projects

Gateway Pilot Program

Nano-Tera.ch strives to enable mechanisms that can map the high productivity of research ideas, publications and patents of the Swiss community into a significant momentum in terms of industrial growth as well as job and enterprise creation. In this perspective, Nano-Tera.ch first strongly contributed to the design of Bridge, a new concept for jointly funding research and pre-competitive technological innovation that will be deployed by the Swiss National Science Foundation (SNSF) and the Swiss Commission for Technology and Innovation (CTI) in the form of a novel common funding instrument for the period 2017-2020.

In a second step, Nano-Tera.ch decided to joint efforts with CSEM and EMPA to embody several of the core ideas developed during the design of Bridge into a specific pilot program, the Gateway program, intrinsically positioned at the frontier between research and innovation and aiming at the translation of research results obtained within Nao-Tera.ch projects into industrial demonstrators directly exploitable by the involved industrial partners.

The Gateway program has been concretely set up as follows:

- Creation of a Gateway working group, with two representatives for Nano-Tera.ch, one representative for CSEM, one representative for EMPA, and one representative for the precoR program (the SNSF-initiative for funding precompetitive research);
- Identification of the NT projects involving an industrial partner able to efficiently support translation of research results into activities with high economic potential;
- Interaction with the project partners for the definition of concrete proposals for industrial extension;
- Selection the proposals based on a severe evaluation and corresponding to the best compromise between economic potential and industrial risk:
- Set up a specific monitoring mechanism under the supervision of a dedicated innovation manager.

The deployment of the Gateway program resulted in the selection of 4 proposals with high potential for industrial impact. These projects, which started in October 2015 and will last 18 months, involve laboratories, institutions specialized in technology transfer (EMPA and CSEM) as well as industrial partners. The goal of these projects is to convert laboratory prototypes resulting from Nano-Tera.ch research projects (Technology Readiness Level 4) into industrial demonstrators (TRL 6-7) with high economic potential.

Gateway project	**FLUSIGATE2015**	**HEARGATE2015**
Original project	FlusiTex	HearRestore
Partners	PI: Luciano Boesel, EMPA CSEM, Flawa, Schoeller Textil, Kenzen	PI: Edo Franzi, CSEM Atracsys
Targeted demonstrator	Fluorescence based PH sensing wound monitoring pad.	Metrology module for surgical navigation system.

Gateway project	**PARAGATE2015**	**SYNGATE2015**
Original project	ParaTex	Synergy
Partners	PI: René Rossi, EMPA Forster Rohner, Meister & Cie, Art of Technology	PI: Christophe Ballif, CSEM EMPA, Meyer Burger, Solaronix, Flisom
Targeted demonstrator	Pressure/oxygenation/perfusion monitoring textile sensor for pressure ulcer detection.	High-performance/flexible perovskite tandem solar cells.

Strategic Actions

To further strengthen the impact of the program, the Nano-Tera.ch Executive Committee has launched three new strategic actions, which all started in November 2015.

Biomedical Devices – BioDev *PI : G. De Micheli, EPFL*
Developing advanced architectures for ultrasound beamforming, demonstrating 3D ultrasound imaging capabilities, fabricating drug-sensing devices operating on whole blood

Bringing Membrane Type Surface Stress Sensors (MSS) to the Market – MSSdevices *PI: E. Meyer, UniBas*
Developing and producing up to ten measurement electronics readout setups for end users pilot testing of membrane surface stress sensor technology to be introduced to the market by NanoWorld AG.

Development of an Air Quality Crowdsensing Platform – OpenSWISS *PI: A. Martinoli, EPFL*
Developing a crowdsensing platform for high resolution pollution maps and assess the health impact of exposure to air pollution.

SOME NANO-TERA RESEARCHERS

Below are the profiles of some Nano-Tera reseachers. Unless otherwise specified, the publications statistics are taken from Google Scholar.

Prof. Luca Benini, ETHZ

Nano-Tera projects involvement: Co-PI in IcySoC, UltraSoundToGo, YINS

606 publications since 2006 • 30'809 citations (13'662 since 2011) • H-index 84

Research interests: Many-core architecture, Embedded Systems, Low Power, Wireless Sensor Networks, Ambient Intelligence

Key publications:

- Networks on chips: a new SoC paradigm, L Benini, G De Micheli, Computer 35 (1), 70-78 (2002)
- A survey of design techniques for system-level dynamic power management, L Benini, A Bogliolo, G De Micheli, Very Large Scale Integration (VLSI) Systems, IEEE Transactions on 8 (3), 299-316 (2000)
- System-level power optimization: techniques and tools, L Benini, G Micheli, ACM Transactions on Design Automation of Electronic Systems (TODAES) 5 (2), 115-192 (2000)

Prof. Giovanni De Micheli, EPFL

Nano-Tera project involvement: PI of UltraSoundToGo

507 publications since 2006 • 33'496 citations (11'361 since 2011) • H-index 87

Research interests: design technologies for integrated circuits and systems, heterogeneous platform design including electrical components and biosensors, as well as data processing of biomedical information.

Key publications:

- Networks on chips: a new SoC paradigm, L Benini, G De Micheli, Computer 35 (1), 70-78 (2002)
- Synthesis and Optimization of Digital Circuits, G DE MICHELI, McGraw-Hill, 579p (1994)
- A survey of design techniques for system-level dynamic power management, L Benini, A Bogliolo, G De Micheli, Very Large Scale Integration (VLSI) Systems, IEEE Transactions on 8 (3), 299-316 (2000)

Prof. Nico de Rooij, EPFL

Nano-Tera project involvement: Co-PI in PATLiSci II

539 publications since 2006 • 20'691 citations (6'738 since 2011) • H-index 74

Research interests: MEMS, NEMS

Key publications:

- Microfluidics meets MEMS, E Verpoorte, NF de Rooij, Proceedings of the IEEE 91 (6), 930-953 (2003)
- Operation of chemically sensitive field-effect sensors as a function of the insulator-electrolyte interface, L Bousse, NF De Rooij, P Bergveld, Electron Devices, IEEE Transactions on 30 (10), 1263-1270 (1983)
- Electrokinetically driven microfluidic chips with surface-modified chambers for heterogeneous immunoassays, A Dodge, K Fluri, E Verpoorte, NF de Rooij, Analytical chemistry 73 (14), 3400-3409 (2001)

Prof. Jérôme Faist, ETHZ

Nano-Tera project involvement: PI of IrSens II

424 publications since 2006 • 26'665 citations (10'148 since 2011) • H-index 84

Research interests: Quantum Cascade Laser, microcavity, strong coupling, Terahertz

Key publications:

- Quantum cascade laser, J Faist, F Capasso, DL Sivco, C Sirtori, AL Hutchinson, AY Cho, Science 264 (5158), 553-556 (1994)
- Continuous wave operation of a mid-infrared semiconductor laser at room temperature, M Beck, D Hofstetter, T Aellen, J Faist, U Oesterle, M Ilegems, E Gini, H Melchior, Science 295 (5553), 301-305 (2002)
- High-power directional emission from microlasers with chaotic resonators, C Gmachl, F Capasso, EE Narimanov, JU Nöckel, AD Stone, J Faist, DL Sivco, AY Cho, Science 280 (5369), 1556-1564 (1998)

Prof. Hubert Girault, EPFL

Nano-Tera project involvement: Co-PI in Envirobot

239 publications since 2006 • 17'992 citations (7'208 since 2011) • H-index 70

Research interests: Electrochemistry

Key publications:

- UV laser machined polymer substrates for the development of microdiagnostic systems, MA Roberts, JS Rossier, P Bercier, H Girault, Analytical Chemistry 69 (11), 2035-2042 (1997)
- Mixing processes in a zigzag microchannel: finite element simulations and optical study, V Mengeaud, J Josserand, HH Girault, Analytical Chemistry 74 (16), 4279-4286 (2002)
- Electrochemistry of liquid-liquid interfaces, HHJ Girault, DJ Schiffrin, Electroanalytical chemistry 15, 1-141 (1989)

Prof. Michael Grätzel, EPFL

Nano-Tera projects involvement: Co-PI in SHINE, Synergy, TANDEM

704 publications since 2006 • 196'447 citations (112'131 since 2011) • H-index 197

Research interests: nanocrystalline junctions, photovoltaic cells, light energy conversion & storage…

Key publications:

- Photoelectrochemical cells, M Grätzel, Nature 414 (6861), 338-344 (2001)
- Conversion of light to electricity by cis-X2bis (2, 2'-bipyridyl-4, 4'-dicarboxylate) ruthenium (II) charge-transfer sensitizers (X= Cl-, Br-, I-, CN-, and SCN-) on nanocrystalline titanium dioxide electrodes, MK Nazeeruddin, A Kay, I Rodicio, R Humphry-Baker, E Müller, P Liska, N Vlachopoulos, M Grätzel, Journal of the American Chemical Society 115 (14), 6382-6390 (1993)
- A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO2 films, M Grätzel, Nature 353 (6346), 737-740 (1991)

Prof. Ursula Keller, ETHZ

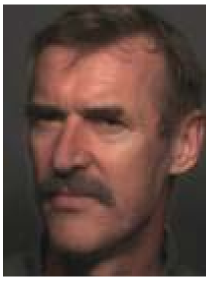
Nano-Tera project involvement: PI of MIXSEL II

458 publications since 2006 • 28'942 citations (10'955 since 2011) • H-index 88

Research interests: Physics, Ultrafast Science, Laser Physics, Attosecond Science

Key publications:

- Semiconductor saturable absorber mirrors (SESAM's) for femtosecond to nanosecond pulse generation in solid-state lasers, U Keller, KJ Weingarten, FX Kartner, D Kopf, B Braun, ID Jung, R Fluck, C Honninger, N Matuschek, J Aus der Au, Selected Topics in Quantum Electronics, IEEE Journal of 2 (3), 435-453 (1996)
- Recent developments in compact ultrafast lasers, U Keller, Nature 424 (6950), 831-838 (2003)
- Solid-state low-loss intracavity saturable absorber for Nd: YLF lasers: an antiresonant semiconductor Fabry–Perot saturable absorber, U Keller, DAB Miller, GD Boyd, TH Chiu, JF Ferguson, MT Asom, Optics letters 17 (7), 505-507 (1992)



Prof. Jean-Yves Le Boudec, EPFL

Nano-Tera project involvement: Co-PI in SmartGrid

192 publications since 2006 • 21'944 citations (8'067 since 2011) • H-index 69

Research interests: Performance Evaluation, Networking, Smart Grid

Key publications:

- Performance analysis of the CONFIDANT protocol, S Buchegger, JY Le Boudec, Proceedings of the 3rd ACM international symposium on Mobile ad hoc networking & computing, ACM, 226-236 (2002)
- Network calculus: a theory of deterministic queuing systems for the internet, JY Le Boudec, P Thiran, Springer-Verlag (2001)
- A robust reputation system for mobile ad-hoc networks, S Buchegger, JY Le Boudec, LCA-REPORT-2003-023 (2003)

Prof. Ernst Meyer, Uni Basel

Nano-Tera project involvement: PI of PATLiSci II

179 publications since 2006 • 19'539 citations (5'996 since 2011) • H-index 67

Research interests: Physics

Key publications:

- Translating biomolecular recognition into nanomechanics, J Fritz, MK Baller, HP Lang, H Rothuizen, P Vettiger, E Meyer, H-J Güntherodt, Ch Gerber, JK Gimzewski, Science 288 (5464), 316-318 (2000)
- Multiple label-free biodetection and quantitative DNA-binding assays on a nanomechanical cantilever array, R McKendry, J Zhang, Y Arntz, T Strunz, M Hegner, HP Lang, MK Baller, U Certa, E Meyer, H-J Güntherodt, Ch Gerber, Proceedings of the National Academy of Sciences 99 (15), 9783-9788 (2002)
- Noncontact atomic force microscopy, Springer (2002)

SOME NANO-TERA RESEARCHERS

Prof. Demetri Psaltis, EPFL

Nano-Tera project involvement: Co-PI in SHINE

242 publications since 2006 • 16'470 citations (5'543 since 2011) • H-index 66 *

Research interests: optofluidics, biophotonics, nonlinear optics, holography, optical information processing

Key publications:

- Developing optofluidic technology through the fusion of microfluidics and optics, D. Psaltis, SR Quake, CH Yang, Nature 442 (7101), 381-386 (2006)
- Non-volatile holographic storage in doubly doped lithium niobate crystals, K. Buse, A. Adibi, D. Psaltis, Nature 393 (6686), 665-668 (1998)
- Optical implementation of the Hopfield model, NH. Farhat, D. Psaltis, A. Prata, E. Paek, Applied Optics 24 (10), 1469-1475 (1985).

Prof. Philippe Renaud, EPFL

Nano-Tera projects involvement: Co-PI in Envirobot, ISyPeM II

266 publications since 2006 • 13'516 citations (6'066 since 2011) • H-index 61

Research interests: bioMEMS, microfluidics, nanofluidics

Key publications:

- SU-8: a low-cost negative resist for MEMS, H Lorenz, M Despont, N Fahrni, N LaBianca, P Renaud, P Vettiger, Journal of Micromechanics and Microengineering 7 (3), 121 (1997)
- Transport phenomena in nanofluidics, RB Schoch, J Han, P Renaud, Reviews of Modern Physics 80 (3), 839 (2008)
- High-aspect-ratio, ultrathick, negative-tone near-UV photoresist and its applications for MEMS, H Lorenz, M Despont, N Fahrni, J Brugger, P Vettiger, P Renaud, Sensors and Actuators A: physical 64 (1), 33-39 (1998)

Prof. Joseph Sifakis, EPFL

Nano-Tera project involvement: Co-PI in UltraSoundToGo

84 publications since 2006 • 15'632 citations (4'680 since 2011) • H-index 57

Research interests: software engineering, formal methods, web services, middleware, networks

Key publications:

- The algorithmic analysis of hybrid systems, R Alur, C Courcoubetis, N Halbwachs, TA Henzinger, PH Ho, X Nicollin, A Olivero, J Sifakis, S Yovine, Theoretical computer science 138 (1), 3-34 (1995)
- Specification and verification of concurrent systems in CESAR, JP Queille, J Sifakis, International Symposium on Programming, 337-351 (1992)
- Symbolic model checking for real-time systems, TA Henzinger, X Nicollin, J Sifakis, S Yovine, Information and computation 111 (2), 193-244 (1994)

Prof. Lothar Thiele, ETHZ

Nano-Tera projects involvement: PI of X-Sense II, Co-PI in OpenSense II, UltraSoundToGo, YINS

321 publications since 2006 • 35'619 citations (18'110 since 2011) • H-index 68

Research interests: models and methods for the design of embedded systems, embedded software, networked (wireless) systems, embedded multiprocessor systems, bioinspired optimization techniques

Key publications:

- Multiobjective evolutionary algorithms: a comparative case study and the strength Pareto approach, E Zitzler, L Thiele, Evolutionary Computation, IEEE Transactions on 3 (4), 257-271 (1999)
- SPEA2: Improving the strength Pareto evolutionary algorithm, E Zitzler, M Laumanns, L Thiele, E Zitzler, E Zitzler, L Thiele, L Thiele, Eidgenössische Technische Hochschule Zürich (ETH), Institut für Technische Informatik und Kommunikationsnetze 8 (2001)
- Comparison of multiobjective evolutionary algorithms: Empirical results, E Zitzler, K Deb, L Thiele, Evolutionary computation 8 (2), 173-195 (2000)

* Statistics based on Web of Science

THEMATIC OUTPUT

The Nano-Tera projects can be grouped into thematic clusters related to health, environment and energy. Health-related research is split into health monitoring, smart prosthetics and body repair, and medical platforms. Below is an analysis of the projects output by topic.

Health Monitoring

FlusiTex • ISyPeM II • NewbornCare • ObeSense • WearMeSoC

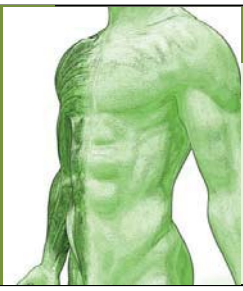
~200 staff members, including **33** PhD students

72 publications ⏩ 34 journal articles + 38 conf. proceedings

118 conference presentations, including 13+ invited oral presentations

4 awards **1** patent

Smart Prosthetics and Body Repair



HearRestore • MagnetoTheranostics • SmartSphincter • SpineRepair • WiseSkin

~130 staff members, including **23** PhD students

36 publications ⏩ 18 journal articles + 18 conf. proceedings

104 conference presentations, including 60+ invited oral presentations

3 awards **7** patents

Medical Platforms

BodyPoweredSenSE • MIXSEL II • PATLiSci II • UltraSoundToGo • WearableMRI

~120 staff members, including **32** PhD students

48 publications ⏩ 12 journal articles + 36 conf. proceedings

71 conference presentations, including 27+ invited oral presentations

4 awards **1** patent

Environmental Monitoring

Envirobot • IrSens II • OpenSense II • X-Sense II

~110 staff members, including **24** PhD students

47 publications ⏩ 11 journal articles + 36 conf. proceedings

118 conference presentations, including 58+ invited oral presentations

3 awards **4** patents

Smart Energy

HeatReserves • IcySoC • SHINE • SmartGrid • Synergy • YINS

~140 staff members, including **41** PhD students

112 publications ⏩ 36 journal articles + 76 conf. proceedings

164 conference presentations, including 60+ invited oral presentations

5 awards **5** patents

THE NANO-TERA PHD STUDENTS

Distribution by institution type

There are 154 PhD students who are (or were) part of a currently running Nano-Tera project.

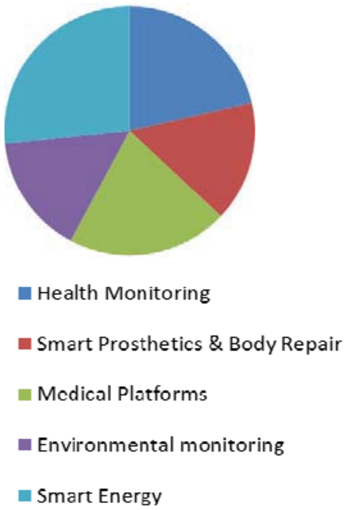
DISTRIBUTION OF PHD STUDENTS BY INSTITUTION

About 79% of all PhD students are affiliated with EPFL, ETHZ or another ETH Board institution, as shown in the graph to the left.
About 16% study in a university or a university of applied sciences. The rest are affiliated with hospitals or other institutions.

DISTRIBUTION OF PHD STUDENTS BY TOPIC

Based on the thematic clusters described above, the distribution of PhD students by topic is shown in the graph to the left. Currently, 24 PhD students are involved in a project related to environmental monitoring, and 41 are involved in smart energy. The three health-related clusters (health monitoring, smart prosthetics & body repair, medical platforms) have 33, 24 and 32 PhD students respectively.

Distribution by topic



More precisely, the breakdown by project is as follows:

Health Monitoring	
FlusiTex	0
ISyPeM II	9
NewbornCare	2
ObeSense	7
WearMeSoC	8
Others (NTF, etc.)	7
	33

Smart Prosthetics & Body Repair	
HearRestore	7
MagnetoTheranostics	3
SmartSphincter	4
SpineRepair	6
WiseSkin	4
	24

Medical Platforms	
BodyPoweredSenSE	9
MIXSEL II	7
PATLiSci II	1
UltraSoundToGo	7
WearableMRI	8
	32

Environmental Monitoring	
Envirobot	3
IrSens II	1
OpenSense II	8
X-Sense II	12
	24

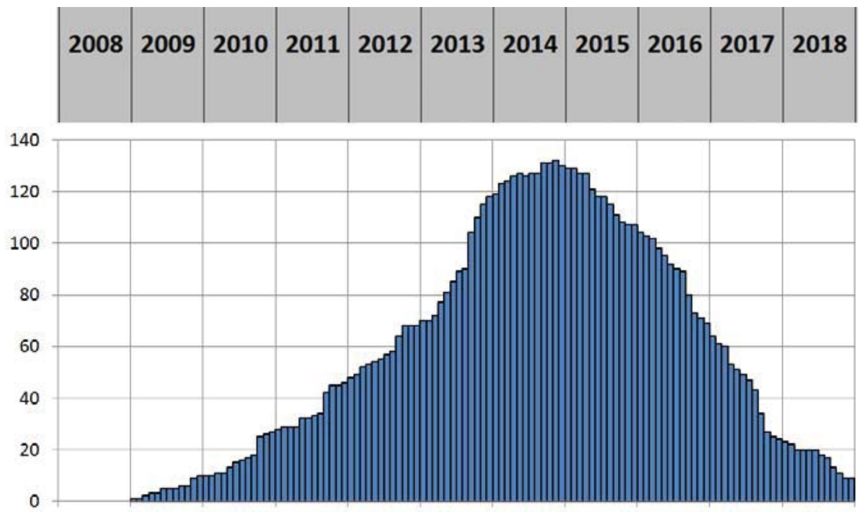
Smart Energy	
HeatReserves	6
IcySoC	4
SHINE	5
SmartGrid	11
Synergy	6
YINS	9
	41

DISTRIBUTION OF PHD STUDENTS BY GENDER

There are 36 female PhD students, representing about 23% of the total.

TIMELINE

Based on the starting dates and expected end dates of the PhD students, the graph below indicates how many PhD students are active at any given time.



Profile directory of PhD students

A special page devoted to PhD students is available on the Nano-Tera website. It consists of a complete directory of students, which can be sorted and filtered by project, by institution and several other criteria:
www.nano-tera.ch/phd

The NextStep program for PhD students

To strengthen the importance of PhD students within the program, Nano-Tera has set up a new action specifically for PhD students. This action, called "NextStep", is designed to help them explore possible ways to exploit the scientific skills that they are gaining during their PhD. In particular, NextStep is promoting the possibility for them:

- to apply for specific research grants to fund collaborative research involving several PhD students. (Track 1)
- to be exposed to different ways of considering economic exploitation of the scientific skills and results obtained during their PhD work. (Track 2)

Track 1 – Scientific collaboration

As the multidisciplinary nature of Nano-Tera projects illustrates, it is becoming more and more crucial to be able to conduct research in a collaborative manner.

The objective of Track 1 of the NextStep action is therefore to give students the opportunity to consider the development of a collaborative work, within the framework of their thesis.

This can be done via a joint validation of their results, for example by building a common prototype.

In general, the goal is to expose the PhD student to new concepts and approaches, thus strengthening the educational impact of the NextStep program within a multidisciplinary framework.

Concretely, this Track 1 gives them the opportunity to learn the full procedure of submitting proposals to get concrete funding: from building a consortium, picking the research challenges, writing the scientific proposal, and building a reasonable budget.

Track 2 - Entrepreneurship

A survey of the Nano-Tera PhD students who were involved in the program during its earlier phase (2009-2013) has shown that only about 40% of PhD students stayed in academic research, while the other 60% have moved on to the industry or other activities. It is therefore important for them to think as early as possible about their next steps, in particular to consider how to exploit the experiences gained in their PhD work for future professional activities outside of academia.

This is the purpose of this Track 2. It allows them to interact with experts and coaches in entrepreneurship, in order to learn how to

- describe the skills they have acquired in an efficient way for potential future industrial contacts (“elevator pitches”).
- develop ideas on how to economically exploit their thesis results and skills for goals such as licensing or startup creation.

Concretely, NextStep gives them the possibility to follow a coaching program to elaborate their own business idea and present it to a real investor panel to seek funds. For example, they were given the opportunity to dry run a pitch, with the possibility to win a trip to a high impact event such as CeBit or CES.

Timeline and outcome

Each track consists of 4 modules, with a first one which took place in March 2015: the scientific collaboration track gathered all interested students for a day in order to start sharing their preliminary ideas of potential collaborations, while the entrepreneurship track introduced the students to the ideas of business development and helped them think of their own ideas that they can safely test run.

The second module took place on May 4th, during the Nano-Tera Annual Meeting, giving participants the possibility to present their collaborative research ideas (Track 1) and initial business ideas (Track 2) to a panel of experts. Based on this first interaction, the ideas have become more mature and more precise: participants in Track 1 have submitted proposals, all of which have been accepted for funding.

Name	NT Project	Acronym	Title
T. Brusa, UniBE *PI: P. Büchler*	SmartSphincter	BAFIARS	Assessment of anatomic, physiologic & bio-mechanical characteristics of the anal canal & pelvic floor: an observational study in patients
M. Thielen, ETHZ *PI: C. Hierold*	BodyPoweredSenSE	BioFlex	Soft dry Biopotential Electrodes for Long-Term EEG recording
T. Wyss, UniBE *PI: P. Büchler*	HearRestore	BonePro	HearRestore: Bone Impedance modelling
P. Hager, ETHZ *PI: L. Benini*	UltraSoundToGo	LightProbe	Digital UltraSound Head
J. Ansó, UniBE *PI: S. Weber*	HearRestore	NerveSafe	Facial nerve monitoring during robotic cochlear implantation
D. Mikulik, EPFL *PI: A. Fontcuberta*	Synergy	SolCelMeas	Analyzing optical and electrical measurements of GaAs nanowire solar cells
H. Huang, BFH *PI: V. Koch*	WiseSkin	MultiHaptic	Human study: info transfer analysis & early evaluation of multi-modality haptic displays for sensory feedback

THE NANO-TERA PHD STUDENTS

Following their pitch at the annual meeting 2015, the PhD students involved in Track 2 have been awarded a grant to attend an impact event or their choice by a jury composed of Nano-Tera Executive Committee members and expert scientists.

These pitches cover interesting ideas ranging from solar wearable devices to lightweight wearable sensing devices: The students involved have been receiving mentoring support (two workshops and monthly personalized coaching) in order to help develop and refine their business project.

In addition, Nano-Tera has offered other actions open to all PhD students interested, consisting of:

- 6 coaching sessions (30 min each), from October 2015 to February 2016, to work on the business case
- 2 half day workshops (Sept. 2015 and January 2016) to support the project development, prepare the presentation, etc.
- selection of existing entrepreneurial contests in the Swiss ecosystem, to participate
- among all groups having submitted a project to the Swiss ecosystem, 2 of them will be selected and will present at the 2016 Annual Meeting

Finally, the last module will take place at the Nano-Tera Annual Meeting 2016, where in Track 1, some first results of the approved collaborative projects will be presented, and where Track 2 participants will get the opportunity to make a business pitch in front of the whole Nano-Tera.ch audience.

My Thesis in 180 seconds

In addition to doing excellent science, it is important for researchers to be able to communicate their work and results, in a clear and appealing way, easily understandable outside their field of specialization.

As it is now done in many higher education institutions to help their junior researchers acquire the required communication skills, Nano-Tera has organized an MT180 ("My Thesis in 180 Seconds") contests, where PhD students have 3 minutes to present the content of their research to a wide audience, with the support of only one static slide.

To contribute further to strengthening the communication skills of the junior researchers active in the Nano-Tera projects, Nano-Tera.ch has been organizing an MT180 contest specifically dedicated to the Nano-Tera.ch PhD students.

This contest, open to all Nano-Tera PhD students, gives 6 of the participants the opportunity to benefit from personal coaching under the supervision of Swiss journalists specialized in science and technology. Furthermore, 3 PhD students have been selected by a jury involving journalists and researchers to make their MT180 presentation in front of the whole NT community at the Nano-Tera Annual Meeting 2016.

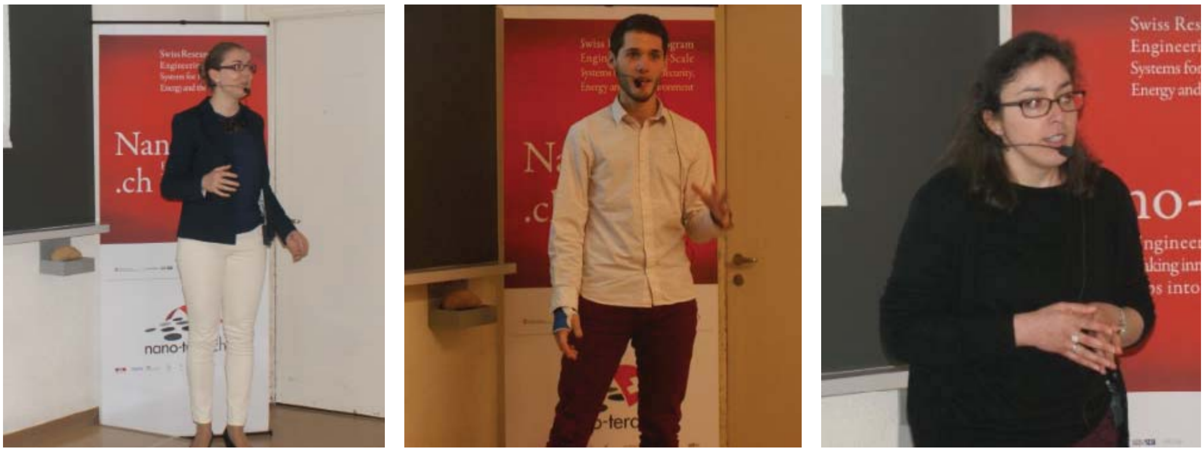
Concretely, interested participants first had to submit their draft MT180 presentation in the form of a video contribution or maximum 3 minutes, involving the presentation of one static slide.

The contributions have been evaluated by a jury composed of 6 researchers and 6 scientific journalists. They have selected the 6 most promising contributions, and each of the 6 selected PhD students benefitted from a personalized coaching by one of the scientific journalists in the jury, to help them improve the content of their presentation.

The selection criteria are as follows:

- Science – is the science itself correct? Is it interesting? How novel is it?
- Pedagogical aspects – are the explanations clear and understandable?
- Scenic effects – is it a good show? Is it interesting?
- Fluidity and style – is the participant exhibiting charisma?

After their coaching, the 6 selected PhD students participated to a "semi-final" in the form of a live presentation in front of the jury. The 3 best participants are facing off in the final at the Nano-Tera Annual Meeting 2016.

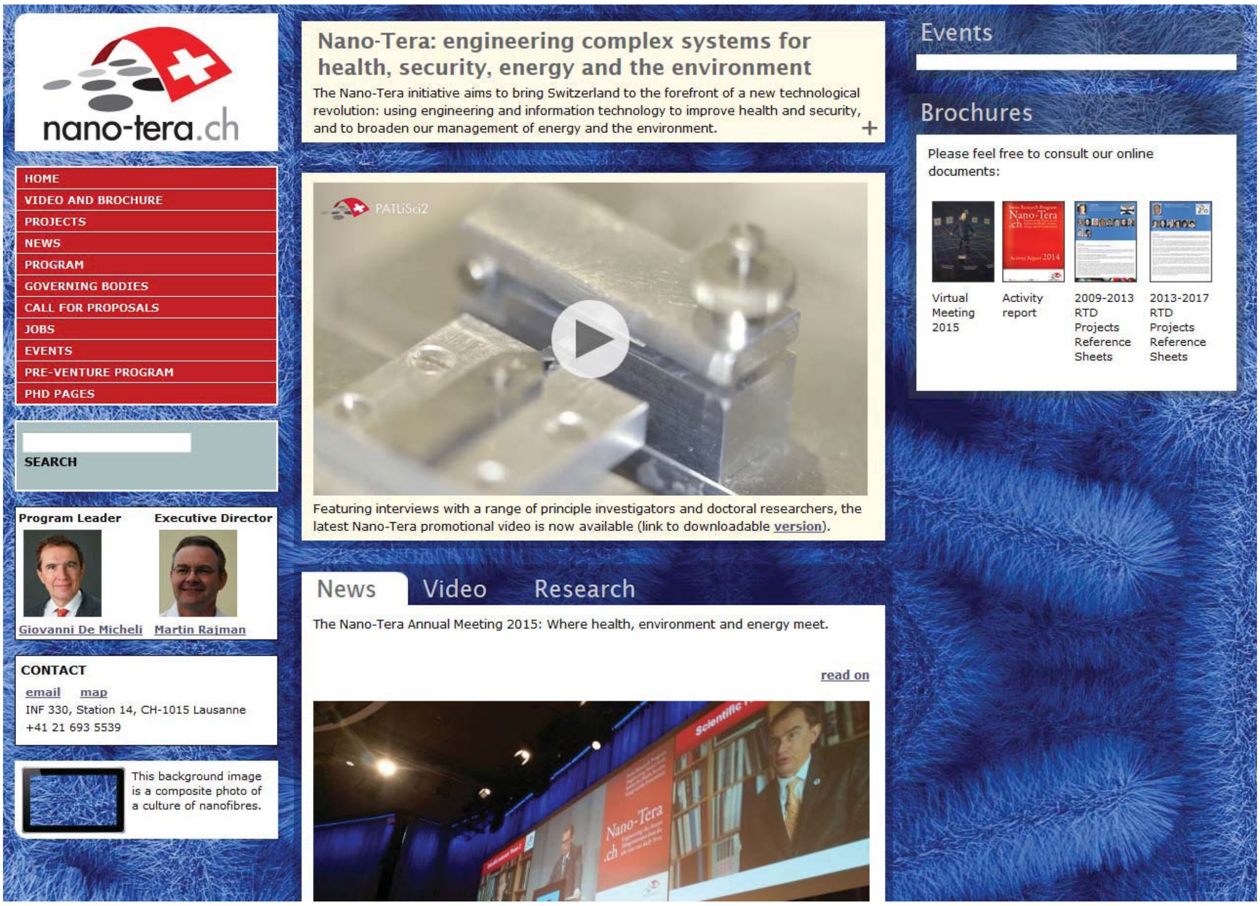


Débora Bonvin (EPFL), Romain Jacob (ETHZ) and Leila Mirmohamadsadeghi (EPFL), 3 semi-finalists qualified for the final.

NANO-TERA WEBSITE

The Nano-Tera website (www.nano-tera.ch) represents one of the main dissemination channels for the Nano-Tera program. The number of visits to the site continues to be monitored and used for decisions related to information dissemination.

During the current reporting period, Nano-Tera.ch received more than 100,000 page views corresponding to 30'000 visits, from **142** countries. More than half of the visitors originated from outside Switzerland.



www.nano-tera.ch

DISSEMINATION AND PROMOTION ACTIVITIES

NANO-TERA ANNUAL MEETING 2015

The 6th Annual Plenary Meeting of Nano-Tera.ch took place on May 4-5th, 2015 at the Allegro Grand Casino Kursaal in Bern and was once again a success thanks to the active participation of all principal investigators, senior researchers and PhD students involved in the projects supported by Nano-Tera.ch. This edition equaled last year's record audience of **350 participants**. It showcased about **150 posters** and **9 videos**. In addition, a wide majority of the 25 RTD projects have featured **demonstrations and early prototypes**.

In the 2015 event, a special focus was given to the contribution of PhD students. In particular, each running RTD project designated **one PhD student** who was be given the important responsibility to present the results obtained in the project. These presentations of roughly 20 minutes were given in parallel sessions during a special event on Monday, May 4th afternoon. Participants could learn of the progress made on various topics, including bio-robotic eels taking care of our environment and approximate computing that might save our cell-phone battery life. One of the presentations of this first session was about care for premature babies. For those who are lucky enough not to have interacted with incubators, premature care is made of interconnected tubes and cables that link the baby to electronic interfaces that are constantly beeping. NewbornCare drastically reduces the amount of attachments for the same vital result.

While speeches in the Smart Energy room were giving an interesting overview of the multiple energy saving possibilities, the UltraSoundToGo project was presented in the Medical Platforms room. Instead of the usual heavy equipment for ultrasonography, this project proposed an ultrasound device connectable on a cell phone and with an excellent resolution and a better frame rate than other state of the art devices.

In the second half of the afternoon, PhD students were invited to present their research in order to prepare possible collaborations with industries in the framework of the **NextStep program**. Among the most exciting projects was the Ezechiel project on stretchable electronics. Solstice, another interesting project was presenting "solar stickers", or soft photovoltaic surfaces made of GaAs vertical nanowires that allow to create solar panels a thousand times lighter than today's. These stickers could be used for battery charging of a great array of electronic equipment. Moreover, several students presented their preliminary ideas of collaborative projects that they would wish to carry out. Most of these participants ended up applying for a NextStep grant later on.

After this first approach, **Prof. Giovanni de Micheli** opened the proceedings of the second day by stressing once again the importance of PhD students in the program. Nano-Tera presently over 150 PhD students, and these researchers are the best means of technology transfer with a great impact on economy and society, he insisted. De Micheli pointed out that in Switzerland there is an innovation gap, called the "Valley of Death", where it is difficult for new and promising projects to find financial resources because of the fact that they sometimes lack expertise and solidity on the market. How could it be different? Nano-Tera wants to bridge that gap by giving more communication opportunities between industries and academics, and already proposed, for example, co-teaching courses by teams involving industrial specialists.

Professor Jan Rabaey from the University of California Berkeley gave the **keynote speech** "On the Symbiotic Nature of Information Technology and Neuroscience". He started by warning the audience that Moore's law was going to reach its end in the next ten years. Until now, Moore's law has been astonishingly successful in predicting the doubling of the number of transistors in a dense integrated circuit. This seems to be the end of it, but not a good enough reason to start getting depressed. The main challenge today, according to Jan Rabaey is data processing. The solution may reside in mimicking the human brain: "the most powerful computer that is 2 to 3 orders more efficient than today's silicon equivalent". A computational engine that reaches amazing performances with "mediocre" components, according to Jan Rabaey. Building computers on these premises, trying to imitate what our brain is capable of, to classify and index thanks to our associative memory. Tomorrow's computers would need to be able to couple random indexing with associative memory in a four-step process. The sensor part analyses data in a redundant mode and extracts the different features. The in-memory computing part transforms and classifies by associative memory. This random indexing/associative memory allows, for example, the creation of language identification programs with 98% accuracy. Approximate computing seems to become a major and promising resource as the IcySoC project tends to demonstrate. Many applications, especially with the way we use them, do not need exact computing to give an acceptable result. Thinking about most videos we are watching on the internet or music that we play through our earphones, approximate or inexact mathematics could do the work without anybody noticing a difference, but nevertheless "saving six times the amount of dynamic power used today by reducing the supply voltage from 1.0 V. to 0.4 V.

After a brief **presentation on posters** where all participants had two minutes to introduce their theme of research to the audience, another round of lectures began with Nano-Tera's three main domains of predilection: health, environment and energy:

Martin Wolf, from the University Hospital Zurich said how glad he was that this year's Nano-Tera event was dedicated to PhD students, they have the energy and the drive to go forward, seeing old problems with new eyes. Martin Wolf focused on the needs of all the human components of the medical chain, emphasizing that the three main groups of interrelated professionals, physicians, administrative regulators and scientists have different needs that are difficult to combine but essential to understand. Among the different on going researches that he presented, his Nano-Tera NewbornCare project was given as an illustration of the sometimes draining process researchers have to go through when confronted with the complexity of administrative approval. NewbornCare is a remote monitoring of premature babies in incubators through cameras.

Today, several tubes and cables are connected to the newborn, causing a large amount of false alert, up to 87.5%, due to the interaction of the baby with the different attachments. This system, instead, captures all the vital data through visual signals only. This project needs to go through the same paperwork as, say, a chemical drug for the treatment of cancer. Martin Wolf almost launches a distress signal: too much paperwork may kill good ideas, or at least, delay the application of discoveries that do not need the same level of security checks before becoming public. It would be good to have a division of risks between invasive and non invasive devices such as cameras that could drastically change the comfort of the patients and the medical staff.

The "environment part" lecture was given by **Jan van der Meer**, from the Department of Fundamental Microbiology UNIL who is working on sensors and bio-sensors projects, called Envirobot and Bravoo, specialized in the detection of pollutants in lakes, rivers and seas.

Envirobot is a robotic eel composed of seven modules connected together with actuated hinge joints. When put in motion, the anguilliform robot goes wavy in a very natural fashion swimming like an eel. Each of its modules is being packed with an array of physical, chemical or biological sensors that constantly feed a database with information on, for example, water temperature, oxygen, salinity or on the presence of pollutants such as lead, copper or mercury.

One of Envirobot's bio-sensors is composed of a chamber where the alteration of movement of five to six daphnia individuals upon contact to a water sample can be followed. Daphnia, or water fleas, are small crustaceans the size of one to five millimetres, which are very sensitive to chemical variations in the water. Modifications in the frequency of their movement within the chamber are automatically analyzed and compared to calibrated non-polluted controls. The advantage of a swimming robot is its ability to move without creating disturbance in the water, which is not the case for a robot with propellers. By adding or removing modules, the robot is reconfigurable for the type of pollutant to study. The final goal of the project is to produce a new Envirobot, which is going to be able to find pollution on its own, on the basis of input given by its sensors. Bravoo is the static version of the robotic eel. It is a buoy packed with all sorts of sensors with a much longer autonomy, since this buoy can stay an entire month collecting data versus only one day for Envirobot.

The Smart Energy part was presented by **David Atienza**, Professor at the Embedded Systems Laboratory, EPFL, and like Jan Rabaey, David Atienza warns the audience about the end of Moore's law and the enormous quantity of data that will need processing. If in 2013, data collection and processing was evaluated at 4.4 ZB, this number will grow to 44 ZB in 2020.

Today, data centers are essential to society, they are used in all our activities: health, science, services, information, commerce or personal life. Each data center consists of thousands of computing servers that store and process on our behalf. We are now facing a threshold, performance growth has stopped, more energy will always be needed to get higher power density for the same server size. Today, the energy cost is as high as the investment needed into servers on a three-year replacement policy. Power is becoming the most expensive aspect of a data center.

David Atienza says that brains are the most efficient computing systems, and brains do approximate computing. They are accurate only when it is really necessary and they have optimal power management. "YINS", a Nano-Tera project, is an energy and thermal aware design of future data center based on energy recovery where all levels or parts of a big data center would participate in enhancing energy awareness. Better chip design together with inexact arithmetic and smart grid science with a real time monitoring based on local power optimization can save power on a large scale.

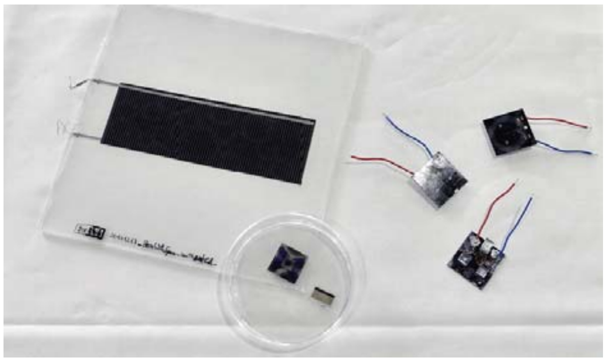
As always, a crucial part of the event was the long time devoted to the **posters and demonstrators exhibition**.

This year, most projects presented components or early prototypes and demonstrators, thus letting participants get a very concrete idea of what the projects are building and that the research will ultimately lead to.

For example, the **OpenSense II** project brought a pollution sensor box mounted on an electrical car (pictured left), as part of their efforts to produce high-resolution maps of urban pollution based on mobile sensors.

The **HearRestore** project presented its setup illustrating the development of a high accuracy surgical platform for minimally invasive interventions in the ear. The system explained how the positioning of the head is calculated in order to ensure a safe and very accurate procedure. It for example showed exactly the techniques and models that are being refined in order to avoid affecting the facial nerve when drilling.

The **SHINE** project is developing a new generation of hydrogen production using sunlight, aiming at mimicking natural photosynthesis in a next-generation device able to exploit efficiently incoming sunlight in order to direct it into Photo-ElectroChemical components designed to split water into hydrogen and oxygen (pictured right).



The **Envirobot** project showed its prototype of an anguilliform robot, whose task consists in locating toxic elements in water, such as arsenic or pesticides and finding the source of this pollution.

The **WiseSkin** project is working on a non-invasive solution to restore a natural sensation of touch by embedding miniature tactility sensors into the cosmetic silicone coating of prostheses, which thereby acts like a sensory skin. A demonstration (pictures) allowed visitors to gain a feel for the problems being tackled.

DISSEMINATION AND PROMOTION ACTIVITIES

The 2015 Nano-Tera.ch Annual Plenary Meeting ended with the **Best Poster and Video Award**.

Nano-Tera researchers have produced lots of quality posters, reaching a record number of 150 this year. All posters presented were evaluated by a jury that ranked the three most outstanding ones, based on their scientific excellence and their ability to present the results in a way that can be understood and appreciated outside their specific research community. The jury was composed of Dr. Alena Simalatsar (EPFL), Olga Saukh (ETHZ) and Kate Gerber (UniBE), pictured right.

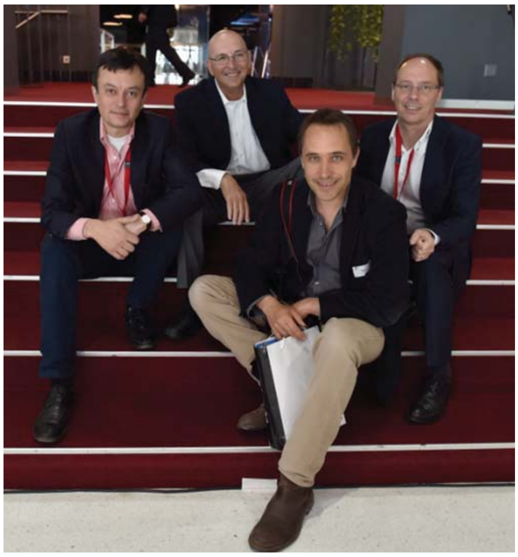
The winners are:

1st place: *Single-Chip 3D ultrasound beamforming*– **UltraSoundToGo**
Pascal Hager, Andrea Bartolini, Luca Benini (ETHZ)

2nd place: *Development of a pH sensor by inkjet printing of layer-by-layer deposition of IrOx nanoparticles* – **Envirobot**
Milica Jovic, Fernando Cortés-Salazar, Jonnathan Cesar Hidalgo Acosta, Géraldine Margeretha, Alice Stauffer, Andreas Lesch, Hubert Girault (EPFL)

3rd place: *Polydimethylsiloxane thin film preparation for dielectric elastomer actuators* – **SmartSphincter**
Tino Töpper, Bekim Osmani, Florian Weiss, Vanessa Leung, Marco Dominietto, Simone Hieber, Bert Müller (UniBE)

Poster award winners congratulated by Prof. Giovanni De Micheli. Left to right: T. Töpper (3rd place), M. Jovic (2nd place), Pascal Hager (1st place)



Several video contributions have also been received, and were also evaluated by a jury made of Alexandre Elmér, Claude Comina, Alban Kakulya and Roland Pesty (pictured right).

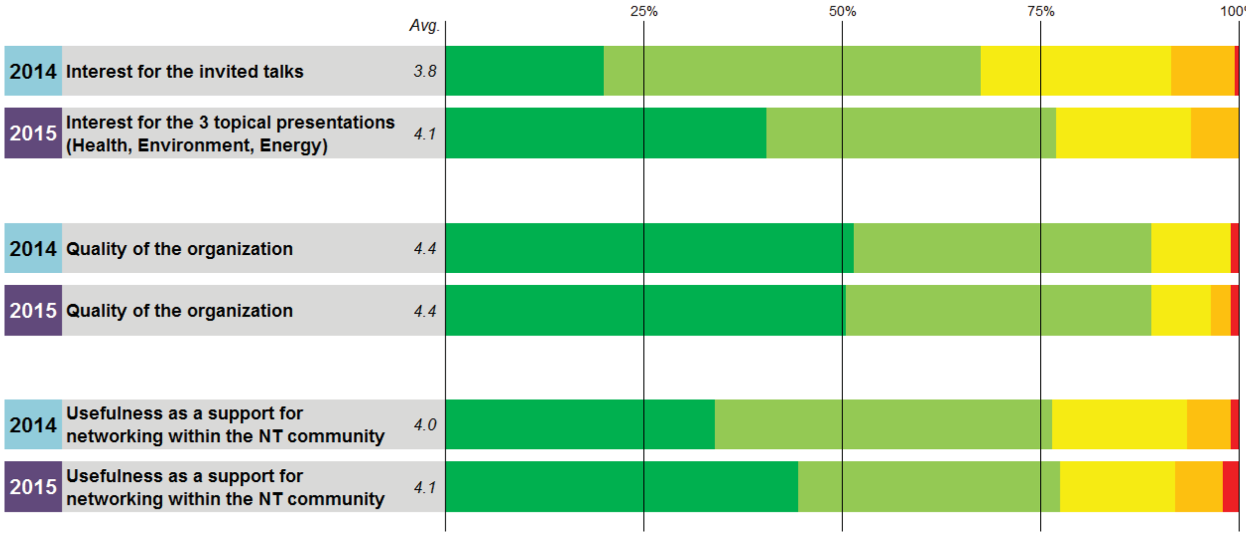
The winning video was the one made by **SHINE**, on hydrogen production using sunlight. It was awarded with the shooting of a professional film to present their work to a larger audience.

Finally, a jury composed of Nano-Tera Executive Committee members and expert scientists decided that the students who had pitched their business ideas in the framework of the NextStep program would be awarded a grant to attend an impact event or their choice, such as CES.

Some of the students who pitched their entrepreneurial ideas

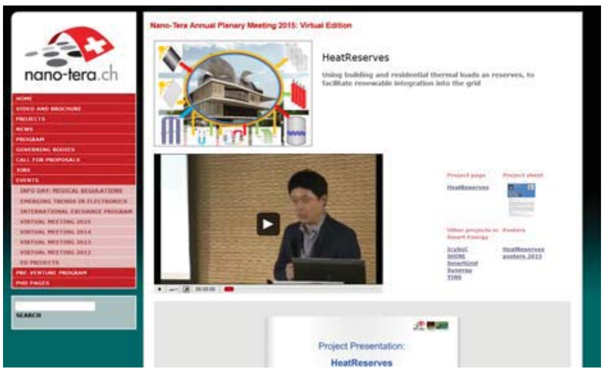
In an **evaluation survey** following the meeting, 89% or respondents rated the organization of the meeting as either good or very good. Moreover, the meeting was deemed useful as a support for networking within the Nano-Tera community by 78% of respondents. The fact that, this year, the project presentations were delivered by PhD students also garnered positive feedback from the audience (80%). Overall, 81% of participants have rated the Nano-Tera annual meeting as either good or very good, with only 6% voicing a negative opinion.

When comparing some of these results with the questions which had been asked in the same way for the annual meeting 2014 feedback, we get the following results:



Like last year, all the content of the annual meeting 2015 has been made available online on a **virtual annual meeting** platform.

The posters and the videos of all the presentations can be browsed at http://www.nano-tera.ch/events/virtual2015.html.



DISSEMINATION AND PROMOTION ACTIVITIES

Symposium on Emerging Trends in Electronics

Organized in the framework of the Nano-Tera.ch International Exchange Program and chaired by Prof. Giovanni De Micheli, the Symposium on Emerging Trends in Electronics has brought to Montreux in December 2014 about 100 renowned scientists and business leaders and addressed the means to grow the European economy by creating new jobs and products enabled by advances in electronics.

The symposium featured presentations in technology applications, ranging from A. Chandrakasan (MIT) who addressed miniaturized circuit design, to T. Sakurai (U. Tokyo) who described flexible electronic circuits to achieve electronic skin, and K. Shepard (Columbia niversity) who demonstrated electrical circuits applicable to sensors and DNA sequencers. S. Furber (U. Manchester) explained progress in neuromorphic energy sustainable high-performance computing with the Spinnaker chip, while G. Fettweis (U. Dresden) showed how 5G communication technology will improve our living standards, from automatic driving to the connected smart city.

Representatives from the European Industry presented the latest semiconductor processes for high-performance, low-power applications and the Internet of Things. Academic and industry leaders discussed the advantages and limitations of the American and European models for design and product creation.

The symposium featured several round tables, including one panel of University Presidents, Rectors and VPs/VRs addressing how electronic means influence education (e.g., through MOOCs) and how education should address more emerging technologies. Emphasis was placed on students and the universities' task to forge thinking skills, while educating the best scientists, engineers and managers for a rapidly evolving world.

Sponsored by the Swiss Federal research program Nano-Tera.ch, this event featured excellent presentations and discussions that are available on the Nano-Tera.ch web portal in the form of a virtual meeting.

Swiss Research Program

Nano-Tera.ch

Engineering Multi-Scale Systems for Health, Security, Energy and the Environment

nano-tera.ch

Prof. Giovanni De Micheli Nano-Tera.ch Program Leader

A successful funding program

Since 2008:

- **140** research projects funded • **250,000,000** US$ total budget
- **1,200** researchers • **310** PhD students
- **1,000** publications • **2,000** presentations worldwide • **54** awards

Taking nanotechnology from the labs into our daily lives

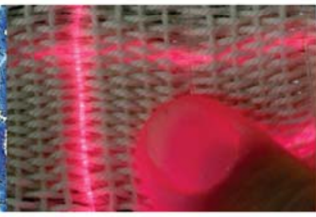
Concrete results: from environmental monitoring to intelligent textiles

Nano-Tera.ch has achieved outstanding results in the areas of biosensing, design of medical implants and diagnosis tools, and monitoring systems for the environment. Success stories include:

- ✓ sensors for biomarkers in the bloodstream
- ✓ wearable ECG with wireless data transmission
- ✓ electro-optical textiles for monitoring skin ulcers
- ✓ optical sensing platform to detect doping agents in saliva
- ✓ networked rock-displacement detectors to protect against rockslides

Monitoring alpine mass movements at multiple scales

Network of low-cost mobile pollution sensors for high resolution, real time information about air quality



Smart sensor-equipped textiles, able to monitor tissue oxygenation

Real-time ECG device, for example in the context of obesity monitoring

Novel surgical platform for minimally invasive interventions in the ear

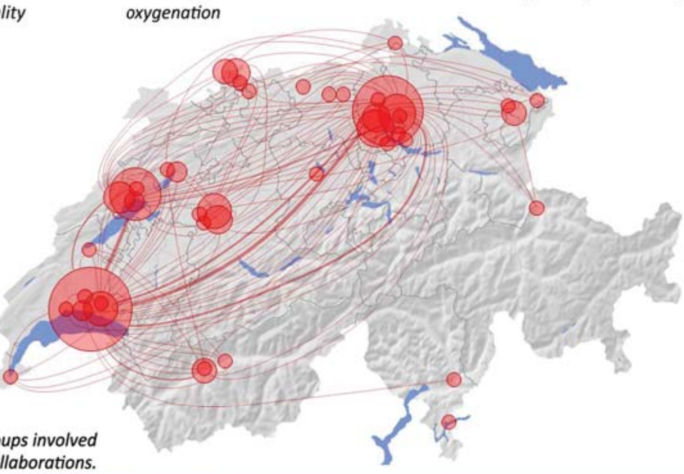
A dense research network

50 Swiss research institutions

- ✓ the two Swiss Polytechnics (EPFL, ETHZ)
- ✓ 9 universities
- ✓ 5 universities of applied sciences
- ✓ 6 university hospitals
- ✓ many other public or private partners

74 industrial partners and hospital end-users

- ✓ additional funding of 16,000,000 US$
- ✓ 43 patents filed



The nodes indicate the number of research groups involved and the links the number of collaborations.

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Under the general supervision of the Swiss State Secretariat for Education and Research

FNSNF ETH BOARD SUK·CUS

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PROJECTS TIMELINE

Phase I Projects, 2009-2013

RTD		2009	2010	2011	2012	2013
CabTuRes	C. Hierold					
CMOSAIC	J. Thome					
GreenPower	J.-A. Månson					
i-IronIC	G. De Micheli					
IrSens / IR-N-ox	J. Faist					
ISyPeM / TWPeM	C. Guiducci					
LiveSense	P. Renaud					
MIXSEL	U. Keller					
NanowireSensor	C. Schönenberger					
Nexray / COSMICMOS	A. Dommann					
NutriChip / Ca-NutriChip	M. Gijs					
OpenSense / OpenSense+	K. Aberer					
PATLiSci / MINACEL	H. Heinzelmann					
PlaCiTUS	Q. Huang					
QCrypt	N. Gisin					
SelfSys / SelfSys+	J. Brugger					
SImOS / SImOS+	P. Ryser					
TecInTex	G. Tröster					
X-Sense	L. Thiele					

SSSTC		2009	2010	2011	2012	2013
i-Needle	S. Carrara					
M3WSN	T. Braun					
NaNiBo	A. Züttel					
NetCam	J. Lygeros					
SiC-nanomembranes	J. Brugger					
3DOptoChemiImage	D. Psaltis					

NTF		2009	2010	2011	2012	2013
BioAnt	A. Skrivervik					
BioCS-Node	P. Vandergheynst					
EMoA	F. Tièche					
Enabler	A. Ionescu					
G-DEMANDE	M. Schumacher					
MicroComb	T. Kippenberg					
NanoUp	A. Sienkiewicz					
NaWiBo	T. Zambelli					
NeoSense	M. Wolf					
PMD-Program	S. Maerkl					
SecWear	M. Sami					
SMTS	C. Dürager					
TWIGS	D. Briand					
ULP-Logic	Y. Leblebici					
ULP-Systems	Y. Leblebici					

Phase II Projects, 2013-2017

RTD		2013	2014	2015	2016	2017
BodyPoweredSenSE	P.-A. Farine					
Envirobot	J. van der Meer					
FlusiTex	B. Nelson					
HearRestore	S. Weber					
HeatReserves	J. Lygeros					
IcySoC	A. Burg					
IrSens II	J. Faist					
ISyPeM II	C. Guiducci					
MagnetoTheranostics	H. Hofmann					
MIXSEL II	U. Keller					
NewbornCare	P. Vandergheynst					
ObeSense	J.-P. Thiran					
OpenSense II	A. Martinoli					
PATLiSci II	E. Meyer					
SHINE	C. Moser					
SmartGrid	M. Kayal					
SmartSphincter	B. Müller					
SpineRepair	S. Lacour					
Synergy	C. Ballif					
UltraSoundToGo	G. De Micheli					
WearableMRI	K. Prüssmann					
WearMeSoC	Q. Huang					
WiseSkin	J. Farserotu					
X-Sense II	L. Thiele					
YINS	D. Atienza					

NTF		2013	2014	2015	2016	2017
Breathe	M. Liley					
DINAMO	K. Aberer					
IronIC++	S. Carrara					
MiniHolter	J.-M. Vesin					
NAMBP	J. Solà					
ParaTex	M. Wolf					
TANDEM	A. Weidenkaff					
3D-SensTex	D. Briand					
3D-Systems	Y. Leblebici					

GATEWAY		2013	2014	2015	2016	2017
FLUSIGATE2015	L. Boesel					
HEARGATE2015	E. Franzi					
PARAGATE2015	R. Rossi					
SYNGATE2015	C. Ballif					

GOVERNING BODIES

The Executive Committee

The Executive Committee (ExCom) acting on behalf of the Steering Committee, is the scientific executive body of Nano-Tera.ch; it consists of scientists from the partner institutions appointed by the Steering Committee and is chaired by the spokesperson of Nano-Tera.ch; it is responsible for defining and monitoring the scientific and academic strategy of the program and for providing scientific guidance.


Prof. Giovanni De Micheli
Chair, EPFL


Prof. Nico de Rooij
EPFL


Dr. Michel Despont
CSEM


Dr. Alex Dommann
EMPA


Prof. Boi Faltings
EPFL


Prof. Christofer Hierold
ETHZ


Prof. Qiuting Huang
ETHZ


Prof. Miroslaw Malek
USI


Prof. Hugo Zbinden
UniGE

The Steering Committee

The Steering Committee (SC), representing the Presidents, Rectors, CEO of the partners of the Nano-Tera.ch consortium; The Steering Committee is composed of the Rectors, Presidents, Directors, CEOs of the partner institutions involved in the Nano-Tera.ch consortium. The Steering Committee is responsible for all decisions/actions requiring statutory authority, as well as the overall monitoring of the program, including reporting, and the implementing evaluations/recommendations of the Scientific Advisory Board and of the SNSF Evaluation Panel.


Prof. Patrick Aebischer
Chairman and President
of EPFL


Prof. Philippe Gillet
Alternate to the Chair and
Vice-President for
Academic Affairs, EPFL

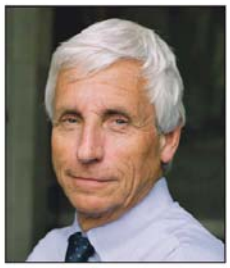

Dr. Mario El-Khoury
CEO
CSEM


Prof. Detlef Günther
Vice-President
ETHZ


Prof. Antonio Loprieno
President
UniBas


Prof. Piero Martinoli
President
USI


Prof. Martine Rahier
President
UniNE


Prof. Jean-Dominique Vassalli
Rector
University of Geneva

The SNSF Evaluation Panel

The SNSF Evaluation Panel, a group of international experts appointed by SNSF to evaluate the RTD proposals; the selection of the RTD proposal to be funded, as well as their funding level, is decided by SNSF based on the recommendations of the Evaluation Panel.

The current members of the SNSF Evaluation Panel of Nano-Tera.ch are:

- Dr. Amara Amara, ISEP
- Prof. Manfred Bayer, TU Dortmund
- Dr. David Bishop, Boston University
- Prof. Chris Boesch, University of Bern
- Prof. Harald Brune, SNSF
- Prof. Frederica Darema, NSF (USA)
- Dr. Urs Dürig, SNSF
- Prof. Rolf Ernst, TU Braunschweig
- Prof. Georges Gielen, Leuven University
- Prof. Chih-Ming Ho, UCLA
- Dr. Patrick Hunziker, University of Basel
- Prof. Mary Jane Irwin, Penn State University
- Dr. Karl Knop, SATW
- Prof. Paul Leiderer, SNSF Chair, Uni Konstanz
- Prof. Leila Parsa, Rensselaer Polytechnic Institute
- Prof. Jan Rabaey, University of Berkeley
- Prof. Albert van den Berg, University of Twente
- Prof. Hubert van den Bergh, SNSF
- Dr. Marco Wieland
- Prof. Hiroto Yasuura, Kyushu University

The Scientific Advisory Board

The Scientific Advisory Board (SAB) consists of academy and industry representatives from institutions other than the ones participating in the Nano-Tera.ch consortium; it is appointed by the Steering Committee, and provides an external evaluation of the overall performance of the program, as well as recommendations for its improvement.

The current members of the SAB of Nano-Tera.ch are:

- Dr. Andrea Cuomo, STMicro
- Prof. Satoshi Goto, Waseda University
- Prof. Enrico Macii, Politecnico di Torino
- Prof. Heinrich Meyr, SAB Chair, University of Aachen
- Prof. Khalil Najafi, University of Michigan
- Prof. Calton Pu, Georgia Tech
- Prof. Lina Sarro, Technical University Delft
- Prof. Göran Stemme, Royal Institute of Technology Stockholm

The NTF Evaluation Panel

The NTF Evaluation Panel consists of international experts who have conducted a thorough examination of the NTF proposals, establishing a ranking. The Executive Committee then decided how many of the top proposals could be funded according to the funds available.

The current members of the SAB of Nano-Tera.ch are:

- Dr. Thomas Burg, Max Planck Inst. for Biophys. Chemistry
- Dr. Thomas Ernst, CEA-LETI
- Dr. Victor Erokhin, Università degli studi di Parma
- Prof. Luca Fanucci, Università di Pisa
- Dr. Ahmed Jerraya, CEA-LETI
- Prof. Jan Madsen, Technical University of Denmark
- Dr. Firat Yazicioglu, GlaxoSmithKline

The Management Office

The Management Office (MO), responsible for operational tasks, led by an executive director, and involving specific staff for accounting, controlling, reporting, dissemination and web presence; the Management Office is operating under the supervision of the ExCom.

Dr. Martin Rajman, Executive Director

Yann Dixon
Finance & Control Coordinator

John Maxwell
Webmaster

Dr. Patrick Mayor
Scientific Coordinator

Jocelyne Vassallli
Administrative Assistant

Leading house

EPFL	Swiss Federal Institute of Technology Lausanne

Consortium institutions

CSEM	Swiss Center for Electronics and Microtechnology
EPFL	Swiss Federal Institute of Technology Lausanne
ETHZ	Swiss Federal Institute of Technology Zurich
UniBas	University of Basel
UniGE	University of Geneva
UniNE	University of Neuchâtel
USI	University of Lugano

Other partners

ABB	
ACP AG	Advanced Circuit Pursuit
ALP	Agroscope Liebefeld-Posieux
BFH	Bern University of Applied Sciences
BrainServe	
CePO	Pluridisciplinary Oncology Center
CHUV	University Hospital of Vaud
Credit Suisse	
CRR-SUVA	Clinique Romande de Réadaptation, SUVA
Eaton	
Eawag	Swiss Federal Institute of Aquatic Science and Technology
EM	EM Microelectronic-Marin
EMPA	Swiss Federal Laboratories for Materials Testing and Research
FHNW	University of Applied Sciences Northwestern Switzerland
FHO	University of Applied Sciences of Eastern Switzerland
FOEN	Federal Office for the Environment
FSRM	Swiss Foundation for Research in Microtechnology
GAMMA	Gamma Remote Sensing
HES-SO	University of Applied Sciences Western Switzerland
IBM ZRL	IBM Zurich Research Laboratory
Icare	Icare Institute
IDQ	id Quantique
InselSpital	Bern University Hospital
IRB	Institute for Research in Biomedicine
IST	Institute for Work and Health
Kinderspital ZH	University Children's Hospital Zurich
METAS	Federal Institute of Metrology
PSI	Paul Scherrer Institute
REMSMED AG	
Sefar	
Spitäler SH	Spitäler Schaffhausen
SPZ	Swiss Paraplegic Center
ST	STMicroelectronics
SUPSI	University of Applied Sciences and Arts of Southern Switzerland
SwissGrid	
Symbios	
UniBE	University of Bern
UniFR	University of Fribourg
UniSG	University of St.Gallen
UNIL	University of Lausanne
USB	University Hospital of Basel
USZ	University Hospital of Zurich
UZH	University of Zurich

Chinese institutions

DICP	Dalian Institute of Chemical Physics
PICB	Partner Institute for Computational Biology, Shanghai Institute for Biological Sciences
PKU	Peking University
USTC	University of Science and Technology of China, Suzhou
SIAT	Shenzhen Institutes of Advanced Technology

Consortium institutions

Other partners

Chinese institutions

Program Leader
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