PL-1-INV

30 years of superconductivity in molecular solids

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Following the discovery of C_{60} (a quasi-spherical molecule with dimensions of ~1 nm) in 1985, the subsequent isolation and preparation of bulk crystalline samples of fullerenes—a set of hollow, closed-cage molecules consisting purely of carbon—from arc-processed carbon in 1990 sparked off a remarkable interdisciplinary research activity, encompassing diverse fields of chemistry, physics and materials science. The early research activity quickly culminated in 1991 in the synthesis of superconductors with stoichiometry A_3C_{60} (A = alkali metal) and considerably enhanced superconducting transition temperatures, T_c, when compared with any other molecular system. This was followed by a long period during which the established fulleride chemistry failed to deliver new materials. Therefore the physical picture of fullerene superconductivity remained unaltered until 2008 when the discovery of Cs_3C_{60} led to their rebirth and demonstrated their commonality with other classes of unconventional superconductors such as the cuprates and the iron chalcogenide/pnictide systems. C_{60}-based solids with stoichiometry A_3C_{60} are now established as archetypal examples of molecular superconductors with the highest superconducting transition temperatures ($T_c = 38$ K) among all molecular systems known. In addition, they also display the highest upper critical magnetic field ($H_{c2} > 90$ Tesla) among all known three-dimensional superconducting solids. The dominance of strong electron correlations in defining their behavior poses significant challenges for understanding the highly robust superconducting response to both temperature and magnetic field in these highly correlated organic metals. Here I will attempt to trace the development of this field of science to date with emphasis on its current status and future prospects.

PL-2-INV

Status Of Long Length MgB_2 Wire Manufacturing After a Decade Of Industrial Production

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We present the status after ten years of industrial manufacturing of MgB2 wires through the ex-situ process. Various conductor architectures have been meanwhile developed, and found suitable for MRI as well as cable applications. The process has been scaled up to very long lengths, enabling us to produce single batches up to 12,6 km long. Wire performance has now reached the target values for 1.5T whole body MRI systems, i.e. in the range of 800 A at 4 Tesla and 4.2K. The development now also includes superconducting joints, which are proven to be reliable in performance and processing even on our fully reacted wires. Ex-situ processed wires are robust enough to be handled in fully reacted state and employed in practical applications flawlessly. As a matter of fact, high current cables have been successfully realized and tested without any wire degradation. Successful demonstrators for various applications including magnets, generators, fault current limiters will be finally reported.

PL-3-INV

The near future power grid in TEPCO and superconducting applied technology

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Nowadays the four ‘D’ are well discussed in the energy industry and utility as a whole. That is, it is ‘Deregulation, Decentralization, Decarbonization, Degitalization’.

In Japan, after the earthquake of 3.11, review and consideration of social infrastructure as well as electric power utility is actively carried out.

Especially as Japan’s fifth ‘D’, technological development is required to be conscious of ‘Depopulation’ and solve it. I would like to talk about the possibility of related superconductivity application technology.

Keywords: Superconductivity application technology, depopulation, future electric grid

PL-4-INV

R&D of applied superconductivity by a small business: experiences and future perspective

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The increasing commercial availability of High-Tc Superconducting (HTS) wire in the decade following the discovery of this amazing class of materials opened the door to a range of unique application opportunities. The early international focus was on the power industry with a promise of a significant transformation in efficiency and supply security; however the realities of funding large and technically demanding prototypes and the lengthy timelines involved in realistic commercialisation pathways, meant that for a small business nearer-term opportunities would need to be explored. From a background in materials research and wire development activities, HTS-110 was established over 13 years ago to design and manufacture HTS magnets for a wide range of scientific and industrial applications; over the last decade significant progress has been made in the commercialisation of HTS magnets, both by HTS-110 and other manufacturers, paralleling the improvements in wire performance and quality. In this paper we review the developments of HTS magnet technology and applications leading to a range of niche application areas, from sample environments for synchrotron and neutron beamlines and other materials analysis applications, through to developments for the demanding realm of magnetic resonance, all of which leverage the benefits of high current density relative to copper and a relatively high operating temperature compared to the low-temperature superconductors. New future application areas promise to extend these developments and greatly expand the role of HTS magnets in our industrial society.

Fig. A 200 MHz HTS-NMR magnet produced by HTS-110

Keywords: HTS magnets, Applied superconductivity, Industrial

PL-5-INV

Recent Progress in the Development of Superconducting Wires in the U.S.A.

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Recent progress on the research-and-development (R&D) of superconducting wires in the U.S.A. will be reviewed. Significant efforts in the U.S.A. are on-going to develop long length manufactured wires of major families of superconductors, including $REBa_2Cu_3O_{7-x}$ (REBCO or YBCO) coated conductors, $Bi_2Sr_2CaCu_2O_{8-z}$ (Bi-2212), MgB_2, low temperature superconductors such as Nb_3Sn, and exploratory materials such as Fe-Se or Fe-As based. Efforts focus on improving properties for applications including long length uniformity, manufacturing issues, reducing wire cost, and also improving wire properties for applications such as by flux pinning and filamenting. The latest research to improve flux pinning of REBCO coated conductors by nano-defect additions for different manufactured processes will be reviewed, and the impact to dramatically improve performance and enable new applications and capabilities will be presented. Evolving improvements of the critical current density J_c(H,T,theta) values being achieved will be reviewed for ranges of temperatures from T = 5 K to 100 K, magnetic fields from H = 0.1 T to 30 T, and angular dependence theta = 0 to 90 degrees.

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PL-6-INV

30 Years of History and Future Perspectives of Superconducting Electronics

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From early on, Superconductive Electronics was in the mind of people looking to extend the boundaries of sensitivity, speed and energy efficiency. In Large Scale Applications, Kamerlingh Onnes very early on thought of creating high magnetic fields in a permanent current configuration. For Superconductive Electronics, it took a little longer to use the advantages of superconductivity: first digital devices – the Cryotrons - were developed in 1955 by Buck. With the invention of Josephson junctions in 1962, the age of the modern Superconductive Electronics began: within a short time, microwave effects like the Shapiro steps were found and the combination of Josephson effect and flux quantization led to the invention of rf- and dc SQUIDs and their application as highly-sensitivity magnetic field sensors, e.g. for detecting brain and heart magnetic signals. Applications in digital electronics followed: the famous IBM superconducting computer project and projects in Japan opened the field. Transition edge bolometers and tunnel junction detectors are very successful as sensitive detectors over a very wide frequency range - the list of device applications is too long to be fully covered in this talk.

The industrial side of Superconducting Electronics is a mixture of success and failure: the rise of the IBM Josephson computer project was a big stimulation for research on Superconductive Electronics, it’s fall on the other side was a big blow to the community and only the steady excellent work of research groups like the groups in Japan kept digital SE alive. New ideas came up like RSFQ of the group around Likharev and stimulated new research and new enthusiasm in the field. With the need for very high energy efficiency and with superconducting quantum computing, it seems that digital superconducting electronics has finally found its niche to successfully compete with semiconductor electronics.

The situation for the commercial superconducting sensor market is similar: superconducting sensors are very successful in science, e.g. in astronomy, but gained only slowly access to the industrial markets. But in the last decade, applications in detecting minerals were very successful and the application for ECG in hospitals (demonstrated e.g. in Tsukuba and Osaka) finally seems to get ground.

Seen the long time, superconductivity and superconductive electronics is around, and seen the excellent results achieved internationally – well supported by the availability of smaller and high-reliability cooling techniques - it is highly likely that wider applications of this technique in our societies will take place.