T_CSUH/IEEE-CSC Special Lecture

Status of Digital Aplications of High-T_c Superconductors

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HSC 102: 12:00PM – 1:00PM

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IEEE Council on Superconductivity Distinguished Lecturer

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ABSTRACT:

Since the beginning of the High-Tc fever, one of the major goals was to develop Josephson junction based digital circuits that would allow operation at higher temperatures, e.g. at 77 K. Apart from a speed advantage, there would be a huge advantage in the required cooling power: whereas one needs about 3,500 W of electrical power for 1 W of cooling at 4.2 K, it would only be 20 W at 77 K – thus allowing for compact and low-power systems. Till recently, the development of HTS digital circuits more or less failed because of the difficulty to fabricate sufficiently large numbers of Joseph o junctions with small parameter spread – for a reasonable application one needs about 1,000 to 100,000 junctions, but the fabrication technology allowed only for less than 100.

The situation nowadays looks brighter: recent promising results in the fabrication of High-Tc Josephson junctions with very narrow ion-damaged barriers [1] could create new opportunities for the application of these junctions in semi-complex superconducting electronic circuits at temperatures up to 77 K. In addition, large numbers of step-edge junctions have been reported [2] with quite a low parameter spread. It still needs to be investigated, how these linear junctions perform in superconducting analog and digital circuits when operated at elevated temperatures and new design rules for HTS digital circuits have to be developed. In this talk I will introduce the necessary basics for High-Tc Josephson junctions and superconducting digital circuits as well as report on difficulties that still need to be resolved, e.g. the influence of thermal activation at higher temperatures and how it's influence can be limited in practical applications. Some key applications will be discussed, where superconducting digital circuits, even with a limited amount of Josephson junctions, can make a significant difference, such as for the interfacing classical superconducting digital circuits operated at 4.2 K to room-temperature electronic devices (e.g. for the Superconducting Supercomputer Project), and for microwave applications like fast ADCs, signal generators and correlators for real-time signal processing.

BIO ON THE OTHER SIDE

Persons with disabilities who require special accommodations to attend this lecture should call (713) 743-8213

BRIEF BIOGRAPHY:

Horst Rogalla was born in Germany in 1947. He studied Physics and Mathematics in Munster, Germany, and finished his study with a Ph.D in Physics. In 1986 he finished his habilitation in Physics in Giessen, Germany. After 2 years in the group of Mike Tinkham in Harvard, he accepted in 1987 a professorship in Low Temperature Physics at the University of Twente in the Netherlands from which he retired 2012. In 2010 he joined the Superconducting Electronics group of Sam Benz at NIST Boulder, USA, and joined the ECEE Department of the University of Colorado at Boulder as a Research Professor. Since 2015, he is "IEEE Distinguished Lecturer for Superconductive Electronics". In his time at the University of Twente, he was Director of the Material Science Institute CMO for a number of years and a founding member of the MESA+ institute. In the European Community he was a member of the board of the Network of Excellence in Superconductivity SCENET. He was also initiator and founding member of the European Society of Applied Superconductivity (ESAS) and the European Foundry Network FLUXONICS. He is member of the board of the ESAS and the IEEE Council on Superconductivity, and on international advisory boards of conferences such as EUCAS, ISEC, ISS and ASC. Since April 2016, he is Editor in Chief of the Superconductivity News Forum.

In his scientific carrier, he worked on the materials properties of superconductors, their deposition as thin films and application in Superconductive Electronics. Before the finding of High Temperature Superconductivity (HTS), he worked on the application of Nb3Ge thin films in SQUIDs and nanobridge sensors. After the finding of the High-Tc superconductors he invented the HTS ramp-Type Josephson junction and developed with his colleagues in Twente a multi-layer integration technique, which allowed to realize superconducting circuits with up to 4 HTS layers. This technique was successfully applied to the realization of HTS Superconductive Electronic devices such as digitizers and σ-δ-converters. Later on he was involved in the development of s-d-wave Josephson junctions based on Nb/YBCO ramp-type junctions, which allowed to realize π- junctions and apply them to new types of circuits. At NIST, he is working on noise thermometry using normal and superconducting electronics. For the Air Force he ran a project on arrays of YBCO split-ring resonators for meta-material applications. Recently, he started another Air Force project on digital applications of HTS Josephson junctions. In 2011 he received the IEEE Max Swerdlow Award and in 2013 he became life-time honorary voting member of the board of the European Society of Applied Superconductivity ESAS.