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STANFORD UNIV CA DEPT OF APPLIED PHYSICS T H GEBALLE
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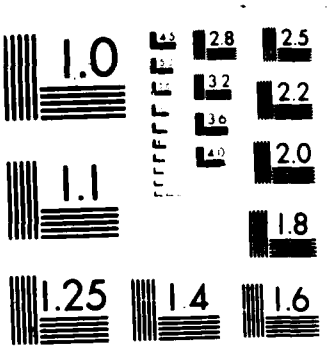

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1 Oct 85 to 30 Sep 86

Low energy ion beam cleaning of the substrates prior to deposition has been found to enhance the quality of ultrathin (100A) refractory superconducting - (Nb, V) films. Nb film thin as 7A has been grown from which it has been possible to fabricate good superconducting tunnel junctions. Both the native films and the tunnel junctions can be thermally recycled without any degradation. In-situ surface studies along with transmission electron microscopy suggest the removal of the carbon atoms from the surface of the substrate and possible the increased chemical reactivity of the substrate atoms are the causes of the improvement. TEM results indicate that the Nb films grow perfectly lattice matched to the sppphire substrate when the substrate is ion-beam cleaned. This strained-layer epitaxy is observed up to 40 A, the maximum thickness investigated through TEM.

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19. **ABSTRACT**

Niobium, Vanadium

Low energy ion beam cleaning of the substrates prior to deposition has been found to enhance the quality of ultrathin (< 100Å) refractory superconducting (Nb, V) films. Nb film thin as 7Å has been grown from which it has been possible to fabricate good superconducting tunnel junctions. Both the native films and the tunnel junctions can be thermally recycled without any degradation. In-situ surface studies along with transmission electron microscopy suggest the removal of the carbon atoms from the surface of the substrate and possibly the increased chemical reactivity of the substrate atoms are the causes of the improvement. TEM results indicate that the Nb films grow perfectly lattice matched to the sapphire substrate when the substrate is ion-beam cleaned. This strained-layer epitaxy is observed up to 40Å, the maximum thickness investigated through TEM.

Good-quality tunnel junctions have been fabricated on ultrathin films of Nb whose thicknesses ranged from 9 to 900Å. As the film thickness is reduced below 50 Å, T_c decreases, $2\Delta/kT_c$ increases, and mode softening is observed by d^2V/I^2 measurements. These results imply that as the thickness decreases below 50 Å the electron-phonon constant, λ, becomes larger than expected from the drop in T_c.

Molybdenum Germanium (1-X)

Absolute specific-heat measurements have been made through the metal-insulator transition in thin film Mo_xGe_{1-x} determining the thermodynamic electronic density of states. The density of states is found to show no critical behavior at the metal-insulator transition. An anomalous excess specific heat below the metal-insulator transition has been found.

Tantalum

Nb/Ta multilayered films prepared by magnetron sputtering have been studied by critical field measurements. The effects of substrate orientation and deposition temperature on the properties of the films has been determined. The behavior of the critical field as a function of temperature has been found to change from three to two dimensional. For films with larger Nb layer thicknesses, an additional transition in $H_{c2\|}$ at lower temperatures is observed which cannot be accounted for by the interfacial regions, and is believed to arise from a spatial displacement of the vortex lattice.

Considerable progress has been made in the design and construction of the new advance electron beam deposition facility. The manifold has been modified permitting the use of 2 ion sources at the sametime, or the mixing of several gases into one ion source. The modified water cooled ion source has been important in several experiments, including the formation of α - Si:H for another program.

ANNUAL TECHNICAL REPORT

FOR AFOSR-TR- 87-0341

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Contract No. F49620-82-C-0014

1 October 1985 - 30 September 1986

SUPERCONDUCTING THIN FILMS, COMPOSITES AND JUNCTIONS

By

Professor T. H. Geballe

Principal Investigator

Department of Applied Physics

Stanford University

Stanford, California 94305

G. L. Report 4157

December 1986

87 4

PUBLICATIONS

(period covered 1 October 85 - 30 September 1986

1. "Unusual Variability of the Lattice Constant in Polycrystalline Epitaxial Growth of Superconducting A15 Nb-Si," by R. D. Feldman, T. H. Geballe, R. L. Opila and S. Celaschi, Thin Solid Films, 137, 315 (1986).

2. "The Metal-Insulator Transition and Superconductivity in Amorphous Molybdenum-Germanium Alloys," S. Yoshizumi, D. Mael, T. H. Geballe and Richard L. Greene, ***Localization and Metal Insulators Transitions,*** Edited by Hellmut Fritzsche and David Adler Plenum Press (1986),pg. 77.

3. "Conversion Electron Mossbauer Study of Thin Nb_3Sn Films," by C. W. Kimball, P. P. Vaishnava, J. L. Matykiewicz, F. Hellman and T. H. Geballe, Bull. Am. Phys. Soc. 30, 608 (1985).

4. "Strain Mechanisms in Superconducting Nb_3Sn Compounds, J. Bevk, W. A. Sunder, F. Hellman and T. H. Geballe, Bull. Am. Phys. Soc. 30, 608 (1985).

5. "Magnetron Sputtering of A15 Compound Nb-Sn," by A. D. Kent, F. Hellman, and T. H. Geballe, Bull. Am. Phys. Soc. 30, 608 (1985).

6. "Growth of "Single Crystal" A15 Nb-Sn Thin Films," by F. Hellman, A. F. Marshall and T. H. Geballe, Bull. Am. Phys. Soc. 30, 607 (1985).

7. "Sputtered Niobium-Tantalum Multilayers," P. R. Broussard and T. H. Geballe, Bull. Am. Phys. Soc. 30, 349 (1985).

8. "T_c Depression in Thin Nb Films," by S. I. Park and T. H. Geballe, Physica 135B, 108 (1985).

9. "A New Look at the Growth of Thin Films of Nb-Sn," F. Hellman, J. Talvacchio, T. H. Geballe, and A. F. Marshall, published in Adv. Cryog. Eng., 32 593, (1985).

10. "Study of Liquid-Infiltrated Nb-Sn Superconducting Composite Wire by Specific Heat Measurements," by F. Hellman, M. Hong, G. W. Hull, Jr. and T. H. Geballe J. Appl. Phys. 60, 3978 (1986).

11. "Low Carrier Density and Ultrathin Superconducting Films," by T. H. Geballe, submitted to 1986 MRS Fall Meeting.

12. "Superconducting Tunneling in Ultrathin Nb Films," by S. I. Park and T. H. Geballe, Phys. Rev. Letts. 57, 901 (1986).

13. "Specific Heat of Amorphous Mo_xGe_{1-x} Through the Metal-Insulator Transition," by D. Mael, S. Yoshizumi and T. H. Geballe, Phys. Rev. B 34, 467 (1986).

14. "Critical Fields of Nb/Ta Multilayers," by P. R. Broussard and T. H. Geballe, submitted to Physical Review B1.

15. "Superconductivity of Nb Films Recovered From Megabar Dynamic Pressures", by W. J. Nellis, H. B. Radousky, T. H. Geballe, R. H. Hammond, R. Koch, andG. W. Hull, Jr., Applied Phys. Lett. 49 413 (1986).

16. "Electron-Phonon Coupling," by T. H. Geballe, to appear in Condensed Matter Physics: The Theodore D. Holstein Symposium.

17. "Superconductivity", T. H. Geballe and S. I. Park, ***1986 Yearbook of Science and Technology***, McGraw Hill, New York, New York.

18. "Superconductivity in La-S Films", by A. D. Kent, A. Kapitulnik and T. H. Geballe, Bull. Am. Phys. Soc. 31, 316 (1986).

19. "Critical Field and Critical Current Measurements on Niobium-Tantalum Multilayers", P. R. Broussard and T. H. Geballe, Bull. Am. Phys. Soc. 31 318 (1986).

20. "Specific Heat Studies of Nb(NC) Samples", by B. Oh and T. H. Geballe, Bull. Am.Phys. Soc. 31, 336 (1986).

21. "Tunneling Measurements of Ultrathin Nb Films", by S. I. Park and T. H. Geballe, Bull Am. Phys. Soc. 31, 437 (1986).

22. "Superconducting Properties of Nb Films Recovered from Megabar Dynamic Pressure", by W. J. Nellis, H. B. Radousky, T. H. Geballe, R. H. Hammond, R. Koch, and G. W. Hull, Jr., Bull. Am. Phys. Soc. 31, 640 (1986).

23. "Magnetoresistance of Amorphous Mo_xGe_{1-x} Near the Metal-Insulator Transition", by Shozo Yoshizumi, T. H. Geballe, Milind Kunchur, and W. L. McLean, Bull. Am. Phys. Soc. 31, 678 (1986).

VISITORS

1. Dr. Frank Di Salvo, Dept. of Chemistry, Cornell University, February 26-27, 1986.
2. Dr. Harold Weinstock, AFOSR, Washington, DC, March 6-7, 1986.
3. Professor William McLean, Rutgers, University, March 17-19, 1986.
4. Dr. Peter Psaris, NAS, April 21, 1986
5. Dr. Jim Allen, Bellcore, April 21, 1986.
6. Dr. Ray Orbach, UCLA, May 8, 1986
7. Dr. Fred Muller, Los Alamos, June 19, 1986
5. Dr. Arnold Toxen, IBM, San Jose, June 19, 1986
6. Dr. Tord Claeson, Chalmers University, Sweden, June 19, 1986
7. Dr. John Hulm, Westinghouse, July 17 - 18, 1986.
8. Dr. Harold Weinstock, Dr. Edelsack, and Dr. M. Nissenoff, AFOSR, ONR, July, 18, 1986.
9. Dr. V. Kresin, Lawerence Berkeley Laboratory, August 14, 1986
10. Dr. Tim Sands, Lawerence Berkeley Laboratory, August 21, 1986
11. Dr. R. L. Greene, IBM Yorktown Heights, New York, September 12, 1986
12. Dr. R. M. White, Control Data, August 1986.
13. Dr. Rudi Bormann, University Gottingen, August 1986.

VISITORS AND SEMINARS

1. Dr. Tom McGill, Caltech, *"Tunnel Structures - **What We Know About the Basic Mechanisms; and New Device Structures"***, November 7, 1985.
2. Dr. David Young, Lawrence Livermore National Laboratory, ***"Theory of Biological Pattern Formation,"*** November 4, 1985.
3. Dr. Piers Coleman, ITP, UC Santa Barbara, ***"Coherence in Narrow F Band Systems: An Almost Broken Symmetry"***, December 2, 1985.
4. Dr. Klaus Sattler, University of Konstanz, ***"Clusters in Beams"***, December 5, 1985.
5. Dr. Peter Hirschfeld, Tech. Univ. Munic, West Germany, ***"Anomalous Electromagnetic Response in Heavy Fermion Superconductors"***, January 9, 1986

6. Dr. D. McWhan, AT&T Bell Laboratories, ***"Magnetic Properties of Metallic Superlattices"***, January 16, 1986.

7. Professor David Belanger, University of California, Santa Cruz, ***"Random Field Effects in Dilute Antiferromagnetis,"*** February 6, 1986.

8. Dr. Andre Ruckenstein, UC, San Diego, ***"Spin-Polarized Hydrogen--A New Magnetic Quantum GaS,"*** February 13, 1986.

9. Professor Douglas L. Mills, UC, Irvine, ***"Properties of Magnetic Superlattices,"*** February 20, 1986.

10. Dr. James Boyce, Xerox PARC, ***"Molecular Hydrogen in Amorphous Silicon"***, March 6, 1986

11. Dr. Ravindra Bhatt, AT&T Bell Laboratories, ***"The Doped Semiconductor-- The Spin Glass That Wasn't"***, April 10, 1986.

12. Dr. Ronald Willens, AT&T Bell Laboratories, ***"New Amorhpus Superlattices. Electronic and Photoelectric Properties"***, April 17, 1986

13. Dr. Ole Krogh Anderson, Max Planck Institute-Stuttgart, ***Electronic Structure in Real and Reciprocal Space"***, April 24, 1986.

14. Dr. Ian Robinson, AT&T Bell Labs, ***"X-ray Diffraction Studies of Surfaces"***, May , 1986.

15. Dr. Simon Mochrie, AT&T Bell Labs, ***"Wandering Walls and Melting in Bromine Growing in Intercalated Graphite"***, June 9, 1986.

16. Dr. Brian Stephenson, IBM Yorktown Heights, ***"Coupling of Diffusion, Stress and Glow During Interdiffusion in Amorphous Systems,"*** June 12, 1986

17. Dr. Fred Mueller, Los Alamos Scientific Labs. ***"Half-metallic Ferromagnetis - Designer Materials,"*** June 19, 1986.

THG - SEMINARS

1. ***"Vapor Deposition Synthesis of New and Improved Superconductors,"*** Symposium on New Superconducting Materials, Shiba Yayoi Kaikan, Tokyo January 23-25, 1986.
2. ***"ElectronPhonon Coupoing",*** The Theodore D. Holstein Symposium, UCLA, March 28, 1986.
3. Seminar on Thin Films, Rutgers University, New Jersey, April 29, 1986
4. Symposium on Thin Films, THG presiding, May 7, 1986, Stanford University
5. PURDUE UNIVERSITY, ONR WORKSHOP, June 3 through 3, 1986
6. ***"Superconducting Materials - An International Challenge",*** invited talk presented at the ASC Conference, Baltimore Maryland, September 29 - October 3, 1986.

COMMITTEES

1. The National Research Council
2. Solid State Science Committee
3. Ad Hoc Committee for NSF-MRL Directors
4. Member, Editor for Materials Letters, North-Holland Publishing Company, The Netherlands
5. SSSC National Symposium for Advancing Materials - Chairman
6. Member, Editorial Advisor for ***Phys. & Chem. of Mat. with Low-Dimensional Structures,*** D. Reidel Publ. Co., Holland.
7. Member, National Academy of Sciences
8. Member, American Academy of Arts and Sciences

Scientific projects are being carried out in close collaboration with industry

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

J. Boyce, Xerox Coporation, Palo Alto, California

J. H. Wernick, Bell Communications Research, Red Bank, New Jersey
J. M. Rowell, Bell Communications Research, Red Bank, New Jersey
G. W. Hull, Bell Communications Research, Red Bank, New Jersey
M. Hong, Bell Communications Research, Red Bank, New Jersey

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A. Braginski, Westinghouse Research Laboratories, Pittsburhg, PA

A. Green, Naval Research Laboratory, China Lake, California
V. Rehn, Naval Research Laboratory, China Lake, California

New discoveries, inventions or patent disclosures

NONE

Persons working on the contract during the period 1October 85 - 30 September 1986

Hammond, Robert H.	Senior Research Associate
Broussard, Phillip	Ph.D. received August 1986
Park, Sung I .	Ph. D. expected October 1986
Mael, David	Ph.D. expected Summer 1987
Kent, Andrew	Ph.D. expected Summer 1988
Howland, Rebecca	Ph.D. expected Summer 1988

END

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