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on Superconducting Electronics

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# TOWARDS A TERAHERTZ VIDEO CAM: FAST AND CRYOGEN-FREE SECURITY CAMERA

**by Torsten May**

*IPHT Jena*
*Germany*

*Fig. 1. Deployment of a terahertz security camera during the NATO manoeuvre 'Defence Against Terrorism (DAT)' in Eckernförde, Germany (September 2008)*

Security checks are part of our daily life – e.g. at airports or soccer stadiums. However, most people feel themselves annoyed or even hurt by such measures. Therefore, modern research should cope with the development of high level security technology whilst accepting the moral commitment of respecting privacy. One promising solution would be a passive terahertz (THz) security camera, which utilizes unique properties of THz waves to uncover hidden hazardous objects like weapons or explosives. Such ability is attractive not only in civil but also in military environments, as for example to protect field camps in the course of military actions (Fig. 1)

To achieve that task, a THz camera visualizes electromagnetic waves with frequencies below 1 THz. That is because damping of such waves in atmosphere and textiles strongly accumulates above that line. Admittedly, at low frequencies the optical resolution of images worsens because of diffraction. In lab experiments and simulations a good compromise for that trade was found at frequencies around 0.35 THz.

Based on security requirements to recognize objects as small as 1 cm from a few meters distance, a sizeable aperture is essential to achieve the needed spatial resolution. In use is a reflective optics of Cassegrain type with a 50 cm main and 12 cm secondary mirror (see Fig. 2). Even that large aperture receives only 0.1 % of the radiation emitted at 5 m distance. At THz frequencies, this implies that any detector which should create a greyscale image (256 shades) of a human has to resolve power differences of a few tens of femtowatts...

Therefore, the receiver developed at IPHT works at very low temperatures to decrease intrinsic thermal noise. To achieve the cooling a two-stage pulse tube cooler manufactured by Vericold (Germany) is used as initial stage. With that, the need to refill liquid cryogens by qualified personnel dispels. A supplemental 3He sorption cooler stage provides a stable base temperature of 0.3 Kelvin. Although this stage stabilizes the temperature oscillations of the pulse tube, inherent vibrations require decoupling the receiver mechanically (see Fig. 3).

The detector is based on the concept of the transition edge sensor. The whole setup is placed on a 1 micrometer thick silicon nitride membrane which is manufactured by micro lithography. Because of its low thermal conductivity of about 10nW/K this membrane ensures a measurable radiation-induced temperature increase of a dipole antenna absorber (see Fig. 4). To quantify the absorbed power, a superconductor electrically operated at its transition to normal state conductivity transforms the absorbed heat into an electrical current. The current signal is detected by a superconducting quantum interference device (SQUID) by feeding it to a coil and measuring the induced magnetic field.

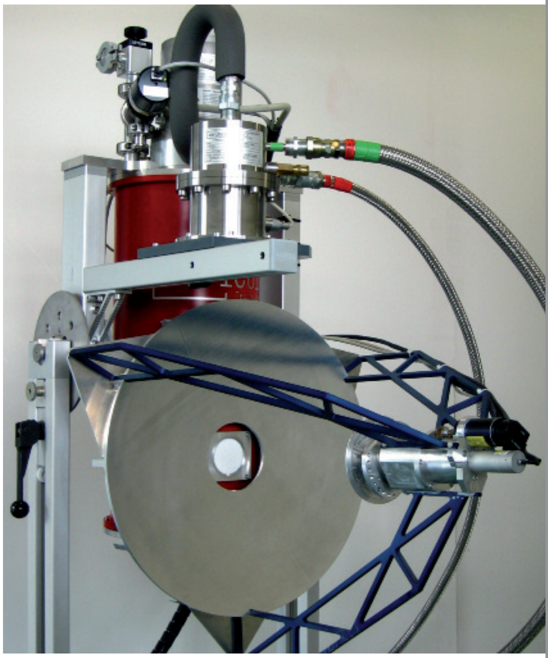

*Fig. 2. Prototype of the terahertz security camera, as assembled at IPHT. Visible are the optical components (Cassegrain mirrors) in front and the pulse tube cooler behind.*

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# ...TOWARDS A TERAHERTZ VIDEO CAM: FAST AND CRYOGEN-FREE SECURITY CAMERA

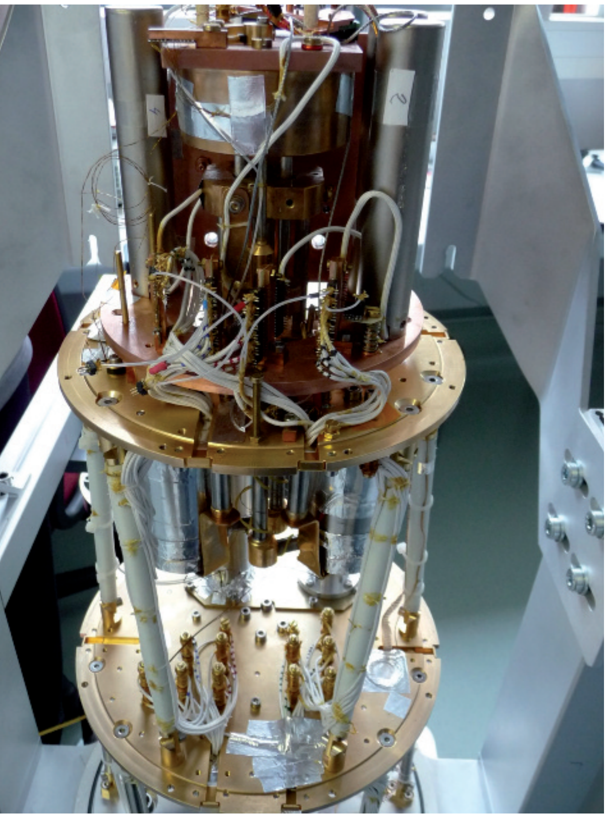

*Fig. 3. Inner workings of the cryogen-free cooler with receiver head and mechanical stabilizers.*

...A receiver with only 20 transition edge sensors in a circular array is used in the current camera generation, together with a parallel read-out by 20 current-sensor SQUIDs. Its instantaneous field of view of about 25mrad needs to be scanned over an image size of about 1.2 m diameter by an appropriate mechanism. The realized idea is to use the secondary mirror in order to keep the number of optical element small. The required two-dimensional tilting was transformed into a rotation with only one tilting degree of freedom. This reduces the influence of the inertial mass of the sizable mirror but implies the consequence of an unconventional spiral scanning.

The camera system is completed by an in-house development of data acquisition electronics to record 20 detector channels and synchronized position data from the scanner mechanism. This electronics bases on a 24bit digitization with high sampling rate whilst retaining a minimized back-action on the detectors. A personal computer translates the sensor and position data into an orthogonal grid and creates the image; and at the same time controls all main functions of the camera.

The described configuration of the IPHT THz camera is able to record images with 5 to 10 Hertz repetition frequency. That is already close to video rate, however, it is not yet sufficient to image persons passing the camera at walking pace without motion blurring. For that reason the forthcoming next generation will use receivers with 50 detectors to achieve full video rate at 25 Hz.

For an example, figure 5 shows the potential of the THz camera. It is obvious that THz images show a human body as a thermal map without anatomic features. In front of the person, underneath their clothing, objects with different THz emission characteristics become apparent. These can be metallic objects, which almost completely block body emission while reflecting the (colder) background. Up to a certain degree the same is true for ceramics, whose reflectivity is smaller but still sufficient. More ambitious is the detection of substances which absorb and emit THz radiation. Many organic compounds belong to this category, amongst them many common explosives. However, typically such substances have fingerprint spectra, which eventually allows detecting them in case of previous knowledge on these characteristics.

The ability of recognizing objects of various compositions already stands out of the performance of established security technologies like metal detectors. This is one of the major criteria for an introduction on the market. Only in case of a noticeable gain of security, officials and politicians will authorize the use of THz cameras to protect critical infrastructures. With the shown performance the IPHT camera is well prepared for that challenge.

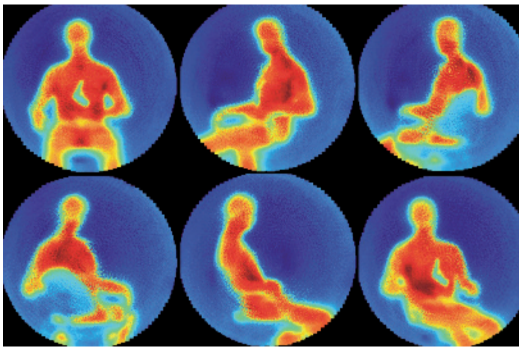

*Fig. 5. Freeze images of a person sitting on a lab chair, with a handgun mock-up hidden underneath its clothing. The images have been taken from a movie with 4 Hz frame rate.*

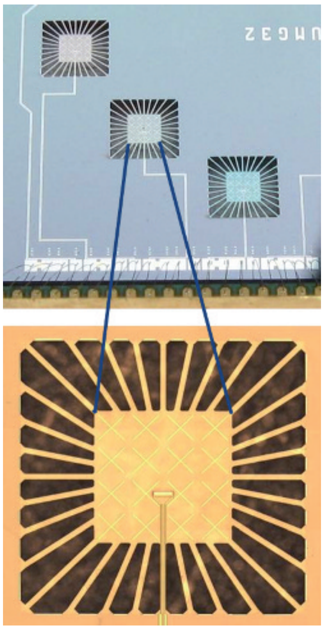

*Fig. 4. Micrograph of the detector array and zoom into a single pixel (below), showing the spider-web membrane with absorber dipoles.*

# SUPERCONDUCTING THIN FILM DEVICES AT VTT TECHNICAL RESEARCH CENTRE OF FINLAND

by Juha Hassel
and Panu Helistö

*VTT*
*Finland*

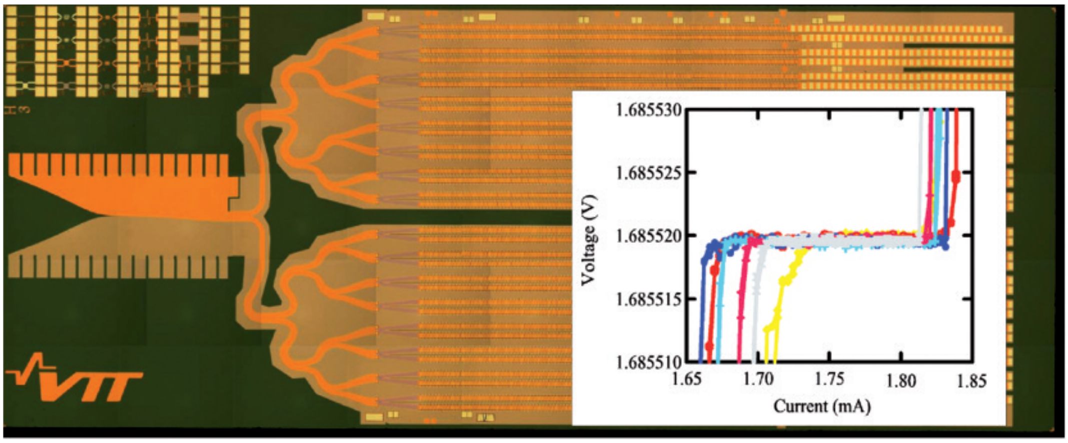

*Fig. 1. A micrograph and a measured quantized voltage step from a programmable Josephson voltage standard [1].*

>> Superconducting electronics and sensors have been a subject of research at VTT for a couple of decades. Historically, the research started from the need to develop ultrasensitive magnetic field sensors for brain imaging. As a consequence, the SQUID magnetometers developed by VTT are used as the sensors in market leader magnetoencephalography (MEG) brain scanner application of Elekta AB. The sensors are nowadays commercialised by the spin-off company Aivon OY.

VTT has a Nb trilayer Josephson junction fabrication line, which has been used in a variety of projects. As examples there has been the development of programmable Josephson voltage standards. Arrays of about 2 x 3500 overdamped junctions producing nonhysteretic quantized Josephson voltage of about 2 x 1.7 V were developed (Fig. 1) [1]. Within the 6th framework programme of the European Commission project RSFQubit, the process was modified for milli-Kelvin RSFQ applications [2], and RSFQ operation with electron temperatures of the shunts down to 50 mK was also verified [3]. VTT fabricated the mK Nb junction devices for the project. At VTT linear but frequency-dependent damping was demonstrated as a means to reduce the decoherence in RSFQ/qubit circuits (Fig. 2) [4].

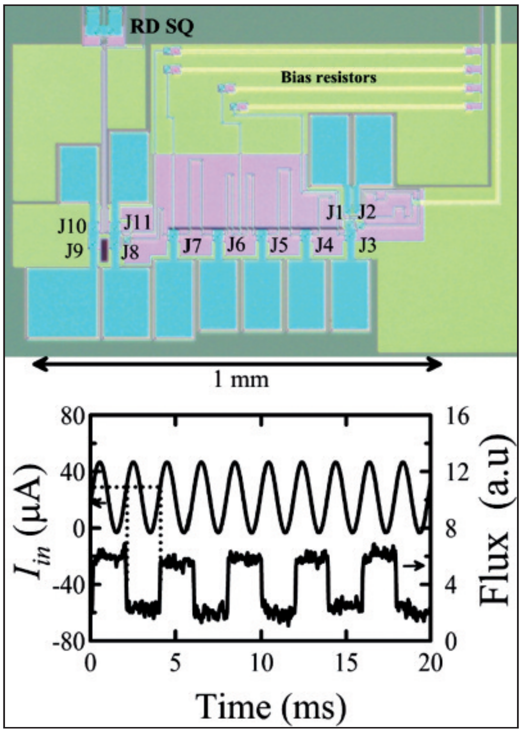

*Fig. 2. A measurement result verifying stable operation of an RSFQ circuit with frequency dependent shunts [4].*

At the moment there is ongoing SQUID development related to the IXO mission of the European Space Agency (ESA). The role of VTT is to develop SQUID based readout for cryomultiplexed X-ray calorimeter arrays based on transition edge sensors. The challenge there is to develop a high dynamic range readout for the frequency multiplexed sensor array. VTT develops SQUIDs, readout concepts and electronics [5,6].

There is also a renewed interest for SQUIDs in medical applications. Now the aim is to develop sensors to a hybrid imager enabling both MEG and low-field magnetic resonance imaging (MRI), i.e. simultaneous functional and structural mapping of human brain. This is done as a part of the EU 7th framework project MEGMRI. As a preliminary result we have developed an improved optical Nb process with 0.7 μm linewidth (Fig. 3) based on projection lithography. We have also verified recovery from field pulsing of at least 10 mT in our magnetometer modules having about 2 fT/Hz1/2 field resolution.

VTT has also developed a passive multichannel THz imager for concealed weapon detection [8]. The core of the setup are antenna coupled NbN wire bolometers and special room temperature readout electronics, developed at VTT. The core issue of the fabrication process is the release etching of the bolometer element to ensure thermal insulation from the substrate. An interesting recent spinoff from the superconducting device research is thermoacoustic sound source essentially based on the bolometer process. We have demonstrated the generation of sound and ultrasound (up to 110 dB sound pressure) with the device [8].

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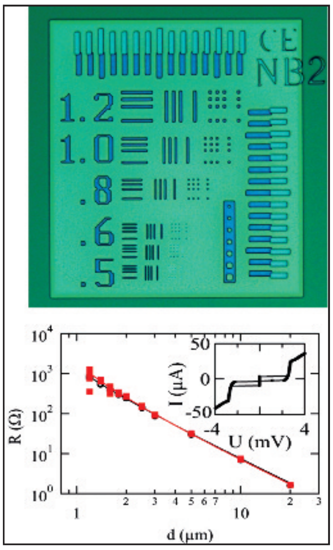

*Fig. 3. A microphotograph and characterisation results of Josephson junctions fabricated by projection lithography (room temperature resistance versus dimension, and 4.2 K current-voltage characteristics).*

# Superconducting Technology Highlight

## HIGH-TC JOSEPHSON SQUARE-LAW DETECTORS AND HILBERT SPECTROSCOPY

**by Y.Y. Divin**

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From the point of view of electronics, a Josephson junction is a voltage-controlled oscillator with a frequency $f_j$ directly proportional to a voltage across the junction, namely $f_j = 2eV/h$ where e is the electron charge and h the Planck constant. Intensities of Josephson oscillations are usually quite low, and Josephson oscillators did not attract much attention. But, Josephson junctions can be used as very efficient detectors of electromagnetic radiation. When a weak external monochromatic signal is applied to the Josephson junction, Josephson frequencies $f_j = 2eV/h$ are pulled to the frequency f of the external signal. The result of this frequency pulling is reflected on the dc current-voltage characteristics so, that a response $\Delta I(V)$, i.e. a difference between the I(V) curve, modified by the electromagnetic signal, and the unmodified $I_0(V)$ curve, demonstrates an odd-symmetric resonance around the voltage $V = hf/2e$ and a square-law dependence on the amplitude of the external signal. Thus, a Josephson junction can be considered as a square-law frequency-selective detector.

Hilbert spectroscopy is exactly based on these analytical properties of a voltage dependence of a response $\Delta I(V)$ of a Josephson junction to external electromagnetic radiation. In more general case of an arbitrary spectrum S(f) of the external signal, the response function $H(V) \propto \Delta I(V) \cdot I(V) \cdot V$ was found to be proportional to the Hilbert transform of the spectrum S(f) [1]. Applying an inverse Hilbert transformation to the measured response H(V), the spectrum S(f) can be recovered [1].

The first Hilbert spectrometers, realized on low-Tc Josephson junctions demonstrated a feasibility of fast spectral measurements at the frequency range up to a few hundreds GHz [2]. After discovery of high-$T_c$ superconductivity, we have started to fabricate and study Josephson junctions, made from these materials, with a hope to improve the main parameters of Josephson detectors such as spectral and power dynamic ranges and increase the temperature range of operation. Among the different types of high-$T_c$ junctions, the $YBa_2Cu_3O_{7-x}$ grain-boundary junctions were found to be the best ones for detector applications [3]. The TEM image and micrograph of one of our $YBa_2Cu_3O_{7-x}$ bicrystal junctions developed for Hilbert spectroscopy is shown in Fig.1.

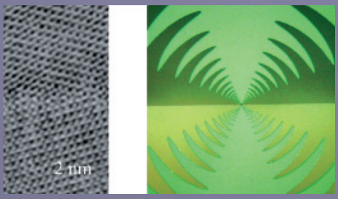

*Fig.1. TEM image of the [001]-tilt YBa2Cu307-x grain-boundary Josephson junction (left) and micrograph of the junction with integrated broadband antenna for Hilbert spectroscopy (right).*

The characteristic $I_cR_n$ -values were up to 0.34 mV at 77K and up to 3 mV at 35 K for our [001]-tilt bicrystal junctions [3] and could reach the values up to 1 mV and 8 mV for our [100]-tilt junctions at the temperatures of 77 K and 5 K, correspondingly (Fig. 2). In the last case, the ac Josephson effect was observed up to 5.2 THz, which is an absolute record for Josephson frequencies [4]. A frequency-selective response of high-$T_c$ Josephson junctions demonstrates a frequency bandwidth of almost two decades at a junction temperature T = 85 K close to the critical temperature $T_c = 92$ K (Fig. 3) and the center frequency of this bandwidth scales with the $I_cR_n(T)$-product of Josephson junction, where $I_c$ is the critical current and $R_n$ is the normal-state resistance of the junction [3].

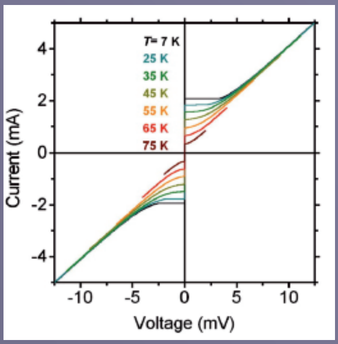

*Fig.2. Current-voltage characteristics of the [100]-tilt YBa2Cu307-x grain-boundary Josephson junction at various temperatures.*

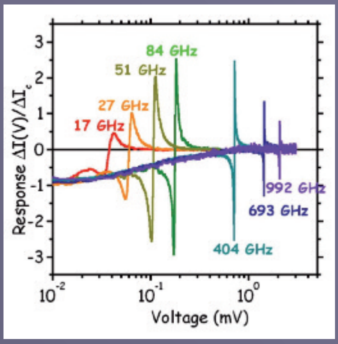

*Fig. 3. Spectral range of the Hilbert spectroscopy using YBa2Cu307-x grain-boundary Josephson junction at 85 K.*

The intrinsic sensitivity of our Josephson junctions to millimeter-wave and terahertz electromagnetic radiation is very high and the response $\Delta I$ demonstrates a linear dependence on input signal power $P_{in}$ in a very broad range of $P_{in}$. The values of intrinsic noise-equivalent power (NEP) of high-$T_c$ Josephson detector were obtained as low as $8 \cdot 10^{-15}$ W/Hz$^{1/2}$ and a power dynamic range $D = P_{max}/(NEP \cdot \Delta F^{1/2})$ - as high as $2 \cdot 10^5$ for a post-detection bandwidth $\Delta F = 1$ Hz even, when a high-$T_c$ Josephson detector was kept at a rather high temperature of 80 K (Fig. 4). The high values of the dynamic range are of importance, when a detector is intended for high-speed measurements, because a large post-detection bandwidth $\Delta F$, say of 1 MHz, will be required and the resulting dynamic range will be of $2 \cdot 10^2$, i.e. three orders lower than at $\Delta F = 1$ Hz. Due to this high dynamic range of high-$T_c$ Josephson detectors it was possible to measure radiation spectra of pulsed sources in a time interval of a few milliseconds [3].

Several prototypes of Hilbert spectrometers have been developed and tested in collaboration with the Institute of Radio Engineering & Electronics of Russian Academy of Sciences (Moscow, Russia), Central Electronics Laboratory of Research Center Juelich and TESLA Test Facility at DESY (Hamburg). We have successfully measured the following emission spectra: Lorentz spectra of Josephson oscillations, high-harmonic contents of commercial millimeter-wave oscillators, polychromatic radiation from optically-pumped far-infrared gas lasers (Fig. 5) and spectra of coherent transition radiation from relativistic electron bunches at the TESLA Test facility at DESY (Hamburg) [3].

Recently, we attracted attention to great potential of high-$T_c$ Josephson technology in security research [4]. We have developed a concept of liquid identification, based on our new Hilbert spectroscopy and high-$T_c$ Josephson junctions, which can operate at the intermediate range from microwaves to terahertz frequencies. A demonstration setup has been developed consisting of a polychromatic radiation source and a compact Hilbert spectrometer integrated in a Stirling cooler (Fig. 6). Reflection polychromatic spectra of various bottled liquids have been measured at the spectral range of 15 – 300 GHz with total scanning time down to 0.2 second and identification of liquids has been demonstrated (Fig. 7) [5].

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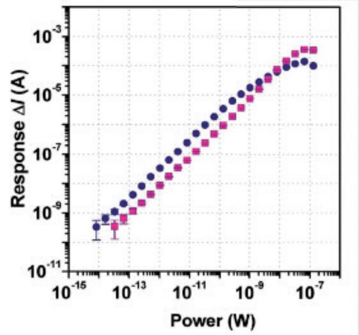

Fig.4. Power dynamic range of YBa2Cu3O7-x Josephson detector for electromagnetic radiation with frequency of 84 GHz. T = 80K.

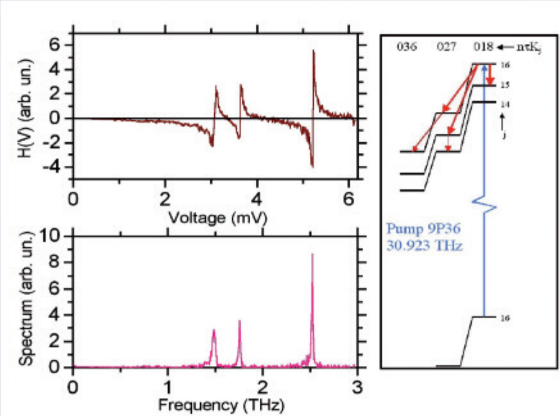

Fig. 5. Results of spectral measurements of radiation from optically pumped CH3OH laser by Hilbert spectroscopy (left) and energy diagram for CH3OH laser (right).

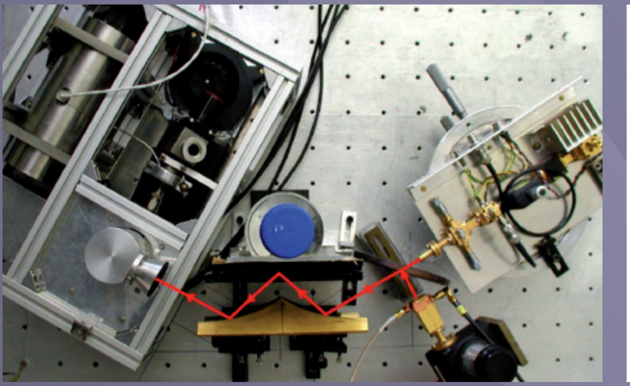

Fig.6. Demonstrator of liquid identifier, based on Hilbert spectrometer in Stirling cooler.

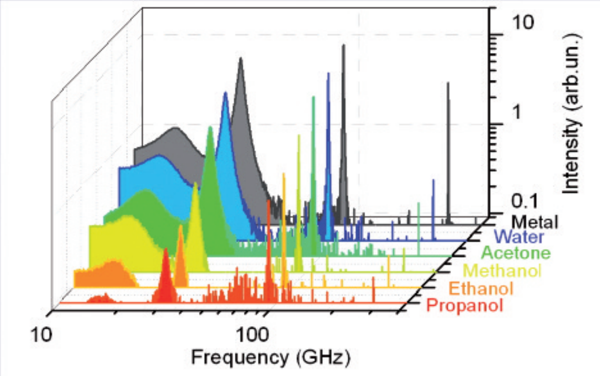

Fig. 7. Reflection spectra, measured by Hilbert spectrometer, from a metal plate, water, acetone, methanol, ethanol and propanol in bottles.

# NIOCAD READIES WORLD'S FIRST INTEGRATED SCE CIRCUIT DESIGN TOOL FOR COMMERCIAL LAUNCH

Stellenbosch University-originated technology transfer project gets second-round funding

**By Retief Gerber,**

*CEO of NioCAD, Stellenbosch, South Africa*

***NioCAD, the South African firm credited with the world's first integrated design automation tool for building superconducting electronics circuits, has secured €1.15 million in second-round funding from the country's Industrial Development Corporation (IDC). Having successfully removed considerable barriers in the way of commercial design of superconductive electronics (SCE), the company has now begun its own commercialisation drive, with a beta product produced by year-end 2009 and commercial product expected mid-way through 2010.***

### >> The technology of the future

It is commonly agreed that superconductive electronics (SCE) circuits, based on the Rapid Single Flux Quantum (RSFQ) family, are the most likely technology to replace current semiconductor technologies in key areas.

Many diverse application fields can benefit from commercially-developed SCE solutions, ranging from high-density and ultra-high frequency processors and telecommunications (wireless and fixed networks) to ultra-high sensitivity sensors.

### >> Critical barriers

Since the late 1990s, the technology has been exhaustively researched to bring these applications to fruition, but due to critical barriers industry uptake has been slow.

> The chief obstacle is the lack of an end-to-end electronic design automation (EDA) suite, consisting of an RSFQ cell library and a complete integrated suite of EDA tools. As current SCE design processes and tools do not scale, this has stunted the introduction of commercial applications.
> The lack of an easy-to-use design tool has further resulted in SCE circuit designers having to be highly-skilled physicists or engineers with PhDs and many years of experience.
> The absence of capable, integrated tools has also led to designs plagued by human error.
> The need for cryogenic cooling – this is no longer considered a problem as many high-performance systems require such cooling, which has brought costs down.
> Current superconductive integrated fabrication capabilities are far behind those of the semiconductor industry, but major facilities have recently been successfully adapted to accommodate SCE fabrication processes with NEC advanced process 2 leading the way.

### >> Current tools

As a result, nearly all integrated circuits are currently still fabricated with semiconductor tools and processes, combined with custom-designed, home-grown tools. This has had only limited success. RSFQ, the dominant digital superconductor technology, differs in crucial and fundamental ways from CMOS (Complementary Metal-Oxide Semiconductor), the dominant semiconductor technology.

> RSFQ requires a cryogenically-cooled environment;
> It uses ultra-short electrical pulses as a signalling technology rather than voltage levels;
> RSFQ circuit operation is described by way of quantum mechanical equations rather than electromagnetic ones;
> The technology requires carefully-engineered transmission lines, not just metallic connections, for signal propagation between logic elements. Propagation distance is limited, placing restrictions on circuit layout.
> RSFQ is highly sensitive to parasitic inductance and capacitance in circuit layouts and requires extremely accurate parameter extraction and process modeling.

### >> Drawbacks of current tools

The significant differences in design methodologies, design architectures and manufacturing processes of semiconductor and superconductive technologies make it extremely difficult, unproductive, expensive and error-prone to develop SCE circuits using semiconductor tools.

Current superconductive design is a labour-intensive process requiring manual integration and translation of data between many different tool components. The design process does not generally provide automatic feedback, so that changes made in one part of a design can be propagated automatically throughout the design, leading to inconsistencies and flawed designs.

Current tools also do not adequately verify the correct operation of a circuit, leaving it up to designers to verify its correct functioning, once manufactured. However, while it is possible for humans to detect and eliminate errors from circuits with tens or hundreds of components, greater circuit populations present problems. Currently, the trial-and-error process of verification used in commercial designs is time-consuming and leads to failed projects.

### >> A novel solution

NioCAD, developed since 2001, is the first and only company to develop an integrated software package, NioPulse, that addresses the specific needs of superconductive circuit design.

The software is easy to use and intuitive, allowing engineers to design circuits faster and with less requisite knowledge of quantum physics.

NioPulse caters for all SCE design needs, including schematic and cell-based design, circuit analysis and optimisation, physical as well as mixed-signal design, schematic versus physical verification and design and electrical rule checking – most of which are firsts in superconductive design.

The integration of physical and schematic design through a unifying data model further makes real-time circuit extraction and verification possible – which used to be done offline, even in semiconductor design tools. For the first time, circuit optimisation can be done on the physical layout rather than symbolic models, making it possible to model critical components much more accurately.

Featuring a closed-cycle design process, NioPulse eliminates the need for manual data migration and ensures that all changes at any point in the design process are propagated throughout the design, increasing designer productivity and reducing errors.

NioPulse's software architecture is flexible and modular, enabling extension of the suite to address new requirements as they occur. In addition, third-party developers and expert users are free to develop their own plug-in or script-based extensions.

### >> The NioPulse difference

The pressing current need for commercially-developed SCE technology, combined with the shortcomings of current design tools and processes, have made NioPulse's arrival very timely. Hardware Original Equipment Manufacturers (OEMs) and other design firms will benefit from its:

> Quick turnaround time
> Integrated, closed-cycle design process
> High levels of integration and automation
> Ease-of-use and design
> Highly extensible architecture

www.niocad.co.za

## UPCOMING events

**ISCM2010, Antalya, Turkey**
**April 20-30, 2010**

The International Conference on Superconductivity and Magnetism (ICSM2010) will be held in Antalya between 20-30 April, 2010 with a spring school (20-25 April, 2010) and educational courses prior to the conference (25-30 April). Members of the international scientific and engineering communities interested in recent developments in superconductivity, magnetism, magnetic materials and related technologies are cordially invited to attend the Conference (25-30 April 2010) with spring school (20-25 April 2010). More information at www.icsm2010.org.

**ASC2010, Washington DC, USA**
**August 1-6, 2010**

The next edition of the Applied Superconductivity Conference (ASC 2010) will be held in Washington DC, USA to highlight the latest development in the field of superconductivity. More information available at www.ascinc.org.

**Superconductivity Centennial Conference 2011 (EUCAS2011, ISEC2011, ICMC2011), The Hague, Netherlands**
**September 18-23, 2011**

For the first century of the discovery of superconductivity, the EUCAS, ISEC and ICMC conferences will be held simultaneously to deal with the development in the field of superconductivity and applications, of superconducting electronics and of cryogenic materials. More information: www.eucas2011.org; www.isec2011.org; www.icmc2011.org.

# S-PULSE INTERNATIONAL RSFQ TECHNOLOGY WORKSHOP

Institute of Photonic Technology, Jena, Germany, 22-23 October 2009

**By Juergen Kunert and Hans-Georg Meyer**

*IPHT Jena*
*Germany*

The dissemination of knowledge about Superconducting Electronics is a major aim of the European S-PULSE project. With this in mind, two technology workshops were organized in Jena. International experts lectured about design, fabrication, and the measurement of RSFQ circuits. The first technology workshop in 2008 introduced the fabrication steps of RSFQ circuits and was followed by a clean room tour with demonstrations of some of the fabrication tools. The second technology workshop in 2009 gathered experts from international and European RSFQ facilities. The workshop provided an overview of the RSFQ fabrication technologies and addressed both the current status and future developments.

We were fortunate to welcome Prof. Hidaka from SRL-ISTEC (Japan), D. Yohannes from Hypres (USA), and J. Hassel from VTT (Finland). A total of 23 scientists from Japan, the United States, Finland, France, and Germany participated to the workshop.

The first lesson, given by Prof. M. Hidaka, was entitled "Toward a better fabrication process for Nb devices". It was a very impressive demonstration of the powerful facilities for RSFQ fabrication in Japan that results in reliable integrated circuits. The highlight is the advanced process ADP2.1 with eight niobium layers. These complex devices contain more than 50,000 Josephson junctions. The success of this technology is related to the meticulously controlled process environments as well as the automated measurement of circuit parameters during and after fabrication.

D. Yohannes gave an overview of the "RSFQ Technologies at HYPRES". He emphasized the focused growth of this full-cycle digital RF electronics company that concentrates on the commercial wireless communication market as well as the military RF market. The stringent requirements of these applications are satisfied by a well controlled and up-to-date technology.

The workshop host, IPHT, presented the European FLUXONICS Foundry for RSFQ circuit design and fabrication. This Foundry is distributed in Europe on three locations in the University of Technology of Ilmenau (Germany), the University of Savoie (France) and IPHT Jena.

J. Hassel introduced the "Superconducting thin film technologies at VTT". One of several interesting projects at VTT is RSFQ technology in combination with quantum bits (Qu-bits) at milli-Kelvin temperatures.

D. Balachov from the PTB in Germany discussed technological possibilities for robust Josephson junctions with appropriate parameters for voltage standards.

The talk of J.-C. Villégier from CEA-Grenoble (France) about "CEA NbN-Nb-TiN RSFQ technology and foundry" displayed activities to increase the operation temperature of the devices to 9 K.

T. Ortlepp from the design part of the FLUXONICS Foundry at the University of Technology of Ilmenau completed the overview of the current developments in international RSFQ facilities with a presentation about "Design for unified characterization and testing".

Guided tours of the clean room facilities and the laboratories demonstrated the capability of IPHT from the development of ideas to instruments for real applications.

The workshop was followed by a visit at the optical museum in Jena. In the rebuilt manufacturing workshop of Carl Zeiss microscopes, today's nanometer engineers encountered the roots of microtechnology.

The participants emphasized that they enjoyed a workshop that addressed exclusively RSFQ fabrication issues. The workshop finished with a round table discussion in a very cooperative atmosphere. Necessary modifications of the technology were discussed. Of particular interest were novel materials for junctions that might allow increasing the critical current density reliably. Above all, it was stressed that common directions for RSFQ technology developments in Europe, Japan and the United States are vital and that new applications should be searched for.

## Contributions to this newsletter

*If you wish to write an article, mention an event or make an announcement about Superconducting Electronics in this Newsletter, please send the content in text or word format with separate files for pictures (with high resolution: 300 dpi minimum) at the following e-mail address, one month before publication: Pascal.Febvre@univ-savoie.fr .*

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