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Thin Film Superconductors

Kansas City Division

B. Z. Rosenblum

KCP-613-5434

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Final Report

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THIN FILM SUPERCONDUCTORS

B. Z. Rosenblum

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Final Report

B. Z. Rosenblum, Project Leader

Technical Communications
Kansas City Division

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Abstract

This project was initiated to develop thin film superconductors and to incorporate them as elements of weapon safety. Although a vacuum system was modified and the materials procured for fabricating the components, few samples were produced because of a change in priorities and the lack of personnel resources.

Summary

Thin film superconductors are used in a variety of technologies and applications. Efforts were made to fabricate thin film superconductors and incorporate them as components in weapon safety. It was proposed to follow the conventional fabrication techniques by vacuum sputtering on a variety of substrates using YBCO (yttrium barium copper oxide) type superconducting material as a source.

A thorough literature search was conducted to learn the methodology of fabricating these types of superconducting films by sputtering. A vacuum system dedicated for this endeavor was modified and all materials procured. Few samples were prepared to determine sputter rates for various film thicknesses. The project was cut short due to change of priorities and lack of human resources.

Discussion

Scope and Purpose

Superconductivity is a phenomenon where materials exhibit a complete disappearance of electrical resistance at temperatures near absolute zero. In the last few years a great deal of attention was devoted to superconductivity, and a number of superconductive materials were developed where superconductivity was achieved at relatively higher temperatures (120 K) and are referred to as high temperature superconductors. Thin film superconductors were developed and are used in a variety of applications such as diagnostic equipment in science and medicine, high-speed electronics, and communication.

This project was undertaken to develop procedures for the fabrication of thin film superconductors to be used as components of weapon safety and security. It was proposed that the films be vacuum sputtered onto the substrates in an existing sputter gun vacuum system.

Activity

A thorough literature search was conducted aimed at studying the theories of superconductivity in high-temperature thin film superconductors, as well as existing procedures for sputtering high-temperature superconducting films. The literature search pointed out that the most widely used high-temperature superconducting material is YBCO, an alloy of yttrium, barium, copper and oxygen that can be sputtered onto various solid substrates by conventional vacuum sputtering techniques. A list of articles

discovered during the literature search is given in the Appendix.

A sputter target of YBCO and SrTiO_3 substrates was procured, substrate heater and related fixtures were fabricated, and a few samples were sputtered for determining fabrication parameters for 1000-angstrom-thick films. At this point, the project was terminated as a result of changes in priorities and the lack of personnel resources.

Accomplishments

Procedures for fabrication of YBCO type thin film high-temperature superconductors on SrTiO_3 substrates were developed. Vacuum sputtering techniques were employed using YBCO target and SrTiO_3 substrates procured from commercial vendors. The desired thickness uniformity was obtained.

Future Work

Future work should concentrate on applying, by vacuum sputtering, electrical pads and analyzing the superconductivity of the films produced by the parameters established by this work.

Appendix

Literature Search Results

During the literature search, the most useful source uncovered was *Science and Technology of Thin Film Superconductors*, edited by Robert D. O'Connell and Stuart A. Wolf and published by Plenum Press (New York) in 1989. The most helpful articles from that volume are cited below. Citations are grouped by subject.

Laser Deposition

"Superconducting Properties of Ultra-Thin Films of $Y_1Ba_2Cu_3O_{7-x}$ " by T. Venkatesan and others, page 1.

Evaporation

"In-Situ Growth of High T_c Thin Films" by D. K. Lathrop and others, page 81.

" $YBa_2Cu_3O_7$ Thin Films Prepared by Evaporation From Yttrium, Copper and BaF_2 " by I. D. Raistrick and others, page 121.

"Preparation of Thin Films $YBaCu(F)O$ with High T_c and J_c " by X. K. Wang and others, page 141.

Sputtering

"Superconducting Phase Control for Rare-Earth-Free High- T_c Superconducting Thin Films" by K. Wasa and others, page 147.

"As-Deposited Superconducting Y-Ba-Cu-O Thin Films on Si, SiO_2 , GaAs and Ni/Cu Substrates by High Pressure DC Sputtering Process" by R. J. Lin and P. T. Wu, page 157.

"Interaction of High Temperature Superconductors With Conductive Oxides" by A. C. Greenwald and others, page 193.

"High T_c Y-Ba-Cu-O Films Prepared by Multilayer, Reactive Sputtering From Separate Y, Cu, and $Ba_{0.5}Cu_{0.5}$ Targets" by S. J. Lee and others, page 215.

"Structure and Properties of Magnetron Sputtered Superconducting Y-Ba-Cu-O Films" by M. E. Golovchanskii and others, page 237.

"Effect of Annealing Conditions on the Structural and Superconducting Properties of Y-Ba-Cu-O Films" by J. Ryu and others, page 245.

"Study of High Quality $YBa_2Cu_3O_{7-y}$ Thin Films" by B. R. Zhao and others, page 259.

Substrate Studies

"Microstructure and Critical Currents of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Thin Films on SrTiO_3 and a New Substrate: KTaO_3 " by R. Feenstra and others, page 327.

"Superconducting Films of YBCO on Bare Silicon" by J. Tate and others, page 347.

"Preparation of Superconducting Y-Ba-Cu-O Thin Films on Metallic Substrates" by M. Ozaki and others, page 363.

"Substrate-HTcS Thin Film Interaction Studies by (S)TEM" by P. P. J. Ramaekers, D. Klepper, and A. Mackor, page 371.

"Characterization of ZrO_2 Buffer Layers for Sequentially Evaporate Y-Ba-Cu-O on Si and Al_2O_3 Substrates" by G. J. Valco and others, page 377.

Characterization

"The Transport Behavior of the YBaCuO Superconducting Thin Films in the Magnetic Fields" by G. G. Zheng and others, page 387.

"Measurement of Superconducting Transition Temperatures of Thin Films of $\text{YBa}_2\text{Cu}_3\text{O}_7$ by Four-Terminal Resistance and Magnetic Susceptibility" by J. R. Matey, page 423.

"Determination of Oxidation States of Copper in YBaCuO Thin Films by Electrochemical Analysis" by S. Salkalachen and others, page 431.

Patterning and Applications

"The Fabrication of Josephson Junctions on Y-Ba-Cu-O Thin Films" by J. Yoshida and others, page 459.

"Processing and Patterning Techniques for Thin Films of $\text{YBa}_2\text{Cu}_3\text{O}_7$ " by C. M. Mombourquette and others, page 501.

General Properties

"Introduction to Superconductivity" by J. U. Trefny, page 517.

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