# FLUXONICS

## NEWSLETTER

*SUPERCONDUCTIVE ELECTRONICS IN EUROPE*

N° 1 - February 2012

## Edito

The FLUXONICS Society has been founded in 2002 by a group of European laboratories and research centers working on Superconductive Electronics. Its goal is to create throughout Europe an infrastructure of research and development and to promote the manufacture of superconductive electronics. The objective is the dissemination and exploitation of the members' know-how in a structured, open european network, in the interest of more efficient research at a high level. For a few years, some small and large companies are part of the Society to tighten the links between research, innovation and transfer of know-how. For the decennial anniversary of the founding of FLUXONICS, this newsletter will highlight on a regular basis the main capabilities and achievements of Superconducting Electronics, placed in the perspective of past developments and future challenges. Superconductors, through their unique macroscopic quantum properties, can bring fresher and cleaner air during changing times. Shifting paradigms takes time but supercurrents last forever.



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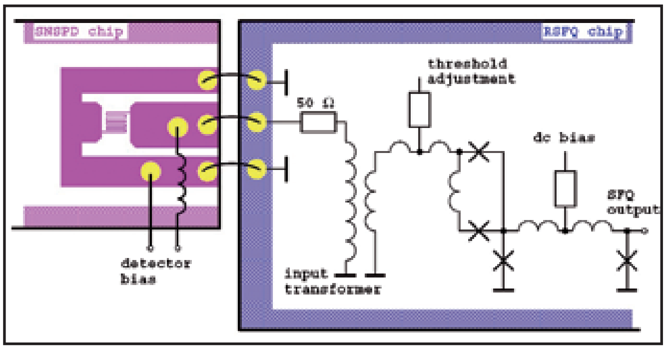
# Technology highlight

## Towards Superconductor Electronics as an enabling Technology for large Photonic Detector Arrays




*Schematic circuit diagram of the SNSPD and the SFQ circuit.*

The ability to detect single photons with high detection efficiency is one of the major breakthroughs in modern physics. Recent advances in superconducting photon detector (SPD) technologies enabled secure quantum key distribution over record distances, but their impact goes far beyond that of the quantum information world. SPDs are also affecting optical fields such as astronomy, laser ranging, remote sensing and imaging. Conventional SPDs are based on photomultipliers and avalanche photodiodes, with silicon-based devices. In the past few years, superconducting detectors achieved excellent results for infrared operation. Superconducting materials provide a very wide bandwidth for incoming photons, in principle they are sensitive to photons ranging from X-ray to terahertz wavelengths. Light is fundamentally composed of quantized energy packets known as photons. The energy of a single photon at visible or infrared wavelengths is around 1 eV (approximately $10^{-19}$ J). The detection of such a small energy is a serious challenge which can be met naturally only with a technology providing similar switching energies.

One such example is the superconducting nanowire single-photon detector (SNSPD) based on niobium nitride. Approximately 100 nm wide and 4 nm thick, these wires are cooled to below their critical temperature and are biased close to the critical current. After the photon absorption, a localized region is formed within the superconducting wire, a so-called hot spot. As a result, the entire cross-section of the SNSPD stripe becomes resistive, leading to a short voltage pulse with about 1 ns pulse width. The typical readout scheme consists of a bias tee, a microwave amplifier and a pulse counter. The weak voltage pulses require cryogenic low noise amplifiers with wide bandwidth. The high complexity of such a readout scheme is the most serious challenge for both multi-pixel detector arrays and imaging systems. Today, only a very few detectors can be installed in a system due to rapidly growing complexity and total power consumption [1]. In contrast to semiconductor amplifiers, superconducting single flux quantum (SFQ) circuits combine very low power dissipation (a few microwatts) with very high operation speed, thus enabling count-rates of several GHz [2]. The connection between SNSPD and SFQ electronics is very natural because voltage level, switching speed and operation temperature match perfectly. The combination of superconductor electronics and superconducting detectors enables large numbers of detectors for future compact multi-pixel systems with single photon counting resolution. Even though superconductors have to operate at cryogenic temperatures, this in turn gives them the advantage of an extremely good signal-to-noise ratio. In our most recent paper [3], we demonstrate the transfer of single photon triggered electrical pulses from a SNSPD to a single flux quantum (SFQ) pulse. The unique feature of the digital SNSPD readout circuit is the transformation of one quantized portion of energy (single photon) into another quantized unit (single magnetic flux quantum) by using a similar superconducting thin-film technology. Our experiments demonstrate the reliable detection of single photons by direct electrical conversion into single flux quanta. The detector was fabricated at Karlsruhe Institute of Technology, Germany [4] and the superconducting chip was fabricated by the

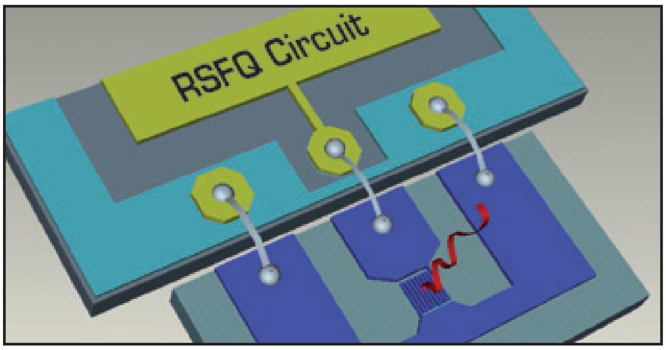


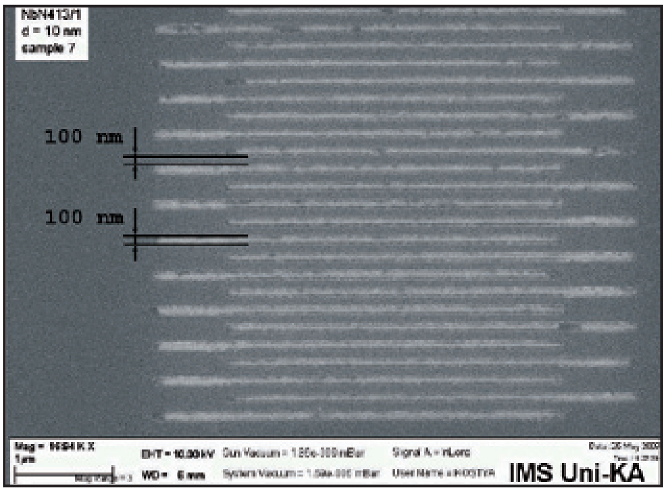

*Illustration of the electrical connection of the detector and the readout chip*


[1] M. Freebody, "Superconductors strengthen single-photon detectors," Photonics Spectra 45, 51–53 (2011)
[2] S. Anders et al. "European roadmap on superconducting electronics: status and perspectives," Physica C 470, 2079–2126 (2010).
[3] T. Ortlepp et al. "Demonstration of digital readout circuit for superconducting nanowire single photon detector," Optics Express, Vol. 19, Issue 19, pp. 18593-18601 (2011), Free download available at http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-19-19-18593
[4] M. Hofherr et al. "Intrinsic detection efficiency of superconducting nanowire single-photon detectors with different thicknesses," JAP 108, 014507 (2010)
[5] FLUXONICS Foundry, IC Foundry of Superconductor Electronics at IPHT Jena, Germany, www.fluxonics-foundry.de
[6] T. Ortlepp et al. "Reduced power consumption in superconducting electronics," IEEE Trans. Appl. Supercond. 21, 770–775 (2011).

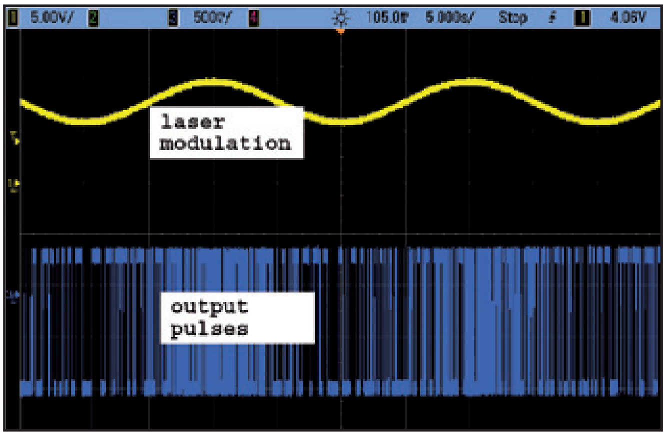
FLUXONICS Foundry, located at the Institute for Photonic Technology in Jena, Germany [5].

In contrast to semiconductor-based readout, an SFQ-based readout can operate with a power consumption of less than 1 µW per channel [6]. This is about one-thousand times less than the power consumption of a cryogenic semiconductor amplifier. The proposed concept is suitable for direct scaling to a multi-channel system with single photon counting resolution on two chips: one for the detector array and the other one for the multi-input SFQ circuit. In such a case, the number of readout channels is limited only by available packaging constraints for the multi-chip module. Therefore, scaling of this concept is straightforward and provides a promising solution for readout, multiplexing and processing of about 1000 detectors by means of superconductor electronics. Due to the similarity of the fabrication technologies for the SNSPD and the SFQ circuit, the integration of our hybrid approach on a single chip seems feasible in the near future. In this case the demonstrated interface solution offers for the first time a scalable approach for building multi-pixel arrays and cameras with a much higher number of detectors.

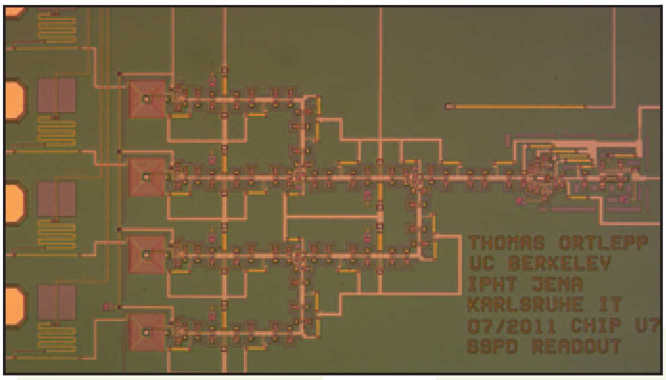
**Dr. Thomas Ortlepp**
*University of California Berkeley*
*Electrical Engineering and Computer Sciences*
*ortlepp@berkeley.edu*



*SEM image of a SNSPD fabricated at Karlsruhe Institute of Technology*



*Oscilloscope screenshot showing the digital response for a modulated optical input signal*



*SFQ chip fabricated at the FLUXONICS Foundry at IPHT Jena (Germany).*

## The FLUXONICS Society is composed of the following members:

- Institute of Photonic Technology (IPHT) - Jena - Germany
- University of Savoie - Chambéry - France
- University of Technology Ilmenau - Germany
- University of Twente - Enschede - The Netherlands
- Physikalisch-Technische Bundesanstalt (PTB) - Braunschweig - Germany
- Consiglio Nazionale delle Ricerche (CNR) - Naples - Italy
- University of Karlsruhe - Germany
- University of Cambridge - United Kingdom
- Chalmers University of Technology - Göteborg - Sweden
- Istituto Nazionale di Ricerca Metrologica (iNRiM) - Torino -Italy
- University of Stellenbosch - South Africa
- NioCAD (Pty) Ltd. - Dennesig - South Africa
- CNRS/THALES - Palaiseau - France

## Superconducting Electronics Research in Ukraine: History and some current activities

One hundred years after the discovery of superconductivity and nearly 50 years after the discovery of the Josephson effect, superconducting electronics research remains to be a current and increasing part of the low-temperature physics in Ukraine. Studies of material properties at the liquid-nitrogen temperature and below started in 1928 in Kharkov by establishing the Ukrainian Physical and Technical Institute where the first Soviet (and fourth in the world) cryogenic laboratory was organized. Its first years were connected with such well-known names as Lev Shubnikov, who came to Kharkov after his training in Leiden and initiated, in particular, studies in the field of superconductivity, and his friend Lev Landau. Along with fundamental research, Shubnikov started some applied activities and in 1933 proposed to organize a specialized technical laboratory with the task to link academic science with industrial Innovation. The laboratory with the name «Pilot Station for High Cooling» was established in 1935 and the tradition of the cooperation between fundamental and applied research has remained one of the main trends in the Ukrainian low-temperature physics up to now.

The first superconducting devices developed in Ukraine were cryotrons fabricated in the 50s of the last century in the Ukrainian Physical and Technical Institute by a group of scientists headed by Boris Lazarev. A new step in the development of superconducting electronics started in Kharkov in 1960 with a new specialized Institute for low temperature physics, the Institute for Low Temperature Physics and Engineering (now named from its first director B.I. Verkin). Five years after its establishment, three physicists from this Institute, Igor Yanson, Vladimir Svistunov and Igor Dmitrenko, using a conventional detector, succeeded to observe directly radiation emitted from a Josephson junction by the ac supercurrent (see the Nobel lecture of Brian D. Josephson). During the next years the first Soviet high-sensitivity SQUID-magnetometers ($10^{-12}$ T/m) and gradiometers ($10^{-13}$ T/m) for field and aviation geophysical purposes were designed and fabricated in the Institute for Low Temperature Physics and Engineering, as well as superconducting IR bolometers, high-frequency resonators, filters, and gravimeters with unique characteristics for that time.

*Cardiomagnetic scanner CARDIOMAGSCAN: 1 -cryostat holder, 2 -patient positioning system, 3 -base, 4 -cross-arm, 5 -counterweight, 6 -gantry*


*Three-channel scanning magnetic SQUID-microscope*

Among the current achievements of the researchers from the Institute for Low Temperature Physics and Engineering in Kharkov there are a scanning magnetic microscope with three measuring channels based on a high-temperature SQUID (patent of Ukraine UA 14098A) [1] and a scanning laser microscope [2]. The original design of the first device allows to study magnetic properties at room and liquid-nitrogen temperatures (see picture), for example, the hyper-vortex dynamics [3]. A new superconducting electronic device based on a superconducting ring with a point Josephson contact which does not need a traditional thermal switch has been proposed and realized as well [4].

More than 30 years ago the director of the Kyiv Institute for Cybernetics Victor Glushkov initiated intensive activities concerning superconductive technology applications in microelectronics. The initial idea was to develop a Josephson-junction based computer which has been transformed later into the creation of SQUID-magnetometers and bio-magnetic measuring systems with applications in medicine and biology. The main efforts of the team have been directed to magnetocardiography and biosusceptometry. An improved technology for manufacturing superconducting Nb-based tunnel junctions has been elaborated with prompt monitoring of their structure using an "anodization spectroscopy" which allows to get a valuable information about thicknesses of the layers and the interface quality [5,6]. Original oscillating

[1] S.I. Bondarenko et al. "Three channel non-force magnetic SQUID microscope". Physica B, vol. 329, pp. 1512-1513, 2003.
[2] A.P. Zhuravel et al. "Lazer scanning microscopy of HTS films and devices". Low Temperature Physics, vol. 32, pp. 592-607, 2006.
[3] A.A. Shablo et al. "The displacement and annihilation of macroscopic regions with hypervortices in ceramic $YBa_2Cu_3O_{7-x}$. Low Temperature Physics, vol. 36, pp. 110-114, 2010.
[4] V.P. Korverya et al. "Freezing and quantization of current passing through a two-connected superconductor with a point contact". Low Temperature Physics, vol. 36, pp. 605-610, 2010.
[5] T. Lebedeva et al. "Creation and properties of thin-film multilayer structures Nb/Al2O3-Al/Nb for Josephson junctions". Interface Controlled Materials, vol. 9, pp. 38-43, 2005.
[6] T.Lebedeva et al. "Anodization spectroscopy express-control system for thin-film technologies". Metal Matrix Composites and Metallic Foams, vol. 5, pp. 53–58, 2005.
[7] O. Zakorcheny et al. "Studying SQUID-system for active & passive biomagnetic researches at unshielded environment". Proc. 5th IEEE Workshop IDAACS, Rende (Cozenca), Italy, 2009, pp. 77–81

*Igor M. Dmitrenko (1928-2009) founded and headed the Department of Superconducting Electronics in the Institute for Low Temperature Physics and Engineering in Kharkov*

*Vladimir M. Svistunov (born in 1941) works in the field of single-particle tunnelling spectroscopy of conducting materials, performed one of the first tunnelling experiments under high pressures*

*Igor K. Yanson (1938-2011), received the Hewlett-Packard Prize of the European Physical Society for discovery and development of the point-contact spectroscopy in metals.*

relaxation mode for the SQUID operation with unshunted hysteretic Josephson junctions (patent of Ukraine UA 75434) was proposed, the first one-channel SQUID-magnetometers were developed with their application. Now SQUID-magnetometers are mainly based on a traditional dc mode with high balance of a gradiometer achieved by manufacturing (patent of Ukraine UA 16882) and by advanced mechanical balancing (patent of Ukraine UA 19997). Tests of both types of devices in unshielded environment proved that their signal-to-noise ratio is high enough for supersensitive bio-magnetic measurements [7,8]. It became evident that SQUID-based systems enable operation even in presence of strong urban noises without any expensive magnetically shielded room.

In a magnetocardiograph developed in the Kyiv Institute for Cybernetics data are obtained from contactless measurements at 36 spatial points by eight SQUID-channels: four of them register heart currents, 3 reference ones are needed to measure magnetic noise plus one electrocardiographic channel. Special software developed for the data acquisition and post-processing includes filtering, noise compensation averaging, and reconstruction of magnetic field maps, inverse problem solution, as well as an analysis of current density distribution maps [9]. The device is used for non-invasive cardiology including early stages of diseases, difficult-to-diagnose cases, and asymptomatic forms.

During the 2005-2008 period the same group, jointly with the "Kyiv Medical Group" company, developed a cardiomagnetic scanner CARDIOMAGSCAN which was installed in the Strazhesko Institute of Cardiology in Kyiv [10] (see picture). A new and improved device CARDIOMAGSCANER was installed in the General Military Clinical Hospital in Kyiv and is equipped with a computer-aided electro-mechanical patient positioning system and a novel software package CARMAG. At the same time the researchers performed intensive studies in the field of biosusceptometry, a non-invasive method to identify and localize magnetic materials within a living body. A research system for monitoring the presence of magnetic nanoparticles as well as transport of magnetic medicals was developed [11,12] with the aim to study magnetic nanoparticles inside an animal body for developing magnetic drug delivery and cancer therapy [13].

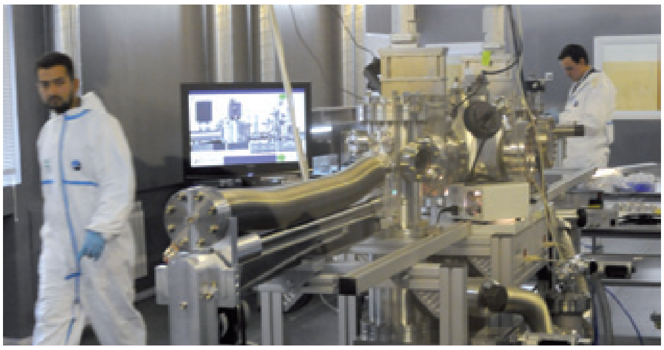
We have described only activities of two Ukrainian groups from a broad spectrum of superconducting electronics-oriented research performed by other teams in Kyiv, Kharkov, Donetsk, and Lviv. The main part of these groups is involved into international cooperation with European countries like Germany, Italy, the Netherlands, France, and Slovakia, which has intensified every year and proves to be useful for the collaborating parties. The first modern scientific and educational "Nanoelectronics and nanotechnologies" centre, launched in October 2011 in the National Technical University of Ukraine "Kyiv Polytechnic Institute" within a joint Ukrainian-Russian program on nanotechnologies, opens new perspectives for the development of superconducting electronics in the country (see picture). Fabrication and characterization facilities of the nano-centre are based on an open-access platform NanoFab 100 with a cluster arrangement of the modules which is produced by the NT-MDT company from Zelenograd, in Russia.

More information concerning superconducting electronics activities in Ukraine and possible contacts with Ukrainian colleagues can be obtained from Mikhail Belogolovskii at bel@fti.dn.ua.

**Igor D. Voitovych**
*V.M.Glushkov Institute for Cybernetics, National Academy of Science of Ukraine, Kyiv 03680, Ukraine*

**Stanislav I. Bondarenko**
*B.I.Verkin Institute for Low Temperature Physics and Engineering, National Academy of Science of Ukraine, Kharkov 061103, Ukraine*

**Mikhail A. Belogolovskii**
*A.A.Galkin Donetsk Institute for Physics and Engineering, National Academy of Science of Ukraine, Donetsk 83114, Ukraine*



*Modern scientific and educational centre "Nanoelectronics and nanotechnologies" in Kyiv launched in October 2011*

[8] M. Budnyk et al. "Improvement of small-channel MCG system for unshielded environment". IFMBE Proc. Series, vol. 28, Berlin, Germany, 2010, pp. 66–69.
[9] M. Primin et al. "Inverse problem solution algorithms in magnetocardiography: New analytical approaches and some results". International Journal of Applied Electromagnetics and Mechanics, vol. 29, pp. 65-81, 2009.
[10] M. Budnyk et al. "Development of 4-channel cardiomagnetic scaner and technical requirements for 9-channel scaner to diagnose the heart abnormalities". Proc. 6th IEEE Workshop IDAACS, Prague, Czech Republic, pp 77–81, 2011.
[11] M. Budnyk et al. "SQUID-magnetometry system project for in vivo studying magnetic nanoparticles into the small animal body". Proc. 4th IEEE Workshop IDAACS, Dortmund, Germany, pp. 55-59, 2007.
[12] M.Budnyk et al. "SQUID imaging system for studying magnetic nanoparticles". Biomagnetism: Interdisciplinary Research and Exploration, Sapporo, Japan, pp. 30-32, 2008.
[13] M. Khodakovskyi et al. "Experimental studying magnetic nanocomplexes with doxorubicin for drug delivery and cancer therapy". Proc. Meeting Nano-EuroMed, Uzhgorod, Ukraine, p. 192, 2011.

# Beyond paradigms

## SuperGreen Computing

*Superconducting Computers as Green Technology*

Superconducting computing has been 'the next great thing' since the 1960s, promising speeds that appear out of reach of semiconductor technologies, and yet it has remained stuck in a few niche applications. However, the demand for green technologies in large-scale computing may change everything.

Superconducting computing is quite different to traditional computing, mainly because of the very low temperature at which systems operate and the technology used to perform logic switches. Niobium-based circuits need to be cooled at approximately 4 K (-269°C - the temperature of liquid helium) in order to become superconducting, which means they require cryogenic cooling to bring them to the appropriate temperature. Also, where semiconductor electronics use transistors to perform logic functions as part of complementary metal–oxide–semiconductor (CMOS) technology, superconductor circuits make use of Josephson junctions as part of rapid single flux quantum (RSFQ) technology.

The reasons for superconducting computing's failure to launch are many, but boil down to large-scale computing vendors and consumers not yet seeing its advantage over CMOS, the dominant semiconductor technology since the 1980s. Recent developments in the world of large-scale computing make energy efficiency of key importance. This new need for green technology has created an opportunity for superconducting computing to play a major role and perhaps become the dominant technology.

Large-scale computing is dominated by two classes of machines with different applications. Computing power and efficiency have become important for both classes.

Supercomputers are created to perform tremendous numbers of operations per second to simulate things like weather/climate, automobile crashes, combustion, biological processes, cosmological events, etc. The TOP500 project has maintained a list of the 500 most powerful supercomputers in the world since 1993. More recently, supercomputers have been ranked according to their energy efficiency too. A focus on the energy use of supercomputers has resulted in the creation of the Green500 project, which has listed the 500 most energy efficient supercomputers since 2007.

Data centres are facilities built to house a large number of computer systems that store huge quantities of data and continue to grow as more information storage and processing is performed in the cloud. Lists of data centres include Datacentres.org and the US Data Center List. Other terms for this class of machines includes server farms, mainframes and capacity computers.

Some overlap between the two paradigms is starting to appear. Amazon's Cluster Compute Eight Extra Large project is an attempt to provide customers with the ability to make use of Amazon's considerable computing resources for High-Performance Computing (HPC) purposes. Google has donated a billion core-hours to scientific research with its Google Exacycle for Visiting Faculty project. By making use of spare computing capacity at their facilities, data centres can supply those that cannot afford a dedicated HPC system, or would only require it infrequently, with the infrastructure they need to perform computationally intensive calculations.

The growing realisation occurring world-wide that supercomputing is a contributor to economic competitiveness has meant that supercomputing has become a priority for governments. It makes it possible for complex systems - including those from biological, engineering, mathematical, geological and cosmological realms - to be modelled. This may either not be possible any other way, or it may require experiments that are more expensive, complex or unethical. These capabilities would give researchers in the countries that have a greater HPC capacity an advantage over researchers in those countries that do not have access to such infrastructure.

Currently, the ultimate goal is to reach exascale performance which requires more than $10^{18}$ **fl**oating **p**oint **o**perations **p**er **s**econd (FLOPS) or about 10 million times more powerful than the CPU in the average home PC. However, even though supercomputers are becoming more efficient, power consumption has been identified as a major hurdle on the road to exascale computing. Moving, storing and processing information in the supercomputer takes energy, which costs money. The quantity of available computing can be limited by energy or power. Ultimately, the economic benefits of the work performed on these machines must exceed the cost of building and running them, so increasing the FLOPS/W efficiency is becoming critical for the growth of supercomputing.

The European Mont-Blanc exascale project must achieve 50 GFLOPS/W to remain within the 20 MW energy budget (which may only be possible by 2022), but the current efficiency leader only achieves 2.03 GFLOPS/W. An exascale computer at that efficiency would require

477 MW of power, which would cost approximately $280 million (at industrial rates) to $430 million (at commercial rates) per year to supply in the USA. It will be a tall ask to achieve the 25x improvement.

Currently, the three leading supercomputers are the 705 024 core, 10.51 PFLOPS K computer, 2.6 PFLOPS Tianhe-1A and 1.8 PFLOPS Jaguar. The K computer requires at least 12.7 MW of power (an efficiency of 830 MFLOPS/W) to run at an annual cost of about $10 million. Since the average US household uses 10 896 kWh of electricity a year, that is enough to power over 10 000 homes!

For all the electricity that supercomputers use, data centers use far more. The data center companies are using so much power that they are having a major impact on energy consumption world wide. Data centers are currently consuming an estimated 31 GW of power (272 TWh of energy per year), responsible for approximately 200 million metric tons of $CO_2$ emissions per year (equivalent to approximately 40 million cars). In comparison, the fastest 500 supercomputers only use approximately a quarter of a gigawatt of power in total.

In the next year the power requirements of data centers is expected to grow by a further 4.4 GW. World electricity production in 2009 was an estimated 20 055 TWh, so data centers alone use approximately 1.4% of the world's electricity output. We would require 14 times the current total commercial solar electricity production, 22 average-sized nuclear power plants, or 40 of the world's largest wind farm to supply enough power to operate all data centres.

The impact of the energy requirements of computers has become such a large issue for some in the industry that they have started energy-related groups such as The Green Grid and Climate Savers Computing. These groups aim to provide a platform for the various stakeholders to collaborate on improving the energy efficiency of anything from PCs to data centres in order do reduce their environmental impact.

What is the best solution to the ever-increasing electricity usage in data centers and supercomputers? Superconducting chips could very well be it. Even if current technology achieves the order of magnitude improvement in power efficiency that is preferred for exascale computing, superconducting circuits may be an order of magnitude more efficient. In this context, researchers have shown a superconducting logic device to be 300 times more efficient than projected nanoscale semiconductors, even when including cooling. However, the details of this calculation are not published in the paper in which the claim was made, making it difficult to know how well this figure would translate to a large-scale computer. Other emerging energy efficient superconducting circuit architectures include RQL, eSFQ, eRSFQ and Adiabatic circuits. Moreover, the speed record for a superconducting circuit is 770 GHz, compared with 96.6 GHz for a similar semiconducting circuit, potentially making superconductive circuits a more versatile technology.

Huge amounts of money are spent on R&D into semiconductor technology. The 2008 Historical Annual Report of the Semiconductor Industry Association claims that the semiconductor industry provides $100 million per year to support research at US universities, and spends $15 billion on R&D annually. Intel planned to spend $7.3 billion in 2011 alone. Superconducting chips already outperform semiconducting chips in terms of speed and possibly efficiency. Convincing the HPC fraternity of the value of superconducting technology to their cause should be high on the agenda of groups in the superconducting circuit industry, though government support will likely remain critical. It will not be easy because some of the chips currently used were designed for consumer applications, thereby reducing the percentage of the development cost that the HPC industry needs to carry. However, potential energy savings and speed improvements may help build the case for them to take a closer look at superconducting technology.

A 2005 superconducting technology assessment found that there were "no significant outstanding research issues for RSFQ technologies" for the development of supercomputers based on the technology. A 2008 report on technology challenges in achieving exascale systems identified superconducting circuits as the most studied alternative to silicon-based logic technology. Efforts have already begun to develop appropriate chips for HPC applications. It is a good start in the right direction.

**Frank Ortmann, Retief Gerber and Mark Volkmann**
*NioCAD (Pty) Ltd*
*South Africa*

# Past Events

## Seventh FLUXONICS RSFQ Design Workshop at Ilmenau University of Technology / Germany - September 26 - 28, 2011

RSFQ stands for Rapid Single-Flux-Quantum and specifies a microelectronic integrated circuit technology. It is based on effects which can be observed in superconductive materials and therefore it belongs to the branch of superconductive electronics. Its special interest results from the fact that it combines very low power consumption on chip level with operation clocks in the Gigahertz range at the same time.

The FLUXONICS RSFQ design workshops were established following the foundation of the FLUXONICS e.V. [1]. They are an important means for knowledge dissemination with particular attention to inspire industrial interest as well as on the assessment of application fields for superconductive electronics. These workshops have been held every second year since 2001. From 2007 to 2009, this activity was included in the European S-PULSE activity to support superconductive electronics and during this period, the workshops were held on an annual base.

The 7th RSFQ design workshop took place in Ilmenau from September 26 -28. Also in this year, the number of participants again increased to 37 which demonstrates the growing interest in design and simulation aspects of superconductive electronics. Again, the international character of the event was significant. The general intention behind the programme was to assess the current status of superconductive electronics as well as to provide a critical review about possible application fields in order to identify required research issues to enable these applications. Furthermore, the education of young scientists and students should be fostered by incorporating them into the scientific and technical discussions.

For these reasons, the workshop was organised in seven technical chapters:

1. Tutorials on Basics of Rapid Single-Flux Quantum electronics
2. RSFQ Technology and Circuit Technique
3. RSFQ circuits for Detector readout
4. RSFQ circuits for Sensor readout
5. Advanced Aspects of RSFQ-Based Systems
6. Superconductive Electronics Systems
7. Design Automation for RSFQ Circuits

The workshop aimed at accomplishing the FLUXONICS mission of disseminating know-how on the RSFQ microelectronic circuits technique. Besides the concise information mainly directed to the young scientists and students among the participants. Thus, forming a common understanding on near-term research issues in the field of superconductive electronics can be considered as another result also of the 7th RSFQ design workshop in Ilmenau.

Statistics: 37 participants
**Germany: 19 - Japan: 10 - France: 2 - South Africa: 2**
**Turkey: 2 - U.S.A.: 2**

**by Hannes Toepfer**
*Ilmenau University of Technology*
*Germany*

[1] http://www.fluxonics.org

# Upcoming Events

## ISCM 2012, Istambul, Turkey April 20-May 4, 2012

**http://www.icsm2012.org**
The Third International Conference on Superconductivity and Magnetism (ICSM 2012) will focus on advances in all major disciplines of superconductivity and magnetism.

## ASC 2012, Portland, Oregon, USA October 7-12, 2012

**http://www.ascinc.org**
The next edition of the Applied Superconductivity Conference (ASC 2012) will highlight the latest development in the field of superconductivity.

## ISS 2012, Tokyo, Japan December 3-5, 2012

The 25th International Symposium on Superconductivity (ISS 2012) will emphasize advancements in the fields of superconductivity, science and technology

Edited for the FLUXONICS Society by:
Pascal Febvre - IMEP-LAHC - CNRS UMR5130 - University of Savoie - France - Email: Pascal.Febvre@univ-savoie.fr - Phone: +33 47 975 8864