MIDWEST SUPERCONDUCTIVITY CONSORTIUM

1994 Progress Report

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Midwest Superconductivity Consortium

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SUMMARY

The mission of the Midwest Superconductivity Consortium, MISCON, is to advance the science and understanding of high T_c superconductivity.

During the past year, twenty-seven (27) projects produced over one hundred twenty-three (123) talks and one hundred thirty-nine (139) publications. Three (3) Master's Degrees and ten (10) Doctor's of Philosophy Degrees were granted to students working on MISCON projects.

Group activities and interactions involved two (2) MISCON group meetings (held in August and January); with the second MISCON Workshop held in August; thirteen (13) external speakers; seventy-nine (79) collaborations (with universities, industry, Federal laboratories, and foreign research centers); and forty-eight (48) exchanges of samples and/or measurements.

Research achievements this past year focused on understanding the effects of processing phenomena on structure-property interrelationships and the fundamental nature of transport properties in high-temperature superconductors.

In the synthesis and processing area: new low-temperature routes for processing bulk and thin film materials were developed; understandings of crystallization, grain growth and texture development in solidified melts and deposited thin films were broadened; important effects of substitutions, second phases, texture alignments, modulated microstructures and composite and microlaminate structures on superconducting properties were characterized; and, processing routes for improving the density and texture of tubular shielding structures were explored.

In the area of transport phenomena: theories for universal conductivity at superconductor-insulator transitions, flux-lattice melting transitions, the electrodynamics and thermodynamics of vortex motion, electromagnetic wave dissipation, and Josephson current densities through insulating barriers were advanced; important experimental techniques for measuring magneto-transmission and reflections of mm microwaves, vortex

correlation fluctuations, magnetic penetration depths, the softening of in-plane phonon modes, flux pinning by complex defects and interfaces, weak-link behaviors, and reproducible sub-energy-gap structures were studied.

The following are examples of notable achievements by MISCON investigators during the year:

- A quasi-periodic array of nanometer-scale, Pb quantum dots has exhibited quantum confinement. Quantum confinement resulted in a broadening of the transition temperature from 7°K for bulk lead to 30-7°K from onset to completion for the quantum array (A. E. Miller and S. Bandyopadhyay, University of Notre Dame).
- Studies on deoxygenated YBCO show that the theoretically-predicted dimensional crossover field H_0 decreases as anisotropy increases. All vortex-glass phase boundaries can be collapsed onto a single universal curve, suggesting that there is a general magnetic phase diagram for all HTS materials (M. W. McElfresh and E. P. Kvam, Purdue University).
- A quantitative model of a three-dimensional superconductor has been developed which predicts the change in transition temperature with the number of conducting planes (J. M. Honig and J. Spalek, Purdue University).
- Superconductivity has been induced for the first time in materials of the phase $\text{Ba}_{1+x}\text{Bi}_{1-x}\text{O}_{3-\delta}$. The transition temperature is in the vicinity of 25°K, which is the highest reported for a non-cubic bismuth oxide phase (J. Betanabhatla, University of Nebraska-Omaha, J. R. Hardy, University of Nebraska-Lincoln, R. R. Berliner, University of Missouri-Columbia).
- Reproducible processing of silver-clad BSCCO tubes by centrifugal slip casting was demonstrated, and a patent for the process filed. This work demonstrated that a high degree of preferred orientation in the

centrifugally-cast tubes enables significant densification (K. P. Trumble, K. J. Bowman and M. W. McElfresh, Purdue University).

- NMR measurements with simultaneously-applied pulsed currents confirm that the vortex system in single-crystal YBCO is in the "liquid" state within the resistive transition temperature region, and that the diffusion distances are much greater than the intervortex spacing within times less than 100 μ sec (C. Pennington, The Ohio State University).
- The melt-texturing of YBCO was found possible in metal-precursor-derived laminates fabricated from Y-Ba-Cu-Ag-Pd tapes without melting the Ag-Pd noble metal alloy (P. J. McGinn, University of Notre Dame, and K. H. Sandhage, The Ohio State University).
- Atomic beam studies of the vortex lattice in Nb films can be fitted with a hexagonal lattice which has sample-wide orientation order and short-range (about 5 lattice constants) translational order (G. Lafyatis, The Ohio State University).
- Significant improvements in the magnetization of YBCO have been achieved by Nd doping; and extended hold times above the peritectic result in increased pinning (and J_c) at 77°K, attributed to increased dislocation density with 211 phase coarsening (P. J. McGinn, University of Notre Dame).
- Highly-refined measurements of the magnetic penetration depth in YBCO films now leave no doubt that dopants increase the penetration depth without affecting its T dependence (T. R. Lemberger, The Ohio State University).

- For S-I-S tunneling junctions under suitable situations the inelastic scattering of tunneling electrons with barrier phonons can lead to an increase in tunneling probability (G. F. Giuliani, Purdue University).
- Studies of flux melting in highly anisotropic, high- T_c superconductors, such as BSCCO, show strong evidence for a dimensionality crossover (3D to 2D transition) which is accompanied with a conspicuous change from mean-field-like to fluctuation-dominated behavior (D. G. Stroud, The Ohio State University).
- A molecular precursor with the correct Y:Ba stoichiometry of YBCO has been successfully synthesized (D. V. Baxter, K. G. Caulton and M. H. Chisholm, Indiana University).
- A new superconducting phase, RNi_2B_2C , was synthesized with Y and Er. The Y and Er samples had T_c 's of 15.5°K and 11°K, respectively (S. K. Malik, Tata Institute of Fundamental Research and W. B. Yelon and J. W. Farmer, University of Missouri-Columbia).
- In YBCO with 211 additions, the flux pinning seems to be induced by extended defects (dislocations and CuO-layer stacking faults) associated with the particles rather than directly by the particles themselves (E. P. Kvam, Purdue University).
- Fluorination has been found to enhance significantly the superconductivity of $La_{2-x}Sr_xCuO_{4+y}$ (J. M. Honig and J. Spalek, Purdue University).
- In small Josephson junctions, Abrikosov vortex penetration tends to increase I_c . Specifically, for suitable vortex configurations the dependence $I_c(H)$ is determined by the magnetization in such a way to lead to an increasing $I_c(H)$ (G. F. Giuliani, Purdue University).

- The preferred orientation of YBCO films deposited on MgO substrates by the metallo-organic deposition process can be varied with increasing firing temperature from a broad fiber texture to an epitaxial orientation (G. L. Liedl, A. L. Bement, Jr., and S. Mansour, Purdue University).
- The Blackstead-Dow model, which asserts that Ba-site substitution by magnetic Pr^{+3} ions breaks electron-pairs while rare-earth site substitution does not, has been verified experimentally (H. A. Blackstead, University of Notre Dame).
- Monte Carlo calculations establish that the superconducting vortex state does not occur at finite temperatures in the limit of 2D films with point disorder (A. H. MacDonald and S. M. Girvin, Indiana University).
- The H - T phase diagram for single-crystal BSCCO consists of a penetration (or depinning) field boundary and a 2D-3D crossover field boundary (which separates phases of 3D vortex lines and interacting 2D vortices) for c-axis-oriented fields of $H > H_{c2}$ (J. C. Garland, The Ohio State University).
- A process for fabricating spiral-wound tubes from Ag-Pd sheet has been developed for the powder-in-tube processing of YBCO composites (P. J. McGinn, University of Notre Dame, and K. H. Sandhage, The Ohio State University).

PROGRAM OVERVIEW

The Midwest Superconductivity Consortium, MISCON, in the fifth year of operations further strengthened its mission to advance the science and understanding of high T_c superconductivity. These goals of the organization and the individual projects continue to reflect the current needs for new knowledge in the field and the unique capabilities of the institutions

involved. Group efforts and cooperative laboratory interactions to achieve the greatest possible synergy under the Consortium continue to be emphasized. Industrial affiliations coupled with technology transfer initiatives were expanded. Activities of the participants during the past year achieved an interactive and high level of performance. The number of notable achievements in the field contributed by Consortium investigators increased.

The programmatic research continues to focus upon key materials-related problems in two areas. The first area has a focus upon "Synthesis and Processing" while the second is centered around "Limiting Features in Transport Properties of High T_c Materials". The two areas involve twenty-seven (27) research projects and thirty-seven (37) principal investigators. The research projects involve ten (10) undergraduate students, fifty-eight (58) graduate students and nine (9) postdoctoral associates. In the past year, these participants have published eighty-three (83) papers. Nineteen (19) more papers are in press and an additional thirty-seven (37) have been submitted. Further, the participants have given over one hundred twenty-three (123) talks or conference presentations. During this past year, three (3) Master's Degrees and ten (10) Doctor's of Philosophy degrees were granted to students working on MISCON projects.

Group activities and interactions with others were again a major activity under the Consortium. MISCON group meetings were held in January and August. A two day schedule for each meeting provided ample opportunity for the desired interactions to take place. Based upon these meetings the Program Committee reexamined the goals and programmatic research and made desirable program changes.

In addition to the group meetings, a workshop entitled "Synthesis, Processing and Analysis of High Temperature Superconductors", was held on August 11-12, 1994. Outstanding speakers from both within and outside MISCON participated.

Coupled with the group meetings and workshop, the participants were very active in cooperative interactions with MISCON Affiliates and other

organizations. Among these activities were thirteen (13) external speakers, seventy-nine (79) collaborations, forty-eight (48) exchanges of samples and/or measurements, and three (3) gifts of equipment from industry. The number of actively participating industrial affiliates was increased to 14 with the addition of Hypres, Inc., Keithley Instrument Company, Superconductive Components, Inc., and Wright Patterson AFB. Additional affiliations are pending.

Group activities are fostered by four programs: first, a seminar exchange promotes interaction within and between the groups; second, a programmatic exchange facilitates the use of special capabilities by all participants; third, a program augmentation grant of \$10K is provided under active projects where specific joint technology transfer developments involving participating affiliates on a cost sharing basis are formally agreed to by both parties; finally, a special capital equipment competition addresses group needs as the primary criterion. Cost sharing realized over \$360K worth of equipment, that was selected to provide new capabilities to the Consortium with less than \$120K of MISCON funds invested.

Industrial affiliations and technology transfer activities were expanded during the year. Twelve (12) written agreements and two (2) equipment access agreements were formalized this year with fourteen (14) different industry and national laboratory groups. Two (2) additional agreements are pending. Such interactions make all participants more aware of industry's needs for new knowledge and the current state of the technology.

PEER REVIEW

In accordance with MISCON procedures all fourth-year proposals and new proposals are reviewed by an independent external peer review panel. The 1994 peer review was conducted by ten outstanding experts in the field of high- T_c superconductivity. Project renewal decisions were then based on the results of this peer review. Prior to the review, two existing projects were withdrawn: for one, the goals had been completed and the other one was reconstituted as a new proposal. Consequently, five fourth-year projects and nine new proposals were submitted to this outside panel for review. As a result of the panel's review, the five ongoing projects were renewed and four of the new proposals scored sufficiently high to justify funding for 1994/95. These were funded at a reduced level for the first year for a combined total of \$379,071.

The peer review scoring is based on NSF method which scores according to "excellent", "very good", "good", and "reject". The average score of all projects is near the midpoint between "very good" and "excellent".

These changes in research projects are indicated in Appendix I.

The process of peer review will continue to be the principal means within MISCON for continuous improvement of project quality, productivity and synergy and for dynamic renewal of project compositions within the two main program thrusts.

RESEARCH PROGRAM THRUSTS

MISSION: The basic mission of the Consortium is to advance the understanding of high- T_c superconductivity and to promote the development of new materials and improved processing technology for the commercialization of superconductivity.

GOALS: The goals of the Consortium are:

- a) To develop, utilizing effective group efforts, the scientific and technological foundation for the industrial applications and commercialization of high-temperature superconductivity;
- b) To facilitate the transfer of technology from the Consortium research laboratories into the industries of the Midwest; and
- c) To ensure that there is a continuing supply of engineers and scientists trained in this important field.

PROGRAMMATIC RESEARCH: To achieve the research goals within the mission of the Consortium, two general programmatic areas of research have been defined. These two areas were selected from many possible ones to focus upon key materials-related problems where unique capabilities exist within the Consortium. In addition to cooperative research programs in these areas, the Consortium encourages proposals for studies of new materials which can be expected to exhibit useful high-temperature superconductivity.

**Area 1: New and Improved High T_c Superconducting Materials:
Phase Relations, Reactions, Synthesis and Processing**

The development of high-temperature superconductors is contingent upon a thorough understanding of their material properties and of the processing variables that control these properties. Such properties include both thermodynamic and kinetic information about superconducting and

normal-state phases. Processing variables encompass those necessary for optimizing synthesis and processing procedures for materials properties control. The Consortium supports investigation of these topics, as well as studies pertaining to the fabrication and characterization of high-temperature superconducting composites, multilayers, modulated structures, thin films, and other novel structures of potential usefulness.

Area 2: High T_c Superconductor Transport Properties:
Controlling/Limiting Factors

Most proposed applications of high-temperature superconductors involve their ability to carry bulk supercurrents (e.g., wires, ribbons), to screen magnetic fields (e.g., enclosures, cavities), or to be components of electronic devices (e.g. sensors, magnetometers). All of these applications are contingent upon an understanding and control of transport properties. The Consortium supports research in this general area, including studies of weak links (both artificially produced, and naturally occurring, as by defects, grain boundaries and textures); dynamics (flux lattice pinning, melting, and related phenomena); and interfacial transport (such as that between grains, films, contacts, substrates, and coatings).

RESEARCH PROGRAM

Titles of the projects within the two principal research program areas are given in Appendix I, along with industrial affiliations of the principle investigators for each project. A major emphasis during the past year was to increase the number of affiliations with other organizations. Six (6) out of twenty-seven (27) projects now involve formalized working agreements. Those affiliations covered by formalized agreements are also indicated in Appendix I.

SELECTED RESEARCH HIGHLIGHTS

The following are selected research accomplishments by MISCON participants in the past year. These achievements provide an insight into

some of the new and exciting areas of research in progress by MISCON participants. Formal affiliations are noted by an asterisk.

**Area 1: New and Improved High T_c Superconducting Materials:
Phase Relations, Reactions, Synthesis and Processing**

***Low Temperature Routes to Processing of High-Temperature
Superconductors***

***David V. Baxter, Kenneth G. Caulton, and Malcolm H. Chisholm
Indiana University
Advanced Technology Materials, Inc.****

The objectives of this research are to:

- 1. elucidate the mechanisms through which molecular precursors are transformed into superconducting materials during the CVD process; and*
- 2. understand the mechanisms responsible for the actual deposition of films using these precursors.*

A mechanistic role for H_2O in the decomposition of the commonly used precursor $Cu(hfacac)_2$ has been identified. The role of the ligand in determining the oxidation state of the resulting film has also been explored. This work has important implications not only for CVD of superconducting oxides, but also for Cu metallization in ULSI integrated circuits.

We have also been successful in the synthesis of a molecular precursor with the correct Y:Ba stoichiometry of YBCO ($YBa_2Cu_3O_7$). We are currently characterizing the thermolysis behavior of this precursor and will be looking to introduce Cu to the molecule.

Our experiments with sputtered Cu/Ge films have pointed to a previously unreported metastable phase of Cu and Ge as the source of an unexpected (low-temperature) superconductivity. These results may prove important to the application of Cu metallization in integrated circuitry (particularly when combined with Si/Ge heterostructures).

***Investigations of Structure and Superconducting Properties Relationship in
Copper-free Bismuth Oxides***

J. Betanabhatla

University of Nebraska-Omaha

J. R. Hardy

University of Nebraska-Lincoln

R. R. Berliner

University of Missouri-Columbia

The objectives of this research are to study the:

- 1. correlation between the structure and superconducting properties of copper-free bismuth oxide phases; and*
- 2. effects of oxygen annealing temperatures and pressure on the crystal structure and superconducting properties of these bismuth oxides.*

We have induced superconductivity for the first time in the materials of the phase $\text{Ba}_{1+x}\text{Bi}_{1-x}\text{O}_{3-\delta}$. These materials are thoroughly characterized using X-ray powder diffraction, SQUID magnetization, thermal analysis, SEM, and EDAX. The X-ray powder diffraction studies indicate that the materials are of single phase and that the unit cell symmetry is tetragonal. The superconducting transition temperature (T_c) determined from SQUID magnetization data is in the vicinity of 25K. To the best of our knowledge this T_c is the highest ever observed in a non-cubic bismuth oxide phase.

Our preliminary results suggest that potassium can be substituted for barium in $\text{Ba}_3\text{Bi}_2\text{O}_7$ over a narrow concentration range. Some of these materials exhibit superconducting transitions. We are carrying out a systematic study of these materials.

***Microstructural Dependence of Critical Current Density in Melt Textured
YBa₂Cu₃O_{6+x} Superconductors***

Paul J. McGinn

University of Notre Dame

Argonne National Laboratory*

Superconductive Components, Inc.*

The goal for this project is to investigate the microstructural dependence of J_C in zone-melt-textured YBCO so as to optimize its microstructure and improve its properties and processability.

Thermal cycling of textured Y-123 (700-850°C) has been found to lead to improvements in low temperature (20-60°K) critical current density. The cycling is believed to be increasing the defect density, resulting in improved pinning.

Significant improvements in Y-123 magnetization (and J_C) at 77°K have been achieved by doping of Y-123 with Nd.

Extended hold times above the peritectic (which lead to 211 coarsening) have been found to result in increased pinning (and J_C) at 77°C. This is thought to be due to increased dislocation densities.

A joint program with Superconductive Components, Inc. is underway to pursue improved RE-123 bearings for levitation applications. Specifically, we are looking at improved texturing, enhanced pinning, and the use of low pO₂ processing of Nd-123.

***Growth of Single Crystals and/or Textured Specimens of High-T_C
Superconductors Using Oxygen Seeding***

Patrick K. Gallagher

The Ohio State University

The objective of this research project is to demonstrate the efficacy of oxygen seeding for the growth of single crystal or highly textured YBa₂Cu₃O₇ (123).

Attempts this year focused on the use of gravity-based extrusion, and relied on the lower melting point for the superconductor at lower partial pressures of oxygen. The problems encountered concerned: 1) creep of the melt up the sides of the crucible rather than through the extrusion orifice, 2) corrosive attack of the crucibles, and 3) erratic behavior of the melt in the vicinity of the orifice. The two experimental processes that will be stressed during the next period are: 1) the pressurized extrusion of the melt at high temperatures, and 2) variations of the melt stoichiometry in the direction (copper rich) to facilitate crystal growth. An improved apparatus to overcome previous problems has been developed.

Processing of Textured Superconducting Oxide/Noble Metal Microlaminates

Paul J. McGinn

University of Notre Dame

Ken H. Sandhage

The Ohio State University

The objective of this research is to produce fracture-tough, high J_c superconducting composites consisting of thin layers of superconducting oxide alternating with thin layers of noble metal.

Powder-in-tube $\text{YBa}_2\text{Cu}_3\text{O}_y$ (in a 90Ag/10Pd alloy tube) has been successfully melt-textured in a 1% oxygen-bearing atmosphere at a peak temperature of 960°C. The Ag-Pd tube was only minimally attacked by the peritectic oxide liquid.

A mechanically-alloyed, hot-rolled Y-Ba-Cu-Ag-Pd tape has been oxidized at 650°C at low oxygen partial pressures so as to yield a chemically segregated composite with outer layers enriched in oxide and a core enriched in metal. After complete oxidation of the Y-Ba-Cu-Ag-Pd tapes, further annealing at 960°C did not result in melting of the noble metal. This means that melt-texturing of $\text{YBa}_2\text{Cu}_3\text{O}_{6+y}$ is possible in metal-precursor-derived laminates without melting the noble metal alloy.

A process for fabricating spiral-wound tubes from Ag-Pd sheet has been developed suitable for powder-in-tube processing of $\text{YBa}_2\text{Cu}_3\text{O}_y$ composites.

***Anisotropic Grain Growth and Isothermal Grain Alignment of Bulk,
Superconducting Oxides
Ken H. Sandhage
The Ohio State University***

The current goals of this program are to develop a better understanding of:

- 1. the influence of solid-state decomposition and reformation reactions on grain growth and grain alignment in bulk Bi(Pb)-Sr-Ca-Cu-O superconductors; and*
- 2. grain growth in bulk, solid solution $\text{Nd}_{1+x}\text{Ba}_{2-x}\text{Cu}_3\text{O}_y$ superconductors.*

Further improvements have been made in the grain alignment of $\text{Bi}_2\text{Sr}_2\text{Ca}_1\text{Cu}_2\text{O}_{8\pm\delta}$ thick films. To date, the best alignments were produced from decomposed films containing well-aligned $\text{Bi}_2(\text{Sr,Ca})_2\text{Cu}_1\text{O}_{6\pm\xi}$ -type grains.

A number of long-term (96-hour) anneals have been conducted to evaluate the stability of the $(\text{Bi,Pb})_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10\pm\delta}$ -type compound at high and low oxygen pressures. The conditions required for decomposition of this compound are less severe at the extremes of oxygen pressure than for the $\text{Bi}_2\text{Sr}_2\text{Ca}_1\text{Cu}_2\text{O}_{8\pm\delta}$ -type compound. These observations are consistent with the former compound (Pb-bearing) being a less stable oxide than the latter compound (Pb-free).

Scanning Auger microprobe analyses are being conducted at Case Western Reserve University on *in-situ* fractured polycrystalline specimens of $\text{Nd}_{1+x}\text{Ba}_{2-x}\text{Cu}_3\text{O}_y$ ($x \leq 0.5$) specimens to compare compositions of grain boundaries versus bulk grains.

The Influence of Oxygen Pressure and Temperature on Oxygen Stoichiometry and Phase Equilibria in the System Bi-Sr-Ca-Cu-O

David R. Gaskell

Purdue University

The purpose of this project is to conduct a comprehensive study of the influence of oxygen pressure and temperature on the phase equilibrium and distribution of Ca and Sr between equilibrated phases in the system Bi-Sr-Ca-Cu-O.

Although single "pure" phase specimens of 2212 could be prepared with ease, single "pure" phase specimens of 2223 could not be prepared in air. Specimens with volume fractions of 2223 ranging from 65-85% were prepared using the initial stoichiometry $\text{Bi}_2\text{Sr}_{1.5}\text{Ca}_{2.5}\text{Cu}_3\text{O}_x$. The TGA traces obtained for both 2212 and 2223 showed four distinct slopes, which indicates a complex scheme of decomposition during heating. Tentative decomposition paths for these two phases during heating have been worked out.

Pair Breaking Phenomena in the $\text{La}_{2-x}\text{Sr}_x\text{Cu}_{1-y}\text{Ni}_y\text{O}_4$ Systems

J. M. Honig and J. Spalek

Purdue University

Two questions are being addressed by this project:

- 1. What is the influence on T_c of Ni substitutions for Cu as a function of the Sr concentration in $\text{La}_{2-x}\text{Sr}_x\text{Cu}_{1-y}\text{Ni}_y\text{O}_{4+\delta}$?; and*
- 2. What are the electron states and real space pairing of a statistical spin liquid (SSL) in which double occupancies of the same quasiparticle level are not allowed?*

Extensive experimentation has shown that fluorination of $\text{La}_{2-x}\text{Sr}_x\text{CuO}_{4+y}$ leads to a significant enhancement of superconductivity relative to the host

material. In fact, the oxide which for $x < 0.055$ remains a normal material, is rendered superconducting by this procedure. These experiments delineate the very beneficial effects of the fluorination procedure in this class of materials, and by implication, in cuprates exhibiting much higher transition temperatures.

A quantitative model of a three-dimensional superconductor has been developed, using the two-dimensional statistical spin liquid as a point of departure. The theory invokes real space pairing of electrons within the Cu-O conducting planes and tunneling of such pairs between these planes. The model predicts the change in transition temperature as a function of the number of conducting planes. The excellent agreement with experiment for the BSCCO system lends credence to the validity and usefulness of the model.

***High Temperature Superconducting Tubes for Magnetic
Shielding Applications***

K. P. Trumble, K. J. Bowman and M. W. McElfresh

Purdue University

IBM Thomas J. Watson Research Center*

Quantum Magnetism/Quantum Design*

Los Alamos National Laboratory*

The objectives of this research project are to:

- 1. develop processes for fabricating superconducting shield tubes;*
- 2. characterize the texture and properties of the processed tubes; and*
- 3. investigate the effects of annealing conditions on the superconducting properties of BSCCO-silver composites.*

Reproducible processing of silver-clad BSCCO tubes by centrifugal slip casting was demonstrated, and a patent application "Process for Slip Casting Textured Tubular Structures" was filed. This work demonstrated that a high

degree of preferred orientation in the centrifugal slip cast tubes enables significant densification.

A process for incorporating fine dispersions of silver in BSCCO microstructures via colloidal precipitation was developed. Microstructural studies suggest the constrained solidification of BSCCO in silver channels may yield a high degree of preferred orientation.

Significant progress was made in measuring magnetic shielding characteristics of processed tubes. We have recently shown that the vortex-glass phase transition of the grain boundary is significantly reduced with respect to the bulk. This reduction may be the result of oxygen depletion, which pushes the vortex-glass transition to lower temperatures and fields. The field dependence of the weak-link behavior is consistent with these results.

Structural Defects and Interfaces in $\text{YBa}_2\text{Cu}_3\text{O}_7$

E. P. Kvam

Purdue University

Argonne National Laboratory

The objectives of this project are to:

- 1. examine the microstructure, and in particular, the extended defect and intercrystalline boundary structures of textured bulk polycrystals and epitaxial thin films (including bicrystals) of YBCO; and*
- 2. correlate these microstructural aspects with transport property characteristics.*

In materials with 211 additions, it had previously been found that the enhancement of critical currents through flux pinning depended on the size of the 211 particles. However, recent results (with McGinn) suggest that coarser 211 particles can have a more pronounced effect, particularly if solidification occurs from a more highly undercooled melt. The pinning seems to be induced by other extended defects (dislocations and CuO layer

stacking faults) associated with the particles, rather than directly by the particles themselves.

Pt and Ni additions also appear to have substantial effects on the microstructures and properties of the bulk materials. Pt additions have been seen to enhance defect introduction during oxygenation, and may also affect the 123/211 interface. Ni additions cause substantial improvements in low temperature properties; the microstructures of these materials also show a very notable increase in defect densities, especially stacking faults (with bounding dislocations), in which the defects are inhomogeneously distributed.

In the calculation of the flux pinning by dislocations in 123 materials, we have shown that screw components should have no strain-related effects on the flux lines, although the edge components may be significant contributors to pinning. On the other hand, spiral growth-related screw dislocations would have very large Burgers vectors, and consequently very large normal-state cores, in which flux lines could be readily trapped. The calculated pinning forces and energies correlate well with those measured in both thin films and bulk materials. They also correlate with our observations of increased dislocation densities leading to increased in-field J_c through flux pinning.

Efforts to prepare BSCCO/Ag composites for high-current leads in collaboration with Argonne National Laboratory were successful. The total current capacity, measured with and without applied fields, was seen to be equal or superior to all but the very best powder-in-tube materials.

Processing and Texture Development in $YBa_2Cu_3O_{7-\delta}$ Films from Metallo-

Organic Precursors

G. L. Liedl, A. L. Bement, Jr., and S. Mansour

Purdue University

The objectives of this project are to:

- 1. achieve rapid thermal processing of $YBa_2Cu_3O_{7-\delta}$ (YBCO) films on suitable substrates employing metallo-organic precursors; and*

2 understand and control the development of film orientation by varying the process parameters.

Results indicate that preferred orientation in $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ films could be varied, with increasing film firing temperature, from c-axis fiber texture to near-CSL and cube-on-cube epitaxy. On cleaved (100) MgO substrates the degree of preferred orientation could be varied from broad fiber texture to an epitaxial orientation having an angular spread with a half maximum width of 6.4° . Polishing the MgO substrates resulted in a decrease in the degree of preferred orientation to a distribution with a half maximum width of 20° . Epitaxial growth was promoted by lattice matching on (100) SrTiO_3 substrates at lower film firing temperatures and exhibited a narrow orientation distribution (half maximum width of 2.5°).

**Area 2: High T_c Superconductor Transport Properties:
Controlling/Limiting Factors**

Statistical Mechanics of High T_c Superconductors and Flux Line Liquids

A. H. MacDonald and S. M. Girvin

Indiana University

The objectives of this project are to:

- 1. clarify how superconductivity coexists with very intense magnetic fields at low temperatures in the limit when the effects of Landau quantization becomes important;*
- 2. investigate the quantum phase diagram of superconductivity in two-dimensional systems (e.g., thin films) in the presence of magnetic fields and/or disorder; and*
- 3. numerically simulate how columnar defects pin vortices in the high T_c superconductors.*

We have completed extensive Monte-Carlo simulations of the Ginzburg-Landau model which yield predictions for the relationship between the irreversibility temperature and other measurable properties of clean layered superconductors.

We have completed analytic high-temperature expansion calculations which clarify the nature of the phase transition to the Abrikosov vortex-lattice state in clean superconducting films.

We have published Monte Carlo calculations which establish that the superconducting vortex state does not occur at finite temperatures in the limit of 2D films with point disorder.

Electrical and Optical Investigations of Pristine and Doped 124 Materials
Meera Chandrasekhar
University of Missouri-Columbia

The objective of this project is to study the role of Zn and Fe doping in $\text{YBa}_2\text{Cu}_4\text{O}_8$ (Y124). We propose to perform two key experiments: (1) a study of the softening of the in-plane phonon modes at T_c via Raman scattering; and (2) a study of the variation of dT_c/dP in pristine and doped 124 specimens using Raman scattering and resistivity under hydrostatic pressure in a diamond anvil cell (0-200 kbar at 15-300°K).

A collaborative study with the University of Cincinnati (P. Boolchand, et. al.) was made of heavily oxygen doped, Fe-doped Y-124's. The process of incorporating oxygen lowered T_c from 78 to about 25°K. The conjecture is that the presence of 2% Fe helps get oxygen into the grain boundaries. This was confirmed by our Raman scattering measurements, where we found that the oxygen associated modes were unaffected in intensity by oxygen doping as compared to other phonon modes.

We have studied both Raman scattering and photoluminescence (PL) of samples of quantum wires and dots of CdS grown by S. Bandyopadhyay, et. al., University of Notre Dame. While the PL spectra were extremely broad, they did show a characteristic blue shift typical of quantum confinement.

We have recently installed a back-illuminated CCD detector which will enable us to perform Raman scattering experiments on high T_c samples of the highest research interest but weakly scattering. We have also begun studies of the temperature and pressure dependence of Raman scattering in Tl-2201 which has been shown by ac susceptibility measurements to have an anomalous dT_c/dP . We propose a microstructural verification of a model that proposes that interstitial oxygen reorders when warm but not when cold.

Polarized Neutron Reflectivity Studies of HTC Superconductors

P. F. Miceli

University of Missouri-Columbia

The purpose of this project is to study the physical properties of flux lines as well as the temperature dependence of the London penetration depth in high T_C superconductors using polarized neutron reflectivity.

Our initial work has been to evaluate with x-ray reflectivity the effects of surface roughness for $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ films and of substrate flatness on our neutron reflectivity experiments. We find that SrTiO_3 substrates exhibit far superior macroscopic flatness than LaAlO_3 substrates. Furthermore, films grown by laser ablation exhibit less diffuse scattering than films grown by sputtering, even though both exhibit substantial scattering.

Funding was obtained jointly from MISCN, the University of Missouri and the Missouri University Research Reactor (MURR) to design and construct a special split-core magnet that will enable a neutron beam to pass in and out of the cryostat over a broad angular range. The cryostat will operate from 1.5-300°K with fields up to 7T.

Neutron Diffraction and Defect Studies of High T_C Superconductors

W. B. Yelon and J. W. Farmer

University of Missouri-Columbia

The goals of this project are to:

- 1. pursue studies of complex high T_C oxide systems in collaboration with leading investigators using neutron diffraction; and*
- 2. understand enhancements in critical current density induced by neutron irradiation.*

A new superconducting phase $\text{RNi}_2\text{B}_2\text{C}$ was synthesized with Y and Er by S. K. Malik (Tata Institute for Fundamental Research) while in residence

at the MURR and UM-Rolla. The Y sample showed a T_c of 15.5°K while the Er sample had a T_c of 11°K. The crystal structure of this phase was successfully studied with natural B rather than separated ^{11}B because of the design of the PSD neutron diffractometer available at the MURR.

Flux creep measurements in Y-123 showed that the pinning potential diverged as the magnetic-field-induced current approached zero. This finding is in agreement with new models that predict that the creep will have an inverse power law dependence on current.

***Microwave and Optical Studies of High-Temperature Superconductors:
Flux-Lattice Dynamics, Crystal Anisotropy, Flux Pinning and Photo-
Modulated Superconductivity***

H. A. Blackstead

University of Notre Dame

Lakeshore Cryotronics*

This project studies transport properties of high-temperature superconductors, in particular field-induced changes in the microwave resistance, to derive information on flux-lattice dynamics, crystal anisotropy and flux pinning.

In cooperation with a group at the Naval Research Laboratory, we have been studying a new form of low-temperature superconductor, NbN. Our interest in this material had its origin in an effort to find a "test-bed" for the Coffey-Clem theory of surface resistance. Much to our surprise, the resistivity of this material was not at all dominated by flux flow. We found no dependence on the angle between the dc field and the dc current. Our results show that the Coffey-Clem models do not describe the surface resistance data for this material.

From a prediction from the Blackstead-Dow (B-D) model, we hold that the apparent lack of superconductivity in Pr123 arises primarily from Ba-site substitution by Pr^{+3} ions. The model asserts that Ba-site magnetic Pr breaks pairs, while rare-earth site Pr does not. Two techniques, polarized neutron

scattering and Magic Angle Spinning NMR, have discovered the presence of Pr on the Ba site. We have found that samples prepared with limited substitution exhibit small regions ($\approx 3\text{-}5\%$) in which superconductivity exists. Sputter SIMS measurements at NRL did not detect the presence of any other rare earth contaminants in the samples. Vacuum annealing of the material removed the superconducting response. This strongly suggested that oxygen is necessary for the observed behavior. Electron spin resonance measurements on bulk Pr123 processed using low pO_2 revealed that the Cu spins disappear in the expected transition region. These results are ruled out by the spin-fluctuation model but are consistent with the B-D model.

The B-D model has now been applied to a number of high-temperature superconductors. The model features the principle of local charge neutrality and leads naturally to a BCS-like picture in which the carriers are holes. For $YBa_2Cu_3O_{6.5+\delta}$, the two-stepped character of the transition temperature as a function of oxygen content δ is a natural consequence, and δ is predicted to range from 0 to 0.5 in the superconducting state. The model also predicts that Ba-site occupancy by magnetic ions will lead to pair breaking. This pair breaking provides an opportunity to optimize flux pinning in the 123 class of high temperature superconductors.

Superconducting Quantum Structures

A. E. Miller and S. Bandyopadhyay

University of Notre Dame

Lake Shore Cryotronics*

The objective of this project is to fabricate lateral surface superlattices (two dimensional periodic arrays of quantum dots) of the medium temperature superconductor BKBO.

The process of producing a "template" for fabricating a two-dimensional, quasi-periodic array of superconducting quantum dots has been mastered. The template is a porous alumina film with a quasi regimented

array of pores. The average pore diameter is 10nm with less than 1nm variation and the average pore separation is of the same order. We have now demonstrated that a wide range of elements and compounds can be ac electrodeposited within the pores to realize a two-dimensional quasi-periodic array of quantum dots without damaging the nanostructures.

Materials electrodeposited within the pores have been characterized by energy-dispersive analysis of x-ray, optical characterization (photoluminescence and Raman spectroscopy), magnetic characterization and ac susceptometry. The last measurements by Lake Shore Cryotronics indicate that Pb quantum dots with 13nm diameter show a significant enhancement in the transition temperature because of quantum confinement. Quantum confinement caused the superconducting transition to become broad with the onset occurring at 30°K and the completion taking place at 7°K. In contrast, bulk Pb samples showed practically no transition width and a T_c of 7°K.

Transport Properties of YBCO Thin Films

S. T. Ruggiero

University of Notre Dame

The objective of this project is to understand and control the electronic properties of YBCO thin films; in particular, to:

- 1. study critical-current enhancement by induced-defect generation; and*
- 2. investigate the far-infrared responsivity of step-edge YBCO devices.*

We have studied YBCO film growth on LaAlO_3 with Ag underlayers in the range 0-11 nm. We find that T_c is independent of Ag underlayer thickness, ranging from 86-89°K with ΔT_c 's of roughly 1K. X-ray diffraction results also remain virtually unaffected, showing primarily c-axis material with and without the presence of underlayers. However, AFM studies of the films show those on Ag to be distinctly disordered/microcrystalline.

Consistent with these results is a significantly elevated YBCO film resistivity for all Ag underlayer thicknesses (again without a change in T_c).

Finally, we have found the behavior of J_c to be the most interesting of the effects observed. J_c was seen to decrease with Ag underlayer thicknesses of 0-11nm, approaching the value obtained on bulk Ag at the end of this range. On top of this behavior there appears to be a significant *enhancement* in J_c in the vicinity of 7-8nm, the origin of which is at present unclear.

High T_c Superconductivity Composites, Arrays and Crystals

J. C. Garland

The Ohio State University

The objectives of this project are to:

- 1. develop high- T_c machinable Ag/YBCO bulk composites with superconducting fractions ranging from 10-100 percent;*
- 2. develop high- T_c Ag/YBCO weak links and fabricate two-dimensional (2D) Josephson Junction Arrays; and*
- 3. prepare BSCCO single crystals and understand the effects of interplane vortex interactions.*

Tesla-field dc magnetization measurements of random bulk Ag/YBCO superconducting composites showed two distinct behaviors as the superconducting volume fraction f was varied between 0.1 and 1.0. The normalized magnetization hysteresis curves were nearly identical for $f \geq 0.70$, reflecting the behavior of isolated superconducting grains. For $f \leq 0.60$, however, the samples displayed smaller magnetic moments and smaller penetration fields, suggesting that an appreciable fraction of their bulk superconducting grains were grouped in cluster geometries.

Transport measurements showed that the resistive transition of our large high- T_c Ag/YBCO weak link arrays is characterized by a Kosterlitz-

Thouless-type transition. In addition, initial magneto-resistance measurements in small transverse magnetic fields ($H < 10$ Oe) revealed quantum oscillations at both integer and half-integer multiples of the flux quantum $\Phi_0 = h/2e$, suggesting that long-range phase coherence may be established in our arrays.

The structure of the vortex phase diagram of BSCCO single crystals near the superconducting transition was determined using six-terminal transport measurements in small external magnetic fields ($H < 100$ Oe). We found that for c-axis-oriented fields $H < H_{c2}$, the H-T diagram consists of a penetration (or depinning) field boundary $H_p(T)$ and a 2D-3D crossover field boundary $H_m(T)$ which separates phases of 3D vortex lines and interacting 2D vortices.

Atomic Beam Studies of Vortex Lattices at Superconductor Surfaces

G. Lafyatis

The Ohio State University

The long-term goals of this project are to measure vortex correlation functions at the surface of superconductors by developing a new atomic beam technique and to use this technique to study the behavior of the vortex lattice in high- T_c materials.

We have initially demonstrated our technique by studying sputtered niobium film samples. For this traditional superconductor, we expected to find a crystalline long-range translational lattice. Our measurements have ruled this out. They also ruled out a "gas"- type vortex lattice (random placement of the vortices) and any isotropic vortex lattice including a "liquid." The data are well fitted to a "hexatic" vortex lattice showing sample-wide orientational order and short-range (about 5 lattice constants) translational order.

We find that we are able to extract a sample's penetration depth from the temperature dependence of our signal.

Device-Related Properties of Doped $\text{YBa}_2(\text{Cu}_{1-x}\text{M}_x)_3\text{O}_{7-\delta}$ Films

T. R. Lemberger

The Ohio State University

The objective of this project is to expand on our discovery that low concentrations of Ni and Zn in $\text{YBa}_2(\text{Cu}_{1-x}\text{M}_x)_3\text{O}_{7-\delta}$ greatly increase the magnetic penetration depth, λ .

We have now constructed the world's best apparatus for measuring the magnetic penetration depth in superconducting films. The apparatus can measure the absolute value of $\lambda(T)$ to better than $\pm 150 \text{ \AA}$ with a noise level of $\pm 4 \text{ \AA}$. Using this apparatus, we have measured $\lambda(T)$ in 4% and 6% Ni-doped YBCO films. These measurements confirmed previous results that were based on heuristic arguments. There is now no doubt that dopants increase λ dramatically without affecting its T dependence significantly.

We have also refined our measurements of λ dependence on oxygen content in YBCO. We can now say with confidence that the superfluid density, $n_s \propto 1/\lambda^2$, decreases monotonically as T_c decreases. We are refining our studies of the λ dependence in annealed (oxygen depleted) and reoxygenated films.

NMR Studies of Vortex Dynamics in High T_c Superconductors

C. Pennington

The Ohio State University

The objective of this project is to make NMR measurements on several high T_c samples with the goal of finding situations favorable to the detection and characterization of vortex motion.

We have performed NMR spin echo experiments on a high quality single crystal of YBCO in the superconducting state and in a 9T field, simultaneously applying pulsed currents to displace the vortex liquid/glass.

The resistive transition begins near 90°K and the resistivity reaches zero near 76°K. Our NMR measurements with applied current pulses demonstrate that the vortex system is in a liquid-like state in this temperature range, with vortex diffusing distances much greater than the intervortex spacing within times less than 100μsec. As the crystal is cooled below the zero-resistance temperature (76°K) the NMR linewidth abruptly increases, indicating that the motional narrowing which occurs above 76°K has subsided. This observation is consistent with a transition from a liquid to a solid (or glass) state.

Dynamical Properties of Josephson-Coupled Systems: Applications to High-Temperature Superconductors

D. G. Stroud

The Ohio State University

This project is intended to study the structures of various high T_c superconductors, their defects, the correlations between their defects and physical properties, and the control of these defects.

We have made substantial progress in studying flux lattice melting and related phenomena in highly anisotropic high- T_c superconductors. We have now extended these calculations to three-dimensional lattices. We see strong evidence for a dimensionality crossover at anisotropies typical of BSCCO. While there appears to be only a single first-order phase transition (in the unpinned regime), the crossover is accompanied by a conspicuous change in behavior of the superfluid density (from mean-field-like to fluctuation-dominated), suggesting that the crossover might be easily seen experimentally. We are presently investigating the possibility that this crossover accounts for the disappearance of structure factor peaks reported in some recent experiments.

Besides this work we have:

- collaborated with Z. Tesanovic at John Hopkins University to show that, in a 2D regime, the flux solid, though it has a finite shear modulus, has only exponentially decaying phase coherence.
- developed a simple model for flux line dynamics in a model material. Our main result is that, for sufficiently weak coupling or sufficiently strong current, the vortex "pancakes" in the upper and lower arrays decouple, moving thereafter as independent two-dimensional objects. The resulting 3D-2D transition (or crossover) is characterized by a peak in the voltage in the secondary layer.
- developed a simple model which can produce a penetration depth which varies linearly with temperature at low T , *without* invoking a node in the order parameter. In this model, the linear T -dependence arises from fluctuations in the phase of the order parameter at different points within the sample.
- collaborated on a project in which we consider a periodic superconducting array (such as a high- T_c superconductor in which are drilled a periodic arrangement of cylindrical holes). We have shown that in such an arrangement, it is possible to propagate an electromagnetic mode, polarized in the c direction, with frequency below the probable gap frequency of the superconductor. Furthermore, the equation which describes the propagation of the wave is identical to the Schrödinger equation in two dimensions.

Study of Vortex Dynamics and Flux Pinning on Different Length Scales

M. W. McElfresh and E. P. Kvam

Purdue University

The purpose of this project is to better understand the distribution of electric currents and the factors influencing critical current densities in films of superconducting YBCO and other Bi- and Tl-based CuO superconductors.

Studies on deoxygenated $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ thin films have shown how the anisotropy γ of the material evolves with oxygen stoichiometry. The anisotropy increases with increasing δ with γ approaching closer to that of the strongly anisotropic HTS material Tl-2212.

Studies on deoxygenated $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ thin films have shown how the magnetic phase diagram of a superconductor evolves with anisotropy. We have shown that the theoretically predicted dimensional crossover field H_0 can be decreased to a value within our measurement window as g increases. In addition, we have shown that all of the vortex-glass phase boundaries can be collapsed onto a single universal curve, suggesting that there is a general magnetic phase diagram for all HTS materials.

Our work on understanding the effects of transport currents and magnetic fields on thin superconducting samples was expanded to include the effects of relaxation. Furthermore, an understanding of the anomalous signal shapes in SQUID magnetometer measurements of superconductors was developed. Some common types of anomalies arise from the shielding currents that are generated as the sample is moved through the inherently inhomogeneous field of the magnetometer.

Vortices in Anisotropic Superconductors

P. Muzikar

Purdue University

The objectives of this project are to study vortex lattices and their instabilities in an effort to find minimum energy configurations and to study the pinning of a vortex line to a defect in a two-dimensional superconducting sheet.

One highlight of our recent work has been the investigation of the effects of impurity scattering on d-wave superconductors. Many experiments over the past two years have focused on the question: is the order parameter in the high T_c materials of the usual s-wave type, or does the order parameter have the more intricate d-wave character? We have made detailed calculations of both penetration depth and the density of states for these types of order parameter. Both of these quantities are being experimentally probed at present, and theory indicates that there should be dramatic differences between the s-wave and the d-wave scenarios.

Transport Properties of High T_c Superconductors

G. F. Giuliani

Purdue University

The objectives of this project are to:

- 1. advance the theory of Josephson junctions and the flux dynamics in Type-II superconductors; and*
- 2. characterize the transport properties of artificially manufactured Josephson junctions as a means of better understanding the Josephson effect in layered superconducting structures.*

We have developed a theory of the finite size dependence of the critical current I_c in small Josephson junctions. Both the Meissner phase

and the case in which an ordered array of Abrikosov vortices penetrates the electrodes have been investigated. We have found that in general, for the same H , because of an interesting cancellation property of the Josephson phase gradient, vortex penetration tends to *increase* I_C . More specifically for suitable vortex configurations the dependence $I_C(H)$ is determined by the magnetization in such a way as to lead to an increasing $I_C(H)$. These results are relevant to both junctions of high temperature superconductors as well as to those characterizing polycrystalline samples.

We have theoretically investigated the linear response of a Josephson junction made inhomogeneous by the presence of randomly distributed Abrikosov vortices to an external alternating voltage. We have shown that the spectrum of the system is characterized by a plasmon band which manifests itself through a correspondingly broad maximum in the frequency dependence of the response function $R(\omega)$. Both the position and the magnitude of this maximum depend on the length L of the junction, and on ρ , the correlation length characterizing the disorder in the Abrikosov vortex lattice.

We have developed a microscopic theory of the critical current I_C of a S-I-S tunneling junction in the presence of inelastic scattering processes in the layer barrier. In particular we have studied a model in which tunneling electrons interact with a bath of phonons within the barrier. We have found that in suitable situations this interaction can in fact lead to an increase of the tunneling probability which more than compensates for the inevitable loss of coherence.

MISCON TALKS and PRESENTATIONS

January 1994 - December 1994

1. **Kenneth G. Caulton**, Invited Speaker, Wesleyan University, Middletown, CT, October 1994.
2. **Malcolm H. Chisholm**, Invited Speaker, Auburn University, Auburn, AL, November 1994.
3. **Malcolm H. Chisholm**, Invited Speaker, University of Alabama, Tuscaloosa, AL, November 1994.
4. **Malcolm H. Chisholm**, Invited Speaker, University of Mississippi, November 1994.
5. "Absence of a Finite Temperature Vortex Glass Transition in Two Dimensions", Ross Hyman, **S. M. Girvin**, Mats Wallin, A. Peter Young, and Matthew P. A. Fisher, March APS Meeting, Bull. Am. Phys. Soc. **39**, 183, 1994.
6. "XY Fluctuations and the Temperature Dependence of the Penetration Depth in High T_c Materials", **S. M. Girvin**, Aspen Center for Physics, Aspen, CO, July 1994.
7. "Just What is Superconductivity Anyway?" **S. M. Girvin**, Spring College on Quantum Phases, International Center for Theoretical Physics, Trieste, Italy, June 7, 1994.
8. "The Superconductor-Insulator Transition, Part I", **S. M. Girvin**, Spring College on Quantum Phases, International Center for Theoretical Physics, Trieste, Italy, June 8, 1994.
9. "The Superconductor-Insulator Transition, Part II", **S. M. Girvin**, Spring College on Quantum Phases, International Center for Theoretical Physics, Trieste, Italy, June 9, 1994.
10. "The Superconductor-Insulator Transition, Part III", **S. M. Girvin**, Spring College on Quantum Phases, International Center for Theoretical Physics, Trieste, Italy, June 10, 1994.
11. "Spontaneous Interlayer Coherence in Double-Layer Quantum Hall Systems", **Allan MacDonald**, Purdue University, January 21, 1994.
12. "Phases and Phase Transitions in Layered Superconductors", Jun Hu and **A. H. MacDonald**, March APS Meeting, Bull. Am. Phys. Soc. **39**, 119, 1994.
13. "Correlations in Two-Dimensional Vortex Liquids", Jun Hu and **A. H. MacDonald**, March APS Meeting, Bull. Am. Phys. Soc. **39**, 122, 1994.

14. "Magneto-oscillations in Type-II Superconductors", H. Akera, M. R. Norman, and **A. H. MacDonald**, March APS Meeting, Bull. Am. Phys. Soc. **39**, 304, 1994.
15. "Vortex-lattice Melting in Anisotropic Superconductors", **A. H. MacDonald**, Oak Ridge National Lab, January 1994.
16. "Vortex-lattice Melting in Anisotropic Superconductors", **A. H. MacDonald**, AT&T Bell Labs, April 1994.
17. "Raman Scattering Studies of Yb-124 Single Crystals and Y-124 Superconductors Under High Pressure", D. J. Payne, E. M. Baugher, R. J. Thomas, M. S. Boley, **M. Chandrasekhar**, H. R. Chandrasekhar, Y. Wu, P. Boolchand, and B. Dabrowski, APS March Meeting, Bull. Am. Phys. Soc. **39**, 728, 1994.
18. "Cation Disorder and Charge Transfer in $\text{Nd}_{1+x}\text{Ba}_{2-x}\text{Cu}_3\text{O}_{7-\delta}$ ", R. W. McCallum, M. J. Kramer, S. I. Yoo, **W. B. Yelon**, and H. Xie, TMS Meeting, March 1, 1994.
19. "Flux Creep: Effects of Grain Boundaries and Neutron Damage", **J. W. Farmer**, Solid State Seminar, Department of Physics, UMC, February 1994.
20. "Effects of Neutron Damage on Magnetic Relaxation in Single Crystal Y123", **J. W. Farmer**, D. C. Bradford, D. L. Cowan, and X. Ding, Bull. Am. Phys. Soc. **39**, 587, 1994.
21. "Flux Creep in Twinned, Untwinned, and Neutron Irradiated $\text{YBa}_2\text{Cu}_3\text{O}_7$ Single Crystals", **J. W. Farmer**, D. L. Cowan, X. Ding, and D. Bradford, International Conference on Materials and Mechanisms of Superconductivity/High-Temperature Superconductors (M2S-HTSC IV), Grenoble, France, July 1994.
22. "Flux Pinning Studies via Flux Creep Measurements in As-grown and Neutron Irradiated $\text{YCBa}_2\text{Cu}_3\text{O}$ Single Crystals", **J. W. Farmer**, X. Ding, D. L. Cowan, and D. C. Bradford, Midwest Solid State Conference, Kansas City, MO, October 1994.
23. "Effect of Sr and Ca Substitution on the Structure and Superconductivity of $\text{Ba}_{0.6}\text{K}_{0.4}\text{BiO}_3$ ", **B. Jayaram**, H. Srikanth, and **J. R. Hardy**, 42nd Midwest Solid State Conference, Kansas City, October 14-15, 1994.
24. "Structure and Superconductivity of $(\text{Ba}/\text{A})_{0.6}\text{K}_{0.4}\text{BiO}_3$, where A: Ca, Sr, or La", **B. Jayaram**, H. Srikanth, and **J. R. Hardy**, 1994 Fall Meeting of MRS, Boston, MA, November 28-December 2, 1994.
25. "Observation of High Temperature Superconductivity in Some Low Symmetry Bismuth Oxides", **B. Jayaram**, H. Srikanth, and **J. R. Hardy**, 1994 Fall Meeting of MRS, Boston, MA, November 28-December 2, 1994.

26. "Quantum" Confined Metallic Oxygen, the Key High Temperature Superconductivity", **Howard Blackstead**, Notre Dame, The College of Science Distinguished Scholar Lecture, April 20, 1994.
27. "Quantum" Confined Metallic Oxygen, the Key High Temperature Superconductivity", **Howard Blackstead**, Physics Dept. Colloquium, University of Missouri, April 27, 1994.
28. "The Role of Neutral Oxygen in High Temperature Superconductors", **Howard Blackstead**, Chemistry Dept. Colloquium, San Jose State University, May 27, 1994.
29. "Quantum" Confined Metallic Oxygen, the Key High Temperature Superconductivity", **Howard Blackstead**, Solid State Seminar, Purdue University, June 15, 1994.
30. "Charge-Distributions in $Y_{1-x}Pr_xBa_2Cu_3O_x$ ", **H. A. Blackstead**, J. D. Dow, J. F. Federici, W. E. Packard, and D. B. Pulling, 4th INTERNATIONAL CONFERENCE, Materials & Mechanisms of Superconductivity, High Temperature Superconductors, Grenoble France, July 6, 1994.
31. "Depression of T_c Caused by Nd^{+3} Pair-Breaking in $NdBa_2Cu_3O_x$ ", **H. A. Blackstead**, J. D. Dow, W. E. Packard, and D. B. Pulling, 4th INTERNATIONAL CONFERENCE, Materials & Mechanisms of Superconductivity, High Temperature Superconductors Grenoble, France, July 6, 1994.
32. "Evidence of Superconductivity in $PrBa_2Cu_3O_7$ ", **H. A. Blackstead**, D. B. Chrisey, J. D. Dow, J. S. Horwitz, A. E. Klunzinger, and D. B. Pulling, 4th INTERNATIONAL CONFERENCE, Materials & Mechanisms of Superconductivity, High Temperature Superconductors Grenoble, France, July 6, 1994.
33. "Oxide Superconductivity", **H. A. Blackstead** and J. D. Dow, Electrochemical Society Meeting, San Francisco, May 22, 1994.
34. "Superlattice Model of Superconductivity", **H. A. Blackstead** and J. D. Dow, Electrochemical Society Meeting, San Francisco, May 22, 1994.
35. "Oxide Superconductivity", **H. A. Blackstead** and J. D. Dow, Bull. Am. Phys. Soc. **39**, 876, 1994.
36. "Field and Temperature Dependent Surface Resistance of Superconducting Polycrystalline Hg-Ba-Ca-Cu-O", D. B. Pulling, **H. A. Blackstead**, M. Paranthaman, and J. Brynstad, Bull. Am. Phys. Soc. **39**, 787, 1994.
37. "Phase-Slip and Renormalized Flux-Flow Resistivities in Y-Ba-Cu-O and -Ca-Cu-O Superconductors", **H. A. Blackstead**.
38. "Effect of Metallic Additives on the Microstructure of Melt Textured $YBa_2Cu_3O_7$ ", V. Pavate and **E. P. Kvam**, Electron Microscopy 1994, Vol. 2, ed. B. Jouffrey and C. Coliex, les editions des physique, Paris, 941-942, 1994.

39. "Identification of Nanoscale Precipitates in Solid Liquid Melt Grown $\text{YBa}_2\text{Cu}_3\text{O}_7$ ", V. Pavate, **E. P. Kvam**, C. Varanasi, and **P. J. McGinn**, Electron Microscopy, Vol. 2, ed. B. Jouffrey and C. Coliex, les editions des physique, Paris, 939-940, 1994.
40. "Fine 211 Precipitates in SLMG $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ ", C. Varanasi, **P. McGinn**, V. Pavate, and **E. Kvam**, MISCON Group Meeting, Indiana University, January 1994.
41. "Interactions Between 90Ag/10Pd and Y-Ba-Cu-O During Reduced pO_2 Melt Processing", **P. J. McGinn** and M. A. Black, Indiana University, MISCON Group Meeting, January 1994.
42. "Processing of Melt Textured $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$ With Fine 211 Precipitates", C. Varanasi and **P. McGinn**, TMS Annual Meeting, San Francisco, CA, February 1994.
43. "Interactions Between 90Ag/10Pd and Y-Ba-Cu-O During Reduced pO_2 Melt Processing", **P. J. McGinn** and M. A. Black, TMS Annual Meeting, San Francisco, CA, February 1994.
44. "Processing of Melt Textured $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$ With Fine 211 Precipitates", **P. McGinn**, MISCON Group Meeting, Purdue University, August 1994.
45. "Low pO_2 Melt Processing of $\text{NdBa}_2\text{Cu}_3\text{O}_{6+x}$ ", C. Varanasi, M. Black, and **P. McGinn**, MISCON Group Meeting, Purdue University, August 1994.
46. "Effects of Y_2BaCuO_5 Additions to $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Processed by Solid Liquid Melt Growth", C. Varanasi and **P. McGinn**, 1994 Fall MRS Meeting, Boston, MA, November 1994.
47. "Far-Infrared Superconducting Devices Collaboration", **S. T. Ruggiero**, NIST, Boulder, CO, August 5, 1994.
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1. "Magnetic and Heat Capacity Measurements on Zn- and Ga-doped $\text{PrBa}_2\text{Cu}_3\text{O}_{7-\delta}$ ", S. K. Malik, H. Jhans, S. K. Dhar, **W. B. Yelon**, J. J. Rhyne, Ram Praaad, and N. C. Sonl, accepted by Physica B.
2. "Flux Creep in Twinned, Untwinned and Neutron Irradiated $\text{YBa}_2\text{Cu}_3\text{O}_7$ Single Crystals", **J. W. Farmer**, D. L. Cowan, X. Ding, and D. Bradford, Physica, C, in press.
3. "Magnetic, Thermal, Transport and Structural Properties of Sr_2RuO_4 : Enhanced Charge-Carrier Mass in a Nearly-metallic Oxide", J. J. Neumeier, M. F. Hundley, M. G. Smith, J. D. Thompson, C. Allgeier, H. Xie, **W. Yelon**, and J. S. Kim, Phys. Rev. B, in press.
4. "Field and Temperature Dependent Surface Resistance of Superconducting Polycrystalline Two-Phase Hg-Ba-Ca-Cu-O ", **H. A. Blackstead**, D. B. Pulling, M. Paranthaman, and J. Brynstad, accepted by Phys. Rev. B.
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6. "Depression of T_c Caused by Nd^{+3} Pair-Breaking in $\text{NdBa}_2\text{Cu}_3\text{O}_x$ ", **H. A. Blackstead**, J. D. Dow, W. E. Packard, and D. B. Pulling, accepted by Physica C.
7. "Evidence of Superconductivity in $\text{PrBa}_2\text{Cu}_3\text{O}_7$ ", **H. A. Blackstead**, D. B. Chrissey, J. D. Dow, J. S. Horwitz, A. E. Klunzinger, and D. B. Pulling, accepted by Physica C.
8. "High Temperature Superconductivity", **H. A. Blackstead**, and J. D. Dow, accepted by Journal of the Electrochemical Society.
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15. "2D-3D Vortex Line Transition in Two-Layer Josephson Junction Arrays", Wenbin Yu and **D. Stroud**, Phys. Rev. B, in press.
16. "Effect of Phase Fluctuations on the Low-Temperature Penetration Depth of High- T_c Superconductors", Eric Roddick and **David Stroud**, Phys. Rev. Lett., in press.
17. "Theory of Finite Size Effects and Vortex Penetration in Small Josephson Junctions", Mikhail V. Fistul and **Gabriele F. Giuliani**, accepted by Phys. Rev. B
18. "Dimensional Crossover Field as a Function of Oxygen Stoichiometry in $YBa_2Cu_3O_{7-\delta}$ Thin Films", J. Deak, Lifang Hou, P. Metcalf, and **M. McElfresh**, accepted by Phys. Rev. B Rapid.
19. "Evidence for a Vortex-Solid Phase Transition in $Tl_2Ba_2CaCu_2O_7$ Thin Films", J. Deak, **M. McElfresh**, D. W. Face, and W. L. Holstein, accepted by Physica C.

(Submitted for Publication)

1. "Chemical Vapor Deposition of Cu , Cu_2O and Cu_3N from Bis-(1,1,1,5,5,5-hexafluoropentane-2,4-dionato)Copper(II). The Mechanistic Role of H_2O and the Ligand", Jiri Pinkas, John C. Huffman, **David V. Baxter**, **Malcolm H. Chisholm**, and **Kenneth G. Caulton**, submitted to Chem. Mat.
2. "Synthesis, Structural Characterization, Thermolysis and Volatility Study of Tricarbomethoxymethanate Complexes of Copper (II) and Barium(II)", **David V. Baxter**, **Kenneth G. Caulton**, Wen-Chung Chiang, **Malcolm H. Chisholm**, Vincent F. DiStasi, Sylvain G. Dutremez, James D. Martin, and William E. Streib, submitted.
3. "Synthesis and Structural Characterization of $\text{Cu}[\text{CH}_3\text{C}(\text{O})\text{CHC}(\text{NCH}_2\text{CH}_2\text{OCH}_3)\text{CH}_3]_2$, a Volatile β -Ketoiminate Complex Suitable for Copper Metal MOCVD", **David V. Baxter**, **Kenneth G. Caulton**, Wen-Chung Chiang, **Malcolm H. Chisholm**, Vincent F. DiStasi, Sylvain G. Dutremez, and Kirsten Folling, submitted.
4. "Participation-Ratio Entropy and Critical Fluctuations in the Thermodynamics of Pancake Vortices", Jun Hu and **A. H. MacDonald**, submitted.
5. "Universal Phase Diagram for Vortex States of Anisotropic Superconductors in Strong Magnetic Fields", Jun Hu and **A. H. MacDonald**, submitted to Phys. Rev. B.
6. "Current-Voltage Characteristics of Two-Dimensional Vortex Glass Models", R. A. Hyman, M. Wallin, M. P. A. Fisher, **S. M. Girvin** and A. P. Young, submitted.
7. "Defect Cascades Produced by Neutron Irradiation in $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ ", M. C. Fischherz, M. A. Kirk, **J. Farmer**, L. R. Greenwood, and H. W. Weber, submitted to Physica C.
8. "Catastrophic Quenching of Superconductivity in Melt-Textured $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ with Second Phase Additions", **H. A. Blackstead**, D. B. Pulling, and **P. J. McGinn**, submitted to Applied Physics Letters.
9. "Evidence for Superconductivity in the Bi_2O_3 Layers and not in the CuO_2 Planes of $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_8$ ", **H. A. Blackstead** and J. D. Dow, submitted to Phys. Rev. B.
10. "Role of Ba-site Pr in Quenching Superconductivity of $\text{Y}_{1-y}\text{Pr}_y\text{Ba}_2\text{Cu}_3\text{O}_x$ and related Materials", **H. A. Blackstead** and J. D. Dow, submitted to Phys. Rev. B.
11. "Implications of Abrikosov-Gor'kov Exchange Scattering For Theories of High Temperature Superconductivity", **H. A. Blackstead** and J. D. Dow, submitted to Physics Lett.
12. "Spin Glass Prepared States and the Resistive Transitions of High-Temperature Superconductors", **H. A. Blackstead** and J. C. Phillips, submitted.

13. "Flux-Flow and Phase-Slip Resistivity in Two Phase Polycrystalline $\text{Bi}_{1.6}\text{Pb}_{0.4}\text{Sr}_{1.7}\text{Ca}_2\text{Cu}_3\text{O}_x$ ", **H. A. Blackstead**, D. B. Pulling, and **H. Sato**, submitted.
14. "Superconductivity in $\text{YBa}_2\text{Cu}_3\text{O}_x$ ", **H. A. Blackstead** and John D. Dow, submitted.
15. "Magnetization of Oxygen Deficient Y-Ba-Cu-O Domain Prepared by the Melt Texture Process", C. J. Kim and **P. J. McGinn**, submitted to Journal of Materials Science Letters.
16. "Transport Properties of YBCO Films on Ultra-Thin Ag Layers", C. Zhong, **S. T. Ruggiero**, R. Fletcher, and E. Moser, Proceedings of the 1994 Applied Superconductivity Conference, submitted.
17. "Effects of Oxygen Partial Pressure on the Crystallization of Amorphous Bi-Sr-Ca-Cu-O and Bi-Sr-Ca-Cu-O + Ag", M. J. Kramer, L. Margulies, S. R. Arrasmith, K. W. Dennis, J. C. Lang, **P. K. Gallagher**, and R. W. McCallum, submitted.
18. "An Atomic Beam Study of a Superconductor's Magnetic Vortex Lattice", Samuel Dapore-Schwartz, Nathan G. Woodard, and **Gregory P. Lafyatis**, submitted to Phys. Rev. Lett.
19. "Magnetic Penetration Depth in Ni and Zn-doped $\text{YBa}_2(\text{Cu}_{1-x}\text{M}_x)_3\text{O}_7$ Films", Eric R. Ulm, Jin-Tae Kim and **Thomas R. Lemberger**, submitted.
20. "Magnetic Penetration Depth in Doped $\text{YBa}_2(\text{Cu}_{1-x}\text{M}_x)_3\text{O}_7$ Films", Eric R. Ulm, Jin-Tae Kim and **Thomas R. Lemberger**, submitted.
21. "The Stability of $\text{Bi}_2\text{Sr}_2\text{Ca}_1\text{Cu}_2\text{O}_{\pm 8}$ Thick Films at Elevated Oxygen Pressures and Temperatures", D. H. Chmielewski and **K. H. Sandhage**, submitted to J. Am. Ceram. Soc.
22. "Magneto-transport Behavior of Polycrystalline $\text{YBa}_2\text{Cu}_3\text{O}_7$: A Possible Role for Surface Barriers", Shi Li, M. Fistul, J. Deak, P. Metcalf, **G. Giuliani**, and **M. McElfresh**, submitted.
23. "Reclassification of Early Transition Metal Oxides: Absence of True Mott-Hubbard Materials", J.-H. Park, L. H. Tjeng, J. W. Allen, R. Claessen, C. T. Chen, P. Metcalf, and H. R. Harrison, submitted. (**Honig Group**)
24. "Melting Curve of Condensed ^3He as a Mott-Hubbard Localization Boundary for He Atoms: Elementary Analysis and Comparison with Experiment", **J. Spalek**, submitted.
25. "Electronic Structure and Pairing of Strongly Correlated Fermions: Fermi Liquid Versus Spin Liquid", K. Byczuk, J. Karbowski, **J. Spalek**, and W. Wójcik, submitted.
26. "Universality Classes, Statistical Exclusion Principle and Properties of Interacting Fermions", Krzysztof Byczuk and **Jozef Spalek**, submitted to Phys. Rev. B.

27. "Broad Superconducting Transitions in $\text{Bi}_2\text{Sr}_2\text{Ca}_1\text{Cu}_2\text{O}_{8.8}$ Obtained from Amorphous Precursors", M. Sankararaman, N. Ohnishi, Z. P. Zhang, **H. Sato**, **H. A. Blackstead** and D. B. Pulling, submitted.
28. "Texture Development in $\text{YBa}_2\text{Cu}_3\text{O}_{7.5}$ Films Synthesized from Metallo-organic Precursors", C. Venkatraman, submitted. (**Liedl, Bement Group**)
29. "Synthesis of $\text{YBa}_2\text{Cu}_3\text{O}_{7.5}$ Films from Metallo-Organic Precursors", C. Venkatraman and **G. L. Liedl**, submitted to J. Am. Ceram. Soc.
30. "Mechanism of Development and Control of Orientation Texture in $\text{YBa}_2\text{Cu}_3\text{O}_{7.5}$ Films Fabricated From Metallo-Organic Precursors", C. Venkatraman and **G. L. Liedl**, in preparation.
31. "Single Electron Tunneling in $\text{TlBa}_2(\text{Ca}_{0.8}\text{Y}_{0.2})\text{Cu}_2\text{O}_7$ Thin Films at 10K", T. G. Miller, **R. Reifenberger**, **M. McElfresh**, D. W. Face, and W. L. Holstein, submitted.
32. "Critical Scaling of the Transport Behavior and the Magnetic Phase Diagram of Polycrystalline $\text{YBa}_2\text{Cu}_3\text{O}_7$ ", Shi Li, M. Fistul, J. Deak, P. Metcalf, and **M. McElfresh**, submitted.
33. "Temperature Range for Critical Scaling Behavior in YBCO Thin Films", J. Deak, M. J. Darwin, and **M. McElfresh**, submitted.
34. "Evidence for Two Continuous Vortex Phase Transitions in $\text{Tl}_2\text{Ba}_2\text{CaCu}_2\text{O}_7$ Thin Films", J. Deak, **M. McElfresh**, D. W. Face, and W. L. Holstein, submitted to Phys. Rev. B Rapid Comm.
35. "Local Time-Dependent Magnetization of Superconducting Films in the Presence of a Transport Current", **M. McElfresh**, E. Zeldov, John R. Clem, M. Darwin, J. Deak, and L. Hou. submitted.
36. "Spin Correlation for an Anderson Impurity in Conventional and Unconventional Superconductors", Heesang Kim and **Paul Muzikar**, submitted.
37. "Magnetic Shielding Within a Centrifugally Slip Cast Ag-clad BSCCO Tube", G. A. Steinlage, **K. P. Trumble**, and **K. J. Bowman**, submitted to J. of Eur. Cer. Soc.

MISCON THESES - 1994

MASTERS THESES

"DC Magnetization Measurements of Random $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ /Ag Bulk Composites",
Cynthia Lynn Ash, Ohio State University, 1994. **(Garland Group)**

"The Effect of High Oxygen Pressure on the $\text{Bi}_2\text{Sr}_2\text{Ca}_1\text{Cu}_2\text{O}_{8+\delta}$ Superconductor",
David Harry Chmielewski Jr., M. S. Thesis, Department of Materials Science
and Engineering, The Ohio State University, June, 1994. **(Sandhage Group)**

"Transmission Electron Microscopy Study of Melt Textured Bulk YBCO With
Metallic Additions", Vikram Pavate, Purdue University. December, 1994.
(Kvam Group)

PH. D. THESES

"Thermal Fluctuations and Vortex Lattice Melting in Anisotropic
Superconductors", Jun Hu, Department of Physics, Indiana University,
August 1994, **(MacDonald Group)**

Kyungsun Moon, Indiana University, **(MacDonald Group)**

"Flux Pinning Studies Via Flux Creep Measurements in $\text{YBaCu}_3\text{O}_{7-\delta}$ Single Crystals"
Xiaoning Ding, University of Missouri-Columbia, November, 1994.
(Yelon, Farmer Group)

"The Critical Current Density in High Critical Temperature Superconductors"
Suvankar Sengupta, University of Notre Dame, December 1994,
(McGinn Group)

"A Study of the Effects of Second Phase Additions on the Processing and Properties
of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ " Varanasi Chakripani, University of Notre Dame, August 1994,
(McGinn Group)

“Synthesis and Magnetic Properties of ZrO_2 and MgO-Containing Y-Ba-Cu-O and Bi-Sr-Ca-Cu-O Superconductors Prepared by Self-Propagating Chemical Decomposition”, Siyoung Choi, Ohio State University, **(Gallagher Group)**

“An Atomic Beam Magnetic Resonance Study of a Superconductor’s Magnetic Vortex Lattice”, Samuel Dapore-Schwartz, The Ohio State University, **(Lafyatis Group)**

“Texture Development in YBCO Films Synthesized from Metallo-organic Precursors”, Chandra Venkatraman, Purdue University, **(Liedl/Bement Group)**

“Studies in Layered High Temperature Superconductors with a Low Temperature Scanning Tunneling Microscope”, Thomas Gary Miller, Purdue University, **(McElfresh Group)**

“Local Properties of a Superconductor in the Presence of a Magnetic Impurity”, Heesang Kim, Department of Physics, Purdue University, August 1994, **(Muzikar Group)**

APPENDIX I
RESEARCH PROGRAM LISTING

Area I: New and Improved High T_c Superconducting Materials: Phase Relations, Reactions, Synthesis and Processing

PI	Univ	Title	Funding	Affiliations	Students & Professionals	Status
D. V. Baxter K. G. Caulton M. H. Chisholm	IU	Low Temperature Routes to Processing of High-Temperature Superconductors	105,000	Advanced Technology Materials, Inc.	Wen Chung Chiang Coey Minear Bjorn Borup Jiri Pinkas	Ph.D. anticipated 1995 Ph.D. anticipated 1998 Ph.D. anticipated 1996 Postdoctoral Associate
J. Betanabhatla J. R. Hardy R. R. Berliner	UN-O UN-L UM-Col	Investigation of Structure and Superconducting Properties Relationship in Copper-free Bismuth Oxides	80,441		S. Hariharan J. Ulanday	Postdoctoral Associated Undergrad
P. J. McGinn	ND	Microstructural Dependence of Critical Current Density in Melt Textured YBa ₂ Cu ₃ O _{6-x} Superconductors	130,000		Suvankar Sengupta Varanasi Chakripani Ram Gopalan Hal-feng Yang Hiteshu Balwada V.Chakripani C. Marando Marie Hauck Corey Hamel	Ph.D. awarded 1994 Ph.D. awarded 1994 Ph.D. anticipated 1997 M.S. anticipated 1995 M.S. anticipated 1996 Postdoctoral Associate Undergrad Undergrad Undergrad
P. K. Gallagher	OSU	Growth of Single Crystals and/or Textured Specimens of High-T _c Superconductors using Oxygen Seeding	50,480		Siyoun Choi Thawi Iwagoshi	Ph.D. awarded 1994 Ph.D. anticipated 1995
K.H. Sandhage P.J. McGinn	OSU ND	Processing of Textured Superconducting Oxide/Noble Metal Microlaminates	90,000	Intermagnetics General Corp Ribbon Technology Corporation	S. Vilayannur Marc Black	Ph.D. anticipated 1996 Ph.D. anticipated 1995
K. H. Sandhage	OSU	Anisotropic Grain Growth and Isothermal Grain Alignment of Bulk, Superconducting Oxides	100,390	Superconductive Components, Inc.	Russell Rogenski John Gannon David Chmielewski Holly Miron Seyed M. Allameh	Ph.D. anticipated 1996 Ph.D. anticipated 1997 M.S. awarded 1994 M.S. awarded 1995 Postdoctoral Associate

•New Project

PI	Univ	Title	Funding	Affiliations	Students & Professionals	Status
D. R. Gaskell*	PU	The Influence of Oxygen Pressure and Temperature on Oxygen Stoichiometry and Phase Equilibria in the System Bi-Sr-Ca-Cu-O	78,175		N. Medendorp	M.S. anticipated 1995
J. M. Honig J. Spalek	PU	Effect of Substitutions on Superconducting Properties of High T _c Materials	83,365		S. Perooly X. Yao P. Metclaf P. Wang Y. Ueda F. Chudnovskii	Professional Professional Professional Professional Visitor Visitor
G.L. Liedl A.L. Bement, Jr.	PU	Processing and Texture Development in YBa ₂ Cu ₃ O _{7-δ} Films from Metallo-Organic Precursors	145,236		C. Venkatraman S. Mansour	Ph.D. awarded 1994 Professional
K.P. Trumble M.W. McElfresh K.J. Bowman	PU	High Temperature Superconducting Tubes for Magnetic Shielding Applications	142,453	Quantum Magnetism/ Quantum Design	Shi Li Greg Steinlage N. Medendorp Robert Moon	Ph.D. anticipated 1996 M.S.E. anticipated 1995 M.S.E. anticipated 1995 M.S.E. anticipated 1996

Area II: High T_c Superconductor Transport Properties: Controlling/Limiting Factors

A. H. MacDonald S. M. Girvin	IU	Quantum and Statistical Mechanics of High T _c Superconductors and Flux Line Liquids	90,000		Jun Hu Kyungsun Moon Yong Wang Ross Hyman Ryusuke Ikeda	Ph.D. awarded 1994 Ph.D. awarded 1995 Ph.D. anticipated 1996 Ph.D. anticipated 1996 Visiting Scientist
Eric Sorensen	Postdoctoral Associate				Dale Payne	Ph.D. anticipated 1996
Meera Chandrasekhar	UM-Col	Optical Investigations of Pristine and Doped 124 HTSC's	74,885		San Wook Han	Graduate Student
P. F. Miceli*	UM-Col	Polarized Neutron Reflectivity Studies of High Temperature Superconductors	51,706		Xiaoning Ding David Bradford S. K. Malik	Ph.D. awarded 1994 Ph.D. anticipated 1995 Visitor
W. B. Yelon J. W. Farmer	UM-Col	Neutron Diffraction and Defect Studies of High T _c Superconductors	82,696			

*New Project

PI	Univ	Title	Funding	Affiliations	Students & Professionals	Status
H. A. Blackstead	ND	Microwave and Optical Studies of High-Temperature Superconductors: Flux-Lattice Dynamics, Crystal Anisotropy, Flux Pinning and Photo-Modulated Superconductivity	114,000		Ann Klunzinger Pieder Beell D.B. Pulling	Graduate Student Graduate Student Professional Specialist
A. E. Miller S. Bandyopadhyay	ND	Superconducting Quantum Structures	84,043		Duofeng Yue Gautam Banerjee	Ph.D. anticipated 1995 Postdoctoral Associate
S. T. Ruggiero	ND	Transport Properties of YBCO Thin Films	56,351	Hypres, Inc.	Chunling Zhong	Graduate Student
J. C. Garland	OSU	High T _c Superconducting Composites, Arrays and Crystals	125,683		Y.M. Wan John Markus Matt Trawick Sergio Ammirata C. Ash S.E. Hebboul Chris Keener Hu Jong Lee	Ph.D. awarded 1994 Ph.D. anticipated 1995 Ph.D. anticipated 1996 Ph.D. anticipated 1997 M.S. awarded 1994 Professional Postdoctoral Associate Visitor
G. P. Lafyatis	OSU	Atomic Beam Studies of Vortex Lattices at Superconductor Surfaces	76,000		S. Daport-Schwartz Harold Haughlin Tom Barrett	Ph.D. awarded 1994 Ph.D. anticipated 1996 Ph.D. anticipated 1995
T. R. Lemberger	OSU	Device-related Properties of Doped YBa ₂ (Cu _{1-x} M _x) ₃ O _{7-δ} Films	76,736		Eric Ulm Aaron Pesetski	Ph.D. anticipated 1995 Graduate Research Asst.
C. Pennington	OSU	NMR Studies of Vortex Dynamics in High T _c Superconductors	57,248		Charles Recchia Les Wood	Ph.D. anticipated 1996 Undergrad
D. G. Stroud	OSU	Dynamical Properties of Josephson-coupled Systems: Application to High-Temperature Superconductors	63,000		Ing-Jye Hwang Roman Sasik Seungoh Ryu Wenbin Yu Pak-Ming Hui	Graduate Student Graduate Student Postdoctoral Researcher Student Visitor
G. Giuliani	PU	Transport Properties of High-T _c Superconductors	70,000		Mikhail V. Fistul	Postdoctoral Researcher

PJ	Univ	Title	Funding	Affiliations	Students & Professionals	Status
E. P. Kvam	PU	Structural Defects and Interfaces in High T_c Superconducting Compounds	178,000		D.S. Linehan V. Pavate Y. Luo J.T. Dawley L.B. Williams D.L. Perry	M.S. anticipated 1995 M.S. anticipated 1994 M.S. anticipated 1996 B.S. anticipated 1994 B.S. anticipated 1994 Professional
M. W. McElfresh* R. G. Reffenberger	PU	Intrinsic and Induced Weak Link Behavior in $YBa_2Cu_3O_{7-\delta}$ Films	Carry Over Funds		Thomas G. Miller	Ph.D. awarded 1994
M. McElfresh* E. Kvam	PU	Study of Vortex Dynamics and Flux Pinning on Different Length Scales	117,736	IBM Thomas J. Watson Research Center Lake Shore Cryotronics Quantum Magnetics Weizmann Institute of Science	Shi Li James Deak D.S. Linehan G. Fiete Burke Minsley Tasha Osmond Patti Metcalf	Ph.D. anticipated 1996 Ph.D. anticipated 1995 M.S. anticipated 1995 Undergrad Undergrad Undergrad Professional
P. Muzikar	PU	Vortices in Anisotropic Superconductors	53,500		Heesang Kim G. Preosti	Ph.D. awarded 1994 Ph.D. anticipated 1995

*New Project

** Project Phased Out

APPENDIX II

Cooperative Laboratory Interactions January 1994 - December 1994

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
SEMINAR AND GUEST SPEAKERS		
Allan MacDonald Indiana University	Invited Seminar Speaker	Purdue University
Merwyn Brodsky Argonne National Lab	Guest Speaker at Group Meeting	Indiana University
University of Missouri-Col Columbia, MO	Invited Seminar Speaker	Howard Blackstead University of Notre Dame
In-Sang Yang Department of Physics Ewha Womans University	Invited Seminar Speaker	Purdue University
Wright Patterson AFB Wright Patterson, OH	Invited Seminar Speaker	M. McElfresh Purdue University
Li Gao Texas Center for Superconductivity University of Houston	Guest Speaker at Summer School	Purdue University
Ted Ciszek National Renewable Energy Lab	Guest Speaker at Summer School	Purdue University
Ross Muenchausen Los Alamos National Lab	Guest Speaker at Summer School	Purdue University
Amit Goyal Oak Ridge National Lab	Guest Speaker at Summer School	Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Paul Grant Electric Power Research Institute	Guest Speaker at Summer School	Purdue University
M. Paranthaman Oak Ridge National Lab	Guest Speaker at Summer School	Purdue University
Donglu Shi Argonne National Lab	Guest Speaker at Summer School	Purdue University
William L. Carter American Superconductor	Guest Speaker at Summer School	Purdue University
Zack Schlesinger IBM T. J. Watson Research Center	Invited Seminar Speaker	Purdue University
Steve Teitel Department of Physics and Astronomy University of Rochester	Invited Seminar Speaker	Purdue University
Charles Pennington Ohio State University	Invited Seminar Speaker	Indiana University
Dr. Ronald H. Ono NIST	Invited Seminar Speaker	University of Nebraska
PROGRAMMATIC EXCHANGE PROGRAM		
Varanasi Chakrapani McGinn Group University of Notre Dame	Performed TEM Work	E. Kvam Lab Purdue University
D. H. Chmielewski Sandhage Group Ohio State University	X-ray Work	G. Liedl Lab Purdue University
D. H. Chmielewski Sandhage Group Ohio State University	X-ray Work	G. Liedl Lab Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
S. Parthasarathy Choudhary Group University of Notre Dame	X-ray Work	G. Liedl Lab Purdue University
A. Leonid Indiana Univearsity	Collaborative Experiments	E. Kvam Lab Purdue University
David Baxter Indiana University	TEM Experiments	E. Kvam Lab Purdue University
David Rudman NIST Denver, Colorado	Laser ablated YBCO thin films and S/N/S weak-link systems for FIR measurements	S. Ruggiero University of Notre Dame
Jiri Pinkas Indiana University	Measuring of Samples	G. Liedl Lab Purdue University
Jayaram Betanabhatla University of Nebraska - Omaha	Visit Research Reactor	W. Yelon University of Missouri
PARTNERSHIP AUGMENTATION GRANT		
Suvankar Sengupta Superconductive Components, Inc. Columbus, Ohio	Growth of Large NdBa ₂ Cu ₃ O _x Domains for Bearing Applications	P. J. McGinn University of Notre Dame
Quantum Design San Diego, CA	Automated Measurements of Superconducting Properties	M. McElfresh Purdue University
CO-OP EFFORTS/COLLABORATIONS		
DuPont Research Labs	Possible Collaboration	D. Baxter, K. Caulton and M. Chisholm Indiana University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Larry Kesmodel Indiana University	Possible Collaboration	D. Baxter, K. Caulton M. Chisholm Indiana University
A. Peter Young UCSC	Vortex Glass Transition in 2D	S. M. Girvin Indiana University
Matthew P. A. Fisher UCSB	Vortex Glass Transition in 2D	S. M. Girvin Indiana University
Jun Hu National Magnet Lab	Monte Carlo Studies of Random-pinning Ginzburg-Landau Models	A. H. MacDonald S. M. Girvin Indiana University
John Rowell Conductus	Discussions	P. F. Miceli University of Missouri-Col
Laura Greene University of Illinois-Urbana	Collaboration	P. F. Miceli University of Missouri-Col
Dr. Douglas Lowndes Oak Ridge National Lab	Collaboration	P. F. Miceli University of Missouri-Col
M. J. Kramer and W. McCallum Ames Lab Iowa State University	Collaboration	W. B. Yelon J. W. Farmer University of Missouri-Col
W. J. James University of Missouri-Rolla	Collaboration	W. B. Yelon University of Missouri-Col
J. D. Dow Arizona State	Collaboration	H. Blackstead University of Notre Dame
P. McGinn University of Notre Dame	Collaboration	H. Blackstead University of Notre Dame
A. Miller University of Notre Dame	Collaboration	H. Blackstead University of Notre Dame

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
J. Farmer and W. Yelon University of Missouri-Columbia	Collaboration	H. Blackstead University of Notre Dame
D. Chrisey, R. Treece and J. Horwitz Naval Research Lab	Collaboration	H. Blackstead University of Notre Dame
Tim Peterson Wright Lab	Collaboration	H. Blackstead University of Notre Dame
Dr. Donglu Shi Argonne National Lab	Joint Project	P. J. McGinn University of Notre Dame
Dr. Suvankar Sengupta Superconductive Components, Inc.	Joint Project	P. J. McGinn University of Notre Dame
Dr. Meera Chandrasekhar University of Missouri-Columbia Columbia, MO	Collaboration	A. E. Miller S. Bandyopadhyay University of Notre Dame
H. A. Blackstead, P. J. McGinn and E. Wolf University of Notre Dame	Collaboration	A. E. Miller S. Bandyopadhyay University of Notre Dame
Dr. R. C. Tucker Praxair	Collaboration	A. E. Miller S. Bandyopadhyay University of Notre Dame
Dr. B. Das West Virginia University	Collaboration	A. E. Miller S. Bandyopadhyay University of Notre Dame
Tim Peterson and Eric Moser Wright Patterson AFB	AFM Measurements of YBCO-on-AG Systems	S. T. Ruggiero University of Notre Dame
Greg Firpo, Albert Cardona, and Erik Smith Superconductor Technologies, Inc. Santa Barbara, CA	YBCO Preparation Techniques	S. Ruggiero University of Notre Dame

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Dr. Balu Balachandran Argonne National Laboratory	Joint Project	K. Sandhage Ohio State University
Brian Maple University of California San Diego, CA	Collaboration	D. Stroud Ohio State University
A. MacDonald Indiana University	Collaboration	D. Stroud Ohio State University
Z. Tesanovic Johns Hopkins University	Collaboration	D. Stroud Ohio State University
M. McElfresh Group Purdue University	Theoretical Discussions of the Magneto-transport Properties of Polycrystalline Materials	G. Giuliani Purdue University
C. Broholm Johns Hopkins University	Collaborative Research	J. Honig Purdue University
T. Rosenbaum University of Chicago	Collaborative Research	J. Honig Purdue University
J. Brill University of Kentucky	Collaborative Research	J. Honig Purdue University
P. Eklund University of Kentucky	Collaborative Research	J. Honig Purdue University
J. Aeppli AT&T Bell Laboratories	Collaborative Research	J. Honig Purdue University
J. Acrivios San Jose State University	Collaborative Research	J. Honig Purdue University
C. Stassis Iowa State University	Collaborative Research	J. Honig Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
J. W. Farmer University of Missouri-Columbia	Collaborative Research	J. Honig Purdue University
W. Yelon University of Missouri-Columbia	Collaborative Research	J. Honig Purdue University
P. McGinn University of Notre Dame	Bulk Material Studies	E. Kvam Purdue University
R. Poeppel Argonne National Lab	Bulk Material Studies	E. Kvam Purdue University
C. Carter NIST	Collaboration	E. Kvam Purdue University
U. Balachandran Argonne National Lab	Collaboration	E. Kvam Purdue University
S-Y Liou University of Nebraska	Collaboration on joint project	E. Kvam Purdue University
Dean Peterson Los Alamos National Lab Los Alamos, NM	Collaborations	K. Trumble, K. Bowman, and M. McElfresh Purdue University
Jon Martens Conductus	Collaborations	K. Trumble, K. Bowman, & M. McElfresh Purdue University
Alan Kleinsasser IBM T.J. Watson Research Center Yorktown Heights, NY	Collaborations	M. McElfresh Purdue University
John Neumeier Los Alamos National Lab Los Alamos, NM	Collaborations	M. McElfresh Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Ross Muenchausen Los Alamos National Lab Los Alamos, NM	Collaborations	M. McElfresh Purdue University
S. Teitel University of Rochester	Collaboration Discussion	P. Muzikar Purdue University
Mike McHenry Carnegie-Mellon University Pittsburgh, PA	Collaborations	K. Trumble, K. Bowman, & M. McElfresh Purdue University
SAMPLE EXCHANGE/COLLABORATIONS		
P. Boolchand University of Cincinnati	Sample Exchange	M. Chandrasekhar University of Missouri-Col
B. Dabrowski Argonne National Lab	Sample Exchange	M. Chandrasekhar University of Missouri-Col
J. Schilling Washington University	Experiment on Pressure Dependencies of Raman modes in Tl 2201	M. Chandrasekhar University of Missouri-Col
S. Bandyopadhyay University of Notre Dame	CdS Samples	M. Chandrasekhar University of Missouri-Col
M. Paranthaman Oak Ridge National Labs	Tl 2201 Samples	M. Chandrasekhar University of Missouri-Col
T. Lemberger Oklahoma State University	Y123 Thin Films	W. B. Yelon J. W. Farmer University of Missouri-Col
H. Blackstead University of Notre Dame	Thin Films for Irradiation	W. B. Yelon J. W. Farmer University of Missouri-Col

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
C. Chenkang and B. Wanklyn Clarendon Laboratory University of Oxford, UK	$\text{Pr}_x\text{Y}_{1-x}\text{Ba}_2\text{Cu}_3\text{O}_{7-s}$ Single Crystals	J. Betanabhatla University of Nebraska-Omaha
S. Mansour Purdue University	TEM studies of samples	J. Betanabhatla University of Nebraska-Omaha
E. F. Skelton Naval Research Laboratory	High Pressure Measurements	J. Betanabhatla University of Nebraska-Omaha
Prof. Robert Snyder Alfred University	Sample Exchange/Joint Project	P. J. McGinn University of Notre Dame
Dr. John Hull Argonne National Laboratory	Sample Measurements	P. J. McGinn University of Notre Dame
Dr. Jeffrey A. Eastman Argonne National Laboratory	Characterizing Structures using SEM, TEM	A. E. Miller & S. Bandyopadhyay University of Notre Dame
Dr. Richard Ricker NIST Gaithersburg, Maryland	Anodization and Fabrication of Templates	A. E. Miller & S. Bandyopadhyay University of Notre Dame
NIMET Industries, Inc. J. Abboit I. Abbott	Technology Transfer and Adaptation of the Anodization Process	A. E. Miller & S. Bandyopadhyay University of Notre Dame
Elle Track Hypress, Inc.	YBCO Thin Films	S. Ruggiero University of Notre Dame
David Rudman NIST Boulder, CO	Laser Ablated YBCO Thin Films and S/N/S Weak-Link Systems	S. Ruggiero University of Notre Dame
Howard A. Blackstead University of Notre Dame	$\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8-y}$ Samples	J. C. Garland Ohio State University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Charles Pennington Ohio State University	$\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8-y}$ Samples	J. C. Garland Ohio State University
Thomas R. Lemberger Ohio State University	$\text{Ag}/\text{YBa}_2\text{Cu}_3\text{O}_7$ Arrays	J. C. Garland Ohio State University
Dale Van Harlingen University of Illinois Urbana-Champaign	$\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8-y}$ Samples	J. C. Garland Ohio State University
Charles Pennington Ohio State University	Single Crystals of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$	G. Lafyatis Ohio State University
Tom Lemberger Ohio State University	Measurement of Penetration Depth of Sputtered Niobium Film	G. Lafyatis Ohio State University
Mike McElfresh Purdue University	Laser Ablated Films of YBCO Drawings for Substrate Heater	T. R. Lemberger Ohio State University
Brian Maple University of California-San Diego San Diego, CA	Powder and Single Crystal Samples of ^{17}O -enriched $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$	C. Pennington Ohio State University
James Garland Ohio State University	Single Crystals of BSSCO (2212)	C. Pennington Ohio State University
Alan Hermann University of Colorado	Single Crystals of TlBaCuO (2202)	C. Pennington Ohio State University
Gordon Thomas AT&T Bell Labs	Single Crystals of BSSCO (2212)	C. Pennington Ohio State University
E. Isaacs AT&T Bell Labs	Crystals	J. Honig Purdue University
M. McElfresh Purdue University	SrTiO_3 and LaAlO_3 Crystals	E. Kvam Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
John Clem Ames Lab Iowa State University	Studies of Current Distribution in Superconductors	M. W. McElfresh E. Kvam Purdue University
Dean Face DuPont Central Research Wilmington, DC	Thin Films of TI-based HTS Materials	M. McElfresh E. Kvam Purdue University
Debra Kaiser NIST Gaithersburg, MD	Detwinned Single Crystal of YBCO	M. W. McElfresh E. Kvam Purdue University
Paul Muzikar Purdue University	Phase Phenomena in HTS Materials	M. W. McElfresh E. Kvam Purdue University
Gabriele Giuliani and Mikhail Fistul Purdue University	Josephson Junction Behavior	M. W. McElfresh E. Kvam Purdue University
INDUSTRIAL CONTACTS		
ElectroScan Company Garfield, NJ	Use of ESEM	P. Gallagher Ohio State University
National Nanofabrication Facility Cornell University Ithaca, NY	Sample Fabrication	J. C. Garland Ohio State University
Mike Tomsic Plastronic, Inc. Troy, OH	Industrial Affiliate Discussions	K. Sandhage Ohio State University
Dr. C. E. Oberly Wright Patterson Air Force Base	Informal Collaboration with goal of Formal Affiliate Agreement	E. Kvam Purdue University
Keithley Instruments Cleveland, OH	Equipment Gift - 181 Nanovoltmeter and 197 Multimeter	M. W. McElfresh Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Quantum Design San Diego, CA	Equipment Gift - Sample Rotator and Rotator Probe for QD-MPMS	M. W. McElfresh Purdue University
INDUSTRIAL AFFILIATES		
Advanced Technology Materials, Inc. John Steinbeck Danbury, CT	Written Agreement	K. G. Caulton Indiana University
AT&T Bell Labs Dr. David J. Bishop Murray Hill, NJ	Written Agreement	MISCON Researchers
Hypres, Inc. Elle K. Track Elmsford, NY	Written Agreement	S. Ruggiero University of Notre Dame
IBM Thomas J. Watson Research Center Dr. Stuart Bermon Yorktown Heights, NY	Written Agreement	M. W. McElfresh Purdue University
Intermagetics General Corporation Dr. Pradeep Haldar Guilderland, NY	Equipment Access	K. Sandhage, P. McGinn Ohio State University University of Notre Dame
Kelthley Instruments Cleveland, OH	Written Agreement	M. W. McElfresh, A. L. Bement, Jr. Purdue University
Lake Shore Cryotronics, Inc. B. C. Dodrill Westerville, OH	Written Agreement	MISCON Researchers
NIST Boulder, CO	Written Agreement	MISCON Researchers
Quantum Magnetics Dr. Ronald E. Sager and Dr. Barry Lindgren San Diego, CA	Written Agreement	M. W. McElfresh Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
Ribbon Technology Corporation Dr. Tom Gaspar Gahanna, OH	Equipment Access	K. Sandhage, P. McGinn Ohio State University University of Notre Dame
Superconductive Components, Inc. Columbus, Ohio	Written Agreement	K. Sandhage, P. Gallagher Ohio State University
TRW Superconductivity Research Stephen M. Schwarzbek Redondo Beach, CA	Written Agreement	MISCON Researchers
Dr. Ella Zeldov The Weizmann Institute of Science Rehovot, Israel	Written Agreement	M. W. McElfresh Purdue University
FOREIGN INTERACTIONS		
Mats Wallin Royal Institute of Technology Stockholm, Sweden	Collaboration on Statistical Mechanics of Vortices in High T _c Materials	S. M. Girvin Indiana University
S. K. Malik Tata Inst. for Fundamental Research Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col
P. Awana Tata Inst. for Fundamental Research Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col
A. Tulapurkar Tata Inst. for Fundamental Research Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col
R. Prasad Bhabha Atomic Research Center Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
K. Adhikary Bhabha Atomic Research Center Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col
N. C. Soni Bhabha Atomic Research Center Bombay, India	Collaboration	W. B. Yelon University of Missouri-Col
VIP, Inc India	Anodized Samples	A. E. Miller University of Notre Dame
IIT Bombay, India	Anodized Samples	A. E. Miller University of Notre Dame
Pak-Ming Hui Chinese University of Hong Kong	Periodic Superconducting Array Collaboration	D. Stroud Ohio State University
G. Lander Euratom, Karlsruhe	Crystals	J. Honig Purdue University
L. Dobrzynski Poland	Crystals	J. Honig Purdue University
P. Gopalan University of Bombay	Crystals	J. Honig Purdue University
C. Hagne Zurich, Switzerland	Crystals	J. Honig Purdue University
G. Hearne Tel-Aviv University	Crystals	J. Honig Purdue University
D. Kim Korea	Crystals	J. Honig Purdue University
S. Hayden University of Bristol	Crystals	J. Honig Purdue University

COMPANY/CONTACT	ACTIVITY	MISCON PI/LOCATION
A. Kozlowski and Z. Kakol Akademia Gorniczo-Hutnicza Krakow, Poland	Crystals	J. Honig Purdue University
M. Pieper University of Hamburg Hamburg, Germany	Crystals	J. Honig Purdue University
C. Sood India-Indian Institute of Science Bangalore	Crystals	J. Honig Purdue University
R. Weisendander University of Hamburg Hamburg, Germany	Crystals	J. Honig Purdue University
Dr. Marcin Konczykowski Ecole Polytechnique Palaiseau, France	Joint Projects and Visits	M. W. McElfresh Purdue University
Eli Zeldov The Weizmann Institute of Science Rehovot, Israel	Collaboration	M. W. McElfresh Purdue University
Yosi Yeshurun Bar-Ilan University Ramat-Ganz, Israel	Collaboration	M. W. McElfresh Purdue University
Sergio Zanello CISE Laboratories Milan, Italy	Joint NATO Proposal	M. W. McElfresh Purdue University
Jean-Michel Mariot and Coryn Hague Université Pierre and Marie Curie Paris, France	Study of Fermi Surface of $\text{YBa}_2\text{Cu}_3\text{O}_{7.8}$	M. W. McElfresh Purdue University
Dr. Mao Beijing, China	Hall Effect Measurements	M. W. McElfresh Purdue University

APPENDIX III

ORGANIZATION

January 1, 1994 - December 31, 1994

<u>Name</u>	<u>Location</u>	<u>Telephone Number</u>
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A. SPONSOR

Robert Gottschall Program Manager	Division of Materials Sciences Office of Basic Energy Sciences U.S. Department of Energy	301-353-3428
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B. OFFICE OF THE DIRECTOR

Arden L. Bement, Jr. Director	Purdue University	317-494-5567
Michael McElfresh Assistant Director	Purdue University	317-494-5567
Rebecca Herr Assistant to the Director	Purdue University	317-494-5567
Mary Prill Clerical Support	Purdue University	317-494-5567

C. COMMITTEES

Steering Committee:

Luis M. Proenza Vice President for Research	Purdue University	317-494-2604
Joseph A. Franklin Director Government Policy and Federal Relations	Indiana University	812-855-6394
Ronald J. Turner Special Assistant to the President	University of Missouri-Columbia	314-882-2011
James B. Milliken Vice President for External Affairs	University of Nebraska	402-472-3906

Name	Location	Telephone Number
Nathan O. Hatch Vice President for Advanced Studies	University of Notre Dame	219-239-6291
Richard S. Stoddard Special Assistant to the President for Research	The Ohio State University	614-292-1582
Newton Cattell Ex Officio Member	Midwestern Universities Alliance	202-554-7983
Gerald L. Liedl Ex Officio Member	Purdue University	317-494-5567
Arden L. Bement, Jr. Director Ex Officio Member	Purdue University	317-494-5567
Program Committee:		
Gerald L. Liedl Chair	Purdue University	317-494-5567
Arden L. Bement, Jr. Director	Purdue University	317-494-5567
Michael McElfresh Assistant Director	Purdue University	317-494-5567
Paul McGinn Leader, Group I	University of Notre Dame	219-239-6151
James C. Garland Leader, Group II	The Ohio State University	614-292-7277
David V. Baxter	Indiana University	812-855-8337
Meera Chandrasekhar	University of Missouri - Columbia	314-882-2619
David Sellmyer	University of Nebraska	402-472-2407
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