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**Applications of High Transition Temperature
Superconductors at the Savannah River Site
(Annual Progress Report)**

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Date Published - April 1993

**Prepared for the
U. S. Department of Energy
Under Contract DE-FG09-92SR18273**

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Introduction

The first year of the research program involved evaluating the applications of high transition temperature superconducting devices at the Savannah River Site and initiating the development of high T_c circuit elements that might be of use in programs at the site. Although during the course of this year there were major changes in the direction of and areas of interest at the Savannah River Site, it has been possible to accomplish the first year goals. The technology required to produce a useful nitrogen temperature SQUID for applications such as those that might be encountered at the site has developed more rapidly than was anticipated. This has made it possible to begin the initial studies with a high T_c device as opposed to starting with the helium temperature SQUID. This will have an important impact on the outcome of the project by allowing for a more complete evaluation of a device that can be used in an industrial situation. The goals of the first year of the project are listed below and will be addressed in this report.

First Year Goals

1. Acquisition of the first SQUID system
2. Analysis of the applications environment
3. Initial fabrication of device structures
4. Establishment of criteria for single crystal studies

Accomplishment of Goals

Acquisition of the first SQUID system and analysis of the environment.

As shown in Figure 1. a SQUID system manufactured by Conductus, Inc. is currently in use for the initial characterization studies. In this system the SQUID sensor is a ring of high transition temperature superconductor made of yttrium barium copper oxide ($\text{Y}_1\text{Ba}_2\text{Cu}_3\text{O}_7$, sometimes called YBCO or "1-2-3"). This SQUID is based on materials technology that is only five years old and unlike other systems requires only one cryogenic fluid.

This SQUID system is capable of making the initial measurements, but the second generation device will be required for the more detailed experiments. The present system is limited by the electronics to approximately 2.07×10^{-18} Wb. This is sufficient for magnetic environment studies.

The initial evaluations of the SQUID performance in laboratory situations have established base lines for use of the systems. If the SQUID is configured as a second order gradiometer, all contributions (noise) from equipment and materials in the laboratory can be eliminated. There may be some complications when the more sensitive device is tested in field situations. Delivery of this SQUID is anticipated by the end of May. Improvements in the sensitivity and fabrication techniques have slowed the delivery.

Fabrication of device structures

In conjunction with AVX Corporation the initial devices that have been fabricated are in the form of tubes of YBCO. As indicated in Figures 2 and 3, these samples are nominally 16 cm long with an outer diameter of 1 cm. In this configuration the samples are ideal as electromagnetic shields for detectors that are in use at the site. The tubes have very high critical currents which is of little interest for this work. They have transition temperatures above that of

liquid nitrogen which means they are satisfactory for any detector that must be cooled to 77K or below.

In the present configuration it is not possible to use the SQUID to determine the shielding provided by these materials. AVX is preparing a new set of samples (tubes) that will have a larger inner diameter. It will be possible to insert the SQUID directly into the tube and measure the properties. This will make it possible to determine the amount of shielding provided in time varying fields. In order to make these measurements the tubes must have inner diameters greater than 2.5 cm.

Single Crystal Studies

Considerable progress has been made in this phase of the project. The initial studies are being conducted on fully characterized monocrystalline samples of the high temperature superconductors $\text{Bi}_2\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_x$ where $n = 1, 2, 3$, the "BiSCCO" compounds. These crystals are being grown and characterized at Clemson University for use in our studies. These samples are extremely difficult to work with due to their size, a typical sample will have a mass of less than 50 micrograms. Several samples are presently at the site and are being used to prototype the radiation studies. In addition efforts are under way to grow monocrystalline samples of the YBCO materials. Once the single crystals are characterized and irradiated they will be held at low temperature for an extended period of time. Figure 4 is a photograph of the tail of the cryostat and the sample mount that has been designed and constructed for this phase of the work.

Major Accomplishments

1. With the advancements in the development of a high transition temperature dc SQUID it will be possible to conduct all of the studies proposed using high transition temperature devices.
2. We have successfully produced high T_c device structures that can be used as shields for detectors
3. We have grown and are evaluating the single crystal samples.

Problems Encountered

The delivery of the research SQUID has been slowed due to modifications and improvements by the manufacturer and this has impacted the progress of the field experiments.

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