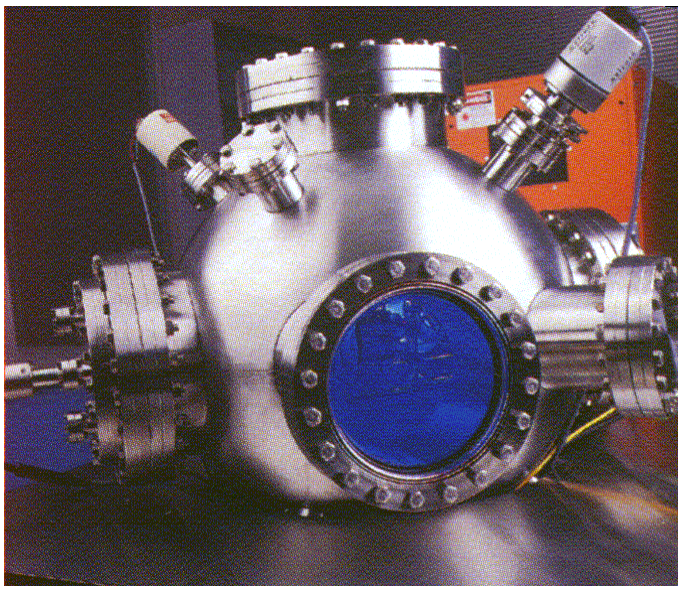
Annual Report

2000



Institute for Superconducting & Electronic Materials

ISEM WOLLONGONG

University of Wollongong

Good Universities Guides Joint Winner

AUSTRALIA'S UNIVERSITY OF THE YEAR 2000-2001 & 1999-2000

Mission Statement

Establish and maintain a world-class co-operative research team in superconducting and electronic materials science and technology and stimulate the technological and commercialisation development of Australian Industry in this field

Professor SX Dou
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Wollongong NSW 2522

Cover Picture: Excimer Laser Ablation System for Thin Film Deposition

Contents

Director's Report

Our institute made significant progress in research and postgraduate training in the year 2000. In particular we continued to raise the standard of fundamental research and innovation of applied research. The Department of Education, Training and Youth Affairs assessment criteria indicates our overall research performance was once again ranked first among University of Wollongong research units. Our institute has held this position for the past five years. Technical progress on all ARC-funded projects will be reported in a separate section. I will highlight some important aspects in our research work.

Quality of Research Standing

Research outcomes on high temperature superconductivity have earned world recognition as evidenced by the large number of scientific citations and the assessment of peer-reviewers. The Fronts 1999 database, of the Institute for Scientific Information's (ISI), a group of science and technology policy researchers managed by Dr. J.S. Katz at the University of Sussex, UK, has identified 500 authors of the most highly co-cited papers in a variety of science and engineering fields. The ISI calls these papers research fronts. One of our papers entitled "Ag-sheathed BiPbSrCaCuO Superconducting Tapes" (published in 1993) has been identified as one of these key papers. This group used a co-citation analysis, which is more immune to the effect of self-citation than conventional citation techniques. A well known Scientist, Dr M. Cardona, a Fellow of the American Academy and Director of the Max-Plank Institute reported on the profile of Australian Scientists to a recent conference. Interestingly, his report shows that the number of citations of the above mentioned paper has been ranked at 14th out of thousands of scientists in Australia. ISEM also has a number of other papers in the list. Scientific citation is commonly used as a main measure of the significance and quality of the work and impact on the relevant field of research.

In the current round of Australian Research Council grants, our Institute was awarded two ARC large grants, two ARC fellowships, two ARC SPIRT grants, one ARC RIEF grant and two International Fellowships, totaling $1.6 million, 17% of all ARC grants obtained by the university. This marks the second most successful year in our history. Dr W. Xu and Dr G.X. Wang have been awarded an ARC Research Fellowship and an ARC Postdoctoral Fellowship respectively. Dr P. Majewski (with Prof HK Liu) from the Max Plank Institute, Germany, and Prof J.H. Ahn (with S.X. Dou) from the National Andong University, Korea, have been awarded ARC International Senior Research Fellowships. Our Institute is currently holding five ARC large grants, five ARC fellowships, nine SPIRT grants, two RIEF grants and three international fellowships, representing more than 70% of our total income from external sources. More than 50 peer reviewers who are experts in the relevant fields have assessed these national competitive grants. This is a good indication of the quality of our research work and researchers.

Response to Emerging Materials

The discovery of superconductivity at 39K in magnesium diboride by Prof Akimitsu has triggered an avalanche of studies of its structural, magnetic and transport properties, similar to the discovery of HTS in 1987. We have quickly responded to this exciting event by producing special quality materials and conducting a wide range of characterizations. We have achieved record high critical current and critical current density in Fe-clad MgB_2 wires by the end of February. The wire has a transport critical current density of 20,000A/cm^2 at 30 K and zero field. This is the best transport J_c reported so far in MgB_2 wires. The critical current density measured by magnetization is over 70,000A/cm^2 at 30 K and zero field, indicating that the value of transport J_c would be much higher if the contact problem could be solved. We have also identified iron not only to be compatible with MgB_2 but also ideal magnetic shielding for reducing the effect of the external field and ac loss. These results demonstrate clearly the great potential of the emerging superconductor for various applications.

We have reported the results of field and temperature dependent magnetization measurements on a pellet of uniform, large-grain sintered MgB_2. We showed that at low temperatures the size of the pellet and its critical current density ensure low field flux jumping. The grain boundaries do not impose limitations on overall J_c. We have also determined the pinning potential using the ac susceptibility technique and introduced effective pinning centers into MgB_2. Various forms of the material have been fabricated, including bulk, thick films and wires. The work has attracted industry support. Joint proposals with Hyper Tech Research and Alphatech International have been put forward to both the ARC and DOE in the U.S.A. The research work on the new superconductor has also promoted interaction between the HTS group and the solid-state physics group.

Strategic Industry Alliances

In the energy storage materials area we have some very encouraging developments in studies of new electrode materials for rechargeable batteries. Some Australian mineral companies have shown great interest in these materials and technologies as these developments present new opportunities for them to enhance their international competitiveness and export opportunities in the high technology area. Queensland Nickel Technology Pty Ltd (QNI), a division of the Billiton Group, Sons of Gwalia Ltd and Jindalee Pty Ltd have jointly sponsored two ARC linkage projects on development of the electrode materials for Li-ion batteries using Australian mineral resources. Our Institute has signed an agreement with QNI Technology to provide consultancy on characterization of the electrode materials developed by UoW.

Another important development is the achievement of high energy density maintenance free lead-acid batteries using novel grid structure design. This innovative prototype product has attracted a number of companies. This increasing industry support augurs well for the health, growth and innovation in the energy storage materials area in the years to come. The Solid State Physics group has enhanced its link with Email Ltd.

I would like to acknowledge the managers of our industry partners, Drs M. Apperley and T. Beales from Australian Superconductors, Mr. Q.S. Duen from Suppo Battery Ltd, Dr. X.F. Gao and Mr J.F. Wu from Lexel Ltd, Drs. R. Guo and R. Wang from Jindalee Ltd, Ms K. Howison, Mr. F. Rozan and Mr. S. Bernett from QNI Technology Ltd of Billiton, Mr R. Neale from Alphatech International Ltd., Mr D. Paull from Sons of Gwalia, Mr. M. Tomsic from Hyper Tech Research, Prof J.S. Wang from Taiyi Ltd. and Mr L. Wild from Electric Transit Ltd. for their kind support and time in participating in the preparation of joint proposals for ARC SPIRT and linkage projects.

National and International Links

We have further enhanced strong collaborative links with institutions in Australia and overseas. A number of distinguished researchers have joined us as partner investigators in our research proposals. They are Prof J.H. Ahn from the National Andong University; Prof. J.Y Lee from the Institute of Science & Technology, Korea; Drs E.H. Brandt, U. Habermeier, C. Li, P. Majewski from Max Plank Institute, Germany; Drs E.W Collings and M. Sumption from Ohio State University; Prof Y.B. Cheng and Dr. R. Krishnamurthy from Monash University; Prof. J. Dahn from Dalhousie University, Canada; Dr S. Kennedy from ANSTO; Prof J. Mazierska from James Cook University; Prof V. Pan from the Metal Physics Institute, Kiev; Dr Polyaskii and Prof D. Larbelastier from the University of Wisconsin, USA; Dr Ramer from the UNSW; Prof. H. Weber from the Atomic Institute Vienna; Prof R. Weinstein from the University of Houston; Dr. X.Q. Yang from the Brookhaven National Lab. USA and Prof. D. Shi from the University of Cincinnati. I appreciate their support and contribution to our research work.

Continuing Improvement of Infrastructure, Equipment and Facilities

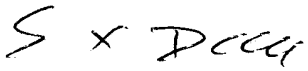
We have increased ISEM's laboratory space by converting postgraduate student offices into four new laboratories. We acquired a magneto-optical imaging system and thermal conductivity measurement system from the physics group at the UNSW. Both are equipped with a cryocooler to allow them to be operational at temperatures from 300K down to 15K. A new ICP Atomic Emission Spectroscope and BET equipment were installed for element analysis and surface area analysis. A successful new ARC RIEF grant will allow the installation of a Magnetic Property Measurement System which will provide high sensitivity and precision for the study of wide range of superconducting properties of superconductors. The wide range of facilities acquired through six continuing ARC RIEF grants over the past six years enables us to conduct high-level research in areas ranging from materials processing to characterization.

Strategies for Future Growth

Although our Institute has been very successful in the past we must recognize that we face continuing challenges regarding funding as 70% of ISEM's income stems from national competitive grant schemes. We must identify and develop new strategies to ensure our long term economic sustainability.

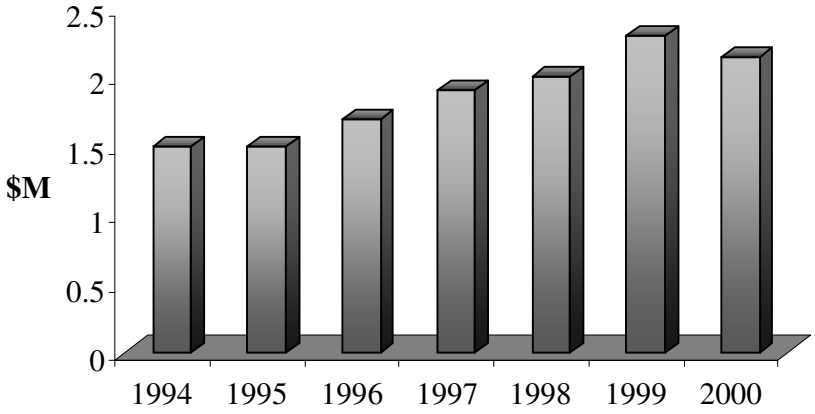
Our future directions will include:

- Pioneering research into emerging technologies and materials such as nano technology and new superconductor and energy storage materials.
- Working with Australian industries to establish strong and long-term alliances with companies to improve their international competitiveness.
- Enhancing existing national and international collaborative networks to continue raising our research standing.
- Giving more emphasis to quality rather than quantity of postgraduate student training. PhD candidate intake will become more selective.

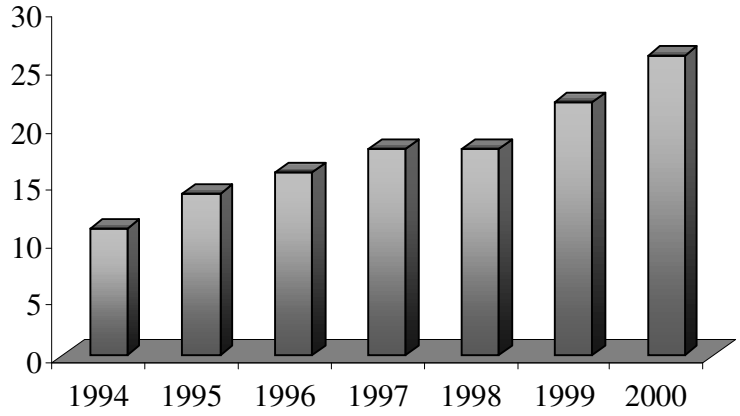


Professor Shi Xue Dou
Director - ISEM

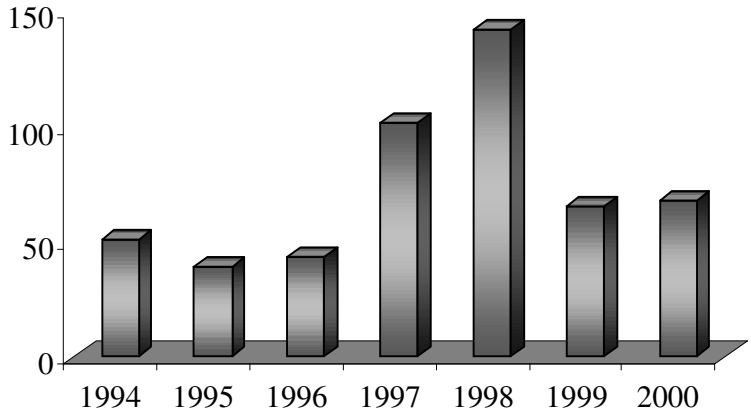
Research Grant Funds



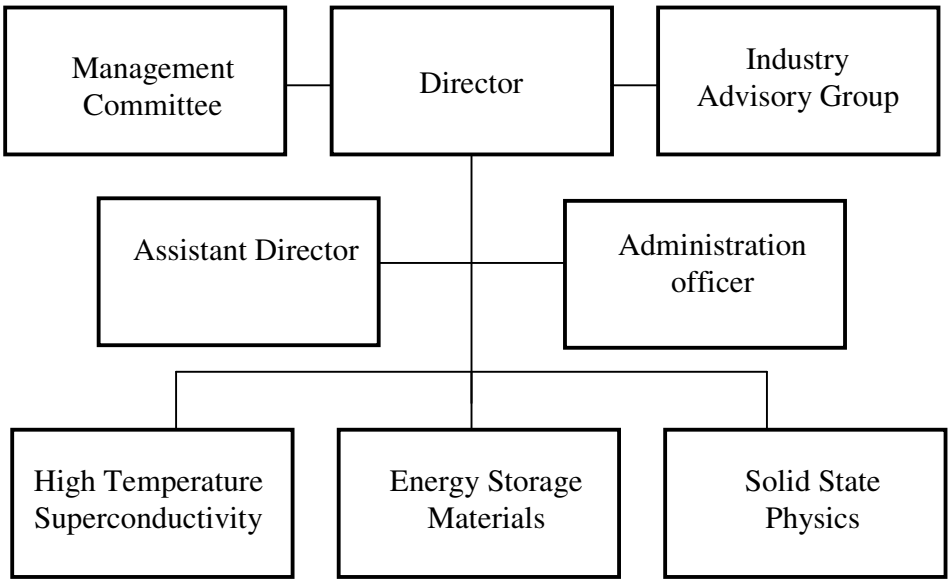
Postgraduate Student Numbers



Refereed Publications (DETYA Categories)



Management



Management Committee

Chairman:	Prof. S.X. Dou	Director, ISEM
	Prof. C. Brink	Pro Vice Chancellor, UoW
	Prof. B. Parker	Dean, Faculty of Engineering, UoW
	Prof. H.K. Liu	Research Co-Ordinator, ISEM
	Prof. P. Fisher	Research Co-Ordinator, ISEM
	Dr. C. Zhang	Research Co-Ordinator, ISEM
	Dr. M. Ionescu	Assistant Director, ISEM

Industry Advisory Group

Dr T. Beales	Manager	Australian Superconductors Ltd, Metal Manufactures Ltd
Mr Bruce Buchtmann	Advanced Systems Engineer	Email Limited
Dr. X.F. Gao	General Manager	Lexel Batteries Co. Ltd, Shenzhen, PR China
Dr. R. Guo	General Manager	Jindalee International Pty Ltd, Brisbane
Ms K. Howison	Process Engineer	Billiton's Nickel Division, QNI Technology Ltd
Mr. R. Neale	Managing Director	Alphatech International Ltd
Mr D. Paull	General Manager of Business	Sons of Gwalia Ltd, Perth
Mr M. Tomsic	Managing Director	Hyper Tech Research Ltd, Ohio, USA,
Prof J.S. Wang	President	Taiyi Battery Co. Ltd., Zhuhai, PR China
Dr R.L. Wang	Manager	Australian Battery Technology Trading Co. Ltd, Hong Kong
Dr X. Wang	Manager	Australian Battery Technology Ltd, Sydney
Mr. L. Wild	Marketing Manager	Electric Transit Pty Ltd, Wetherill Park

Personnel

Director

Prof. S.X. Dou, Dipl, PhD, DSc, FTSE

Assistant Director

Dr M Ionescu, BSc, MSc, PhD

Senior Program Co-Ordinators

Prof. T. Beales, BSc, PhD

MM/UoW Consortium Manager

Prof. P. Fisher, BSc (Hons), PhD, MIOP, FAPS, FAIP, Hon. AINSE Fellow

Prof. H.K.Liu, Dipl. for PGS, ARCSRF.

Dr. C. Zhang, BSc, PhD, MA, MPhil, FAIP

ARC Fellows

Prof. J.H. Ahn, Assoc. Professorial Fellow

Dr. E.H. Brandt, BSc, PhD, ARC International Professorial Fellow

Dr. Y.C. Guo, BSc, MSc, PhD, ARC Postdoctoral Fellow

Prof. H.K. Liu, Dipl. For PGS, Dipl. AQC, ARC Senior Research Fellow

Dr. P. Majewski, ARC International Prof. Fellow

Dr G.X. Wang, BSc, MSc, PhD, ARC Postdoctoral Fellow

Dr. S. Zhong, B.Eng., M.Eng., PhD, ARC Postdoctoral Fellow

Administration Officer

Ms. Babs Allen

Research Staff

Prof. D.H. Bradhurst, PhD,D.I.C., FRACI.

Mr. B. Chao, BSc, MSc

Dr. J. Horvat, BSc, PhD

Dr. K. Konstantinov, MSc, PhD

Dr. M.J. Qin, BSc, MSc, PhD

Dr. T. Silver, BSc, PhD

Dr. X.L. Wang, BSc, MSc, PhD

Dr. R. Zeng, BSc, MSc, PhD

Dr. W. Xu, BSc, MSc, PhD

Affiliated Academic Staff:

Prof. C. Cook, BSc, PhD, FIEAust

Prof. D. Dunne, BSc, PhD, FIEAust

Dr. C. Freeth, MSc, PhD, MAIP

Ass/Prof. R. A. Lewis, BSc (Hons), PhD, FAIP, FRMS

Dr. A.D. Martin, MSc, PhD, MAIP

Dr. A.B. Rosenfeld, MSc(Hon), PhD, Senior Member IEEE, Member Inter. Society BNCT, Member NYAS

Dr. R.E.M. Vickers, MSc, PhD, MAIP

Visiting Staff

Prof. J. Boldeman, BSc, PhD, FTSE

Prof. W.M. Chen,

Ms Yao Chen, Lexel Battery Ltd

Prof. E.W. Collings, Ohio State University

Dr. Y. Pei, BSc, MSC, PhD, Tienjing University

Ms Ling Yuan, Lexel Battery Ltd

Postgraduate Students

Current

High Temperature Superconductivity Group

PhD	Thesis Title	Supervisors
F Darmann	Characterisation of Melt-texture Y-123 Materials	SX Dou, T Beales, C Cook
XK Fu	Superconducting Current Leads using Bi-based high Temperature Superconductors	HK Liu, YC Guo
F. Gao	Preparation and Characterisation of Colossal Magnetoresistance Materials	SX Dou, R A.Lewis
T Green	Transport and Optical Properties in Optically Pumped Electronic Systems	W Xu, SX Dou
A Li	Novel substrates for Bi-Sr-Ca-Cu-O superconducting	M Ionescu, SX Dou
G Li	Numerical Analysis on Electromagnetic Behaviour of High Tc Superconductors in Magnetic Field	HK Liu, MJ Qin
J McKinnon	U-123 Composite Film on Metallic Substrates	M Ionescu, J Horvat
D Marinaro	Flux Pinning Mechanism in Thermal Neutron Irradiated - doped HTS	SX Dou, J Horvat J Boldeman
D Milliken	Enhancement of Flux Pinning through Uranium Doping and Neutron Irradiation in Bi-2223 Tapes	SX Dou, YC Guo
DQ Shi	Investigation of Buffer Layer for Y-123 Coated Conductor Using Laser Ablation	M Ionescu, SX Dou
S Soltanian	Characterisation of CMR Materials & MgB_2	SX Dou, XL Wang
K Uprety	Vortex properties of Bi-HTS	SX Dou, J Horvat
SH Zhou	Density Evaluation During Processing of Bi-2223/Ag Tape	HK Liu, A Pan

Masters		
M Farhoudi	AC Loss of Ag/Bi-2223 Tape in AC Field	J. Horvat, SX Dou
M Ling	Mechanism of Outgrowth in Multifilament Bi-2223 Tape	SX Dou, Y.C. Guo
E Sotirova	Investigation of Colossal Magnetoresistance Materials	HK Liu, XL Wang
J Volf	Alloy Sheathed Bi-2223 HTS Tapes for Current Leads	HK Liu, M Apperley

Energy Storage Materials Research Group

PhD	Thesis Title	Supervisors
Y Chen	Investigation of Cathode Materials for Li-ion Batteries	HK Liu, GX Wang
ZP Guo	Improvement of Energy Density and Cycle Life of Nickel Metal Hydride Batteries	HK Liu, SX Dou
M Lindsay	Anode and Cathode Materials for Lithium Ion Batteries	HK Liu, S Zhong
L Sun	Investigation of Negative Electrode Materials for Ni-MH Batteries	HK Liu, D Bradhurst
C Wang	Investigation of Positive Electrodes for Ni-MH Batteries	HK Liu, S Zhong
GX Wang	Investigation on Electrode Materials for Lithium Ion Batteries	HK Liu, SX Dou
JZ Wang	Bipolar Electrode Materials and Design for Electric Vehicles	HK Liu, D Bradhurst
Masters		
A Howes	Stoichiometric and Non-Stoichiometric AB5 Type Alloys for Nickel-Metal Hydride Rechargeable Batteries	S Zhong, HK Liu

Solid State Physics Group

PhD	Thesis Title	Supervisors
R Baker	Zeeman and Piezospectroscopy of Antimony and Aluminum in Germanium	P Fisher, R Vickers
D Fisher	Dissipation Effect in Resonant Tunnelling through Double Barrier Structures	C Zhang
B Lough	Thermionic Cooling with Semiconductor Multilayers	RA Lewis, C Zhang
Masters		
H Ta	Electronic Properties of Modulated Two Dimensional Semiconductors	C Zhang
S. Lee	Multilayer thermionic cooling in semiconductor heterostructures	R.A. Lewis, C. Zhang

Completions

PhD Name & Thesis Title	Awarded	Position	When Appointed
M Apperley The Fabrication of High Tc Superconductor Wire	1992	Chief Technologist Australian Superconductors	1993
A Bourdillion Microstructure, Phase Characterisation and Texture Processing of HTS	1992	Senior Engineer Hewlett Packard, Singapore Hewlett Packard, USA	1993 2000
Jobe Probakar Chelliah Optical spectroscopy of semiconductors	2000		
J. Chen High Energy Storage Material for Rechargeable Nickel-Metal Hydride Batteries	1999	NEDO Fellow Osaka National Research Institute	1999
N Cui Magnesium Based Hydrogen Storage Alloy Anode Materials for Ni-MH Secondary Batteries	1998	Research Fellow Alberta University, Canada Electrochemist Energizer Co, USA	1997 2000
YC Guo Investigation of Silver-clad $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10-x}$ Superconducting Tapes	1994	Research Fellow ISEM, University of Wollongong STA Fellow Nat. Res. Inst. Of Metals, Japan ARC Postdoctoral Fellow ISEM, University of Wollongong	1994 1997 1998
RJ Heron Far-infrared Studies of Semiconductors in Large Magnetic Fields	1998	Postdoctoral Fellow SUNY, Buffalo, USA	1997
QY Hu Fabrication and Enhancement of Critical Currents of Silver Sheathed $Bi,Pb_2Sr_2Ca_3Cu_3O_{10}$ Tapes	1996	Research Fellow Florida State University, USA Research Scientist Argonne National Lab., USA	1997 1999
M Ionescu Growth and Characterisation of Bi-2212 Crystals and Improvement of Bi-2212/Ag Superconducting Tapes	1998	Assistant Director ISEM, University of Wollongong	1994
JX Jin $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag High T_c superconductors and their Applications in an Electrical Fault Current Limiter and an Electronic High Voltage Generator	1998	Research Fellow ISEM, University of Wollongong ARC, PDF ISEM, University of Wollongong	1997 2000
M Lerch Optical & Electrical Studies of Resonant Tunneling Heterostructure	1998	Research Fellow Medical Physics	1999

PhD Name & Thesis Title	Awarded	Position	When Appointed
BL Luan Investigations on Ti_2Ni Hydrogen Storage Alloy Electrode for Rechargeable Nickel-Metal Hydride Batteries	1997	NRC Fellow National Research Council of Canada	1997
T Silver Near Bandedge Optical Properties Of MBE Gaas And Related Layered Structures	1999	Research Fellow ISEM, University of Wollongong	2000
K Song Processing And Characterisation Of Superconducting Ag/Bipbsrcao Composite	1992	Senior Engineer South Korean Co	1993
S Stewart Theremodynamic And Dielectric Properties In Modulated Two-Dimensional Electronic Systems	1998	ARC Postdoc. Fellow Teacher	1998 1999
L. Sun Amorphous And Nanocrystalline Hydrogen Storage Alloy Materials For Nickel-Metal Hydride Batteries	2000	Research Associate Hydro-Quebec Research Institute, Canada	2000
G Takacs Spectroscopy Of The Effect Of Strains And Magnetic Field On Shallow Acceptor Levels In Germanium	1999	Lab Manager 2nd Year Physics Lab	1999
N. Vo Design And Characterisation Of HTS Coils	1997	Research Fellow Los Alamos Nat. Lab, USA Research Staff Intermagnetics General Co., USA	1999 1998
G.X. Wang Investigation on electrode materials for lithium-ion batteries	2001	ARC Postdoc. Fellow ISEM, University of Wollongong	2001
WG Wang Fabrication And Improvement Of Silver Sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ Tapes By Powder-In-Tube Technique	1998	R&D Manager Nordic Superconductor Tech. Denmark	1997
XL Wang Spiral Growth, Flux Pinning And Peak Effect In Doped And Pure Bi-2212 HTS Single Crystal	2000	Research Fellow ISEM, University of Wollongong	1999
A Warner A Spectroscopic Study of Acceptors in Germanium	1997	Consultant Computer Industry	1999
JA Xia Characterisation of Melt-Texture of YBCO HTS	1994	Research Fellow Solar Cell Ltd	1995
JM Xu Phase Formation and Transformation in the R-Fe-T System (R=Nd, Gd, Tb, Dy, Er, Ho, T and Lu, T=Si, Ti & Zr	1997	Research Fellow University of New South Wales, Australia	1996
J Yau Ag/Bi-2223 Tape Processing and Mechanical Properties	1994	Assistant Professor Chinese Hong Kong University	1995

PhD Name & Thesis Title	Awarded	Position	When Appointed
M Yavus Powder Processing of Bi-Pb-Sr-Ca-Cu-O Superconducting Materials	1997	Ass. Professor Texas A&M University, Texas USA Ass. Research Professor Tohoku University, Sendai, Japan	2000 1997
B Zeimetz High Temperature Superconducting Tapes & Current Leads	1998	Research Fellow Cambridge Univ., U.K.	1999
S Zhong Investigation on Lead-Calcium-Tin-Aluminium Grid Alloys for Valve-Regulated Lead-Acid batteries	1998	ARC Postdoc. Fellow ISEM, University of Wollongong	1997
R Zeng Processing and characterisation of Bi-2223/Ag superconducting tapes	2000	Research Fellow ISEM, University of Wollongong	2000

Masters Name & Thesis Title	Awarded	Position	When Appointed
F Chen The Influence of Selenium on Lead-Calcium-Tin-Aluminium	1998	PhD candidate University of Sydney, Australia	1999
JX Jin $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag High T_c Superconductors and their Applications in an Electrical Fault Current Limiter and an Electronic High Voltage Generator	1994	Research Fellow ISEM, University of Wollongong ARC, PDF ISEM, University of Wollongong	1997 2000
K Uprety Vortex Properties of Bi-HTS	1999	PhD Candidate ISEM, University of Wollongong	2000
JZ Wang Investigations on Anode Materials For Rechargeable Lithium-Ion Batteries	1999	PhD Candidate ISEM, University of Wollongong	2000
G Yang Effect of Element Substitution on Superconductivity	1997	Research Fellow University of Melbourne	2000
N Zahir A New Method for Production and Study of Electrical Properties of Carbon Foam	1996	PhD Candidate Queensland University	1997

National and International Links

The Institute has established a national and international multi-disciplinary collaborative network. This has led to information exchange, co-supervision of PhD students, joint grant proposals and joint publications with more than 40 research teams around the world. The current collaborative organizations are listed below:

Australia

Australian Nuclear Science & Technology Organisation	Dr. S. Kennedy, Dr. J. Boldeman
Australian National University, Canberra	Dr. M. Das
CSIRO Division of Energy	Dr. L. Lam, Dr. D. Rand
Electron Microscope Unit, University of Sydney	Dr. S. Ringer
Monash University	Dr. Y.B. Cheng, Krishnamurthy
University of Melbourne	Prof. D. Jamison
UNSW Schools of Physics, Elec. & Chemical Eng.	Dr. J. Cochrane, Dr. R. Ramer, Prof. M.S. Kazakos
James Cook University	Prof. J. Majierska

International

Atomic Institute of Austrian Universities, Vienna, Austria	Prof. H.W. Weber
Ben-Guirion University of the Negev, Physical Dept, Israel	
Brookhaven National Lab	Dr. X.Q. Yang
Dalhousie University, Canada	Prof. J. Dahn
Harbin Institute of Technology, PRC	Prof. J.S. Wang
Houston University, USA	Prof. R. Weinstein
Institute for Metal Physics, Kiev, Ukraine	Prof. V. Pan
Ludwig Boltzmann Institut für Festkörperphysik, Universit of Vienna, Austria.	Dr. W. Lang
Max-Planck-Institut für Metalloforshung, Germany	Dr. E.H. Brandt, Dr. P. Majewski
Max-Planck-Institut für Solid State Physics, Germany	Prof. U. Habermeier
Nakai University, PRC	Prof. Y.S. Zhang
Nanjing University	Prof. W.M. Chen
Nanyang Technological University	Prof. S. Li
National Andong University	Prof. J.H. Ahn
National Research Institute of Metals, Japan	Dr. R. Togano
New York Polytechnic University, Dept of Physics, New York, USA	
Northeatern University, Shenyang, PRC	Prof. Y.C. Zhai
Ohio State University, Columbus, OH, USA	Dr. E.W. Collings, Dr. M. Sumption
Osaka National Reseach Institute, Japan	Dr. T. Sakai
University of Auckland, Dept of Mater. Eng., School of Mathematical & Information Sciences, NZ	Prof. W. Gao
University of Cincinnati	Prof. D. Shi
University of Wisconsin	Prof. D. Larbalestier, Dr. A. Polyanskii
University of Zagreb, Zagreb, Croatia	Prof. E. Babic, I. Kusevic
Yamagata University, Japan	Dr. S. Kambe

Progress Reports for Projects funded by the Australian Research Council

1. Progress Reports on ARC-large projects

1.1 *Investigation of growth mechanism and flux pinning in spiral grown $Bi_2Sr_2CaCu_2O_y$ and $Bi_2Sr_2Ca_2Cu_3O_y$ monocrystals,* SX Dou

Funded:	1999	2000	2001
Grant No:	A69905260		
Chief Investigator:	SX Dou		
Assoc. Investigator:	E.W. Collings, V. Pan		

The aim of the proposed research is to investigate the newly discovered spiral growth mechanism and the influence of spirals and associated defects on flux pinning characteristics of doped and un-doped $Bi_2Sr_2CaCu_2O_y$ and $Bi_2Sr_2Ca_2Cu_3O_y$ monocrystals. The project proceeded as planned during the second year. Impressive progress has been made through the efforts of all the collaborators.

The peak effect in pure and heavily Pb doped Bi2212 single crystals with different oxygen doping levels was studied by measuring M-H loops. The peak effect in pure Bi2212 crystals was obtained only for crystals with optimum oxygen doping and overdoping, but not for oxygen underdoped crystals. For Pb-doped Bi2212 crystals, a strong peak effect appeared at a higher field than in pure crystals and it persisted up to T_c. The peak effect was characterised by plotting $(H_{max}-H_{min})/H_{max}$ vs T/T_c, where H_{min} represents the background field just before the peak and H_{max} represents the field where the magnetization associated with the peak at a maximum. Results showed that the evolution of the peak effect with temperature in the Pb doped crystals was similar to what is seen in Y123.

Studies of superconductivity and flux pinning were carried out on $(Bi_{1.64}Pb_{0.36})Sr_2Ca_{1-x}Y_xCu_2O_{8+y}$ single crystals grown by the self-flux method. The c lattice parameter systemically decreased as the Y doping level increases. The superconducting transition temperature T_c decreased from 80 to 30 K as x increased. A strong annealing effect on T_c and the superconducting volume has been observed. Resistance measurements show that x = 0.33 samples are semiconductive over a wide temperature range between 4.2 and 300 K for the as-grown state, but become metallic with a T_c of 65-70 K after air or oxygen annealing.

Flux pinning was studied for all the co-doped samples. A peak effect was observed in all the co-doped samples. Results show that at low temperatures, the peak field is smaller than in solely Pb doped crystals and decreases as x increases (x>0.1). However, the peak field at high temperature for the x = 0.05 sample is higher than in heavily Pb doped Bi2212 crystals, indicative of a strong pinning due to the co-doping.

We have studied the flux pinning of $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) single crystals doped with up to 2.2% Fe in the Cu site. The critical current density increased with the doping for doping less than 0.5 at. %. This proves that Fe point defects contribute to the flux pinning. However, high doping levels cause a deterioration in J_c. The effect of Fe doping on the peak effect was also studied. The peak position shifts at high temperatures, but the peak field decreases with increasing doping levels. The spiral growth mechanisms associated with the growth conditions of Bi2212 crystals grown at a KCl surface have been elucidated. As the spiral width is inversely proportional to the supersatuation $\Delta\mu$, a necessary condition for the spirals to form is $\Delta\mu = 0$ around a screw dislocation.

A new model for a "vapour" deposition process with discontinuous growth conditions is put forward. It is proposed that spiral growth in Bi-2212 is similar to that in Y-123 thin films produced by Pulsed Laser Deposition. It is concluded that the formation of screw dislocations and discontinuous growth conditions are responsible for the coexistence between spiral and two-dimensional growth. Seven papers from this project have been published in the second year of this grant.

1.2 *Cryogenic deformation and High T_c phase formation-partial decomposition of superconducting tapes*

Funded:	1999	2000	2001
Grant No:	A89905277		
Chief Investigator:	H.K. Liu		

Effect of High Tc Phase Formation and Decomposition

The effect of oxygen partial pressure on processing conditions and phase transformation in Ag/Bi-2223 tapes was investigated using a two-step annealing process at the final thermal cycle of the powder in-in-tube process. It was found that the temperature window for processing was widened and the volume fraction of the Bi-2223 in the tape increased under low oxygen partial pressure. Using an atmosphere of N_2, the highest Bi-2223 volume fraction appeared at 830°C (first sintering and second sintering) and 785~805°C (final annealing) in a N_2-7.5% O_2 atmosphere.

The samples annealed in N_2-7.5% O_2 retained their J_c values well over a wide annealing temperature range of 785~805°C with only 10% deviation from the highest value. In contrast, for the same level of J_c retention using conventional methods, the temperature window was narrowed down to half this range. This result demonstrated that heat treatments in a N_2-7.5% O_2 atmosphere are advantageous for processing Bi-2223/Ag tapes on a large scale, as there would be much less demand on temperature control.

An intermediate cold pressing prior to the second thermal cycle also played an important role in improving J_c as part of the two-step thermal cycle process. The J_c values of pressed tapes were almost four times larger than for tapes without the intermediate pressing, due to the elimination of residual pores as well as an improved grain alignment of Bi-2223. The highest J_c was 45,700 A/cm^2 when annealing was done at 800 °C, which is higher than that of tape annealed in air under the optimal two-step sintering process, i.e., at 840°C (first sintering and second sintering) and 820°C (final annealing). The enhanced J_c for the tapes annealed in 7.5% O_2 is thought to be attributable to the higher volume fraction of Bi-2223.

The important feature is that the tapes, which were two-step thermal processed in 7.5% O_2, exhibited high J_c values despite a very broad temperature range. When the tapes were treated in air, J_c values are very sensitive to a very small change in annealing temperature, resulting in a different phase evolution. The temperature range for 90% J_c/J_{cmax} is very narrow, 825±2-3°C, while the observed range for the tapes annealed in 7.5% O_2 extends over 20 °C (785 ~805 °C), and nearly 40 °C (770~810 °C) for the 80% J_c/J_{cmax} region. This fact is of importance for large-scale production, when considering that one of major tasks required for Ag/Bi-2223 tapes is to improve reproducibility in the production of long tapes with uniform J_c.

It is observed that the large difference in J_c between the quenched and subsequently annealed tapes provides evidence that the amorphous phase has more detrimental effects on J_c than other impurity phases. For the tapes subsequently annealed during the second cycle, most of the amorphous phase is converted to Bi-2223, hence enhancing J_c. However, if a small amount of the residual amorphous layer still exists even after the second cycle annealing, this may lead to a large decrease in J_c, even though XRD shows very pure Bi-2223 phase. This may indicate that proper conversion of the liquid phase in the tape to Bi-2223 is vitally important in order to improve J_c.

Influence of Deformation Rates of Cryogenic Pressing on critical Current Density

Influence of deformation rates of cryogenic pressing on critical current density has been investigated for Ag-sheathed and Ag-Mg alloy sheathed 37 filamentary Bi-2223 tapes. Compared with Ag-sheathed Bi-2223 tapes processed by using the same processing procedure, critical currents of Ag-Mg alloy sheathed tapes increase 220%, 260%, 214%, 163%, 95%, 34% at the thickness reducation rate of 8.1%, 11.3%, 12.6%, 15.4%, 19.3% and 21% respectively. The results reveal that the cryogenic pressing process has significant improvements on critical current density, core mass density, grain alignment and sheath/oxide core interface for Ag-Mg alloy sheathed tapes.

1.3 *Study of current limiting mechanisms in Ag sheathed (Bi,Pb)SrCaCuO tapes using magneto-optical imaging and magnetic force microscopy*

Funded:	2000	2001	2002
Grant No:	A10012023		
Chief Investigator:	H.K. Liu		
Partner Investigator:	A. Polyanskii		
Assoc. Investigator:	J. Horvat, D. Larbelastier		

In order to study the current limiting mechanisms of (Bi,Pb)SrCaCuO, it is important to be able to observe the current path directly through the tape. This can be done either by magneto-optical imaging or through the use of a magnetic force microscope and a mini-Hall-probe technique.

Magneto-optical imaging has been used to study Ag/Bi2223 tapes processed using flat rolling, sandwich rolling, and pressing methods for the intermediate mechanical deformation in the powder-in-tube process. The results show that not only the density of micro-cracks but also their distributions affect critical current densities. The work was presented at the ASC 2000 conference. A paper “Magneto-Optical Imaging for Ag/Bi-2223 tapes processed by normal rolling, sandwich rolling and pressing” by HK Liu, A Polyanski, WM Chen, YC Guo, SX Dou and M Apperley has been published in IEEE Transactions on Applied Superconductivity in March 2001.

On the other hand, the current-carrying capacity of (Bi,Pb)SrCaCuO tapes is determined by single filaments in the tapes. It is therefore very important to study the transport and magnetic properties, as well as the microstructures of single filaments. In order to study the current limiting mechanisms of (Bi,Pb)SrCaCuO tapes, the first step is to extract single filaments from the tapes. This step has been accomplished in our laboratory by using a chemical solution. The optimum chemical solution for dissolving the silver away has been determined to be NH_4O_4 +H_2O_2 with the concentration NH_4O_4: H_2O_2=5:2. Single filaments have been obtained using this solution.

We have also studied the microstructures of the tapes using SEM and optical microscopy. The images show different microstructures for the filaments in the centre and along the edges of the tape. The filaments in the centre are deformed much more than the filaments along the edges. This may result in different current-carrying capacity for filaments in the centre and along the edges of the tapes. With a higher degree of deformation, the filaments in the central area of the tape may well have higher current-carrying capacity. Therefore, in order to have a higher critical current density, the tapes should have a more uniform deformation during the rolling and pressing process.Our next step is to perform detailed microstructure, transport and magnetic measurements on single filaments. The results can be used to provide feedback for processing and therefore may be used to obtain tapes with a higher critical current density.

1.4 ***Far-infrared laser generation from optically and electrically pumped semiconductor quantum well systems***

Funded:	1998	1999	2000
Grant No:	A49804183		
Chief Investigator:	W. Xu		
Postgrad. Student:	T.J. Green		

As proposed in the application we performed a theoretical investigation carried out at the University of Wollongong. In this project, the following results were obtained:

For optical generation of laser emission, we have accomplished the design of the intersubband laser device which behaves as a 4-level laser system under optical pumping, in collaboration with co-worker T. Green (PhD student). This design, based simply on an AlGaAs-GaAs-AlGaAs single quantum well structure, allows much greater flexibility in the choice of pumping sources and simplifies considerably the growth and fabrication of the sample systems.

This work was selected as an oral presentation at the IEEE Conference on Optoelectronic and Microelectronic Materials and Devices (COMMAD'98) held in Perth in December 1998 and was published in the conference proceedings. Furthermore, we studied the electron density in different electronic subbands in the proposed device system as a function of intensity and frequency of the pumping field and as a function of temperature.

We have thus found out the conditions to achieve population inversion among different electronic subbands and to obtain far-infrared intersubband laser emission. This work was presented at the 11th International Semiconductor and Insulating Materials Conference held in Canberra in 2000 and will be published in the conference proceedings. The final results of this work were published recently in the Journal of Applied Physics (T.J. Green and W. Xu, J. Appl. Phys. **88**, 3116 (2000)

For electrical generation, Xu studied the emission of far-infrared radiation from electrically modulated quantum well systems. In this work, I have demonstrated that using these novel devices, strong far-infrared emission can be generated by applying a dc driving field. By varying the strength and the period of the modulation potential, the emission of far-infrared radiation can be tunable.

This work was published in Microelectronic Engineering (W. Xu, Microelectronic Eng. **43-44**, 437 (1998). Due to the publication of this work, I have been invited by NOVA Science Publishers Inc., USA, to contribute a monograph on this work which has been selected as one of the 150 new titles for publication in 2000.

2. Progress Report on ARC Fellowships

2.1 *Optimization of thermal- and mechanical processing and critical current density of high T_c superconducting Ag-clad Bi(Pb)SrCaCuO tapes*

Funded:	1999	2000	2001	2002	2003
Grant No:	F89905267				
Chief Investigator:	H.K. Liu				

Effects of reduction rate on the superconducting properties of Ag/Bi-2223 tapes: It is found that J_c of tapes have a linear dependence on core density for the three methods of Normal Rolling (NR), Pressing (P) and Sandwich Rolling (SR). But the linear slope is different for the three methods. The SR tape has the largest slope, with P and NR tapes the second and lowest, respectively. Experimental results show that J_c dependence on the reduction rate for the three processes follows the same law. There is an optimal reduction rate in each case, which gives the highest physical density and the highest J_c. When the reduction rate increases, J_c initially increases, reaches a maximum and then diminishes. It is interesting to note that the maximum J_c for sandwich-rolled tape is the same as for pressed tape, but J_c for both the sandwich-rolled and pressed tapes is 35% higher than for normal rolled tape.

J_c has been measured while the magnetic field B was parallel to the ab face and the c-axis of Bi-2223 grains, designated by B//ab and B//c, respectively. The pinning force density F of SR-, P- and NR-tapes was calculated for B//ab and B//c, respectively. The maximum F of SR was a little larger than that of P, but both the maximum F values for both SR and P were much larger than that of NR for both B//ab and B//c. The irreversible magnetic field B_{irr} of SR-, P- and NR-tapes showed similar results. SR-tape had the highest B_{irr}, P- the second and NR the smallest. Optical-magnetic images show that "sandwich" rolling reduces the cracks along the transverse direction in the tape in comparison with normal rolling. As compared to pressing and normal rolling, experimental evidence supported the view that the sandwich rolling was the best intermediate deformation method for improving the J_c of Ag/Bi-2223 tapes.

Magneto optical imaging has been used to study Ag/Bi2223 tapes processed using flat rolling, sandwich rolling, and pressing methods for the intermediate mechanical deformation in the powder-in-tube process. The results show that not only the density of micro-cracks but also their distributions affect critical current densities.As the current-carrying capacity of (Bi,Pb)SrCaCuO tapes is determined by single filaments in the tapes, it is therefore very important to study the transport and magnetic properties, as well as the microstructures of single filaments. In order to study the current limiting mechanism of (Bi,Pb)SrCaCuO tapes, the first step is to extract single filament from the tapes. This step has been completed using a chemical solution in our laboratory.

The microstructures of the tapes have been studied using SEM and an optical microscope. The images show different microstructures for the filaments in the center and along the edges of the tape. The filaments in the center are deformed much more than the filaments along the edges. This may result in different current-carrying capacity for filaments in the center and along the edges of the tapes. With higher degrees of deformation, the filaments in the central area of the tape may have higher current-carrying capacities. Therefore, in order to have higher critical current density, the tapes should have a more uniform deformation during the rolling and pressing process. Our next step is to perform detailed microstructure, transport and magnetic measurements on single filaments. The results can be used to be a feedback for processing and therefore may be used to obtain tapes with higher critical current densities.

2.2 ***New Manufacturing Process for Long Length HighTemperature Superconductors***

Funded:	1999	2000	2001
Grant No:	F89700795		
Chief Investigator:	Y.C. Guo		

The main objectives of the APD project are: (i) to develop 'defined phase balance' superconductor precursor powders (year 1 task), (ii) to investigate the effect of silver alloy sheaths on the properties of Bi-2223 tapes (year 2 task), and (iii) to develop a "continuous tube forming/filling" (CTFF) technique for the continuous fabrication of long Bi-2223/Ag tapes (year 3 task).

Bi-2223 precursor powders were fabricated by using various techniques including solid-state reaction, thermal decomposition, spray drying, freeze drying, co-precipitation, and spray pyrolysis. The variously prepared powders were characterised in terms of size, morphology, phases, melting temperature and composition. These powders were used to fabricate Bi-2223/Ag tapes, and their effects on the properties of the tapes were studied. It was found that the form of Pb in the powders, not the preparation methods, determines the properties of the powders. If Pb is largely incorporated into Bi-2212 phase, rather than in the form of Ca_2PbO_4, the powders will have a higher melting temperature. Consequently, the tapes made from the powders can be sintered at higher temperature and form Bi-2223 phase more quickly and completely. Based on these findings, 'defined phase balance' powders, in which most Pb is incorporated into (Bi,Pb)-2212 phase, with only a small amount of Pb in the form of Ca_2PbO_4, were fabricated.

A series of silver alloys including AgCu, AgAl, AgNi, AgTi, AgMgTi and AgMgNi, were prepared and used to fabricate Bi-2223/alloy tapes. The mechanical strength and workability of the alloy sheaths were investigated. It was found that the sequence of the alloys' hardness from high to low is AgNiMg, AgNi, AgTiMg, AgTi, AgAl, AgCu and Ag. The sequence of the alloys' workability from high to low is Ag, AgCu, AgTiMg, AgTi, AgNiMg, AgAl and AgNi.

The effects of alloys on Bi-2223 phase formation, T_c and J_c were investigated. The detrimental effect on Bi-2223 formation from high to low was found to be AgTi, AgTiMg, AlNiMg, AgAl, AgCu, and Ag. The Bi-2223 fraction in tapes made of first four alloys was <50% after heat treatment and in the last two sheathed tapes was >90%. While the effect of alloys on T_c was insignificant (except for AgTi), J_c was lowered by all alloys, particularly in the cases of AgTi, AgTiMg, AgAl and AgAlMg.

To achieve high mechanical strength, but avoid the detrimental effects, hybrid Ag-alloy tapes were produced, in which pure silver was used for the first packing and alloys were used for the second packing, forming alloy/Ag/Bi-2223 composite tapes. In this configuration, the inner Ag sheath prevented the reaction between alloy and Bi-2223 phase and hence avoided the detrimental effects of alloys on the superconductors. At the same time, the outer alloy sheath enhanced the overall strength of tapes. Results confirmed that this configuration works very well.

More silver alloys were prepared and investigated in a search for alloys which enhance the tape's mecha nical strength, but have little detrimental effect. Among the alloys investigated, Ag-Sb and Ag-Mg were found to be promising, having little effect on the Bi-2223 formation, T_c and J_c. These alloys can be used for both inner and outer sheaths of the tapes.

Some Bi-2223/Ag tapes have been fabricated by using the "continuous tube forming/filling" technique. More experiments are planned to optimise the processing and heat treatment parameters of this technique.

3. Progress Report on ARC SPIRT projects

3.1 *Effective Transverse Matrix Resistivity of Multifilamentary Bi:HTSC/AG Tapes in Response to Variation of Strand Architecture and Processing Method*

Funded:	1999	2000	2001
Grant No:	C69922488		
Chief Investigator:	S.X. Dou		
Partner. Investigator:	E.W. Collings, T. Beales		
Assoc. Investigator:	C. Cook		
Industry Partner:	Australian Superconductors (Metal Manufactures Ltd)		
Postgrad. Students:	F Darmann		

The purpose of the proposed research is to combine experiment and theory in order to show quantitatively the influence of (a) external strand shape and (b) internal filament architecture, on the hysteretic and eddy-current loss components of multifilamentary Bi:HTSC/Ag strands. Armed with the results of this research, it will be possible for the first time, to design MF HTSC ribbons with pre-determined levels of AC loss.

Multi-filamentary superconducting tapes (HTSC tapes) have been manufactured with silver alloys that include Gold, Magnesium, and other elements. Various sizes and aspect ratios of these tapes have been manufactured to allow the Effective Perpendicular Matrix Resistivity (EPMR) to be measured and characterised for each. Techniques for the elimination of bridging between filaments had to be developed.

The problem with bridging between filaments is that it prevents coupling eddy currents from flowing between the filaments and within the sample. Hence, information about the EPMR cannot be obtained from AC loss measurements and only the hysteresis loss of the outside ellipse containing the filaments is measured.

The process of twisting filaments has been refined to allow the manufacture of extremely thin and narrow tapes without filament bridging. Complete success in the manufacture of these types of tape has not yet been achieved, but some positive results have been obtained. These tapes will be suitable for the windings of the high voltage primary coils in a transformer and for use in cables and other AC applications.

An AC loss testing apparatus has been constructed for the purposes of measuring short length AC losses on tapes using a lock-in amplifier. Various techniques have been investigated and employed to eliminate the phase errors in measuring the small signals involved.

A power supply has been specified, designed, delivered, and commissioned. This power supply (footprint, 4 m x 2 m height, 2.2 m) uses a unique resonance technique employing condensers that will be used to supply variable frequency voltage and current to HTSC coils. In addition, a conventional AC coil fitted around the cryostat is powered by this supply to provide a uniform magnetic AC field across the pancake coils.

These techniques will allow the hysteresis and eddy current losses to be extracted from the loss signals of the coils. This will ultimately allow an empirical technique for calculating the losses of HTSC coils to be derived and the extraction of the effective matrix resistivity of tapes with various alloying elements.

3.2 ***Investigation of Bi-2223/Ag Superconductor Winding for Application in an Electrical Fault Current Limiter,***

Funded:	2000	2001	2002
Grant No:	C00001903,		
Chief Investigator:	S.X. Dou		
Partner Investigator:	M. Apperley		
Assoc. Investigator:	C. Cook		
Industry Partner:	Australian Superconductors (Metal Manufactures Ltd)		

The research objectives are briefly stated as follows: HTSC, $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$ Ag-clad wire will be studied for use in making a winding to serve as a dc bias winding of an inductive fault current limiter (FCL). The required performance of the HTSC winding for this application will be investigated and evaluated, based on the FCL rated ac current level and electrical performance.

The electrical performance of this HTSC FCL will be studied to develop an applicable device. The dc winding current-ampere turns, winding configuration, and magnetic field will be studied in relation to the FCL and HTSC wire performance.

A low rating prototype HTS FCL device has been fully built with HTS coils and relevant operating electrical circuits. The prototype set up in Australian Superconductors Ltd has successfully demonstrated the effective electrical fault current limiting principle and the advantages of the HTS winding technology. HTS windings have been proved to be suitable for this type of high rating FCL device with respect to both processing and strong current behaviours. The HTS cooling techniques and electrical magnetic circuits have also been verified as suitable for the proposed FCL device.

Previous HTS study and research have been applied to HTS winding production processing under industrial standards, for verification of the HTS winding techniques. Two HTS coils, one solenoid and one multilayer pancake coil, have been successfully fabricated and incorporated with industry accepted techniques. The HTS wires applied to the prototype were made of 37-filament Ag sheathed Bi-2223 HTS tapes, and supplied by Australian Superconductors. Measurements and analysis show the required HTS winding current ampere-turns can be reached at a 77 K operation temperature for the designed device. It will be rated at 0.12 MVA and use HTS tapes produced at the Australian Superconductors.

The HTS wires required for the FCL project have been identified and the HTS wire and its windings are currently under preparation for the project device. The research work carried out to identify the HTS wire to build the FCL device included detailed practical device design and research on the requirements on the HTS wire; the analysis and simulations of the magnetic field generated by the windings; and the determination of optimum HTS winding configuration. Computer software packages have been used for analysis and the generation of results.

A summary on the required HTS wires and device details has been made and supplied to the industry partner to optimise the HTS wire supply and the setting up of the proposed device.

The next stage will be actually to set up the proposed HTS FCL device, and conduct relevant studies. This will involve carrying out relevant tests and analysis on the HTS, magnetic/electrical circuit, and cooling system at a level close to industry application.

3.3 *Bi-Polar Electrode Materials and Design for Electric Vehicle Batteries*

Funded:	1998	1999	2000
Grant No:	C89805127		
Chief Investigator:	S.X. Dou, H.K. Liu		
Partner Investigator:	L. Lam, D. Rand		
Industry Partner:	Advanced Lead-Acid Battery Coorporation, Pasminco Ltd and Taiyi Battery Ltd		
Postgrad. Student:	J. Wang		

This project aimed to develop a superior, corrosion-resistant and highly conducting alloy, to design new processing techniques using a lead-coated, glass-fibre net to support positive and negative materials; and to construct and evaluate bipolar-electrode battery prototypes to simulate the electric vehicle driving duty cycle.

Significant progress has been achieved since the beginning of this project in June 1998. Major achievements are summarised below:

1. A pure lead-coated glass fibre wire has been investigated in both a positive and a negative grid in a single test cell. Electrochemical treatments on the lead-coated composite wire were performed before assembling test cells in order to improve the coherence force between the grid and the electrode active material. Three kinds of lead and lead-alloy strips have been prepared. They were embedded into the scrim of the composite wire to be used a bus bar or a frame for the test battery. Small size cylindrical test cells with a diameter of 25 mm were designed and fabricated by using PTFE and PMMA materials. Testing electrodes were prepared by the conventional lead-acid battery technique first, and then three new methods were applied. Those new methods were designed specifically for employing the lead-coated reinforcement fibre grid.

2. Standard test batteries (2.5Ah/2V) with the lead-coated fibre grids were assembled in both cylindrical and flat plate types.

3. Barium metaplumbate has been synthesised via solid-state reactions for use as an additive for the electrode paste. The formation mechanisms for the plates with and without this additive appear to be different. It has been proved by experiment that the addition of this material to positive plates gives a significant improvement in formation efficiency. This additive was also very promising when it was applied in a new non-curing-drying process. The low costs of the raw materials, ease of synthesis, and required low loading level in a plate, make this new material an attractive additive to a lead-acid battery

4. Prototypes of spiral wound cells have been designed and fabricated on a laboratory scale. Extensive cycle-life tests have been performed on those cells and valuable data were collected and analysed during this period. These have be used for further optimising of the cell design and for improving battery performance

5. In order to make the new design more practical for the battery manufacturing a purpose designed non-curing-drying process has been developed as a substitute for the conventional curing and drying processes. Substantial improvements in the cycleability have been achieved with the prototype batteries without any fear of positive grid growth and corrosion, as well as positive-material shedding problems. This project started from July 1998 and is expected to successfully conclude by June 2001.

3.4 *Reduction of heat leak of high T_c Superconducting Current Leads*

Funded:	1999	2000	2001
Grant No:	C89922487		
Chief Investigator:	H.K. Liu		
Partner. Investigator:	M. Apperley, R.P. Zhao		
Assoc. Investigator:	B. Zeimetz, T. Chandra		
Postgrad. Student:	J. Volf		
Industry Partner:	Metal Manufactures Ltd, M.		

Choice of alloyed silver material as sheath material to reduce the thermal conductivity

Au-Ag, Ag-Mg and Ag-Sb silver alloys have been chosen as sheath materials to reduce thermal conductivity below that of pure silver. The initial electrical resistivities (ρ) of Ag-alloys as-worked at room temperature and liquid N_2 temperature were measured.

Compared with pure silver, the resistivity of Ag-Au alloy was about 10 times greater at 77K. The next step is to measure the resistivity and thermal conductivity at temperatures lower than 77K. The effects of Ag-Au and Ag-Sb alloys on chemical compatibility with the HTS oxide core have been examined. It has been found that Au and Sb alloy elements have only a slight effect on BSCCO superconductor phase formation.

A series of samples have been prepared and shipped for low temperature thermal conductivity measurements, through a collaborative effort with Dr Jinho Joo of Sunkyunkwan University, South Korea.

An optimization process for Ag-alloy Bi-2223 tapes has been used to maximize the critical current density

Several novel techniques have been combined to optimise the J_c, including pre-annealing of the powder-in-tube composite prior to drawing, a quenching followed by rapid heating in-between thermal cycles, and a slow cooling process (maximum percentage of 2223 phase) in the final heat treatment cycle.

The purpose of the optimising process is to ensure the high grain connectivity, grain alignment and maximum percentage of Bi-2223 phase and eliminate amorphous phase while retaining the texturing, fine precipitates and grain connectivity. At present, our record I_c for normal sized tapes (0.25×3.5 mm^2) has reached 72A (J_e ~ 7,200A/cm^2), while J_e has reached 8,200 A/cm^2 for thin and narrow tapes and 6300 A/cm^2 for alloy tapes.

Four papers from this project were published in 2000.

Bubble eliminated by high temperature vacuum degassing

Several long tapes were fabricated using a high temperature vacuum degassing process. After the first heat treatment, there were no bubbles in the entire tape, the I_c was measured turn by turn, the variation being about 2A over the whole tape. The homogeneity of long tapes was much improved.

3.5 *High energy batteries for electric vehicles*

Funded:	2000	2001	2002
Grant No:	C00001879		
Chief Investigator:	H.K. Liu		
Assoc. Investigator:	D.H. Bradhurst, S. Zhong		
Industry Partner:	Electric Transit Ltd Australian Batteries Technology Ltd, China Liaoning Suppo Battery Ltd		
Postgrad. Student:	C.Y. Wang		

Investigation of positive electrodes for Ni-MH battery in 2000:

It was found that the peaks for nickel hydroxide with added Al and Co can be indexed to α-$Ni(OH)_2$, which indicate that the elements Al and Co have been incorporated into the lattice of nickel hydroxide. Its physical characteristics have been identified with SEM and XRD. Nickel hydroxide with added Al and Co was used as an electrode material in an open Ni/MH cell, and its electrochemical properties have been examined. The results show that the electrochemical properties have been improved by adding Al and Co. Electrodes fabricated from the nickel hydroxide with Al and Co additives show a better reversibility and charge-discharge capability compared with electrodes without an additive.

A maximum capacity of 319mAh/g was also obtained for this electrode. In a cyclic voltammetry study, $\Delta E_{a,c}$, an important parameter for judging the reversibility of the electrode redox reaction, was found to be 158mV for the electrode fabricated out of nickel hydroxide doped with Al and Co, which is smaller than 168mV for the electrode with no additive. This shows that the charge-discharge process is easier and more reversible for the electrode doped with with Al and Co.

Charge-discharge curves show that the electrochemical properties were also improved for the electrode with added Al and Co, which had a lower charge voltage and much higher discharge voltage, and also a much higher discharge capacity. All the results show that Al and Co-substituted α-$Ni(OH)_2$ is promising as an active material in the Ni/MH battery.

A new dry pressing method using a copper grid substrate for fabricating a metal-hydride electrode for Ni-MH batteries was investigated: An expanded copper alloy mesh was used as the electrode substrate to substitute for the conventional nickel foam or nickel-based substrate in order to reduce the cost and increase processing efficiency. The effects of addition of a dry conductive binder to the electrode active material, the adherence of the electrode active material to the copper based substrate under pressure, and their effects on the open test cells and commercial cells were investigated.

Compared with the conventional paste electrode techniques, the dry powder compressed electrode process has the potential to provide a higher processing efficiency and a lower cost of production.

Significant improvements in discharge capacity and cycle life have been achieved by using this new electrode fabrication technique. These improvements have been attributed to better adhesion between the electrode active material and the copper-based substrate under the high compression used in the electrode preparation. In order to explore this particle inlay effect, further investigation will be performed on the surface layer of the copper alloy substrate.

3.6 *Substrates for large area thin films obtained by pulsed laser deposition*

Funded:
Grant No: C89922466
Chief Investigator: J. Horvat, M. Ionescu
Partner Investigator: M. Apperley
Industry Partner: Metal Manufactures Ltd., M. Apperley
Postgrad. Student: J. McKinnon

The proposed aims of the project were to elucidate the mechanisms of the growth of Y123 films by pulsed laser deposition (PLD) onto Ni/CeO_2 substrates and for the student to develop expertise in all aspects of the topic. To achieve these goals it was first necessary to develop an empirical capability to produce the films and the practical capacity to characterise them.

This has been achieved and high temperature superconducting films have been produced on single crystal substrates, and characterised:

Substrate	10mm x 10mm (Yttrium Stabilised Zirconia single crystal)
Film Thickness	200-600nm
Critical Temperature	(T_c) >88K (transport measurement with in-house developed system)
Critical Current	(J_c) > 10^6 A/cm^2 (magnetic measurement)
Surface Roughness	(R_a) < 10 nm
Number of particulates(N_p)	approx 10^5 / cm^2 (determined by optical microscope)
"C" axis orientation	(DcO) > 95%

These are comparable to the best international practice. However, in the process of achieving this it became evident that to develop thicker films, larger surface area, or coated conductors, a deeper understanding of the fundamental mechanisms of the PLD process would be required .

A model of the PLD process is being prepared and assessed against the literature to see if there are any contradictions. The model defines the availability and mobility of atomic species, which have to be met if films with the desirable characteristics are to be produced. The implications of the model should indicate what the necessary conditions for the growth of high-quality large-area films are.

In order to obtain a better match between the crystalline lattices of the substrate and Y123, CeO_2 was deposited on commonly used substrates: yttrium stabilised zirconia (YSZ) and Ni. The conditions of growth and the quality of CeO_2 films were systematically studied for YSZ substrates. It was found that much better results can be achieved by using an hydrogen atmosphere, instead of the commonly used oxygen. When using 10% H_2 in Ar, epitaxially grown CeO_2 on <100> YSZ was obtained in temperature range 470-850 °C.

In comparison, epitaxial growth in an oxygen atmosphere was obtained for 780-820°C. Moreover, the surface roughness of CeO_2 film grown in 10% H_2 in Ar was 6-10 nm, the same as for the YSZ substrate. Similar preliminary results were obtained for CeO_2 grown on Ni substrate. Therefore, we have succeeded in obtaining smooth CeO_2 films, suitable for the use as substrates for the growth of large area Y123 films.

3.7 *Thermionic cooling for domestic refrigeration*

Chief Investigator: R.A. Lewis, C. Zhang
Industry Partner: Email Limited
Postgrad. Students: Ben Lough

ARC support in this project is for an APAI. PhD student. This student, Ben Lough, was recruited in July 2000. We have carried out the following research since last July.

(i) We developed several numerical programs to simulate the performance of single and double layer structures. Numerical results for thermal efficiency for various different structures were obtained.
(ii) We designed the first elementary structure for domestic refrigeration.
(iii) Some preliminary results were reported at three difference international conferences.
(iv) We discussed and presented the preliminary results at a meeting with our industry partner, Email, in Orange, NSW. Since the only support in this project is an APAI and the PhD student only started seven months ago, the main results of this project are not expected until 2002.

4. Report on IREX Project of International Fellowship in 2000

4.1 *Electro-magnetic behaviour of high temperature superconductors in various geometries*

Funded: 2000
Grant No: X00001598
Chief Investigator: SX Dou
Partner Investigator: E.H. Brandt

The aim of the project is to investigate the effect of geometries of superconductors on electro-magnetic properties. Dr Brandt divided his fellowship into two periods, one was during April to June in 2000 and second is in April to June 2001. During the 1st period theories and numerical programs were developed to calculate the electric and magnetic properties of superconductors in particular geometry, namely, thin and thick superconductor strips exposed to a perpendicular magnetic field and/or carrying an electric current. As compared to previous theories the consideration of an electric transport current (applied by contacts) is new. Also new is that these theories now allow for a finite London penetration depth lambda (previous theories assumed lambda=0). These theories and computer programs are useful for the correct evaluation of experiments and for the optimization of the current carrying ability of superconductors for technical applications.

The previous continuum theory of type-II superconductors of various shapes with and without vortex pinning in an applied magnetic field and with transport current, is generalized to account for a finite London penetration depth lambda. This extension is particularly important at low inductions, where the transition to the Meissner state is now described correctly, and for films with thickness comparable to or smaller than lambda. The finite width of the surface layer with screening currents and the correct dc and ac responses in various geometries follow naturally from an equation of motion for the current density in which the integral kernel now accounts for finite lambda. New geometries considered here are thick and thin strips with applied current, and ` ` washers' ' , i.e. thin film squares with a slot and central hole.

A PhD student, Krishna Uprety, under the co-supervision of Dou and Brandt has obtained interesting results from these electrodynamic theories, showing the magnetic field lines and current-density profiles of superconductor strips with rectangular cross section with/without applied magnetic field and/or with/without electric transport current. Also shown are the corresponding magnetization loops.

The second period of the fellowship will conclude by June this year. The final report will be provided by Sept this year.

5. Progress Report Research funded Internally by ISEM

Zeeman Spectroscopy of singly ionised zinc in germanium

Years funded: 2000
Chief Investigator: C. A. Freeth, P Fisher and R. E. M. Vickers

Singly ionised zinc, Zn, in Ge, is a single acceptor which has a similar spectrum to the neutral group III impurities except that the spacings of its energy states are ~4 times larger. The symmetry of the ground state for single acceptors in Ge is γ_8^+. The excited state of the D line of both Zn and group III acceptors in Ge is of γ_8 symmetry. Due to the larger energy spacings between the states of Zn relative to the neutral acceptors, the splitting pattern of $2\gamma_8$ at high fields is very similar to that of group III impurities at low fields. In contrast to the shallow acceptors, the behaviour of the deep ground state of Zn is that of a j = 3/2 atomic state with the same splittings for **B**||<100>, <110> and <111>; these are determined by a single g-factor of value 0.5355.

Impurity spectra in GE due to bulk stress from surface strain

Years funded: 2000
Chief Investigator: P. Fisher, R. E. M. Vickers, B. D. Crowe, and A. B. Rozenfeld

Abrading of surfaces of solids with silicon carbide produces significant damage. In the past, this has been studied using metallographic techniques. Such investigations have been carried out on semiconductors. For Ge, high-resolution FTIR spectrometry permits the effect of this surface damage on the interior to be determined by studying the hydrogenic spectra of bulk donors and acceptors, while treatment which relaxes the traumatized surfaces also can be so monitored. We have examined a series of crystalline Ge samples prepared by grinding opposing optical faces with #400 mesh carborundum. These faces were oriented parallel to either {100}, {110}, {111} or {112}. They contained Ga, Al, P and B; the net acceptor concentration being ~10^{14}/cm^3. The surface damage produced well-defined splittings of the spectral features of these shallow impurities. The spectra were observed with band-gap radiation incident on the sample to give neutral acceptors and donors and minimise Stark broadening. The splittings of the $p_\pm$ lines of P ranged from ~0.1 to ~1.5 cm^{-1}, depending on the sample thickness, with the components of these and the acceptor lines exhibiting precisely the pattern obtained if the sample had been subjected to a uniform external **compressive** force, **F**, applied along the crystallographic direction perpendicular to the optical faces. In this configuration, the infrared beam propagates along **F** and thus the radiation is "polarised" in the plane perpendicular to **F**, the piezospectroscopic equivalent of the Faraday configuration, an arrangement not possible if **F** were applied externally. The stresses attained (up to 1.7 MPa) are in the very low stress regime thus permitting unambiguous quantitative comparision with theory. At such low stresses, all the acceptor lines split linearly with stress and yield more reliable deformation potential constants than previously obtained. For example, d_G of Ga is found to be –1.33 ± 0.02 eV which is to be compared with the earlier value of –(1.10±0.04) eV. The value of this constant for the ground state is found to be –3.00 ± 0.04 eV which is close to the previous value of –2.91 ± 0.06 eV since interaction of this state with others is small even at the larger stresses previously used. Further, the splittings of the A lines of Ga permit the symmetries of their final states to be determined. The bulk of the error in the present results is due to that in the shear deformation constant, Ξ_u, of the conduction band minima of Ge, *viz.*16.4±0.2 eV, since the splitting of the $2p_\pm$ line of P is used to determine the internal stress generated in the samples. Similar results have been obtained for Si. Ultrasonic treatment (UST) was used to remove this stress in Ge using small ultrasonic cleaning baths operating at either 30 or 43 KHz. The splittings of the lines were followed as a function of UST time. The reduction in the splitting of the phosphorus lines, for example, exhibits an exponential decrease with UST time. These lines were restored to within ~0.002 cm^{-1} of their unperturbed energies after ~10 hrs of UST.

Zeeman and piezospectroscopy of some axial defects in germanium

Years funded: 2000
Chief Investigator: P. C. Jobe Prabakar, P. Fisher and R. E. M. Vickers

The diffusion of known impurities such as Cu, Mg, *etc*., into Ge followed by quenching introduces a variety of unknown defects which can be detected by observing their far infrared Lyman spectra; some exhibit classic neutral acceptor spectra others do not. We have examined three which have D lines of energies 101.5, 163.7 and 225.2 cm^{-1}. The first two we name $MgX_1^{(0)}$ and $MgX_2^{(0)}$, respectively, since they appear when Mg is diffused. Here the D and C lines of $MgX_1^{(0)}$ have been observed by others, the spectrum of $MgX_2^{(0)}$ has not been reported before while for the third, named $CuX^{(0)}$, Zeeman results for **B**||<100> have been presented elsewhere by us. The purpose of the present studies is to determine the nature of the centres giving these spectra. Our Zeeman investigations of the spectrum of the D line of the <111> axial defect Zn-H in Ge, which occurs at 77.7 cm^{-1}, provides a template for the identification of such axial defects. It is observed that the magnetic field dependence of the energies of the D components of all the above four defects with **B**||<100> exhibit similar patterns. The excited states replicate the Zeeman behaviour of that of the $2\gamma_{\square}$ state of all five group III acceptors in Ge, while the ground state of each defect splits into two Zeeman levels. From this and the polarization of the D components, we conclude that all three defects, $MgX_1^{(0)}$, $MgX_2^{(0)}$ and $CuX^{(0)}$ are also axial defects of the same type as Zn-H. The difference between these axial defects is in the magnitude of the g-factors of the ground states. These states split linearly with field with g-factors increasing with binding energy. At this time only Zn-H and $CuX^{(0)}$ have been studied with **B**||<111>. The results for Zn-H support an axial model while those for $CuX^{(0)}$ have yet to be fully interpreted. In addition, more detailed piezospectroscopy of Zn-H has been carried out than previously using polarized radiation, not only with the force **F** along <111> but also along <100>; for $CuX^{(0)}$, only **F**||<100> has been used.

Far-Infrared Spectroscopy of the Zinc Acceptor in Indium Phosphide

Years funded: 2000
Chief Investigator: R.A. Lewis

Specimens of undoped, n-type and p-type bulk InP have been investigated using THz radiation. Reflection spectroscopy permits determination of the TO and LO phonon energies as well as the carrier concentration. We have further reported the first absorption spectrum of an acceptor in InP, namely the absorption spectrum of Zn acceptor. The transition energies determined in this investigation are in good accord with electronic Raman scattering and photoluminescence data. Fourier interferometers equipped with Si bolometers were used to collect spectra at sample temperatures down to 1.9 K. Zeeman measurements were made in the Voigt configuration at fields up to 6.5 T with the electric field of the radiation, E, polarised either parallel or perpendicular to the magnetic field, B||<001>. Energies for the G and D lines, corresponding to transitions from the gound to the first two excited states, were determined. Data taken at high resolution establish the intrinsic line width. At low magnetic field (B < 3 T), the D line rapidly broadens, losing intensity and becoming unresolvable. At the highest fields, four components for E parallel to B and two for E perpendicular to B are resolved for the G line. Comparing data at 1.9, 2.9, 5.4 and 10.4 K reveals thermal depopulation effects. These experimental data permit determination of g-factors for the ground and first excited state of Zn in InP.

Current Research Projects

ARC Large Research Grants Scheme

Optical and electric generation of far-infrared laser emission from semiconductor quantum well systems

Years funded:	1998	1999	2000
Amount funded:	$48,000	$50,000	$53,000
Chief Investigator:	W. Xu		
Postgrad. Students:	T. Green		

Laser and laser technologies have been one of the major driving forces in the advancement of science and technology. In this project we have been working on the generation and detection of lasers in the far-infrared (FIR) bandwidth which is very useful for scientific research and for device applications. We have proposed some novel schemes to generate optically and electrically continuous-wave FIR lasers and laser pulses from semiconductor quantum well structures

Investigation of growth mechanism and flux pinning in spiral-grown Bi-High temperature superconducting single crystals

Funded:	1999	2000	2001
Amount funded:	$60,932	$61,989	$62,000
Chief Investigator:	SX Dou		
Assoc. Investigator:	J. Horvat, E.W. Collings, V. Pan		
Research Fellow:	X.L. Wang		
Postgrad. Students:	K. Uprety, F. Gao		

Research aims to investigate a new growth mechanism and the influence of associated screw dislocations on crystal characteristics of doped and un-doped $Bi_2Sr_2CaCu_2Oy$ & $Bi_2Sr_2Ca_2Cu_3Oy$ monocrystals. Comparative studies of crystals grown using different procedures, including the complex flux technique, co-doping, nanorod inclusions and irradiation, will lead to better understanding of the pinning behaviour of Bi-based HTSCs. It is expected that the research outcome will be identification of methods for introducing effective pinning centres into Bi:HTSC in order to raise critical current density to a suitable level for applications.

Cryogenic deformation & high Tc phase transformation-partial decomposition of superconducting tapes

Years funded:	1999	2000	2001
Amount funded:	$60,000	$60,000	$62,000
Chief Investigator:	H.K. Liu		
Assoc. Investigator:	S.X. Dou, B. Zeimetz		
Postgrad. Students:	X.K. Fu,		

This proposal presents two novel concepts: cryogenic processing and high Tc phase formation-partial decomposition for processing high temperature superconducting (HTSC) materials. The aim is to investigate the mechanisms of these two processes and their effect on microstructure, critical current density (Jc) and flux pinning behaviour of Ag-clad Bi(Pb)SrCaCu tapes. The associated critical issues including the formation mechanism of $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$, Pb distribution and Ag addition in the precursor powder, will also be addressed and clarified through comparative studies on various forms of the same HTSC compounds. A new approach will be proposed to take advantage of cryogenic processing, 2223 formation-partial decomposition and hot deformation.

Current limiting mechanism in Ag sheathed (Bi,Pb)SrCaCuO) tapes with magneto-optical imaging and magnetic force microscopy

Years funded:	2000	2001	2002
Amount funded:	$62,488	$66,677	$67,261
Chief Investigator:	H.K. Liu		
Partner Investigator:	A. Polyanskii		
Assoc. Investigator:	J. Horvat, D. Larbalestier		
Postgrad. Student:	G. Li		

The mechanism of supercurrent flow, which underlies the technological success of high temperature superconducting tapes, remains unclear. The aim of this proposal is to understand, determine and model the current limiting mechanisms in Ag/Bi-based high temperature superconducting tapes by using magneto-optical imaging and magnetic force microscopy combined with other techniques such as transport and magnetic measurements.

It is expected that the outcomes of this study will be invaluable in the development of appropriate materials processing techniques to improve the critical current density.

Enhancement of transport critical current density in magnetic fields of Ag/BiPbSrCaCuO tapes by fission tracks

Years funded:	2001	2002	2003
Amount funded:	$71,945	$77,589	$77,888
Chief Investigator:	S.X. Dou		

An important application of high temperature superconductors (HTS) is in the area of high current and high magnetic field where a high critical current density, J_c, in strong magnetic fields is essential. It is well accepted that J_c of Ag/BiPbSrCaCuO tapes is limited by the grain connectivity in the self-field, but by flux pinning in an applied field. The objective of this project is to enhance flux pinning by using a combination of stable uranium compound doping and thermal neutron irradiation to produce fission fragments to act as pinning centres.

The expected outcomes will be improved Jc in magnetic fields and minimised anisotropy of HTS with radioactivity to a level acceptable for handling.

Growth, characterisation and flux pinning behaviour of doped $TiSr_2Ca_2Cu_3O_y$ and $TiSr_2CaCu_2O_y$ and high temperature superconducting single crystals

Years funded:	2001	2002	2003
Amount funded:	$59,954	$58,191	$58,416
Chief Investigator:	H.K. Liu		
Assoc.Investigator:	M. Ionescu, X.L. Wang		

$TISr_2Ca_2Cu_3O_y$ (TISr-1223) and $TISr_2CaCu_2O_y$ (TISr-1212) exhibit significant improvement in critical current at high magnetic fields over the TI- and Bi-based high temperature superconductors (HTS). Flux pinning for both compounds has not been well investigated because of the extreme difficulties involved in growing single crystals. The aim of the proposed research is to investigate the growth, characterisation and flux pinning behaviour in Pb or Ba doped and undoped TISr-1212 and 1223 single crystals.

This study will lead to a better understanding of the intrinsic flux pinning properties of both phases and be beneficial for application involving TI-or Bi-based HTS films and tapes.

ARC Research Fellowships

Optimisation of thermal and mechanical processing and critical current density

Years funded:	1999	2000	2001	2002	2003
Amount funded:	$95,278	$90,666	$92,238	$94,230	$95,278
Chief Investigator:	H.K. Liu, Senior Research Fellow				

This proposal studies mechanisms of novel processing techniques that either together or separately are expected to enhance the critical current density of Ag-sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ (Bi:2223). These include a cryogenic process for mechanical deformation, a two-step sintering for heat treatment, a quench, followed by a rapid heating used in between thermal cycles, the Bi:2223 formation-partial-decompositon process and partial decomposition under hot deformation. All these processes center about the kinetics and thermodynamics of phase transformation during each stage of processing.

Combination of these innovative processes will result in an optimised process that leads to the best microstructure, substantially reduced processing time and a high J_c in B:2223 tapes, making them suitable for applications.

Doping of Silver-Alloy Sheath of Bi-HTS wires

Years funded:	1998 -1999 -2000
Amount funded:	$174,000
Chief Investigator:	Y.C. Guo, Postdoctoral Research Fellow

A novel wire processing technique, called 'the Continuous Tube Forming/Filling (CTFF)' procedure will be developed, which will enable the continuous fabrication of fine, very uniform and extremely long Bi2223 wires directly from powder. This new manufacturing process aims to overcome the process-induced inhomogeneities encountered in the conventional PIT method. In order to reduce heat treatment-induced inhomogeneities, a 'defined phase balance' precursor powder will be used to fabricate superconducting wires and tapes instead of normal multiphase precursor powder and the heat treatment conditions will be optimised during heat treatment. In order to increase the strength of the composite wires and tapes, a series of silver-based alloys will be evaluated as sheath material to replace pure silver.

The effect of the various alloy sheath materials on the electrical and mechanical properties of Bi2223 wires and tapes will also be investigated. Finally, with the combination of CTFF processing, 'defined phase balance' precursor powder and strength-enhanced alloy sheath materials, long and uniform Bi2223 tapes with properties suitable for practical applications will be fabricated.

Generation of coherent-hypersound from semiconductor systems

Years funded:	2001	2002	2003	2004	2005
Amount funded:	$72,276	$74,406	$76,534	$78,665	$80,792
Chief Investigator:	W. Xu				

Coherent-hypersound is an entirely new source of high frequency ultrasound with a pure frequency and coherent nature. It can be extensively applied in industry, medical treatment and scientific research, especially in ultrasonic and electronic devices. This project will investigate the generation and propagation of coherent-hypersound with frequency~1 terahertz using state-of-the-art semiconductor and laser technique. sIt is intended to study theoretically the coherent- hypersound generation via emission of coherent-phonons in GaAs- and GaN-based systems, in conjunction with different experimental techniques. This project will be carried out in collaboration with local and international experimental groups.

Solid-state rechargeable lithium batteries for telecommunication and portable electronic devices

Years funded:	2001	2002	2003
Amount funded:	$60,234	$74,080	$63,922
Chief Investigator:	GX Wang, H.K. Liu, S. Zhong		
Partner Investigator:	X.Q. Yang		
Assoc. Investigator:	D.H. Bradhurst		

It is aimed to develop solid state rechargeable lithium polymer batteries and thin film microbatteries for telecommunications and miniature electronic devices. The significance of this project is to develop advanced solid-state rechargeable technology and stimulate advanced battery manufacture in Australia. The expected outcome will be to produce prototype lithium polymer batteries for cellular phones, notebook computers and palm computers. Thin-film microbatteries will also be fabricated using a pulsed laser ablation technique.

Strategic Partnerships with Industry - Research & Training (SPIRT) Scheme

Effective transverse matrix resistivity of multifilamentary BiHTSC/Ag tapes in response to variation of strand architecture and processing method

Years funded:	1999	2000	2001
Amount funded:	$90,687	$94,442	$77,000
Chief Investigator:	S.X. Dou		
Partner Investigator:	T. Beales, E.W. Collings		
Research Fellow:	J. Horvat		
Postgrad. Students:	F. Darmann		
Industry Partner:	Metal Manufactures Ltd		

Multifilamentary (MF) high temperature superconductor tapes are being manufactured for numerous DC and AC applications. However in an AC environment the MF tape is subject to eddy current loss. The purpose of the proposed research is therefore to combine experiment and theory in order to show quantitatively the influence of:

(a) external strand shape; and

(b) internal filament architecture, on the hysteretic and eddy-current loss components of multifilamentary Bi:HTSC/Ag strands. Armed with the results of this research we hope that it will be possible for the first time, to design MF HTSC ribbons with pre-determined levels of AC loss.

Substrates for large-area Y-123 films obtained by pulsed laser deposition

Years funded:	1999	2000	2001
Amount funded:	$21,000	$21,000	$21,000
Chief Investigator:	J. Horvat / M. Ionecu		
Partner Investigator:	M. Apperley		
Postgrad. Students:	J. McKinnon		
Industry Partner:	Metal Manufactures Ltd		

Current carrying capabilities of high-temperature superconductors are critically dependent on the connectivity of superconducting grains, which is much better for thin films than for other types of superconductors. One of the main limitations in growing large area films is the preparation of suitable substrates onto which the films will be grown. Ideally, the substrate would perfectly match the superconductor's crystalline lattice and be perfectly textured. Surprisingly, some porous substrates can also give high quality films. The aim of the project is to answer why this is so. Knowing this, it may be much easier to prepare large substrates, opening the door to thin films of large size.

Reduction of heat leak of high Tc superconducting current leads

Years funded:	1999	2000	2001
Amount funded:	$80,976	$85,314	$77,632
Chief Investigator:	H.K. Liu		
Partner Investigator:	M. Apperley		
Assoc. Investigator:	B. Zeimetz, T. Chandra		
Research Fellow:	R. Zeng		
Postgrad. Students:	J. Volf		
Industry Partner:	Metal Manufactures Ltd		

The aim of the proposed project is to bring together expertise from UoW's HTS research group and the research and production group at MM Cables HTS Development Facility to study reduction of the heat leak from HTS current leads. The project will focus on minimisation of thermal conductivity using alloyed silver, large silver particle doping and improvement of conductor design on the one hand, and on maximising J_c by adopting optimised processing parameters on the other. Critical issues including general design formulas, effects of thermal cycling on the current leads and transient behaviour in the temperature profile of current leads will be addressed. The outcomes of this research will allow us to design Ag alloy-sheathed HTS current leads with a minimum heat loss, which will ensure greater energy savings and resource conservation.

High Energy Battery for Electric Vehicles

Years funded:	2000	2001	2002
Amount funded:	$71,000	$68,000	$75,000
Chief Investigator:	H.K. Liu, D. Bradhurst, S. Zhong		
Industry Partner:	Electric Transit Pty Ltd, China Liaoning Suppo Battery Ltd, Australian Battery Technology		

The aims of the research will be to study a range of advanced battery electrodes, leading to the development of a high energy battery suitable for powering an electric test vehicle to be provided as an in-kind contribution by our Australian industrial partner. The significance of this research is that it will encourage advanced battery utilisation and manufacture in Australia. The expected outcomes will be the use of advanced batteries by our industrial partner in their Australian-built vehicles and an increased awareness of the advantages of these batteries in competition with the lead/acid types currently used.

Bi-polar electrode materials and design for electric vehicle batteries

Years funded:	1998	1999	2000
Amount funded:	$75,000	$73,000	$73,000
Chief Investigator:	SX Dou, H.K. Liu		
Partner Investigator:	L. Lam D Rand		
Assoc. Investigator:	D. Bradhurst		
Research Fellow:	S. Zhong		
Postgrad. Students:	J. Z. Wang		
Industry Partner:	Taiyi Ltd, Pasminco Ltd		

The proposal's objective, based on an entirely novel design, is to reduce the non-capacity contributing component parts of lead/acid batteries, i.e., the grids and internal connectors, to a considerable degree, or possibly discard them altogether, and to increase the active mass utilization by a proposed new plate manufacturing technique. Specifically, the project will focus on three key areas:

(i) new electrically conducting sheet materials (new alloys/conducting ceramics);
(ii) the coherence of fibre-glass/plastics with the paste (active mass),
(iii) the bipolar electrode fabrication technique.

Investigation of Bi-2223/Ag superconductor winding for application in an electrical fault current limiter

Years funded:	2000	2001	2002
Amount funded:	$99,700	$98,000	$97,000
Chief Investigator:	S.X. Dou		
Industry Partner:	Australian Superconductors Ltd		

As electrical power systems grow in capacity, increased fault current must be managed. Existing electrical equipment in the system has to be able to cope with an increased fault level. The costs of upgrading existing equipment can be enormous; therefore it is necessary to develop a fault current limiter (FCL) which cannot be built using conventional conductors. High T_c superconductors (HTSC) provide an opportunity to develop such an FCL. A HTSC FCL, both its principle, design techniques and performance, will be studied in relation to new HTSC technology. This research will assist the development of a practical HTSC and associated technology for HTSC applications in electrical engineering.

Experimental development of thermionic cooling for domestic refrigeration

Years funded:	2001	2002	2003
Amount funded:	$22,292	$22,292	$22,292
Chief Investigator:	R.A. Lewis, C. Zhang		
Industry Partner:	Email Limited		

The aim is to prove in practice the concept of solid-state cooling by thermionic emission for domestic refrigeration. The proposed experimental work follows naturally from the recent theoretical advances made in this area by us and others. A structure consisting of very thin, alternating layers of semiconductors is calculated to have high cooling efficiency. In contrast to standard compressor-based refrigerators, a refrigerator based on the new concept has no moving parts, is silent, vibration free, environmental friendly and low maintenance. The project links experts in semiconductor physics theory and experiment with Australia's largest manufacturer of domestic refrigerators, whose factory is regionally based (Orange, NSW).

An advanced battery technique charging technique and related apparatus for electric vehicles

Years funded:	2001
Amount funded:	$10,000
Chief Investigator:	S. Zhong, S.X. Dou

This project aims to develop a new, advanced battery recharging technique and related apparatus for electric vehicles (Evs), golf carts, battery-powered wheelchairs and electric bicycles. This innovative charging technique will be one of the critical issues for the successful launch of Evs within the next few years, and the success of this project could lead to the emergence of a new generation of battery charging apparatus with significant advantages over existing types. The expected outcomes will be the manufacturing of the new charging apparatus and its employment by our industrial partners in their Australian-built electric vehicles.

The development and fundamental study of new lithium-ion battery systems

Years funded:	2001
Amount funded:	$10,000
Chief Investigator:	D. Bradhurst, S. Zhong
Assoc. Investigator:	H.K. Liu

This project aims to improve the understanding of electrode processes in novel types of lithium ion rechargeable batteries. New electrochemically active materials of increased energy density will be developed and their structure and properties will be studied in collaboration with scientists in Canada and the USA. The significance of this project is that these new electrode materials could lead to the emergence of a new generation of high energy lithium ion batteries. The expected outcome is a significant contribution to the advanced technology of rechargeable battery materials. A possible longer term outcome could be their profitable manufacture in Australia.

Research Infrastructure Equipment and Facilities (RIEF) Scheme

Multi-layer thin film deposition facility using pulsed laser ablation

Years funded: 1999/2000
Amount funded: $400,000
Chief Investigator: S.X. Dou, H.K. Liu, T. Beales
Partner Investigator: G. Russell, J. Mazierska
Assoc. Investigator: M. Ionescu
Postgrad. Students: D.Q. Shi

This submission sought funding through an ARC RIEF grant to purchase Pulsed Laser Deposition (PLD) facilities. The PLD method consists of sputtering a rotating target using a focused laser beam. The PLD method can be employed to deposit thin films from a wide variety of materials in a single layer or in a multi layer configuration. It has been proven as a reliable method for growing complex ceramic oxides and spinels, as well as for metallic elements or compounds. The main advantages of this method are the high deposition rate and the preservation of stoichiometry during deposition, which is a major problem for complex materials in particular.

In addition, the high energy particles produced as a result of the laser-solid interaction facilitates oriented film growth on the substrate. The laser deposition technique offers the most favourable conditions for the in-situ growth of various films.

High resolution scanning magnetic microscope

Years funded: 2001
Amount funded: $400,0,00
Chief Investigators: S.X. Dou, R.A. Lewis, H.K. Liu
Collaborating Universities: Monash University, University of New South Wales, James Cook University

The high resolution scanning magnetic microscope (HRSMM) is an extremely sensitive near-field imaging system for measuring local magnetic fields. It uses a small, high transition temperature Superconducting Quantum Interference Device as the sensor. It senses magnetic fields down to a field about two million times weaker than Earth' s magnetic field. The HRSMM has wide ranging applications from fundamental research to practical applications in electronic industries. The system can be used to determine the location of short circuits in multi-chip modules or microelectronic circuits, to image rf and microwave magnetic fields from circuits and to detect cracks in superconducting wires and small metal parts by eddy-current imaging .It can also be used to study current limiting mechanisms and vortex configurations in superconductors and detect new magnetic and superconducting materials.

Electrochemical mapping facility

Years funded: 2001
Amount funded: $180,000
Chief Investigators: G. Wallace, H.K. Liu, L. Kane-Maguire, G. Spinks
Collaborating Universities: University of Western Sydney

This proposal seeks to provide advanced state-of-the-art electrochemical equipment, unprecedented in Australia, for researchers at the University of Wollongong and the University of Western Sydney. The equipment will make possible the identification and mapping, at hitherto unobtainable resolution (down to the micron level), of electrochemical processes occurring at the surfaces of a wide range of advanced materials under active development in our laboratories. These materials have a variety of potential applications such as new corrosion-protection coatings, highly selective and sensitive chemical and biochemical sensors, and advanced electrodes for high energy batteries. The equipment will also enable us to undertake exciting new projects such as the assembly of micromachines and microarray systems.

International Research Exchange Program (IREX)

Electro-Magnetic behaviour of high-temperature superconductors in various geometries

Years funded: 2000
Amount funded: $47,649
Chief Investigator: S.X. Dou / E.H. Brandt

The application of high temperature superconductors is currently of high interest. In order to improve the performance of superconducting devices, the material properties of the superconductor have to be optimised by using reliable measuring methods. The aim of this project is to improve these measurements by appropriate theories which correctly account for the geometry of the experiment.

The collaboration is promising since ISEM's research laboratory has performed such experiments on superconductors very successfully since the discover of high-temperature superconductors and Dr Brandt of Max Planck Institut f. Metallforschung, Germany, has developed most of the relevant electromagnetic geometry dependent theories over the last few years.

Investigation of novel metal nickel hydride electrode for rechargeable batteries

Years funded: 2001
Amount funded: $87,178
Chief Investigator: S.X. Dou / J.H. Ahn

Magnesium-nickel alloy has the highest hydrogen storage capacity, lowest cost and least pollution among all of the hydrogen storage materials. However, the slow kinetics of hydriding is a stumbling block in application of this material to rechargeable batteries. The aim of the proposed project is to improve our understanding of the electrode process in new types of rechargeable batteries.

The expected outcomes will contribute to the growing science and technology of rechargeable battery materials, enhancing the Australian manufacturing capability in metal hydride materials. Prof. J.H. Ahn from Andong National University has a world reputation and unique expertise in processing intermetallic materials and will make a significant contribution to the existing collaborative project.

Phase Equilibrium diagram of Ag/Bi203-PbO-SrO-CaO-CuO System

Years funded: 2001
Amount funded: $62,424
Chief Investigator: H.K. Liu / P. Majewski

This project will enhance the strong collaboration between researchers from the University of Wollongong and Max –Planck Instit f. Metallforschung, Stuttgart, Germany, established on the basis of High Temperature Superconductors (HTS) research. Silver (Ag) is widely used as a sheath material for the processing of Bi-based superconducting wires and tapes used for high electric current cables.

Profs. Liu and Majewski are interested in the investigation of the phase relations, the Pb solubility, and the crystallisation of the high Tc (transition temperature) phase from the melt when Ag is present. Experiments on the crystallisation of the high Tc phase out of the melt including Ag will be performed and the collaboration will be continued.

ARC Small Grants Scheme

The development and fundamental study of new lithium-ion battery systems

Years funded: 2001
Amount funded: $10,000
Chief Investigators: D. Bradhurst, S. Zhong
Assoc. Investigators: H.K. Liu

An advanced battery charging technique and related apparatus for electric vehicles

Years funded: 2001
Amount funded: $10,000
Chief Investigators: S. Zhong, S.X. Dou
Assoc. Investigators: D. Bradhurst

Cracking behaviour of silver-sheathed Bi based high temperature superconducting tapes

Years funded: 2000
Amount funded: $8,000
Chief Investigator: Y.C. Guo

Residual critical current in high temperature superconductors

Years funded: 2000
Amount funded: $8,000
Chief Investigator: J. Horvat

Improvement of surface quality of Y-123 high T_c superconducting thin film produced by pulsed laser deposition

Years funded: 2001
Amount funded: $9,000
Chief Investigators: M. Ionescu

Hypersonic laser generation in semiconductors in ultrafast pump and probe experiments

Years funded: 2000
Amount funded: $5,000
Chief Investigators: W. Xu

Preparation and characterisation of advanced nano-crystalline oxide materials based on Australian mineral resources for application in Li-ion batteries

Years funded: 2001
Amount funded: $9,000
Chief Investigators: K. Konstantinov

Optical investigation of colossal- magnetoresistance materials

Years funded: 2000
Amount funded: $8,000
Chief Investigator: R.A. Lewis

Optical study of organic semiconductors

Years funded: 2001
Amount funded: $5,600
Chief Investigators: R.A. Lewis

Far-infrared modulation of photoluminescence from semiconductors in strong magnetic

Years funded: 2000
Amount funded: $5,000
Chief Investigator: R.A. Lewis
Assoc. Investigator: C. Zhang

Exploration of innovative intermetallic alloys as electrode materials for lithium ion batteries

Years funded: 2000
Amount funded: $8,000
Chief Investigator: H.K. Liu

Study of charge and spin ordering and colossal magnetoresistance in perovskite manganites

Years funded: 2001
Amount funded: $9,000
Chief Investigators: X.L. Wang

Department of Energy

Generic high temperature superconducting coils for AC power engineering applications

Years funded:	2000	2001
Amount funded:	$188,150	$50,370
Chief Investigator:	T. Beales, S.X. Dou, C. Cook	

Australian Institute of Nuclear Science & Engineering

Investigation of artificial pinning centres in HTS

Years funded:	1999 - 2000
Amount funded:	$6,550
Postgrad. Student:	D. Marinaro
Supervisor:	S.X. Dou
ANSTO Supervisor:	J. Boldeman

In-situ neutron diffraction for Ag/Bi-2223 tapes with different processing conditions

Years funded:	2000
Amount funded:	$4,200
Postgrad. Student:	X.K. Fu
Supervisor:	H.K. Liu
ANSTO Supervisor:	S. Kennedy

Compensation of boron-doped silicon by neutron transmutation doping with phosphorus

Years funded:	2000
Amount funded:	$13,950
Supervisor:	P. Fisher

Thermal Neutron Irradiation of Ag/Bi-223

Years funded:	2000
Amount funded:	$2,050
Supervisor:	S.X. Dou

Colossal magnetoresistance films grown by laser ablation

Years funded:	2000
Amount funded:	$5,740
Supervisor:	R.A. Lewis

Implant of amorphous tracks in Bi-2212 thin films

Years funded:	2000
Amount funded:	$5,035
Postgrad. Student:	K. Uprety
Supervisor:	M. Ionescu
ANSTO Supervisor:	J. Boldeman

Insitu phase transformation of Bi-2223

Years funded:	2000
Amount funded:	$4,200
Postgrad. Student:	
Supervisor:	M. Ionescu
ANSTO Supervisor:	J. Boldeman

Australian Academy of Science

Investigation of Cathode H-absorbing alloys with high performance

Years funded: 1999 - 2000
Amount funded: $4,000
Chief Investigator: H.K. Liu, S.X. Dou
Partner Investigator: Manqi Lu, Q.Z. Deng

The objective of the collaboration between IMR-CAS and ISEM-UoW is to investigate nickel-metal hydride rechargeable batteries with a view to high energy density and low cost. The research to be carried out covers a wide range of projects from materials aspects to device development. This will play an increasingly important role in the energy industry. The two groups will not only exchange their samples, research results, news, information, experience and researchers, but also support each other for funding applications, joint publications and joint use of facilities.

Scientific Visits to Europe

Years funded: 2000-2001
Amount funded: $4,931
Chief Investigator: R.A. Lewis

Free-electron laser investigations of semiconducting and magnetoresistive materials

Experiments were carried out at the Dutch Free-Electron Laser Facility "FELIX" over a two-week period and an allocation of 8 beam-shifts. A variety of electronic materials were investigated, including GaAs:Be, InP:Zn, GaAs/AlGaAs 2DEG and MgB2. Wavelengths were employed in the range 40 - 110 μm, magnetic fields in the range 0 - 14 T, and temperatures in the range 4 - 300 K. The beam time was spent very productively with much useful data accruing.

University of Wollongong

University Research Council, ISEM Performance Indicators

Year funded: 2000
Amount funded: $149,500

Matching Scholarships

Phase formation and decomposition of high Tc superconductors

Years funded: 1999 2000 2001
Amount funded: $8,100 $8,100 $8,100
Chief Investigator: H.K. Liu
Postgrad. Students: D.Q. Shi

Magnetisation and AC Loss of HTS

Years funded: 1999 2000 2001
Amount funded: $8,100 $8,100 $8,100
Chief Investigator: S.X. Dou
Postgrad. Students: K. Uprety

CMR Materials

Years funded: 2000 2001
Amount funded: $8,100 $8,100
Chief Investigator: H.K. Liu
Postgrad. Students: E. Sotirova

Density evolution during processing Bi-2223

Years funded: 2000 2001 2002
Amount funded: $8,100 $8,100 $8,100
Chief Investigator: H.K. Liu
Postgrad. Students: S.H. Zhou

Conference Presentations

24th Australian and New Zealand Institutes of Physics Condensed Matter Physics Meeting, Wagga Wagga, Australia, 1-4 February 2000

F. Gao, R.A. Lewis, X.L. Wang and S.X. Dou	*Infrared absorption in colossal-magnetoresistance materials.*
C. Zhang and R.A. Lewis	*Effect of electron thermalisation on thermionic cooling in a single barrier structure*

Materials and Mechanisms of Superconductivity High Temperature Superconductors VI, Houston Texas, USA, 20-25 February 2000

W.M. Chen, H.K. Liu, F. Lin, Y.C. Guo, S.S. Jiang and S.X. Dou	*The flux pinning potential of Ag/Bi-2223 tapes for H//c-axis*
W.M. Chen, S.S. Jiang, Y.C. Guo, H.K. Liu and S.X. Dou	*Increase in T_c of $YBa_2Cu_3O_y$ by oxygen plasma treatment*
S.X. Dou	*Connectivity and flux pinning in Ag/Bi-2223 tapes*
T. Hughes, J. Horvat, F. Darmann and S.X. Dou	*Measurement of the a.c. losses in Ag sheathed PbBi2223 tapes with twisted filaments*
A. Gandini, R. Weinstein, Y.R. Ren, R.P. Sawh, D. Parks, Y.C. Guo, B. Zeimetz, S.X. Dou, S. Tönies, C. Klein and H.W. Weber	*Critical current enhancement in $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ tapes via isotropic quasi-columnar defects, induced by uranium fission products*
X.K. Fu, Y.C. Guo, H.K. Liu and S.X. Dou	*Improvement in critical current density of Ag-Mg alloy sheathed Bi-2223 tapes by cryogenic pressing*
F. Gao, R.A. Lewis, X.L. Wang and S.X. Dou	*Infrared absorption of lanthanum manganites*
J.X. Jin, S.X. Dou, F. Darmann, M. Apperley and T. Beales	*Development of an HTS inductor for an electronic high voltage generator"*
J.X. Jin, H.K. Liu, R. Zeng and S.X. Dou	*Developing a HTS magnet for high gradient magnetic separation techniques"*
J.X. Jin, X.K. Fu, H.K. Liu and S.X. Dou	*Performance and applications of bulk Bi-2223 HTS bars produced using a hot-press technique*
J.X. Jin, S.X. Dou, C. Cook, C. Grantham, M. Apperley and T. Beales	*Magnetic saturable reactor type HTS fault current limiter for electrical application*
H.K. Liu, W.M. Chen, A. Polyanskii, Y.C. Guo, G. MacCaughey, S.X. Dou, D. Larbalestier and M. Apperley	*The effect of intermediate deformation processing on J_c of Ag/Bi-2223 tapes*
D. Marinaro, S.X. Dou, J. Horvat, Y.C. Guo, J. Boldeman, A. Gandini, R. Weinstein, R. Sawh, Y. Ren	*The effects of uranium doping and thermal neutron irradiation on the pinning properties of Ag/Bi-2223 tapes*

D. Milliken and S.X. Dou	*Chemistry of uranium compound doping in $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$/silver superconducting tapes*
S. Tönies, H.W. Weber, D. Milliken, Y.C. Guo, S.X. Dou, A. Gandini, R. Sawh, Y. Ren and R. Weinstein,	*Influence of neutron irradiation on the superconducting properties of BiSCCO-tapes containing different amounts of uranium*
K.K. Uprety, J. Horvat, X.L. Wang, G.D. Gu, H.K. Liu and S.X. Dou	*Field and temperature dependence of critical current density of Fe doped Bi2212 single crystals*
K.K. Uprety, J. Horvat, X.L. Wang, M. Ionescu, H.K. Liu and S.X. Dou,	*Flux creep in heavily lead doped Bi2212 single crystal*
X.L. Wang, J. Horvat, H.K. Liu, S.X. Dou, G. Heine and W. Lang	*Origin and characterisation of peak effect in pure and Pb doped Bi-2212 single crystals"*
R. Weinstein, Y. Ren, R. Sawh, A. Gandini, W. Hennig, M. Murakami, T. Mochida, N. Chikumoto, N. Sakai, G. Krabbes, W. Bieger, D. Milliken, S.X. Dou, S. Tönies, M. Eisterer and H.W. Weber	*Properties of HTS for successful U/n processing*

10th International Meeting on Lithium Batteries, Como, Italy, 28 May- 2 June, 2000

G. X. Wang, M.J. Lindsay, M. Ionescu, D. H. Bradhurst, S. X. Dou and H. K. Liu,	*Physical and Electrochemical Characterization of $LiNi_{0.8}Co_{0.2}O_2$ Thin Film Electrodes Deposited by Laser Ablation*
G. X. Wang, Jung-Ho Ahn, M.J. Lindsay, L. Sun, D.H. Bradhurst, S. X. Dou and H. K. Liu	*Graphite-tin Composites as Anode Materials for Lithium-ion Batteries*

International Cryogenic Materials Conference: Superconductors for Applications, Material Properties and Devices, Rio de Janeiro, Brazil, 11-15 June 2000

S.X. Dou, D. Marinaro, D. Milliken, Y.C. Guo, J. Horvat, R. Weinstein, A. Gandini, R. Sawh, Y. Ren S. Tönies, H. Weber	*Critical current density and flux pinning in Uranium compound doped Ag/Bi-2223 tapes*
W.M. Chen, Y.C. Guo, G. McCaughey, H.K. Liu, S.X. Dou and M. Apperley	*Effect of various mechanical deformation techniques on critical current densities of Ag/Bi-2223 tapes*

Applied Superconductivity Conference, Virginia Beach, Virginia, U.S.A., 17-22 June, 2000

F. Darmann, G. McCaughey, M. Apperley, T. Beales, R. Zeng, R. Hughes	*AC loss in Ag sheathed PbBi2223 tapes with twisted filaments and A1203/MgO barrier layers in the presence of an applied AC magnetic field.*
J. Horvat, T. Hughes, S.X. Dou, F Darmann	*Transverse resistivity in Bi2223/Ag tapes*

D. Shi, M. Ionescu, S.X. Dou, J. Yang	*Growth of Gd203/CeO_2 buffer layer on rolled-Ni substrates by pulsde laser deposition*
D. Shi, M. Ionescu, S.X. Dou	*Microstructure of CeO2 buffer layer on the YSZ and sapphire deposited by PLD*
M. Apperley, F. Darmann, G McCaughey	*Alloy sheathed Bi-2223 tapes with engineered properties*
R. Zeng, H.K. Liu, T.P. Beales, S. X. Dou	*Homogeneity and current transport distribution in Ag sheathed Bi-2223 multifilamentary tapes*
H.K. Liu, R. Zhen, W.M. Chen, Y.C. Guo, G. McCaughey, S.X. Dou, A. Polyanskii, M. Apperley	*Magneto-optical imaging for Ag/Bi-2223 tapes processed by using various processes*
W.M. Chen, S.S. Jiang, H.K. Liu, S.X. Dou	*The upper critical field Hc2 of Ag/Bi-2223 tapes*
S. Tönies, H.W. Weber, D. Milliken, Y.C. Guo, S.X. Dou, A. Gandini, R. Sawh, Y. Ren, R. Weinstein	*Improved in-field transport behaviour of uranium doped BiSCCO tapes by enhanced flux pinning*
S.X. Dou	*Grain connectivity and flux pinning in Ag/Bi-2223 tapes*
X.K. Fu, Y.C. Guo, H.K. Liu, S.X. Dou	*Influence of deformation rate and post annealing on critical current density of textured Bi-2223 current leads*
D. Milliken, S.X. Dou, J. Horvat, J. Boldeman, R. Weinstein	*Effect of uranium doping and thermal neutron irradiation on Ag/Bi-2223 tapes*

Dalian Science & Technology Forum, 1-4 July, 2000 (invited presentation)

S.X. Dou	*Recent Developments in High Temperature Superconductors*

2000 International Semiconducting and Insulating Materials Conference, SIMC-XI, Canberra, Australia, 3-7 July 2000

R.L. Causley and R.A. Lewis	*Characterisation of Indium Phosphide using Terahertz Radiation.*

25th International Conference on the Physics of Semiconductors. Osaka, Japan, September 17-22, 2000.

P.C. Jobe Prabakar, P. Fisher & R.E.M. Vickers	*Zeeman and piezospectroscopy of some axial defects in germanium*

9th International Conference on Shallow-Level Centers in Semiconductors, SLCS-9, Awaji Island, Japan, 24-27 September 2000

R.L. Causley and R.A. Lewis	*Far-infrared Spectroscopy of the Zinc Acceptor in Indium Phosphide*
P.Fisher, R.E.M. Vickers, B.D. Crowe and A. B. Rozenfeld.	*Impurity spectra in Ge due to bulk stress from surface strain.*

International Symposium on Metalstable, Mechanically Alloyed & Nanocrystalline Materials (ISMANAM-2000), 9-14 July, 2000 Oxford, United Kingdom

J.H. Ahn, G.X. Wang, M.J. Lindsay, S.X. Dou and H.K. Liu	*Mechanically Milled Nanocrystalline Ni3S4 and FeSi2 Alloys as an AnodeMaterials for Li-ion Batteries*

Pacific Lithium Ltd, New Zealand, 27 November 2000 – (invited presentation)

G.X. Wang	*Electrode Materials for Lithium-ion Batteries*

Conference on Computational Physics 2000, CCP2000, Gold Coast, Australia, 3-8 December 2000

B.C. Lough, S.P. Lee, R.A. Lewis & C. Zhang	*Electronic Thermal Transport and Thermionic Cooling in Semiconductor multi-quantum-well Structures*

Conference on Optoelectronic and Microelectronic Materials and Devices, COMMAD2000, Melbourne, Australia, 6-8 December 2000

B.C. Lough, S.P. Lee, R.A. Lewis & C. Zhang	*Thermionic Cooling of Optoelectronic and Microelectronic Devices*

14th National Congress of the Australian Institute of Physics, University of Adelaide, South Australia, 10-15 December 2000 (invited talk)

R.A. Lewis	*Optical studies of colossal magnetoresistance*
S. Lee, R.A. Lewis, B. Lough and C. Zhang	*Thermionic cooling in semiconductor multilayers*

Seminars by Visiting Scientists

Apr 5	Prof X.L. Lei	Shanghai Institute of Metallurgy, Chinese Academy of Sciences *Balance-Equation Approach to Electron Transport and Optical Absorption in Semiconductors under Terahertz Radiations*
Apr 20	Dr E.H. Brandt	Max-Planck-Instit fur Metallforschung, Germany *Magnetic Behaviour of Superconductors in Various Geometries: Introduction*
May 18	Prof A. Bourdillon	National University of Singapore, Singapore *Ultra High Resolution Lithography using Demagnification by Bias*
May 24	M. Reinhard	Radiation Physics Group, University of Wollongong *Neutron Skyshine and Neutron Shielding Measurements at a 3 MV Van de Graaff Accelerator*
Aug 14	Dr E. Hellstrom	University of Wisconsin-Madison, USA *Challenges to Process High Jc Ag-sheathed 2212 tapes*
Aug 15	Prof J.H. Ahn	Dept. of Materials Eng., Andong National University, South Korea *Nanomaterials for Anode of lithium ion battery*
Aug 17	Dr M. Das	Institute for Advanced Studies, Canberra *Transport and Fluctuations in Mesoscopic Conductors*
Sep 1	Dr B. Ammundsen	Pacific Lithium (NZ) Limited, New Zealand *Novel Layered Oxide Cathode Materials for Lithium-Ion Batteries*
Oct 9	R. Griessen	Vrije University, Amsterdam, The Netherlands *Switchable Mirrors*
Oct 9	Dr J. Chen	Osaka National Research Institute, Japan *Recent R&D on Hydrogen Storage Materials*
Oct 11	Prof J.Y. Lee	KAIST, South Korea *The Improvement of Electrochemical Performance of Li-ion Batteries by Coating Techniques*

Equipment and Facilities

ISEM facilities contain 9 laboratories with a floor space of approx 420m^2 comprising modern facilities for processing and characterization of HTS and energy storage materials; materials processing and a full range of materials characterization.

The majority of these facilities were founded through 6 ARC RIEF programs and the Metal Manufactures Ltd Consortium program over the past six years.

The following institutions and Chief Investigators have been involved with the ARC RIEF proposals:

Australian National University	Dr M. Das
Australian Nuclear Science & Technology Organisation	Dr E.R. Vance
CSIRO	Dr N Saviddes, Dr K Müller
Curtin University	Prof D.Y. Li and Dr I. Low
Griffith University	Dr S Myhra
James Cook University	Prof. J. Majierska
Monash University	Dr S Ringer, Dr Y.B. Cheng Dr. R. Krishanmurthy
Queensland University of Technology	Dr P.D. Killen
RMIT	Prof PJK Paterson
University of Melbourne	D.N. Jamieson
University of NSW	Prof. G. Russell, Prof. C Grantham, Dr B Gleeson, Dr R. Ramer
University of Queensland	Prof D.R. Mackinnon
University of Technology, Sydney	Prof J. Smith and Prof J.N. Bell

Materials Processing Facilities

- Freeze Drier, Lyph-Loch 4.5, 4.5l/24h
- Spray Drier, GA-32, ~100g/h
- Attrition Mill, 01-HD, 0-660rpm
- Planetary Mill, pulverisette 5, 0-300rpm agate
- Drawing Bench, 8m, fixed die, 11.5kW
- High energy ring mill
- Ultrasonic spray unit, 10-30μm droplets, 0.1-1 litre/hour
- Bull Block, 22cm diameter
- Rolling mill, 2 x 60mm flat & square rollers, 5cms
- Rolling mill, 2 x 55mm supported rollers, 5cm/s
- Swagging machine, 15-1mm diameter
- Hydraulic press, 10t-100t
- More than 30 various furnaces
- Controlled atmosphere glovebox

Thin Film Deposition Facility

- Excimer laser, ComPex301, 9W, 10Hz, 248nm
- Thin Films Depositon Chamber, 18" dia. With high vacuum system

Materials Characterisation

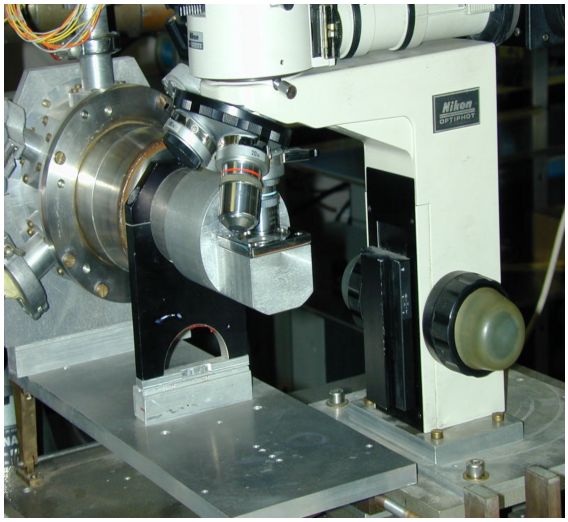
- DTA/TG, Setaram, 18-92, 1750°C
- XRD for Single Crystals
- TEM, J2000FX1, with EDS
- Gas absorption analyzer Nova 1000 for BET and pore size analyses
- XRD, M18XHFCu rotating anode, with HT 2000°C camera
- SEM, Stereoscan 440, with EDS and EBSP
- AFM, Nanoscope IIIa
- Particle Size Analyser, Mastersizer S, 0.05-900μm
- XRD, PW1050, 3kW; XRD Texture, PW1078, 3kW
- DSC, TA300,-170°C+600°C

Physical Property Characterisation

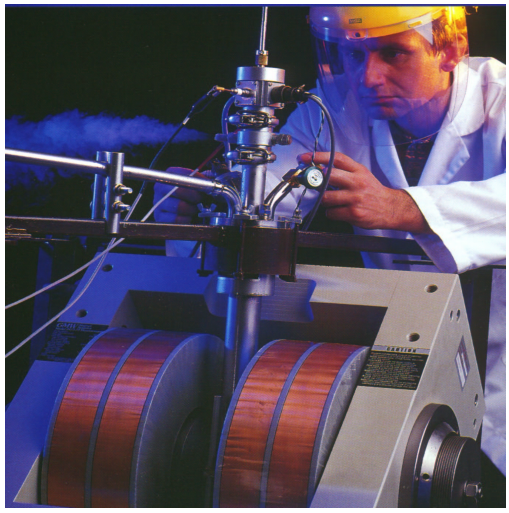
- PPMS, 2-400K, 0-9T DC field
- Horizontal field superconducting Magnet, 0-8T, 5-300K
- Lock-in Amplifier, SR510; Lock-in Amplifier, SR830DSP, PAR 5209 Lock-in Amplifier, PAR 124 Lock-in Amplifier
- Magneto Optical Imaging, 12K-300K
- Electromagnet, HSV-4H1, 2T, 100mm pole diameter
- Five power supplies (HP and Keithley) 0-900A
- Cryogenic Temperature Controller, ITC4, 0-500K
- SR560 low-noise preamplifier
- Pacific Power 3120 AMXoc current source, 12 kVA
- Spectrometers, Bomem DA3 - fast scan interferometer, Polytec FIR 25 (modified) - slow scan interferometer, Beckman FS 720 - slow scan interferometer, SPEX 1402 double grating 1 m instrument, SPEX 1704 single grating 1 m instrument, 2xSPEX 1870 single grating 0.5 m instruments
- Ballantine 1620 transconductance amplifier (up to 100A)
- Magnets, Oxford Instruments superconducting, 2x4 inch iron-cored, Rawson-Lush gaussmeter
- Cantilever (torque force) magnetometer
- Various multimeters, HP and Keithley, including a nano-voltemeter
- VSM, Maglab, 2-400K, 0-12T DC field CTI 8001/8300 cryocooler
- Thermal conductivity measurement
- Function Generator, DSC340; Digital Oscilloscope, TDS320
- Digital Teslameter, DTM-132, with Hall Probe; Fluxmeter, 916
- He Recovery System, including liquefier – 40 litres/day
- Eddy current generator
- Electromagnet, 3473-70, 2T, 150mm pole diameter, Rawson-Lush Gaussmeter
- Lasers, Spectra Physics Model 2040 25 W Ar^+, Spectra Physics Model 165 6 W Ar^+, Spectra Physics Model 3900 Titanium-sapphire, Spectra Physics Model 380 Dye, Spectra Physics 15 mW HeNe
- Detectors, 4xInfrared Laboratories bolometers, Infrared Laboratories bolometers Ga-doped Ge photoconductor, N. Coast Scient. Corp Ge photoconductor, Photomultiplier with GaAs photo-cathode
- Cryostats, A number of L He with optical access, L N cryostats, 60 l L He storage, 30 l L He storage,, 60 l L N storage, 50 l L N storage, 2x30 l L N storage, 25 l L N storage, A system for recovering and compressing He gas is in place
- Leak detector Vacuum system

Chemical Property Characterisation

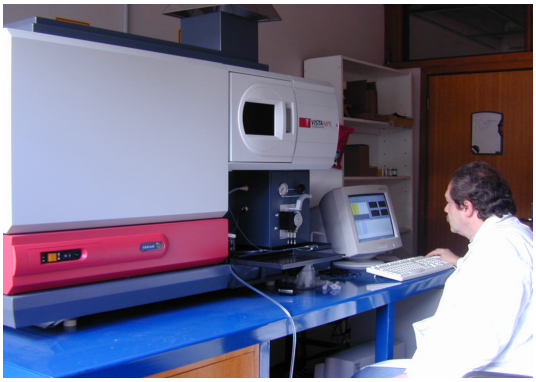
- Cyclic Voltammograph, BAS CV-27
- Impedance Analyser, M6310
- Temperature Controlled Water Bath, F10-MF
- Four Channels Data Collection System, MacLab/4e
- ICP-OES, Vista MPX simultaneous axial spectrometer, 167-785nm range 0.009nm resolution 200nm
- Scanning Potentiostat, M326; Potentiostat, M363
- Power Supply, DCS 20-50, 0-20V, 0-50A
- Eight Channels Data Collection System, MacLab/8
- Controlled Atmosphere System (Glove Box), OP7
- Amplifiers, PAR 124A Lock-in, 2xPAR 5209 Lock-in, Stanford Research SR510



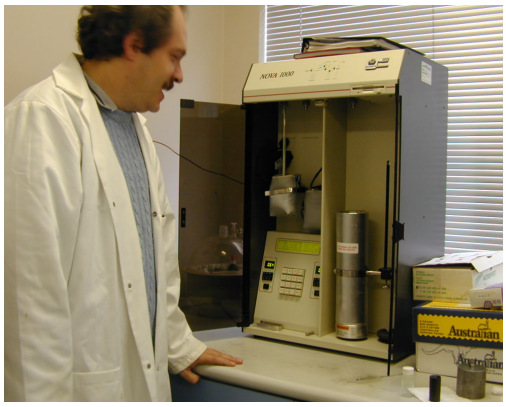
Magneto-Optical Imaging with
Cryocooler from 12K to 300K



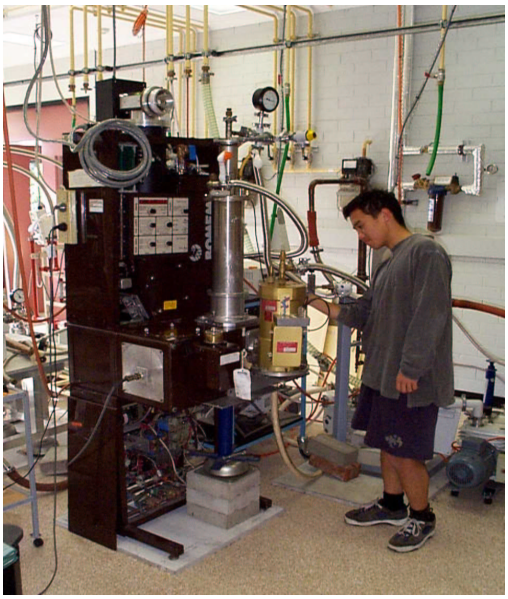
Cryostat with 360° Rotating 2T Magnet



ICP-OES, Vista Simultaneous
Axial Spectrometer



Gas Absorption Analyser Nova 1000
for BET and Pore Size Analyses



Bomem Interferometer

VSM, Maglab, 2-400K, 0-12T DC Field

Refereed Publications

High Temperature Superconductivity Program

M. Apperley, R. Zeng, F. Darmann and G. McCaughey, "Properties of Ag-Mg alloy sheathed Bi-2223 tapes", *Cryogenics* **40** 319-324 (2000)

W.M. Chen, S.S. Jiang, Y.C. Guo, H.K. Liu and S.X. Dou, "Increase in T_c of $YBa_2Cu_3O_y$ by oxygen plasma treatment", *Physica C* **341-348**, 2451-2452 (2000)

W.M. Chen, H.K. Liu, F. Lin, Y.C. Guo, S.S. Jiang and S.X. Dou, "The flux pinning potential of Ag/Bi-2223 tapes for H//c-axis", *Physica C* **341-348**, 1353-1354 (2000)

W.M. Chen, F. Wang, F. Lin, S.S. Jiang, Y.C. Guo, H.K. Liu and S.X. Dou, "Angular distribution of crystal grains in polycrystal Bi-2223/Ag tape", *Adv. in Cryogenic Eng. Mater. Proc. Int. Cryogenic Mat. Conf*, Montreal, Quebec, Canada, 12-16/7/99, 519-526 (2000)

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Funding 2000

Australian Research Council Grants

ARC Large Scheme Grants

S.X. Dou	Growth mechanism & flux pinning in spiral grown HTS crystals	$62,488	
H.K. Liu	Cryogenic deformation and high T_c phase formation-partial decomposition of superconducting tapes	$62,000	
H.K. Liu	Current limiting mechanism in Ag sheathed (Bi,Pb)SrCaCuO tapes using magneto-optical imaging and magnetic force microscopy	$62,000	
W. Xu	Optical & electrical generation of far-infrared laser emission from semiconductor quantum well system	$53,000	**$239,488**

ARC Small Scheme Grants

W. Xu	Hypersonic laser generation in semiconductors in ultrafast pump-and-probe experiments	$5,000	
H. K. Liu	Exploration of Innovative intermetallic alloys as electrode materials for lithium ion batteries	$8,000	
Y.C. Guo	Cracking behaviour of silver-sheathed Bibased high temperature superconducting tapes	$8,000	
R.A. Lewis	Optical investigation of colossal - magnetoresistance materials	$8,000	
R.A. Lewis	Far-infared modulation of photoluminescence from semiconductors in strong magnetic fields	$5,000	
J. Horvat	Residual critical current in high temperature superconductors	$8,000	
C. Zhang	Solid state power generation & refrigeration based on metal-semicond. superlattices andmultilayer systems	$5,000	**$47,000**

ARC Fellowship Scheme Grants

H.K. Liu	Sen. Res. Fellow, Optimisation of thermal & mechanical Processing & critical current density High T_c superconducting ag-clad Bi(Pb)SrCaCuO Tapes	$90,666	
Y.C. Guo	APDA, Silver Alloy Sheathed HTS wires	60,000	**$150,666**

ARC Strategic Partnerships with Industry – Research & Training (SPIRT)

S.X. Dou, T. Beales & E.W. Collings	Effective transverse resistivity of Bi-HTS tapes	$94,442	
S.X. Dou, H.K. Liu L. Lam and D. Rand	Bi-polar electrode materials for design vehicles Lead-Acid Battery	$65,552	
S.X. Dou, M. Apperley	Investigation of Bi-2223/Ag superconductor winding for application In electrical fault current limiter	$99,700	
J. Horvat & M. Ionescu	Substrate for large area YBCO film depositon by laser ablation	$22,283	
H.K. Liu, D Bradhurst S. Zhong	High Energy Batteries for electric vehicles	$73,000	
H.K. Liu, M. Apperley RP Zhao, B. Zeimetz, T Chandra	Reduction of heat leak of high T_c superconducting current leads	$85,314	**$440,291**
Sub Total			**$877,445**

Carried forward			**$877,445**
ARC international Researcher Exchange Program (IREX)			
S.X. Dou	Electromagnetic behaviour of HTS in various geometries	$47,000	
JH Ahn	Preparation of nanocrystalline alloys by mechanically activated annealing		
W. Xu	Nonlinear transport and optical properties of semiconductors		
		$13,000	**$60,000**
Department of Energy of NSW			
T. Beales, S.X. Dou, C. Cook	Generic HTS coils for AC power engineering applications		**$188,150**
Australian Academy of Science			
H.K. Liu, S.X. Dou	Investigation of cathode H-absorbing alloys with high performance	$4,000	
R.A. Lewis	Scientific visits to Europe	$4,931	**$8,931**
Australian Institute of Nuclear Science & Engineering			
S.X. Dou	Thermal Neutron Irradiation of Ag/Bi-2223	$2,050	
P. Fisher	Compensation of boron-doped silicon by neutron transmutation doping with phosphorus	$13,950	
M. Ionescu	Insitu Phase Transformation of Bi-2223	$4,200	
M. Ionescu	Implant of amorphous tracks in Bi-2212 thin films	$5,035	
R.A. Lewis	Colossal magnetoresistance films grown by laser ablation	$5,740	
D. Marinaro, S.X. Dou	Special Postgraduate Award	$6,550	
H.K. Liu	In-situ neutron diffraction for Ag/Bi-2223 tapes with different conditions	$4,200	**$41,725**
Industry Grants			
Metal Manufactures Ltd		$115,000	
Lexel Battery Co Ltd		$30,000	
Suppo Battery Co Ltd		$12,000	**$157,000**
Department of Education Training & Youth Affairs			
Scholarships			**$175,000**
University of Wollongong Support			
ISEM Performance Indicators		$145,900	
Faculty of Engineering funding		$15,000	
ISEM Management Fund		$75,000	
Director's costs		$141,000	
Postgraduate student maintenance funds		$18,000	
Scholarships		$205,000	**$599,90**
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