Superconducting Thin Films, Composites & Junctions

Professor T. H. Geballe (PI)

From 10/1/85 to 9/30/86

February 4, 1987

Thin Films, Superconductivity, Vapor deposition
Single Crystal Films, Small Scale Calorimetry, A15 Structures, Metastable Phases
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 possible 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 60Å, the maximum thickness investigated through TEM.
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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 $d^2V/dI^2$ measurements. These results imply that as the thickness decreases below 50 Å the electron-phonon constant, $\lambda$, becomes larger than expected from the drop in $T_c$.

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.

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 same time, 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 $\alpha$-Si:H for another program.
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PUBLICATIONS
(period covered 1 October 85 - 30 September 1986)


VISITORS

4. Dr. Peter Psaris, NAS, April 21, 1986.
5. Dr. Jim Allen, Bellcore, April 21, 1986.
7. Dr. Fred Muller, Los Alamos, June 19, 1986.
11. Dr. Harold Weinstock, Dr. Edelsack, and Dr. M. Nissenoff, AFOSR, ONR, July 18, 1986.
12. Dr. V. Kresin, Lawrence Berkeley Laboratory, August 14, 1986.
13. Dr. Tim Sands, Lawrence Berkeley Laboratory, August 21, 1986.
15. Dr. R. M. White, Control Data, August 1986.
16. 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.
4. Dr. Klaus Settler, University of Konstanz, "Clusters in Beams", December 5, 1985.

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


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


THO - SEMINARS

3. Seminar on Thin Films, Rutgers University, New Jersey, April 29, 1986
5. PURDUE UNIVERSITY, ONR WORKSHOP, June 3 through 3, 1986

COMMITTEES

1. The National Research Council
2. Solid State Science Committee
3. Ad Hoc Committee for NSF-MRL Directors
5. SSSC National Symposium for Advancing Materials - Chairman
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 Corporation, 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
R. L. Greene, IBM Research Laboratories, Yorktown Heights, New York
J. Harper, IBM Research Laboratories, Yorktown Heights, New York
New discoveries, inventions or patent disclosures

NONE

Persons working on the contract during the period
10 October 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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