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SUPERCONDUCTING THIN FILMS COMPOSITES AND JUNCTIONS(U)
STANFORD UNIV CA DEPT OF APPLIED PHYSICS T H GEBALLE
25 NOV 87 AFOSR-TR-88-0307 F49620-82-C-0014

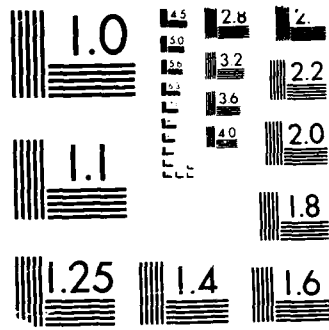
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MICROCOPY RESOLUTION TEST CHART
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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE			4. PERFORMING ORGANIZATION REPORT NUMBER(S)		
4. PERFORMING ORGANIZATION REPORT NUMBER(S)			5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 88-0397		
6a. NAME OF PERFORMING ORGANIZATION Department of Applied Physics		6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Directorate of Electronic & Solid State Sciences		
6c. ADDRESS (City, State and ZIP Code) Stanford University Stanford, California 94305			7b. ADDRESS (City, State and ZIP Code) Air Force Office of Scientific Research Bolling AFB, Building 410 Washington, D.C. 20332		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSSK		8b. OFFICE SYMBOL (If applicable) AE	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F49630-8250014		
8c. ADDRESS (City, State and ZIP Code) Bolling AFB, DC 20332			10. SOURCE OF FUNDING NOS.	PROGRAM ELEMENT NO.	PROJECT NO.
11. TITLE (Include Security Classification) Superconducting Thin Films, Composites & Junctions			10. SOURCE OF FUNDING NOS.	PROGRAM ELEMENT NO. 611027	PROJECT NO. 2506
12. PERSONAL AUTHOR(S) Professor T. H. Geballe (PI)			TASK NO. 01	WORK UNIT NO.	
13a. TYPE OF REPORT Final Report		13b. TIME COVERED FROM 5/1/87 TO 10/31/87	14. DATE OF REPORT (Yr., Mo., Day) November 25, 1987		15. PAGE COUNT 7
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB. GR.	Thin Films, Superconductivity, Vapor Deposition, Single Crystal Films, Small Scale Calorimetry, A15 Structures, Metastable Phases, <i>oxide</i>		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
SEE PAGE # 2					
<p>DTIC ELECTED</p> <p>S a D</p> <p>MAR 28 1988</p>					
<p>DISTRIBUTION STATEMENT A</p> <p>Approved for public release Distribution Unlimited</p>					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS <input type="checkbox"/>			21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
22a. NAME OF RESPONSIBLE INDIVIDUAL T. H. Geballe		22b. TELEPHONE NUMBER (Include Area Code) (415) 723-0215		22c. OFFICE SYMBOL UE	

AFOSR-TR- 88-0307

FINAL TECHNICAL REPORT

FOR

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Contract No. F49620-82-C-0014

May 1, 1987 - October 31, 1987

SUPERCONDUCTING THIN FILMS, COMPOSITES AND JUNCTIONS

By

Professor T. H. Geballe

Principal Investigator

Department of Applied Physics

Stanford University

Stanford, California 94305

November 1987

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ABSTRACT

The successful synthesis of high- T_c $YBa_2Cu_3O_{7-x}$ films by means of electron beam codeposition has been accomplished. Several important growth parameters have been surveyed in a preliminary way. The substrates investigated include Al_2O_3 , ZrO_2 , MgO and $SrTiO_3$. The films were characterized by resistivity measurements, X-ray diffraction, microprobe, and Rutherford backscattering analysis. Some TEM and critical current density studies were also carried out. The best results to date have been obtained on $SrTiO_3$ substrates with which polycrystalline epitaxial growth has been achieved. Resistive superconducting transitions with zero resistance at 89.5K and a 2K width have been observed in these films. Using the vibrating sample magnetometer, high critical current densities in excess of 9×10^4 at 78K and 2×10^6 were found at 4.2K. Also, surface pinning in the parallel direction under some conditions has been observed to be very high. The measurements put a lower limit on the depairing critical current density of $>10^8$ A/cm².

Superconducting thin films of $YBa_2Cu_3O_{7-x}$ have also been successfully made by magnetron co-sputtering from the three metal targets in an Ar and O₂ mixture atmosphere. After a high temperature anneal the films are superconducting with onset temperatures of 90 K, full transition temperatures as high as 88 K, and critical current densities in excess of $\sim 10^6$ A/cm² at 78K and $\sim 10^7$ A/cm² at 4.2 K and in the earth's magnetic field. Highly oriented thin films have been obtained on $SrTiO_3$ (100) substrates, with both the c-axis and the a-axis normal to the substrate.

Optical transmission and reflection spectra (mid IR through UV) and Raman spectra of high quality 90 nm, 180 nm, 400 nm and 1000 nm thick superconducting Y-Ba-Cu-O films have been made. Characteristic excitonic bands, and in particular an absorption band at ~ 0.37 eV reported earlier by other makers, are not observed. No evidence has been found for inferring that the high- T_c superconductivity in the high T_c cuprates arises from exciton-mediated electron pairing. However, there is considerable featureless absorption observed above the plasma edge.



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STATEMENT OF WORK

Prepare new and recently discovered perovskite-like superconducting samples by ceramic techniques as well as by thin film deposition methods.

Develop methods for growing and analyzing tunnel junctions made from perovskite-like oxide electrodes.

Use point contact and if possible scanning tunneling microscopy to investigate superconductivity in the perovskite-like high- T_c superconductors.

Increase the level of effort in making and characterizing new samples.

Incorporate the use of the vibrating sample magnetometer in characterizing superconducting behavior, namely the Meissner-effect, the shielding current, and the critical current of the films and the ceramic samples.

PUBLICATIONS

(Period Covering May 1, 1987 - October 31, 1987)

1. "Critical Current Densities and Transport in Superconducting $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ Films Made by E-Beam Evaporation," by B. Oh, M. Naito, S. Arnason, P. Rosenthal, R. Barton, M. R. Beasley, T. H. Geballe, R. H. Hammond, and A. Kapitulnik, submitted to *App. Phys. Lett.*
2. "Thin Film Synthesis of the High T_c Oxide Superconductor $\text{YBa}_2\text{Cu}_3\text{O}_7$ by Electron Beam Codeposition," by M. Naito, R. H. Hammond, B. Oh, M. R. Hahn, J. W. P. Hsu, P. Rosenthal, A. F. Marshal, M. R. Beasley, T. H. Geballe, and A. Kapitulnik, submitted to *J. Material. Res.*
3. "Superconductivity and Disorder in Low Carrier Density La-S," by A. Kapitulnik, A. D. Kent, T. H. Geballe, and J. H. Kaufman, submitted to *Int. Workshop on Novel Mechanisms of Superconductivity*, June 22-26, Berkeley, 1987.
4. "Trends and Future - As Seen at the Berkeley Workshop," by T. H. Geballe, submitted to *Int. Workshop on Novel Mechanisms of Superconductivity*, June 22-26, Berkeley, 1987.
5. "Superconducting Properties of Thin Films of the High- T_c Perovskite Superconductors," by A. Kapitulnik, B. Oh, M. Naito, K. Char, A. D. Kent, N. Missert, E. Hellman, S. Arnason, J. W. P. Hsu, M. R. Hahn, P. Rosenthal, R. Barton, M. R. Beasley, T. H. Geballe, and R. H. Hammond, submitted to *Trieste Proceedings*.
6. "Reactive Magnetron Sputtering of Thin Film Superconductor $\text{YBa}_3\text{Cu}_3\text{O}_{7-x}$," by K. Char, A. D. Kent, A. Kapitulnik, M. R. Beasley, and T. H. Geballe, submitted to *App. Phys. Lett.*
7. "Optical Measurements on Oriented Thin $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$ Films: Evidence Against Excitonic Superconductivity?" by I. Boovic, D. Kirolov, A. Kapitulnik, K. Char, M. R. Beasley, T. H. Geballe, Y. H. Kim, and A. J. Heeger, to be published in *Phys. Rev. Lett.*
8. "High T_c Thin Film Superconductivity: Science and Technology," by T. H. Geballe, submitted to *Journal of App. Physics*.
9. "Thin Film Research at Stanford University," by T. H. Geballe, abstract submitted to LT18, Kyoto, Japan, August, 1987.
10. "Superconductivity - the State that Came in from the Cold," by T. H. Geballe and J. K. Hulm, submitted to *Science*.
11. "High-Temperature Superconducting Perovskites - Science and Technology," by T. H. Geballe, talk given at Fermilab.

VISITORS

1. Prof. Patrick Lee, MIT, May 14, 1987.
2. Dr. Robert White, Control Data, May 26, 1987.
3. Simon Hodson, June 2, 1987.
4. Wendy Wall, Wall St. Journal, June 11, 1987.
5. Dr. Dallas Hayes, June 15, 1987.
6. Dr. Harold Weinstock, June 19, 1987.
7. Linda Gorman, NOVA, June 19, 1987.
8. Dr. Jack Fellows, NSF, June 30, 1987.
9. Dr. Takafumi Yao, Japan, July 20, 1987.
10. Dr. Hans Morawa, Munich, July 28, 1987.
11. John Walecca and Ed Zschau, July 31, 1987.
12. Dr. Ted Collins, Batelle, August 13, 1987.
13. Dr. John Gordon, Yale, August 28, 1987.
14. Prof. Shelly Schultz, UC San Diego, September 3, 1987.
15. Dr. P. Dhumiers, Paris, France, September 3, 1987.
16. Dr. Lance Haworth, September 17-18, 1987.
17. Dr. Robert White, Control Data, September 25, 1987.
18. Dr. John Hulm, Westinghouse, October 2-3, 1987.
19. Dr. Chuck Powers, Office of Science, Whitehouse, October 23, 1987.
20. Dr. Sumio Ikegawa, Tokyo, November 2, 1987.

T. H. GEBALLE - SEMINARS & TALKS (May - October, 1987)

1. Fermilab Industrial Affiliates 7th Meeting, Batavia , ILL - May 21, 1987
2. Xerox Palo Alto Research Forum, Palo Alto, CA - May 28, 1987
3. Super Collider Seminar, Berkeley, CA - June 5, 1987
4. International Workshop on Novel Mechanisms of Superconductivity, Berkeley, CA - June 26, 1987
5. International Conference on Low Temperature Physics, Kyoto, Japan - August 23, 1987
6. Raychem Corporation, Menlo Park, CA - September 9, 1987
7. The Aerospace Corporation, Los Angeles, CA - September 22, 1987
8. Stanford Institute for Manufacturing and Automation, Stanford, CA - October 8, 1987
9. University of Washington, Seattle, WA - October 12, 1987
10. USAF Scientific Advisory Board Meeting, Washington, D.C. - October 22, 1987
11. Superconductive Electronics Workshop, Los Angeles, CA - October 25, 1987

T. H. GEBALLE , COMMITTEES AND MEMBERSHIPS

1. National Research Council of the NSF-MRL Directors Committee
2. Solid State Science Committee
3. Associate Editor for Materials Letters, North-Holland Publishing Company, The Netherlands
4. Member, National Academy of Sciences
5. Member, American Academy of Arts and Sciences
6. Member, Basic Energy Sciences Advisory Committee (BESAC) DOE
7. Member, Research Briefing Panel on High Temperature Superconductivity, NAS 1987
8. Member, Visiting Committee for Division of Engineering & Applied Science of Cal. Tech.
9. Member, Electronics Research Advisory Panel, E. I. DuPont
10. Member, L.B.L. Materials Review Panel
11. Member, Editorial Review Board of Science Magazine

SCIENTIFIC PROJECTS BEING CARRIED OUT IN COLLABORATION WITH INDUSTRY

R. M. White, Control Data, Minneapolis, Minnesota

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J. Boyce, Xerox Corp., Palo Alto, CA

S. Laderman, Hewlett Packard

J. H. Wernick, Bell Communications Research, Red Bank, NJ

J. M. Rowell, Bell Communications Research, Red Bank, NJ

G. W. Hull, Bell Communications Research, Red Bank, NJ

A. Braginski, Westinghouse Research Laboratories, Pittsburgh, PA

NEW DISCOVERIES, INVENTIONS OR PATENT DISCLOSURES

**Inventions Disclosed in FY '87
under AFOSR contract F49620-83-C-0014**

4 disclosures identified as Stanford University docket numbers:

S-87-107

S-87-108

S-87-109

S-87-111

For more information, please contact:

Hans Wiesendanger
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**PERSONS WORKING ON THE CONTRACT DURING THE PERIOD
May 1, 1987 through October 31, 1987**

Hammond, Robert H.

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Mael, David

Ph.D. received June 1987

Kent, Andrew

Ph.D. expected Summer 1988

Howland, Rebecca

Ph.D. expected Summer 1988

Arnason, Steve

Ph.D. expected Summer 1990

Spielman, Steven

Ph.D. expected Summer 1990

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