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Center: Consortium for Materials Development in Space
The University of Alabama in Hunstville (UAH)

Project Name: **"High Temperature Superconductors"**

The University of Alabama in Huntsville
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Introduction

Our laboratory was the first in the world to develop a material with a transition temperature to superconductivity (Tc) above the temperature of liquid nitrogen. See Appendix I for a copy of the original paper describing the work. Despite efforts by other well-known laboratories around the world there still have been no other major breakthroughs eclipsing our work. This puts us in a good position to continue our leading role in this area.

The two principal objectives of our present work are to develop materials that superconduct at higher temperatures and to better understand the mechanisms behind high temperature superconductivity. To achieve these goals we are carrying out detailed experiments on the thermal reaction, structure, and physical properties of materials that exhibit superconductivity at high temperatures.

If the results of our studies lend credence to some theories now under consideration, we may wish to combine immiscible alloys with proper normal state properties, such as resistivity, crystal structure, and presence of appropriate excitation. If this is the case we will develop a plan to produce superconducting materials in the freefall environment of space.

Areas of Study

1. Development of high-Tc superconductors.

Our breakthrough work evolved from the knowledge that pressure has an effect on the transition temperature of the La-Ba-Cu-O compound. We decided to simulate a high pressure environment by replacing the Ba and La with other differently-sized atoms, thereby changing the interatomic distances. After several configurations we estimated an optimal chemical composition of Y(1.2)Ba(0.8)CuO(4). On January 29, 1987, using this formula, we created the first superconductor in a liquid nitrogen environment, approximately 95 K. Subsequent work has raised the Tc to 98 K.

Recent work has demonstrated that Yttrium can be replaced with a wide variety of rare earth elements and the Tc will still remain around 90 K. Others the field claim to have achieved a Tc as high as 240 K, although these results are unstable, inconsistent, and not reproducible.

2. Understanding the mechanisms behind superconductivity.

The complexity of the compounds involved makes understanding the mechanism of superconductivity difficult, but it is this understanding that will be required to make stable superconductors at high Tc ranges. It has been determined that the traditional theories of superconductivity, primarily the theory of electron-phonon interaction, are insufficient to explain the processes we are observing, but we are finding some tendencies that appear to be related to the superconductivity effect.

Our research indicates that the appearance of superconductivity depends on the heat treatment process, the size of the divalent (Ba) and trivalent (Y) atoms, and the crystal structure, which may be related to the size of the ions.

The following research is being initiated to study these and other aspects of the superconductivity mechanism:

a) Investigation of the thermal processes by simultaneously monitoring the weight loss, the thermal reaction, and the chemical species involved in sample preparation.

b) Investigation of the Ionic Size Effects through further substitutions and partial substitutions of the divalent and trivalent constituents of the compounds.

c) Study of possible infrared electronic excitation at room temperature and at low temperatures.

The CMDS project in superconductivity for FY 1988 will have three parts. First, Dr. M. K. Wu and his associates will continue to investigate basic material questions and the particular properties of these materials. Such investigations are of course fundamental to all future applications. This will be a laboratory effort. Second, a team of other CMDS investigators will follow the development of superconductivity applications and devices. They will also study and summarize the potential use of such devices in commercial space systems. This study will include an examination of the lowest temperatures attainable on spacecraft by passive cooling techniques. This examination will involve another material question, namely what surface treatments on radiation surfaces produce the lowest temperatures. Thermoelectric systems may also be investigated for their possible use on spacecraft to cool superconducting devices.

Third, appropriate industrial contacts and interfaces will be established. This will have the objective of arranging industry participation in this project by FY 1989. Although UAH has already had many discussions with industries, a project agreement is premature under the very fluid circumstances that currently exist.

Papers Published

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