SUPERCONDUCTIVE ELECTRONICS FOR EUROPE

SUPPORT

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THE FLUXONICS SOCIETY

FLUXONICS is a non-profit society. Its goal is to develop Superconductive Electronics in Europe and to promote associated technological innovations through research, training, and transfer of knowledge. FLUXONICS is composed of laboratories from universities and national research centers and private companies. The main activity of FLUXONICS currently deals with Superconductive Digital Electronics. Since this circuit technique needs to closely interact with the external world, specific interfaces with semiconductors, optical systems and cryogenic systems are developed in the same framework by some of the FLUXONICS members, along with analog-to-digital and digital-to-analog converters. Superconductive sensors are also considered: they share the same technologies, closely interact with it, and are of particular importance in different areas of science and society. Furthermore, some work is dedicated to study materials and new developments that are necessary to prepare the next generations of superconductive devices.

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THE 2010 EUROPEAN ROADMAP ON SUPERCONDUCTIVE ELECTRONICS

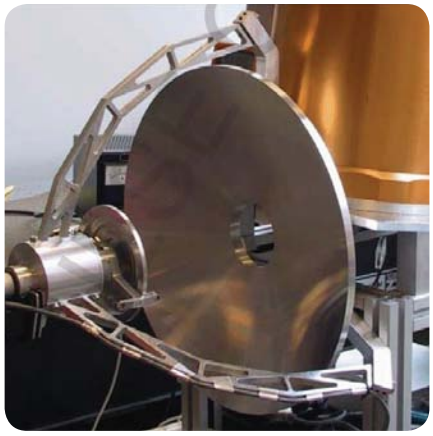
STATUS AND PERSPECTIVES

Digital Superconductive Electronics is a technology for circuits and devices that is inherently faster at much less power dissipation than semiconductor electronics. It makes use of superconductors and Josephson junctions as circuit elements, which can provide extremely fast digital devices in a frequency range – dependent on the material – of hundreds of GHz. This digital technique is scalable and follows similar design rules as semiconductor devices. Its very low power dissipation of only 0.1 μWatt per gate at 100 GHz opens the possibility of three-dimensional integration.

Circuits like microprocessors and analog-to-digital converters for commercial and scientific applications have been demonstrated. Apart from its outstanding features for digital electronics, Superconductive Electronics provides also the most sensitive sensor for magnetic fields. As amplifiers of electrical signals, superconductive solutions can nearly reach the theoretical limit given by quantum mechanics.

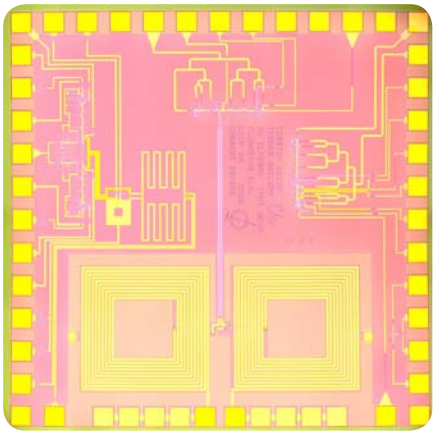
A further important field of application is the detection of very weak signals by superconductive bolometers and superconductive tunnel junctions. Their application as radiation detectors in a wide frequency range, from microwaves to X-rays is now standard.

The number of demonstrated applications is continuously increasing and there are numerous areas in professional high-performance electronics, in which Superconductive Electronics can be applied and surpasses the energy efficiency of classical devices.



THz video camera for passive sensing and imaging.

The cryo-cooled Josephson voltage standard, fabricated at Supracon AG Jena / Germany.



Superconductive integrated circuit with analog-to-digital conversion unit.

Superconductive Electronics is of potential impact in a variety of fields which determine the contemporary way of life as well as its quality:

- Resources and Environment, Health Care,
- Security and Mobility,
- Information and Communication Technology
- Improved Production Processes,
- Standardization and Measurement.

Within the European project S-PULSE, a Roadmap for Superconductive Electronics in Europe has been established by a consortium of leading scientists in the field from 15 partner sites. Besides a thorough assessment of the current state-of-the art, it represents an elaborated proposal for immediate action in order to allow the conversion of the potential offered by this technology into benefits for European society and industry. This document provides an excerpt with the main statements of the roadmap.

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THESES

1. Superconductivity already plays a very important role in scientific measurement techniques and ultra-sensitive detectors. In the future, a growing number of superconductor applications in science and industry can be expected.

2. The European expertise in basic science concerning superconductivity and material science is strong. Also in the area of applying superconductivity in high energy technology, health care, prospecting, standardization and measurement, Europe is still competitive. But with the current level of support, Europe is in danger to loose ground in the areas of health care and prospecting relative to the competitors in the USA and Japan.

3. In the important area of information and communication technology, Europe has already lost ground and urgently needs to close the gap to the USA and Japan. These countries have continuously maintained research programs for exploiting the unique features of Superconductive Electronics.

4. In Europe, the FLUXONICS platform – implemented by means of the European Community – aims at bringing together actors from industry, small and medium-sized enterprises (SME), and research organizations such as universities in the field of Superconductive Electronics.

5. The main challenges for turning the potential offered by Superconductive Electronics into positive effects for European society and industry can be addressed by focusing efforts on four proposed research fields.

SWOT ANALYSIS

Strengths

- Well-structured research community, covering all necessary branches.
- Organization by a society (FLUXONICS).
- Availability of a certified fabrication site for integrated circuits as well as of a dedicated design center for integrated circuits and sensors.

Weaknesses

- Sporadic research support
- Fragmented, often uncoordinated research activities
- Scarce recognition of the potential of Supeconductive Electronics for European society

Opportunities

Development of Superconductive Electronics enables new innovations in the fields of:

- Health Care,
- Security and Mobility,
- Information and Communication Technology,
- Improved Production Processes,
- Standardization and Measurement.

Threads

- National groups are in danger of running below critical mass.
- Continuation of fragmented research actions prevents a breakthrough of this technology.
- Danger of losing ground in comparison with USA and Japan.

PRIORITIES

For putting Superconductive Electronics into action with beneficial effects in major domains of European society, research and development efforts are necessary, also to maintain the European position in this field. As a result of the technology assessment in the roadmap, a prioritization has been carried out, leading to a recommendation of four major research activities.

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RECOMMENDATIONS

With the appropriate support, the European position can be transformed into leadership in a number of important fields. It would be an effective contribution to strengthening the future position of the European industry. Four main research projects have been identified, according to the expected impact on the European competitiveness in Superconductive Electronics so that real-world applications in this technology with significant social and industrial impact become viable:

I. Ultra-Sensitive Sensing and Imaging

Superconductive radiation detectors cover a very wide spectral range from millimeter to nanometer wavelengths or in the energy scale between meV and keV with applications in infrared and THz imaging technology.They are also emerging as detector-of-choice in high-throughput mass identification with of macromolecules. A large effort has to be put on maturing single detectors to devices which combine a large number of superconducting detectors and their readout whilst enhancing the manufacturing technology.

II. Quantum Measurement Instrumentation

Superconductive devices are playing an important role in fundamental metrology and high-precision measurements by means of quantum standards, which enable the reference of physical units to fundamental constants. Important goals consist in the development of electrical current standards in the sub-nanoampere range as well as of a quantum multimeter being a user-friendly multimeter for measuring voltages, resistances, and currents directly referenced to quantum standards.

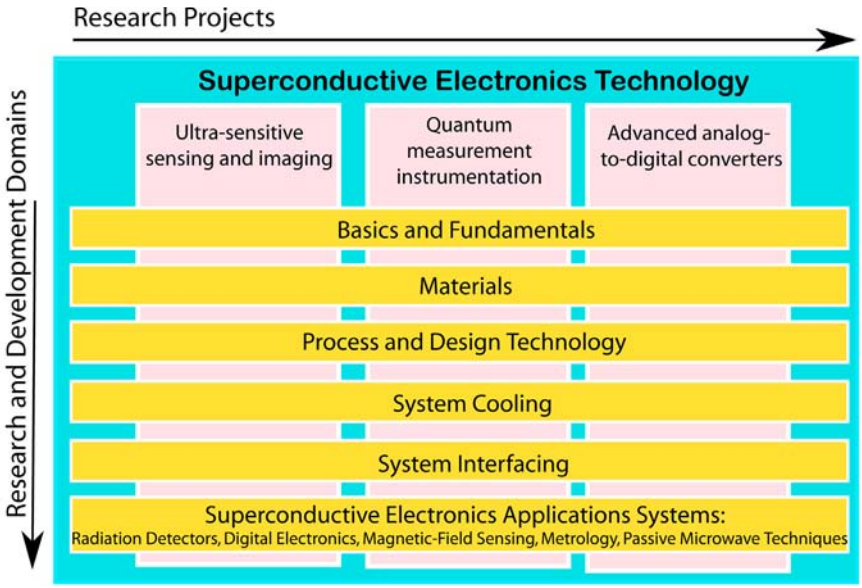
III. Advanced Analog-to-Digital Converters

One of the important stakes of future generations of communication networks relies on the possibility to introduce flexibility through configuration by software. The main objective is to propose systems to operators and users for which parameters like frequency bands, modulation formats, and number of channels per carrier can be modified after the system is built and during its entire life. This technique requires ultrafast analog-to-digital converters. To achieve the goals required by software-defined radio, it is necessary to develop extremely sensitive analog-to-digital converters having the high desired dynamic range using Superconductive Electronics technology.

IV. Superconductive Electronics Technology

The Superconductive Electronics technology must be focused to reach very-large-scale integration level as fast as possible. Only this level of integration allows getting access to real-world applications being of significance for the society and the industry as well. An adequate design infrastructure is seen as the enabler for intentionally introducing functionality into technological structures. In order to get best functionality and compatibility to the international mainstream, the software tools to be developed for Superconductive Electronics should be linked as best as possible to the circuit design software used in semiconductor technology.

The European Superconductive Electronics Research Matrix: It is proposed by the roadmap consortium as a means of coordinating research activities. It illustrates how the recommended research actions are to be integrated in the entire innovation chain from basic research to system implementation. The main purpose is to avoid doubling of R&D effort and to increase effectiveness by combining European research and fabrication capabilities.



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