HIGH-T_c SUPERCONDUCTORS: TECHNICAL AND COMMERCIAL CHALLENGE

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Abstract

Some basic questions of the way, which leads from the discovery of high-T_c superconductors to their applications is surveyed. The influence of high-T_c superconducting technology on the industrial and social development is also briefly analysed.

General

The main problems are how the results of the scientific research can be transferred into technology and in what extent this process can be useful for the society.

Postulation: Superconductivity, as a phenomenon of extremely or ideally lossless state should revolutionize not only the electrical or electronical industry, but through them it should change various segments or sections of technology and the life style of the society too.

The fact: There are certain obstacles (requirement of cooling, critical parameters themselves, a.c. losses, etc.) those make difficult to introduce the physical findings, results and developments into technology.

Disappointments: Some potential users, even professionals (engineers, managers, etc.) are often deeply disappointed when they are aware of the difficulties.

Financing : Both of basic and technical researches require sponsors who are able and eager to invest money into a scientific program without the requirement of making profit within a short term. Governments and companies of developed countries wish to sponsor these themes, but in an other part of countries there is a lack of money to support the superconductivity research.

Usefulness: The new technology induced by the research of superconductivity results in new and efficient modes of production. This leads to bring forth new values for the society.

Superconducting products

Fifty years were necessary after the discovery of conventional superconductivity [1] until the first attempt [2] to elaborate some magnetic application of this phenomenon. The main difficulty is represented by complicated and expensive liquid helium technique which strongly limits the spread of low-temperature superconductors.

A qualitatively new situation appeared by the discovery of high-temperature superconductivity [3], for which the simple and cheap cooling provided by liquid nitrogen is sufficient. Until this date five groups of oxide ceramics can be taken into consideration from the point of view of technical employment, namely La-Ba-Cu-O, Y-Ba-Cu-O, Bi(Pb)-Sr-Ca-Cu-O, Tl-Ca-Ba-Cu-O and Hg-Ba-Ca-Cu-O families having intervals of critical temperature T_c of 32-40 K, 80-92 K, 85-110 K, 60-125 K and 90-150 K, respectively. As far as the other two main parameters are concerned, the upper critical magnetic field H_{c2} falls into interval of 50-200 T, while the transport critical current density J_c extremely depends on the morphological character of the samples [4], having values of 100-300 A/cm^2 for bulk materials, 10^3-10^5 A/cm^2 for melt-textured thick films and 10^5-10^6 A/cm^2 for high quality thin layers.

The reliable and controlled best values of J_c for 100-200 m long wires and tapes are 50000-100000 A/cm^2 for Y-based, 50000-150000 A/cm^2 for Bi-based materials, while 10000-20000 A/cm^2 can be reached for very pure Tl-based short samples. Since some of these superconductors can work in a very high (5-25 T) magnetic field, the possibility of their use for different electrotechnical purposes can be taken to be acceptable.

The problem of rigid and brittle properties of these ceramics and the question of long time stability seems to be soluble.

The most probable applications of these materials concern not only the electrical industry, but the electronics, signal processing, computer technique and informatics too, as is listed in the followings [5]:

1. building magnets and magnetic shieldings,
2. generators, electrical transport lines, magnetic energy storage,

3. fault current limiters,
4. heavy-duty bearings,
5. magnetically levitated machines,
6. sensors for temperature, pressure, magnetic field, frequency, voltage, current, liquid level, radiation, etc.,
7. signal detectors and processors,
8. electronical chips,
9. high frequency receivers, mixers and antennas,
10. fast computers,
11. bolometers and nuclear particle detectors, etc.

New developments: Proposals and experiments regarding technical applications of high-T_c superconductors should compete with existing and reliable products. The new products should have some advantages to substitute the present ones.

Most successful applications have been developed in those fields of technology, where there are no real competitive counterparts.

Commercial challenge

The commercial challenge arises when superconducting products are at the society's disposal in an appropriate quality and quantity and they should be distributed among the demanding institutions and persons by selling and buying. Nowadays we are far from this point, but the society must be prepared to this one, because the new materials, products, instruments and equipments will change the style and quality of the life.

Superconductivity and society

How to influence the society in order to accept easier the novel and unique results of the science and technology?

We think there is a lack of a thorough analysis of economic and social effects of the technology of superconductivity. This analysis must be accomplished by ourselves and its results should be submitted to the decision-making persons.

It is obvious that we are responsible to introduce the teaching of basic and applied

aspects of superconductivity into the education of the universities and secondary schools or to improve their education. Numerous projects aimed at the application of superconductivity are planned to be partly or fully completed by the end of this century. By this time the students who will study the superconductivity in the next years will come to work into the industry, economy, etc., and perhaps they would be more susceptible to new technologies, like superconductivity.

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