International Superconductivity Industry Summit

ISIS -15

Erlangen, Germany

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Communique

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20 Years of High-Temperature Superconductors - Successes and Challenges

EXECUTIVE SUMMARY

The 15th International Superconductivity Industry Summit (ISIS-15) was held at the Dorint Hotel Erlangen, Germany, on September 28-29, 2006. More than 40 delegates attended the summit. Most delegates were members of the Coalition for the Commercial Application of Superconductors (CCAS, USA), the Consortium of European Countries Determined to Use Superconductivity (CONECTUS, EU) and the International Superconductivity Technology Center (ISTEC, Japan). This year's Summit focused on two themes: a review, twenty years after the discovery of High-Temperature Superconductors, of "Successes and Remaining Challenges" in the field; and a look forward at key developments and challenges forecasted for the coming decade.

ISIS is an international forum that allows entrepreneurs to meet under one roof to discuss their common goals of promoting and providing leadership for the industrialization and commercialization of superconductor technology. The annual summits have helped generate a deeper understanding of the benefits of commercial superconductor applications, and to accelerate early market adoption of these technologies.

Superconductor Technology - A Key Competence of the 21st Century

Superconductivity is a phenomenon occurring in certain materials that causes them, when cooled to low temperatures, to lose all resistance to the flow of electricity.

Superconductor technology enables a wide range of solutions, ranging from power components operating at current densities 100 times higher than copper to quantum-based electronic circuits. Key features of superconductor-based equipment include: higher efficiencies; higher currents, fields and forces; higher power densities; smaller weight and size; higher image and signal resolutions; quantum-precision sensitivities or ultra-high speed at ultra-low losses. Such intrinsic performance advantages make superconductors a first choice for overcoming technological barriers.

Streams of information, energy, goods and people continue to steadily increase and will probably do so throughout the 21st century. At the same time, mankind is beginning to face the apparent effects of global climate change which, if anthropogenic in nature as indicated by much of the scientific evidence, could be further intensified by ongoing growth of the world's population. Oil and gas prices experienced a remarkable increase within the past two years, with growing evidence that global petroleum production may be nearing its peak. These energy and environmental trends are strong indicators that it will become increasingly important to pursue strategies for the conservation of energy in the generation, transmission and distribution of electricity. There remains a strong correlation between electricity consumption and the prosperity of society. In this context, if we are to assure the sustainable and efficient use of resources, we must pursue best practice solutions in electrical and electronic engineering. In this respect, the outstanding performance of superconductor technology can provide enabling solutions to many current and future needs. System integration of superconductor technology could thus become one of the key competences of the 21st century.

The Discovery of HTS: 20 Years After

Until the era of the 1980s, superconductivity could only be utilized when materials were held at very low temperatures (Low Temperature Superconductors, LTS). Then, in 1986, a new class of materials was discovered that show the transition to superconductivity at significantly higher temperatures (High Temperature Superconductors, HTS). The discovery of novel superconductors continues to the present day.

However, the high-flying expectations that initially marked the HTS era discounted the fact that the new HTS materials are complex ceramics, and that the manufacture of superior devices from these materials needs highly controlled and reproducible process technologies.

Considerable progress has been made within the past 20 years in the processing of these materials, and the fabrication of components like wires from them. Several successful system demonstrations and field tests have been carried out. In a couple of segments, HTS-based components and systems are already well-established. The broad breakthrough, however, has not yet been achieved. In several cases, the technical performance is not yet comparable with LTS, and not yet sufficient for the anticipated application. In other cases, the capital cost for the devices is still significantly higher than for LTS- or conventional copper-based systems, and thus the required investment outweighs the advantage of lower operating costs. In summary, these new materials continue to hold great economic potential, but sustained efforts are still required in order to improve the technical performance of devices that make use of them, and in order to further bring down process complexity and cost.

It bears observation that LTS technology was first utilized in purely performance-driven sectors, e.g., in science, research and technological development (RTD), and in military applications. The next market area to open up was in medical applications, where competition from non-superconducting devices is weak. At present the largest market is for magnets in medical diagnosis, Magnetic Resonance Imaging (MRI), and the overall market for components, systems and services, exceeding 4 B€ in 2005, is almost all LTS-based. In the highly competitive field of magnetic separations for the clean up of kaolin clay, LTS based magnets totally displaced all alternative approaches on a cost effective basis. However, this penetration of the industrial manufacturing market place has not extended to other applications to date. Neither LTS nor HTS have so far been able to contribute substantially to highly cost-competitive commercial markets such as energy, information, communications, and transportation. Up until now, only slowly growing and again mainly performance-driven niche segments have emerged within these large markets, which are dominated by widely established, non-superconducting components.

The time required to develop the first ready-to-use HTS conductors with industrial performance characteristics was longer than initially hoped or expected. The first pilot projects and prototypes of significant size were not realised until the year 2000. The acceptance of novel devices in the area of power engineering typically requires a timescale of more than a decade from the first demonstration. Consequently, the successful transition of these technologies from demonstration to commercialization requires a combination, on the part of both industry and government, of patience and urgency. At the present time, HTS technology is progressing especially in those countries where the grid infrastructure is aged, or where new fields of development have been identified, such as in the shipbuilding or oil & gas markets. Also, in the “new“ countries such as China and Korea, where new technologies are viewed as a cornerstone of social and economic development, large and robustly-funded national long-term programs have been set up that have enabled these second followers to quickly reach the world-wide development standard. In addition, in parallel with these growing public activities, several new companies have recently been founded with venture capital.

Challenges for the Coming Years

The changing boundary conditions related to globalization, the growing world population and global warming will by necessity have a strong impact on the worldwide economical boundary conditions in the near future. Already today, the rates of growth in energy consumption in rapidly developing countries like China and

India are high. Energy is becoming increasingly expensive, and constraints with regard to environmental protection are becoming more stringent. The challenges lying ahead of us will only be mastered if socially acceptable solutions are underpinned by best-practice technical support. In this respect, electrical and electronic engineering plays a key role. Superconductivity can help to overcome technological barriers, thereby enabling novel solutions with new and expanded functionalities.

The need to operate superconductor-based equipment at very low or cryogenic temperatures presents a range of issues and challenges that are unfamiliar to most future customers. Consequently, the development of highly compact, efficient, low-maintenance and easy-to-use refrigerators is one of the most important tasks to be addressed before HTS equipment can be brought to energy and industrial markets. These developments in refrigeration are going forward worldwide, and are on schedule. It is necessary that efforts related to enabling technologies, including cryocoolers and higher-performance conductors, be continued and that these advances be demonstrated in the next generation of pilot projects.

Superconductivity is a unique phenomenon of nature that can act as a true enabler of technological solutions in a wide range of fields. Recognizing the promise that it offers, private companies and other organizations involved in the superconductor industry will continue and strengthen their efforts to improve the performance and reduce the costs of superconductor materials, wires and devices. At the same time, the superconductor industry will continue and strengthen efforts to broaden the range of economically accessible application areas, since only profitable solutions allow sustainable investments in new fields.

It would be very helpful for governmental bodies with responsibility for regulatory policy and R&D budgets to examine the effects of their policies on an integrated basis. The superconductor industry is typical of other technology-intensive, emerging industries in that it faces a lengthy period of high development costs; moreover, technology users such as regulated or state-run utilities are naturally inclined to be conservative in their rate of adoption of new technologies. Therefore, during these initial viability demonstration years, sustained governmental commitment and support is vital and, indeed, essential. Coming regulatory reforms, as well as the experience of higher energy costs, should be aimed at revealing more clearly the true value of technology solutions in the near future.

Annex:

The ISIS gathers:

The organisations in alphabetic order: CCAS, CONECUTS, ISTEC and representatives from China and Korea.

CCAS: The Coalition for the Commercial Application of Superconductors (CCAS, USA) is the U.S. based non-profit corporation founded in 1987 dedicated to the commercialization of products based on superconductor technology with the goal of providing broad and far reaching societal benefits that are both cost effective and environmentally friendly.

CONECTUS: The Consortium of European Companies determined To Use Superconductivity (CONECTUS, Europe) is a non-profit organization founded in 1994 as a private company in the UK. CONECTUS is the association of leading European companies with the shared vision that full commercialization of superconductor technology will translate into significant benefits to Europe's economy and society.

ISTEC: The International Superconductivity Technology Center (ISTEC, Japan) was established as a non-profit foundation in January 1988, with the approval of the Minister of Economy, Trade and Industry of Japan, pursuant to the Civil Code of Japan. Its designated objective is to contribute to the advancement of superconductivity studies and the sound development of superconductivity-related industries.