Washington Holds First Federal Conference on Commercial Applications of Superconductivity

Need for Effective Tech Transfer Reaffirmed, Legislation Proposed

The Office of Science and Technology Policy, in coordination with the U.S. Department of Energy, sponsored the first Federal Conference on Commercial Applications of Superconductivity. Titled "Superconductivity: Challenge for the Future," the conference was held July 28–29, 1987 at the Washington Hilton and covered both technical aspects and commercial applications of the new high temperature superconducting ceramic oxide materials. Also sponsoring the conference were the Departments of Commerce and Defense, National Science Foundation, and National Research Council of the National Academies of Sciences and Engineering.

Presidential Science Adviser William R. Graham opened the conference, noting that it was not intended to be a scientific conference but one concerning industrial competition and the economic future of the United States. Graham announced that on July 28 a "Council on Superconductivity for American Competitiveness" would be initiated, chaired by former Presidential Science Adviser, George A. Keyworth. Its three objectives will be to understand what the new superconductors will bring to U.S. industrial competitiveness; to understand what is happening in research and at the interface between federal, industrial, and university sectors; and to get feedback from the technical business communities about the eventual commercialization of these materials.

In introducing the initial trio of conference speakers, director of the National Science Foundation Erich Bloch pledged that "the NSF will remain a strong source of support for research in this area." National and federal laboratories are an "important bridge" between research and technology, he continued. This was the first of many references to the need for effective technology transfer between research laboratories and the ultimate marketplace.

After giving a short history of events leading to their discovery, Angelica Stacy (University of California, Berkeley) described the current most common methods for synthesizing the new $YBa_2Cu_3O_7$ materials. Referring to the *New York Times* and the *Peking Peoples' Daily* as "the new physics journals," Stacy emphasized the unprecedented public interest in these new materials.

Paul Chu (University of Houston) noted that oxide superconductors date back to the observation of the phenomenon in strontium titanate in 1964. They progressed to superconductivity at approximately 13 K in a barium-lead-bismuth oxide in 1975. After reviewing what is currently known and unknown concerning the new materials, Chu listed four criteria he would apply to verify superconductivity in new materials: zero resistance, a full Meissner effect, stability of the effect, and high reproducibility of the effect.

The 90 K superconductors fulfill each of these four criteria. If the criteria of stability and high reproducibility are relaxed and only a partial Meissner effect allowed, T_c rises to 225 K. If only zero resistance is required it rises to 290 K, and if only a sudden drop in resistance is required, superconductivity effects have been observed at 350 K. None of these results is presently regarded as confirmation of superconductivity. Chu expressed a hope that support for continued research on these materials would be "steady and not at the expense of other areas of science."

Robert Schrieffer (University of California, Santa Barbara) then described various theoretical concepts which might explain superconductivity at high temperatures. Explaining the need for an electron-electron attractive interaction and the "mattress effect" in the traditional phonon coupling mechanism, he proposed adding a "spin bag" mechanism to the list of possible attractive interactions. In this hypothesis, electrons suppress spin fluctuations in their neighborhood, allowing other electrons to share in the suppressed-fluctuation region.

S. Faris (Hyres, Inc.) and S. Burnett (GA Technology), introduced by Mary Good (Allied Signal Corporation), described current applications of superconductivity in electrical signal analysis, infrared detectors, and magnets for magnetic resonance imaging in the medical field.

That the Administration regards the commercialization of the new materials as extremely important was underscored by President Reagan's appearance at the meeting. He was flanked by the Secretaries of State, Defense, and Energy. Admitting that "it is hard to keep up with rapid advances up the Kelvin scale," the President went on to describe the opportunities these discoveries present. Reagan urged scientists to "bridge the gap from the laboratory to the marketplace," reaffirming the primary motivation for the conference.

Referring to his April Executive Order concerning enhancement of technology transfer to the private sector, Reagan pointed to several goals including revised patent laws and freedom of information requirements, and relaxed antitrust laws so that the United States can react to the global competition in superconductivity. The President said he will send legislation to Congress covering these areas among eleven points of a superconducting initiative. Also proposed is the creation of a "wise-man" advisory group, quick start grants, establishment of superconductor research centers, and $150 million in research and development funding through the Department of Defense over three years. Reagan closed by pointing out "that government can be a catalyst to the future and that human imagination is building the 21st Century out of sand and clay," a clear allusion to the oxide-ceramic composition of the new materials.

U.S. Trade Representative Clayton Yeutter, keynote speaker during the lunch hour, discussed the commercialization of the new materials in the context of international competition. He was introduced by former Congressman Don Fuqua, who previously chaired the House Committee on Science and Technology. Referring to the distribution of U.S. basic research information abroad, Yeutter indicated that it's "not that we don't want to share it with the world, but would like to make a buck in the process." He emphasized that legal redress (in the form of patent protection, etc.) is imperfect, saying that only rapid commercialization will secure the United States' place in this market. Yeutter expressed great confidence in the U.S. research community's ability to take superconductors from the laboratory to the marketplace. He pledged that "we in government are going to do our best to assure scientists . . . that you can operate on a level playing field by reacting to any unfair or artificial edge given to our competition by unfair trade practices."

The afternoon session, introduced by Ernest Ambler, director of the National Bureau of Standards, was devoted primarily to future applications of the new superconducting materials. T. Van Duzer (University of California, Berkeley) and F. Bedard (National Security Agency) described future applications in electronics, computers, and communications. C. Davis (Ford Motor Company) and N. Hingorani (Electric Power Research Institute) provided their views on transportation and power distribution. Finally, R. Schmitt (General Electric Company) and M. Rochkind (North American Phillips Corporation) reviewed foreign technological advances.

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In introducing Van Duzer, P. Chaudhari (IBM) pointed out that at temperatures of liquid nitrogen, hybrid circuitry incorporating both semiconducting and superconducting devices becomes possible, opening the opportunity for hybrids with completely new characteristics. Van Duzer described the many ways Josephson junctions can be used for millimeter or submillimeter wave receivers, voltage standards, parametric amplifiers, signal processors, analog-to-digital converters, and shift registers. He also mentioned infrared detectors, magnetometers, and many broad band device applications.

Bedard, noting that the new materials operate in a "friendlier refrigeration environment," described the history of attempts to use superconducting switching devices in computers. He emphasized that technical operation of the device is only the first requirement toward commercialization. He provided ample evidence that semiconductor competition at several junctures in the past caused superconducting options to go back to the laboratory. He contrasted the far smaller size and far lower power consumption of a superconducting supercomputer with present CRAY machines. Bedard enumerated potential applications in aircraft platforms, communication satellites, scientific computing, and many other fields. He quoted reliability as one major advantage, explaining that "chemistry tends not to happen to you at low temperature."

Davis claimed that the electric car would not benefit greatly by substituting superconductors in most of its components, indicating that an energy-storage superconducting magnet would outweigh the car.

The session closed with two talks which pointed out that government policies in Japan and Europe favor inter-industry cooperation and provide subsidies not available to industries in the United States.

The topic of future applications was continued on July 29 in a session chaired by William Fairbank (Stanford University). Sam Williamson (New York University) and John Steckley (Intermagnetics General) covered future applications in instrumentation, sensing, and diagnostics. Williamson emphasized superconductor detectors for biomagnetism and illustrated how modern techniques allow functional mapping of the human brain. Other things being equal, higher temperature superconductors would allow easier refrigeration and placing the sensor closer to a patient's cranium. Steckley described the application of superconductors to magnetic resonance imaging and noted that refrigeration systems using higher temperature superconductors would be simpler and less expensive than those in use today.

Robert White, President of the National Academy of Engineering, introduced the next two speakers, John Rowell (Bell Communications Research) and John Hulm (Westinghouse Electric Corporation), who dealt with technology issues which still need to be resolved.

Rowell pointed to several problems with the new materials, especially in electronics where they are usually in the form of thin films. He enumerated the "900C problem," the "substrate problem," the "oxygen problem," and the "coherence length phenomenon" (which, depending on applications, may not be a problem). Rowell contended that we "can't create new technologies without knowing what we're building them from," i.e., basic research is an absolute necessity in this area. The need for high temperature processing and possibly nonsemiconductor epitaxial substrates, and the sensitivity to oxygen raise significant materials processing problems for hybrids between superconductors and semiconductors. He closed by asking "where will superconductors introduce unique capabilities that will be irresistible?" He pointed out that only conventional uses already known at 4 K have been proposed for the higher T_c materials and that these new materials are likely to find their maximum economic and commercial value in qualitatively new applications which have yet to be imagined.

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Hulm emphasized the application of the superconductors to critical issues in magnets and electric power, where a massive materials engineering effort is needed. Because the superconducting materials have a predicted, very high critical magnetic field, H_{c2}, Hulm said he expects applications in magnetic resonance imaging, accelerators, resonant cavities, magnetic separators, and research magnets—all current uses for superconductivity today.

Successful demonstration projects have been fielded in AC power transmission, AC power generation, levitating trains, magnetohydrodynamic magnets, and fusion magnets, however, said Hulm, none have met the marketplace criteria. Pointing to the unique problems associated with high critical currents and high critical fields in these materials, he commented that they are so unique relative to the well-known Type II superconductors that "perhaps they should be renamed Type III superconductors." The brittleness of the ceramic material and the presence of intergranular weak links are additional problems to be overcome before applications in magnets and electric power.

Donna R. Fitzpatrick, DOE Assistant Secretary for Conservation and Renewable Energy, then introduced E. McAllister (Office of Science and Technology Policy), who described the President's recent Executive Order concerning easing of barriers against technology transfer. He was followed Herman Postma, director of the Oak Ridge National Laboratory, who discussed the relationship of the federal and national laboratories to industry, the positive aspects of cooperation, and the impediments presented to individual scientists attempting to cross that boundary.

To close the conference, Undersecretary of Energy Joseph F. Salgado introduced Energy Secretary John Herrington. Herrington reiterated the importance of the materials research and development challenge in superconductors that faces the United States and the extent he believes the usual rules of behavior for industry and federal laboratories need to be overcome to meet the challenge of international competition. He emphasized that the gap between the research laboratory and the marketplace needs to be bridged through the use of the national laboratory facilities, the proper handling of intellectual property issues, the acceleration of the patent process, and further liberalized cooperative ventures under relaxed antitrust legislation.

Admitting that in Washington, DC and the federal bureaucracy "sound travels faster than light and long range planning may mean three to five minutes," he committed the resources of government at his command, consistent with the President's prior remarks, to support this effort in every way possible. He noted the need for a nationally coordinated program where government acts as a catalyst and provides the correct environment, but *not* a government-directed program.

The final afternoon of the conference was devoted to five parallel workshops on industrial collaboration possibilities, access to federal laboratories, finances, venture capitalists and small business, science advances in superconductivity, and industry/university/government cooperation.

Judging from the attendance of well over 1,500 persons it seems clear that interest is high and that financial resources, in the government and the private sector, are available to support rapid research and development in the near term. Most speakers warned that real progress will take 10–15 years at the very least, emphasizing that a stable and persevering attack on these problems is required in addition to all due haste at the present.

To obtain a copy of the videotape of this meeting, contact: AVCOM/CMC Corporation, Ref: Superconductivity, 919 12th Street NW, Washington, DC 20005; telephone (292) 638-1513.

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