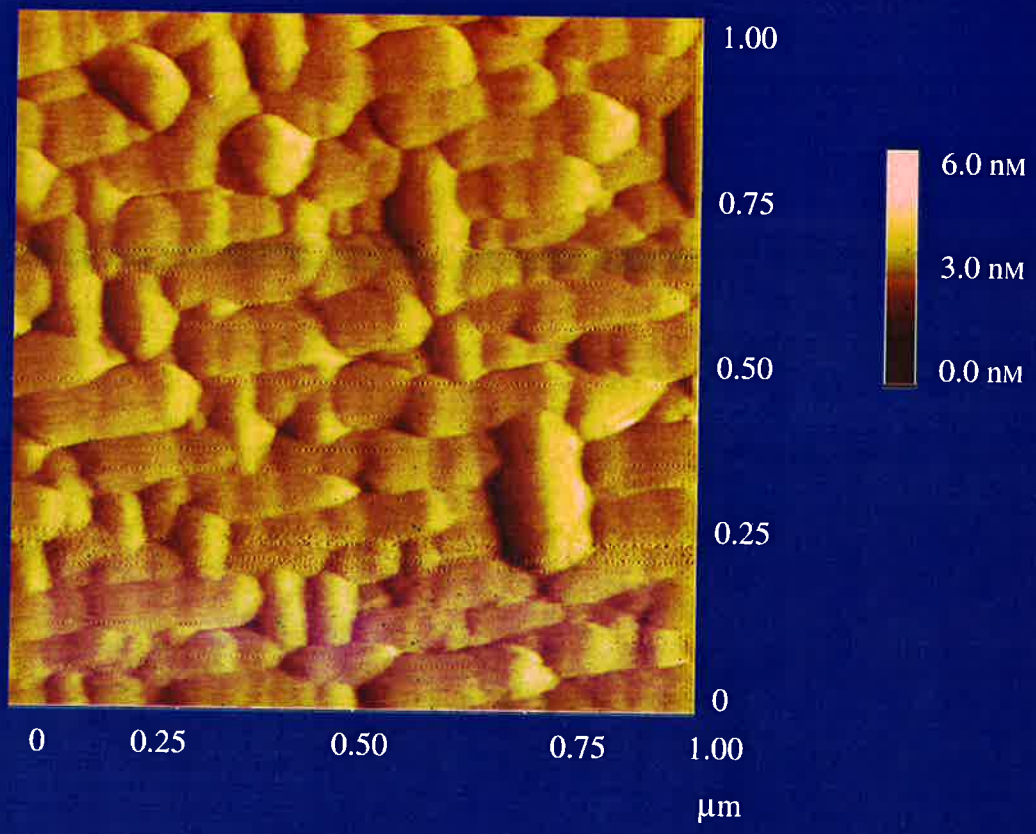
1999
Annual Report



Institute for Superconducting & Electronic Materials

University of Wollongong

Contents

Professor SX Dou
Director
e-mail: shi_dou@uow.edu.au

Dr M Ionescu
Assistant Director
e-mail: mionescu@uow.edu.au

Mrs B M Allen
Administration Officer
e-mail: babs_allen@uow.edu.au

Telephone: 61+2 4221 5730
Facsimile: 61+2 4221 5731
Web site : http://www.uow.edu.au/eng/ISEM

Cover: Surface morphology of CeO_2 buffer layer for YBCO coated conductor obtained using Atomic Force Microscope

Director's Report

1999 was a year of consolidation and continuing success in research and postgraduate training at ISEM. The University of Wollongong was awarded the Good Universities Guide *"Australian University of the Year 1999-2000" for its outstanding research and development partnerships.* There is no doubt that our institute has made an important contribution to the success of our university. The research progress made in three programs are briefly outlined as follows:

High Temperature Superconductivity Program

Research on the ARC project "Microstructure and Flux Pinning in HTS Tapes" has generated some very interesting results. An innovative technique of uranium doping and neutron irradiation has been used in processing Bi-based superconducting tapes. Fission tracks induced by using this method, act as effective pinning centers in Ag-clad Bi-based superconducting tapes, resulting in an enhancement of more than an order of magnitude in J_c(H//ab) in fields higher than 3 T, and 250 times enhancement of J_c(H//c) at 0.7 T at a U-doping level of 0.6 %. Anisotropy was reduced by 23 times at 0.5 T, at a U-doping level of 0.6 %. The irreversibility field was doubled for H//ab and trebled for H//c, due to thermal neutron irradiation. The Ag radioactivity was reduced by two orders of magnitude at a U-doping level of 0.6 %, compared to fast neutron irradiation without U-doping. This technique has been proven to be the most promising one by far, for applications using high temperature superconducting tapes. This project has been carried out in close collaboration with Prof. R. Weinstein's group at the University of Houston, Prof. H. Weber's group at the Atomic Institute and Dr. J. Boldeman at ANSTO.

In the ARC project "Growth Mechanism and Flux Pinning in Spiral Grown HTS Crystals" the origins of the spiral growth mechanism and the influence of spirals and associated defects on the flux pinning characteristics of doped and undoped $Bi_2Sr_2CaCu_2Oy$ (Bi2212) and $Bi_2Sr_2Ca_2Cu_3Oy$(Bi2223) monocrystals were investigated. In contrast to the weak peak effect in pure single crystal material, the Pb-doped crystals showed a very strong peak effect over a very wide temperature range, from 20 K up to T_c. It was concluded that enhanced pinning by Pb-doping was caused by increased c-axis coupling. The nanometer-size laminae observed in heavily Pb-doped Bi2212, are likely to be responsible for the variable range-hopping processes observed at the secondary peak. An improvement in the flux pinning in Bi2212 single crystals can be achieved by increasing the c-axis conductivity. It is therefore important to search for dopant atoms that can generate large c-axis conductivity.

In the ARC SPIRT Project, "Effective Transverse Resistivity of Bi-2223 Tapes" 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 has been studied. Measurements of ac loss in an external field parallel to the tape face were performed using a saddle-shaped pick-up coil. The losses for untwisted tape at 37 Hz and field amplitude smaller than 0.05 T could be well accounted for using a model for losses of a superconductor with fully coupled filaments. The twisted tape results, however were in closer agreement with the model of fully uncoupled superconducting filaments below a field amplitude of 5 mT. A new experimental method has been developed for measuring ac losses and transverse resistivity in the tapes. The losses and transverse resistivity can be obtained by measuring magnetic hysteresis loops with different sweep rates of the field. The losses in the silver matrix are proportional to the sweep rate of the field and to the square of the tape length. This makes it possible to distinguish the losses in the silver from the losses in the superconductor.

In the SPIRT Project, "High Temperature Superconductor High Gradient Magnetic Separator", the required characteristics of high-gradient magnetic separators, and thus the required performance of HTS magnet and cryogenic systems, have been studied. HTS magnets suitable for the high gradient magnetic separator (HGMS) have been designed through both theoretical and experimental analysis. $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$ Ag clad HTS wire has been prepared, tested and analyzed for an HGMS application. Such a magnet can generate a maximum field ~2 T with winding size ϕ_{in}=3.2 cm, ϕ_{out}=12 cm, h=10.5 cm.

These preliminary studies have shown that HTS wire techniques are available for making a practical HGMS magnet. The experimental work has established that Fe_2O_3 removal from the Kaolin samples, sufficient to improve the brightness, requires magnetic field strengths above 3 T.

In the ARC Large Project "Cryogenic Deformation and High Tc Phase Formation-Partial Decomposition of Superconducting Tapes", the effect on phase composition of the final cooling process has been investigated. On cooling, the liquid phase is converted to either an amorphous phase, superconducting or impurity phases, dependent on the cooling step. The optimal annealing temperature to convert the liquid to 2223 was found to be 825°C. The composition of phases formed during cooling had a significant effect on grain connectivity and flux pinning in the tapes. The residual liquid phase was largely responsible for weak links, substantially reducing J_c. Under fixed thermal conditions the physical density was found to be the single most important influence on J_c. The cryogenic pressing process significantly improved critical current density, as a result of higher core mass density, better grain alignment, and a smoother sheath/ oxide core interface for Ag-Mg alloy sheathed tapes. The significant J_c variation with increasing deformation rate for both cryogenic and normal pressed tapes is attributed to their different microstructures.

In the ARC SPIRT Project, "Reduction of Heat Leak of High T_c Superconducting Current Leads", an analytical model for optimising the length of HTS tapes in tapered current leads was derived. A general equation to calculate the heat leak has been obtained. Numerical results for different sheath alloys used in the tapes showed that the optimum length is extremely sensitive to alloy composition. Bi-2223 bar current leads were fabricated by a new method, a combination of cold isostatic pressing and hot-pressing (HP). J_c achieved by this method exceeded 1000 A/cm^2 at 77 K in a self-generated magnetic field. The effect of the deformation rate due to hot-pressing and annealing in 7.5 % O_2/ N_2 on the critical current density of $(Bi, Pb)_2Sr_2Ca_2Cu_3O_y$ current leads has been investigated. The results revealed that the deformation rate due to both hot-pressing and annealing in a low oxygen atmosphere affected critical current densities significantly.

In the ARC SPIRT project "Substrates For Large Area Y-123 Films Obtained By Pulsed Laser Deposition", a pulsed laser deposition (PLD) system was set-up, consisting of an 18" stainless steel chamber with various ports. The substrate heater is a hot plate, capable of heating the substrates up to 1,000°C. A Lambda Physik Compex 301 laser is used as the ablation source. Y123 small-area films were grown on MgO and Yttrium Stabilised Zirconia (YSZ) substrates. XRD techniques showed the films were of high quality and grown epitaxially. Apart from Y-123 films, other high-quality films have been grown, such as CeO_2 on single crystal YSZ and on biaxially textured Ni ribbon; $La_{0.8}Ca_{0.2}MnO_3$ on single crystal MgO; $LiNi_{0.8}Co_{0.2}O_2$ on polycrystalline stainless steel and Ni, and on biaxially textured Ni. This facility has substantially enhanced our capability for processing various materials in the form of thin films.

A small ARC grant was obtained to study new CMR materials. Very encouraging results have been achieved on the fabrication and characterisation of various CMR materials. This has opened a new direction for future research work. It also plays an important role in bringing the HTS group and the solid state physics group together through sharing expertise and facilities.

Energy Storage Materials Research Program

The aim of the ARC SPIRT project "Novel Bi-polar Electrode Materials and Design for Electric Vehicle Lead-Acid Batteries" is to design and to demonstrate the advantages of this technology for electric-vehicle applications. New pastes and new processing procedures are used to fabricate test batteries without using the conventional curing and drying processes. The new process reduces the total time for manufacturing lead acid batteries by one third. More important for the current project is that the new process can make the bipolar-electrode fabrication process more convenient. The addition of tin into the alloy was found to have a beneficial effect in strengthening the electrode materials and improving the characteristics of the grid-active material interface, preventing formation of a passivating film on the electrode.

Due to the lightweight, high conductivity and good mechanical properties of aluminium, alloying lead with aluminium produces alloys which have higher electrical conductivity, reduced weight and increased creep resistance when compared with conventional lead alloys.

A project of "High Energy Storage Materials (Mg_2Ni Alloys) for Rechargeable Nickel-Metal Hydride Batteries" has been successfully carried out with support of a small ARC grant and industrial partner funding. It was found that Mg-based alloys with amorphous structures can be used for Mg-based alloy electrodes with very high discharge capacities in comparison with crystalline Mg_2Ni alloys. A large number of element substitutions into electrode materials were systematically investigated for their effects on fabrication conditions, electrochemical properties, energy densities and cycle life. A project on "Comparative Studies Of Copper Alloys And Nickel Alloys As Electrode Substrate In Nickel Metal Hydride Rechargeable Batteries" has been undertaken to provide the information needed for manufacturing electrodes in nickel metal hydride rechargeable batteries.

In the project on "Investigation of New Cathode Materials and New Anode Materials used for Lithium-Ion Rechargeable Batteries" a large number of lithium containing compounds such as those in Mn-based and Ni-based systems have been fabricated and tested as cathode and anode electrode materials. Prototype lithium ion batteries have been designed and constructed. The results are very promising in terms of both fundamental research and industrial applications.

Solid State Research Program

The research within the solid state physics program focuses on several areas of solid state physics:

Physics of thermionic cooling and power generation in semiconductor multilayers (Zhang and Lewis). Theoretical and experimental work are being carried out to increase our understanding of electronic thermal conduction across multilayered systems and to develop an optimal design for an electron cooling engine. A new mechanism involving electron thermalisation to enhance the thermal efficiency has been proposed.

Impurity states in silicon and germanium (Fisher, Freeth, Rosenfeld, Vickers). This work mainly involves experimental measurements of the electronic and optical properties of impurity states in germanium under various external conditions such as magnetic field, temperature and pressure. Recently we developed a new method to manipulate the internal stress of germanium with the use of ultrasound (Fisher, Vickers and Rosenfeld).

Terahertz generation and imaging (Zhang and Xu). The work involves the theoretical study of light emission from layered semiconductors and the interaction of terahertz lasers with solid state and biological materials.

FIR study of CMR materials (Lewis and Martin). We are carrying out measurements on the frequency dependent transmission and reflection of CMR materials in the FIR regime to identify various phonon modes and their coupling to the FIR laser in CMR materials.

Research Grants

We have had continuing success in ARC funding applications, with a record high success rate of 13 different ARC grants obtained in 1999. Currently, we have five ARC fellows at various levels: H.K. Liu (SRF), Y.C. Guo (PDF), J.X. Jin (PDF), S. Zhong (PDF) and T. Hughes (Int. PDF). We have been particularly successful in the International Exchange Program. Following the success of International Research Fellow, Dr V. Rouessac from the University of Caen, France, we were fortunate to obtain the services of Dr. T. Hughes from Southampton University, United Kingdom. I congratulate Dr. Hughes for his significant contribution and dedication to our laboratory upgrading and the excellent research work on ac loss. Dr. E.H. Brandt from Max-Planck Institute was awarded a prestigious ARC International Professorial Fellowship sponsored by our institute and will be joining us in 2000. Due to our excellent ARC grant success we have increased the number of research staff. Dr. K. Konstantinov, Dr. Y. Kopelevich, Dr. M.J. Qin, Dr. T. Silver, Dr. X.L. Wang and Dr R. Zeng have been appointed as research fellows.

In 1999 we substantially enhanced the capability of our research laboratories. The installation of a pulsed-laser deposition system enables us to fabricate and study thin films made from HTS, CMR and energy storage materials. I would like to acknowledge the unique contribution of Dr M. Ionescu to the design and construction of the first deposition chamber. Drs. J. Horvat and T. Hughes have contributed to the design and construction of an ac loss facility and low temperature laboratory. Dr S. Zhong and G.X. Wang have continuously upgraded the facilities in our energy storage laboratory. With support from five consecutive successful ARC RIEF grants and several Pool-2 grants our research laboratories are truly at a world class level.

Strong Links with Industry and Other Institutions

In 1999 we further extended our strategic alliance with a number of industries. Our commercial industrial partner, Australian Superconductors Ltd, has relocated to Coniston in the vicinity of our laboratory. A number of our postgraduate students and research fellows are working closely with the company, conducting R&D work on HTS for commercial applications. Impressive progress has been made on the improvement of critical current density over kilometre length distances and the design and construction of an energy storage prototype and transformer using HTS tape. We have established collaborative links with Email Ltd, Lexel Ltd, Suppo Ltd and Electric Transit Ltd. The funds attracted from industry have promoted success in obtaining ARC SPIRT grants.

International exchange and collaboration are continuing to flourish as evidenced by the increasing number of personnel exchanges, joint publications and joint grant applications. I am pleased to welcome Prof. W.M. Chen from Nanjing University, China, Prof. J.H. Ahn from Andong National University, Korea, Prof. A. Hussan from Israel, Mrs L. Yuan and Mrs Y. Chen from Lexel Ltd, and Mr C.X. Tang from China as visiting staff at our institute. I appreciate their contribution to our research work. I would also like to acknowledge our collaborators, Profs T. Collings from Ohio State University, R. Weinstein from the University of Houston, H.W Weber from the Atomic Institute, Vienna, W. Lang from Vienna, V. Pan from Kiev, J.S. Wang from Taiyi Ltd. and Dr. M. Yavuz from Texas A&M University for their support and cooperation.

Postgraduate Training

In 1999, our postgraduates and research fellows are doing extremely well internationally:

- Dr. J. Chen was awarded a NEDO Fellowship at Osaka National Research Institute, Japan
- Dr. VPS Awana was accepted as a Research Fellow at the Max-Planck Institute, Germany
- Dr. P. Mikheenko was offered a Research Fellowship at the University of Birmingham, UK
- Dr. B. Zeimetz was offered a Research Fellowship at the University of Cambridge, UK
- Dr. Q.Y. Hu was offered a research position at Argonne National Laboratory, USA
- Dr. W.G. Wang was promoted to Manager of R&D at NST, Denmark
- Dr. B.L. Luan joined the research staff at the National Research Council of Canada
- Dr. N. Vo is on the research staff at the second largest HTS company, IGC, USA
- Dr. M. Yavuz has been offered an Assistant Professorship at Texas A&M University, USA
- Dr. J.X. Jin has won the ARC Postdoctoral Fellowship (industry)
- Mr L Sun has been offered a research position at the Hydro-Québec Research Institute
- Mr C.B. Cai was awarded an STA Fellowship at the Railway Research Institute, Japan
- Mr X.L. Wang and R. Zeng have been offered Research Fellowships at ISEM.

Their continuing success has promoted the international profile and reputation of both ISEM and University of Wollongong.

I would like to congratulate the postgraduate students who have successfully completed their degrees:

PhD: J. Chen, X.L. Wang, R. Zeng; MSc: K. Uprety, J.Z. Wang.

I warmly welcome following new postgraduate students:

M. Farhoudi, Z.P. Guo, M. Khizar, M. Lindsay, S. Soltonian, E. Sotirova, C.Y. Wang and S.H. Zhou

I congratulate them for their success in winning various scholarships, including APA, APA(I), OPRS and ISEM's matching scholarship and top-up scholarships.

Our institute has 20 PGS enrolled in 1999 and will have 31 enrolled in 2000. We regard postgraduate training as a first priority in order to maintain the sustainable growth and long term stability of our institute. We invested $313,000 to support the postgraduate, matching and top-up scholarships in 1999. We will invest a further $290,000 in support of these scholarships in 2000. Additionally, the running costs of the postgraduate program exceeded $100,000 in 1999 and supervision of these PGS has occupied more than one third of our research staff time. The excellent outcomes have demonstrated that the heavy investment in PGS training has been worthwhile.

I am particularly pleased that Dr. X.L. Wang and X.K. Fu won an award at the International Conference on Materials and Mechanisms of HTS. D. Marinaro received a second AINSIE award for his neutron irradiation work.

Challenges and Opportunities

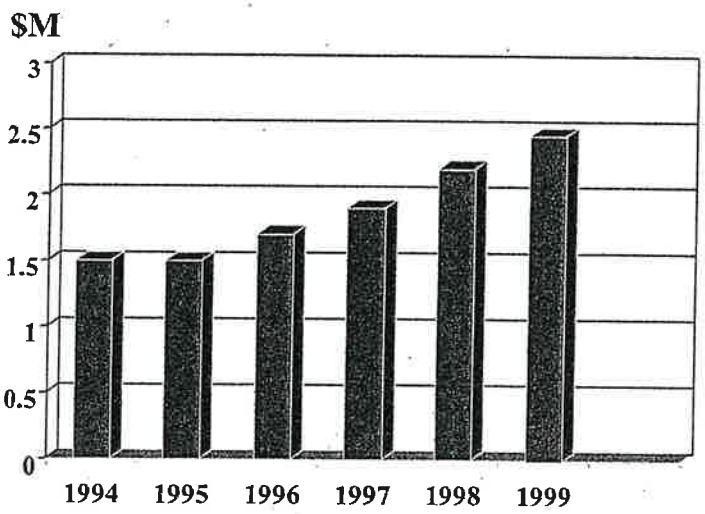
As world technology experiences rapid changes our Institute faces great challenges and we must reinvent ourselves to take advantage of these opportunities.

- In the HTS area, while we consolidate the excellent work on fundamental research and large scale applications, we will extend our efforts to develop second generation HTS and electronic applications.
- In the Energy Storage area we will enhance advanced battery materials and applications in the electric vehicle industry.
- In the semiconductor area strong industrial links will be an important focus point in the years to come.
- We will further explore new research areas such as CMR materials

ISEM's progress and success can be gauged by the results of our performance indicators. Our overall scores have caused us to be ranked number one in the University of Wollongong in 1999, by both quantitative and qualitative measures. Our institute has maintained the same position for the last four years. I am quite confident that our institute will be very successful in 2000, the year of the dragon.

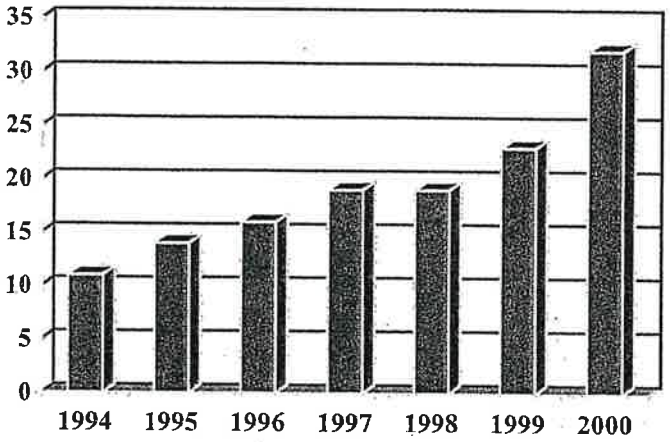
Prof. Shi Xue Dou
Director

Research Grant Funds



Research funding obtained from the ARC and other sources is approximately $1.8m p.a. Forward funding from ARC Fellowships, Large Grants and SPIRTS will provide over $1.0m p.a. over the next 3 years

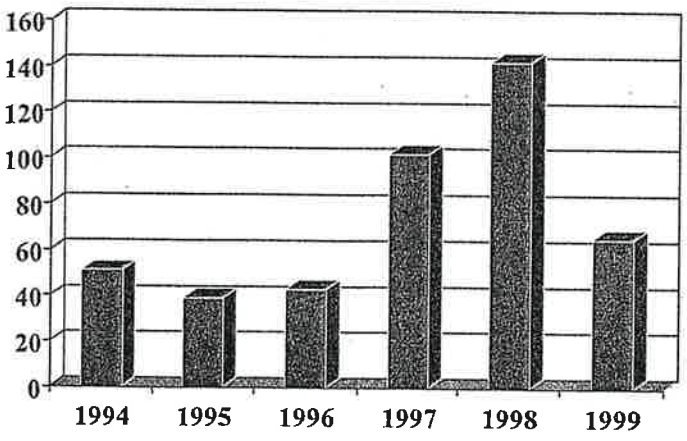
Postgraduate Student Numbers



ISEM regards postgraduate training as a first priority in order to maintain sustainable growth and ISEM's long term stability. $313,000 was spent in scholarship payments in 1999 and a further $290,000 will be spent in 2000.

One third of research staff time is taken up in postgraduate student supervision. The excellent outcomes achieved have demonstrated that this heavy investment in postgraduate training is worthwhile.

Refereed Publications (DETYA Categories)



Over 400 refereed publications in DETYA categories since 1994

Management & Personnel

Director

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

Assistant Director

Dr M Ionescu, BSc, MSc, PhD

Senior Program Co-Ordinators

Prof. H.K.Liu, Dipl. Dipl for PGS, Dipl.AQC, MTMS, MECS, MISC, ARCSRF.

Prof. P. Fisher, BSc, PhD (W.A.), MIOP, FAPS, FAIP

Dr. C. Zhang, BSc, PhD, Ma, Mphil, FAIP

Prof. T. Beales, BSc, PhD

MM/UoW Consortium Manager

ARC Fellows

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

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

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

Dr. T. Hughes, BSc, PhD, ARC International Fellow

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

Dr. J.X. Jin, BSc, MSc, PhD, ARC Postdoctoral Fellow

Administration Officer

Ms. B. Allen

Technical Staff

Mr. C. Rossi

Research Staff

Dr. B. Zeimetz, Dipl. Phys., PhD

Dr. W. Xu, BSc, MSc, PhD

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

Dr. P. Mikheenko, BSc, PhD

Dr. J. Horvat, BSc, PhD

Dr. T. Silver, BSc, PhD

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

Dr. Y. Kopelevich, BSc, MSc, PhD

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

Dr. R. Zeng, BSc, MSc, PhD

Mr. B. Chao, BSc, MSc

Dr. K. Konstantinov, PhD

Affiliated Academic Staff:

Prof. C. Cook, BSc, PhD, FIEAust

Prof. D. Dunne, BSc, PhD, FIEAust

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

Dr. C. Freeth, MSc, PhD, MAIP

Dr. David Martin, MSc, PhD, MAIP

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

Dr. R. Vickers, MSc, PhD, MAIP

Dr. T. Chandra, M.A.Sc , Ph.D, F.I. E. Aust, C. Eng,, P.E

Visiting Staff

Prof. J. Boldeman, BSc, PhD, FTSE

Prof. W.M. Chen,

Prof. J.S. Wang, Harbin University

Prof. E.W. Collings, Ohio State University

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

Mr. S.L. Zhu, BSc, MSc, Institute of Corrosion and Protection

Postgraduate Students

Current

High Temperature Superconductivity Group

PhD	Thesis Title	Supervisors
C.B. Cai	Characterisation of Melt-texture Y-123 Materials	S.X. Dou, M. Ionescu
F. Darmann	Transverse Resistivity and Eddy Current Loss in Bi-HTS Tapes	S.X. Dou, T. Beales, C. Cook
X.K. Fu	Preparation and Characterisation of HTS Current Leads	H.K. Liu, Y.C. Guo
F. Gao	Preparation and Characterisation of Colossal Magnetoresistance Materials	S.X. Dou R. Lewis
S.M. Gong	Improvement of Critical Current Density in Bi-2212 Using Chemical Doping and Neutron Irradiation	M. Ionescu, S.X. Dou
T. Green	Transport and Optical Properties in Optically Pumped Electronic Systems	S.X. Dou, W. Xu
M. Khizar	Current Limiting Mechanism in Bi-2223/Ag Tape	S.X. Dou, J. Horvat
G. Li	Numerical Analysis on Electromagnetic Behaviour of High T_c Superconductors in Magnetic Field	H.K. Liu, J. Horvat
G. McCaughey	Reduction of Heat Leak in HTS Current Leads	H.K. Liu, M. Apperley
J. McKinnon	U-123 Composite Film on Metallic Substrates using Laser Ablation Techniques	J. Horvat, M Ionescu
D. Marinaro	Flux Pinning Mechanism in Thermal Neutron Irradiated -doped HTS	S.X. Dou, J. Horvat, J. Boldeman
D. Milliken	Enhancement of Flux Pinning through Uranium Doping and Neutron Irradiation in Bi-2223 Tapes	S.X. Dou, Y.C. Guo
D.Q. Shi	Investigation of Buffer Layer forY-123 Coated Conductor Using Laser Ablation	M. Ionescu, S.X. Dou
S. Soltanian	Application for HTS Film in Microwave Telecommunications	S.X. Dou
K. Uprety	Vortex properties of Bi-HTS	S.X. Dou, J. Horvat
X.L. Wang	Growth Mechanism and Flux Pinning of Bi-2212 Single Crystals	S.X. Dou and H.K. Liu
R. Zeng	Processing and Characterisation of Ag/Bi-2223 Tapes	S.X.Dou, T. Beales, H.K. Liu
S.H. Zhou	Density Evaluation During Processing of Bi-2223/Ag Tape	H.K. Liu, S.X. Dou

Masters	Thesis Title	Supervisors
M. Farhoudi	AC Loss of Ag/Bi-2223 Tape in AC Field	J. Horvat, S.X. Dou
M. Ling	Local Current Distribution in Multifilament Bi-2223 Tape	Y.C. Guo, S. Nightingale
E. Sotirova	Investigation of Colossal Magnetoresistance Materials	H.K. Liu, X.L. Wang

Battery Group

PhD	Thesis Title	Supervisors
Z.P. Guo	Improvement of Energy Density and Cycle Life of Nickel Metal Hydride Batteries	H.K. Liu, S.X. Dou
M. Lindsay	Anode and Cathode Materials for Lithium Ion Batteries	H.K. Liu, S. Zhong
L. Sun	Investigation of Negative Electrode Materials for Ni-MH Batteries	H.K. Liu, D. Bradhurst
C. Wang	Investigation of Positive Electrodes for Ni-MH Batteries	H.K. Liu, D. Bradhurst
G.X. Wang	Secondary Lithium Ion Battery - Investigation of Cathode Materials ($LiNiO_2$, $LiMn_2O_4$, Li-V-O) and Anode Materials(Carbon); - Design of Lithium Ion Battery	H.K. Liu, D. Bradhurst S.X. Dou
J.Z. Wang	Bipolar Electrode Materials and Design for Electric Vehicles	H.K. Liu, D. Bradhurst,
Masters		
A. Howes	Non-Stoichiometric Nickel-Metal Hydride Alloy for rechargeable Batteries	S. Zhong, D. Bradhurst

Physics Group

PhD	Thesis Title	Supervisors
R. Baker	Zeeman and piezospectroscopy of antimony and aluminum in germanium	P. Fisher, R. Vickers
J.P. Chelliah	Optical spectroscopy of semiconductors	P. Fisher, R. Vickers
D. Fisher	Dissipation effect in resonant tunnelling through double barrier structures	C. Zhang
B. Lough	Thermionic cooling with semiconductor multilayers	R A Lewis and C Zhang
P. Jobe Probakar	Zeeman and piezospectroscopy of some point and axial acceptors in germanium	P Fisher and R Vickers
Masters		
H. Ta	Electronic properties of modulated two dimensional semiconductors	C Zhang

Completions

ISEM Postgraduate students have been well received and highly sought after by such prestigious institutions as:

PhD	Thesis Title	Position		
M. Apperley 1992	The Fabrication of High Tc Superconductor Wire	Chief Technologist	Australian Superconductors	1993
A.Bourdillion 1992	Microstructure, Phase Characterisation and Texture Processing of HTS	Senior Engineer	Hewlett Packard, Singapore	1993
J. Chen 1998	High Energy Storage Materials for Rechargeable Nickel-Metal Hydride Batteries	NEDO Fellow	Osaka National Res. Inst.	1999
N. Cui	Magnesium Based Hydrogen Storage Alloy Anode Materials for Ni-MH Secondary Batteries	Res. Fellow	Alberta Univ., Canada	1997
Y.C. Guo 1994	Investigation of Silver-clad $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10-x}$ High-T_c Superconducting Composites	Res. Fellow	ISEM, University of Wollongong	1994
		STA Fellow	National Research Inst. of Metals, Japan	1997
		ARC Postdoctoral Fellow	ISEM, University of Wollongong, Australia	1998
R Heron 1998	Far-infrared studies of semiconductors in large magnetic fields	Postdoc fellow	SUNY, Buffalo	1999
Q.Y. Hu 1997	Fabrication and Enhancement of Critical Currents of Silver Sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ Tapes	Research Fellow	Florida State University USA	1997
		Research Scientist	Argonne National Lab.	1999
M. Ionescu 1998	Growth and Characterisation of Bi-2212 Crystals and Improvement of Bi-2212/Ag Superconducting Tapes	Assistant Director	ISEM, University of Wollongong, Australia	1994
J.X. Jin 1998	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag High T_c Superconductors and their Applications in an Electrical Fault Current Limiter and an Electronic High Voltage Generator	Research Fellow	ISEM, University of Wollongong, Australia	1997
		ARC, PDF		2000
M. Lerch 1998	Optical and electrical studies of resonant tunneling heterostructure	Research Fellow in medical physics		1999
B.L. Luan 1997	Investigations on Ti_2Ni Hydrogen Storage Alloy electrode for Rechargeable Nickel-Metal Hydride Batteries	NRC Fellow	National Research Council of Canada, Ottowa	1997
		Research Staff		1998
T. Silver 1999	Near bandedge optical properties of MBE GaAs and related layered structures	Research fellow	ISEM, UoW	2000
K. Song 1992	Processing and Characterisation of Superconducting Ag/BiPbSrCaO Composite	Senior Engineer	South Korean Co	1993
S. Stewart 1998	Thermodynamic and dielectric properties in modulated two-dimensionale lectronic systems	ARC postdoc. fellow		1998
		Teacher	Private school	1999

PhD	Thesis Title	Position		
G Takacs 1999	Spectroscopy of the effect of strains and magnetic field on shallow acceptor levels in germanium	2nd Year Physics Lab Manager	UoW	1999
N.V. Vo 1997	Design and Characterisation of HTS Coils	Research Fellow	Los Alamos Nat. Lab., USA	1997
		Research Staff	Intermagnetics General Co, USA	1998
W.G. Wang 1998	Fabrication and Improvement of Silver Sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ Tapes by Powder-In-Tube Technique	Research Scientist	Nordic Superconductor Techn., Denmark	1997
		R&D Manager		1999
A Warner 1997	A spectroscopic study of acceptors in germanium	consultant	Computer industry	1999
J.A. Xia 1994	Characterisation of Melt-Texture of YBCO HTS	Research Fellow	Solar Cell Ltd	1995
J.M. Xu 1997	Phase Formation and Transformation in the R-Fe-T Systems (R=Nd, Gd, Tb, Dy, Er, Ho, T and Lu, T=Si, Ti and Zr)	Research Fellow	University of New South Wales, Australia	1996
J. Yau 1994	Ag/Bi-2223 Tape Processing and Mechanical Properties	Assistant Prof.	Chinese Hong Kong University	1995
M. Yavus 1997	Powder Processing of Bi-Pb-Sr-Ca-Cu-O Superconducting Materials	Assistant Research Prof	Tohoku University Sendai Japan	1997
B. Zeimetz 1998	High Temperature Superconducting Tapes and Current Leads	Research Fellow	Cambridge University, UK	1999
S. Zhong 1998	Investigation on Lead-Calcium-Tin-aluminium Grid Alloys for Valve-Reglated Lead-Acid Batteries	ARC Postdoctoral Fellow	ISEM, University of Wollongong, Australia	1997

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

Research Projects

ARC Large Research Grants Scheme

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

Funded:	1999	2000	2001
Amount funded:	$60,000	$60,000	$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		

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

Cryogenic deformation and 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, M. Khizar		

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.

Microstructure and Critical Current in Bi-HTS

Years funded:	1997	1998	1999
Amount funded:	$57,000	$58,000	$59,000
Chief Investigator:	S.X. Dou		
Partner Investigator:	H. Weber, K. Muller		
Assoc. Investigator:	H.K. Liu		
Research Fellow:	S. Moss, B. Zeimetz		
Postgrad. Students:	D. Milliken, D. Marinaro		

The aim of this project is to investigate the microstructures and critical current density in high temperature superconducting (HTSC) Bi-(Pb)-Sr-Ca-Cu-O tapes. The project will focus on improving our understanding of current distribution and current limiting factors in the tape by establishing two dimensional current distribution profiles. The effects of grain boundaries, grain alignment, residual low T_c phase and defects on the critical current density and magnetic properties in the Bi-based cuprates will be studied. Potential pinning centres will be introduced through a combination of uranium doping and

thermal neutron irradiation, and enhanced mechanical deformation. Extensive studies on electromagnetic properties will be carried out using magnetic and transport measurements, ac susceptibility and multi-Hall probe techniques. The performance characteristics will then be correlated to microstructures and materials processing parameters. Effective means for improving weak links and flux pinning will be proposed for processing the Ag-sheathed tapes in order to improve the critical current density to a level suitable for practical applications.

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	$52,000
Chief Investigator:	W. Xu		
Postgrad. Students:	T. Green		

Laser and laser technologies have been one of the major driving forces of 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.

ARC Research Fellowships

Processing and applications of high Tc superconducting Ag-clad Bi(Pb)SrCaCuO tapes

Years funded:	1999 - 2003
Amount funded:	$450,000
Chief Investigator:	H.K. Liu, Senior Research Fellow

This ARC SRF 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 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 high level J_c of 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

In this project, 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 superconducting tapes with electrical and mechanical properties suitable for practical applications will be fabricated.

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:	$89,300	$91,000	$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:	$79,738	$82,165	$72,948
Chief Investigator:	H.K. Liu		
Partner Investigator:	M. Apperley		
Assoc. Investigator:	B. Zeimetz, T. Chandra		
Research Fellow:	R. Zeng		
Postgrad. Students:	G. McCaughey		
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.

Investigation of HTS Gradient Magnetic Separator

Years funded:	1997	1998	1999
Amount funded:	$89,000	$91,000	$92,000
Chief Investigator:	S.X. Dou H.K. Liu		
Assoc. Investigator:	C. Cook		
Research Fellow:	J.X. Jin		
Industry Partners:	Alphatech International Ltd , & Readings of Lismore		

The aim of the research is to conduct a collaborative research project on the feasibility of applying high temperature superconductor (HTS) magnet technologies to applications in the mineral separation industry. In particular, the programme will focus on determining the required characteristics of high-gradient magnetic separators and thus the required performance of an HTS magnet and cryogenic system. As is demonstrated by the industrial support that this application has attracted, the development of this technology has considerable potential to enhance the quality of products, and the efficiency of their extraction, from the Australian mining and resource industry.

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 fiber-glass/plastics with the paste (active mass),
(iii) the bipolar electrode fabrication technique.

Research Infrastructure Equipment and Facilites (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, D. Bradhurst
Partner Investigator:	G. Russell, J. Mazierska
Assoc. Investigator:	M. Ionescu
Postgrad. Students:	D.Q. Shi

This submission sought funding through an ARC RIEFP 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.

X-Ray diffraction unit with low and high temperature capability

Years funded:	1998/99
Amount funded:	$360,000
Chief Investigator:	SX Dou, D Dunne, HK Liu,
Partner Investigator:	B Gleeson, YB Cheng
Assoc. Investigator:	M. Ionescu

This submission is seeking funds from an ARC RIEFP grant as a critical step in developing a modern, high quality x-ray diffraction (XRD) facility capable of data collection from low temperatures (> 12 K) to high temperatures (< 1870K). X-ray diffractometry is a basic and essential materials characterisation technique which can be used for determination of lattice parameters, crystal structures, grain textures, particle sizes and phase volume fractions, as well measurement and analysis of residual stresses. Wide temperature range accessories will allow exploration of the temperature sensitivity of the crystallographic features of many advanced materials and the development of insights into factors controlling useful electrical, physical and mechanical properties. Such a facility is essential equipment infrastructure for supporting the extensive materials research activities being conducted in the laboratories of the applicants.

International Research Exchange Program (IREX) Scheme

Study of AC losses in multifilamentary Ag-sheathed PbBi-2223 tapes with twisted filaments

Years funded:	1999
Amount funded:	$59,000
Chief Investigator:	S.X. Dou, T. Hughes

The project will be a collaborative program between the University of Wollongong and Southampton University UK with comparative measurements being made at each institution. The aim of the project is to determine how the configuration (twist pitch) and material characteristics (matrix resistivity and superconductor current density) of the tapes will affect the magnitude of the AC losses.

Using detailed magnetisation measurements the different components of the AC loss (superconductor losses and matrix losses) will be studied. Using this data, a theoretical model of the AC losses within these tapes can be produced which will allow multifilamentary tapes with twisted filaments to be produced with predetermined losses. Such analysis will allow device manufacturers and end users to accurately gauge the economic viability of an application

---

Asia Pacific Link

Years funded: 1999
Amount funded: $7,900
Chief Investigator: W. Xu
Assoc. Investigator: Prof XL Lei

This project is in the field of semiconductor-optoelectronic physics. We propose to study theoretically how a low-dimensional semiconductor system (LDSS), e.g. a quantum well structure, interacts with a linearly polarised intense laser field provided by free-electron laser (FEL) sources. This study will be closely related to experimental results obtained very recently by a joint research team with the Netherlands (Eindhoven University of Technology and FOM Institute for Plasma Physics) and Australia (UoW). In 1995, terahertz (THz) or far-infrared FEL radiation was applied, for the first time in scientific research into optoelectronic properties in LDSSs. Since 1997, the Australian and Dutch research groups have worked jointly on experimental study in this field. Important and unusual THz radiation phenomena, such as the photon-modified high-field Hall effect, photon-enhanced high-temperature cyclotron resonance effect, the photon-induced resonant relaxation effect, magneto-photon-phonon resonance effect etc., have been observed by us. Understanding these entirely new experimental findings requires a sophisticated knowledge of many aspects of transport and optical properties in LDSS in the presence of intense laser radiation. The theoretical study proposed in this project will be a contribution to these topics. We are particularly interested in developing fundamental new approaches to the theory of electron interactions under intense laser fields in a dimensionally reduced electronic system. We plan to devise a tractable method for dealing with electron-photon interactions in the presence of phonon and impurity scattering. The approaches will be based on time-dependent quantum transport and many-body theory and will go beyond the conventional treatment of electron interaction with the radiation field. The main aim of the proposed research is to understand the physical mechanism behind the dramatic THz radiation effects, to reproduce theoretically those observed in our experimental measurements, and to reinforce the existing research program carried out by the Australian/Dutch team.

ARC Small Scheme

Micro raman spectroscopy of high temperature superconductors

Years funded: 1999
Amount funded: $5,000
Chief Investigator: C Freeth, R Vickers

The research aims to determine, using Raman spectroscopy, how the phases, oxygen stoichiometry, grain orientation and impurities change throughout superconducting tapes and single crystal superconductors produced at Wollongong University. In conventional Raman spectroscopy the laser light is scattered off the material being investigated. The major component of this scattered light is at the original laser wavelength. A much smaller intensity component of this scattered light consists of wavelengths that are shifted from the original. It is the detail of which particular wavelengths are scattered that enables the identification of both the stoichiometry and phase of the material. A spectrometer is used to identify these wavelengths. Both the incoming light and the scattered light can be polarised to determine the grain orientation.

Solid state detector for nanodosimetry on radiation oncology modalities

Years funded: 1999
Amount funded: $8,000
Chief Investigator: A Rosenfeld

According to microdosimetry, a biologically significant radiation damage distribution should be related to the size of a living cell or to that of its subsystems: ~10nm for the nuclesomes and ~2nm for the double helix of DNA. Some biological models indicate that the maximum radiobiological damage is related to the coincidence of two ionization clusters, each having a size of a few nanometers and being 30-40nm apart. Moreover, in heavy ion therapy it has been recently demonstrated that the radiobiological efficiency (RBE) of two heavy ions beams having the same linear energy transfer (LET) could be essentially different whereas according to the accepted microdosimetric approach these should be the same. It is possible to explain this as being due to the different track structure of heavy ions in the medium of interaction. Therefore it is desirable to develop a new nanodosimeter enabling measurements of ionization statistics within volumes of cubic nanometers or to be sensitive to the track structure, i.e. the distribution of the radial energy deposition of the d-electrons from the direct beam and secondary radiation products originating in the medium. Creation of such instrumentation will be a new step in characterisation of the radiobiological properties of radiation beams and better control of tumours in radiation oncology.

The aim of this project is thus the development of new types of solid state nanodosimeters. Two new approaches will be investigated which will utilize two semiconductor structures: a silicon strip detector with the space between the p-n junctions being less than 1 micron and GaAs quantum wells (QW) with a unique SV of about 20nm.

Inter-grain links in well-oriented high-temperature superconductors

Years funded: 1999
Amount funded: $5,000
Chief Investigator: J Horvat

High-temperature superconductors with well-oriented grains show a range of phenomena specific only to them because of a special type of strong coupling between the grains. Samples without strong coupling have disappointingly poor current carrying capabilities. Despite its significance, the physical background of strong coupling and related phenomena is not understood. A systematic study of different inter-grain links and their properties will be carried out for a range of different superconductors, to try to elucidate the interplay between inter-and intra-grain properties and the nature of strong coupling.

Nonlinear optoelectronic properties of low-dimensional semiconductor systems under intense terahertz laser radiation

Years funded: 1999
Amount funded: $5,000
Chief Investigator: W Xu

Very recently, the application of new sources of tunable laser radiation such as free-electron lasers (FELs) has opened up an entirely new field of scientific research. In this project I propose a theoretical study on optoelectronic properties of low-dimensional semiconductor systems (LDSSs) driven by terahertz (THz) FEL fields, in conjunction with experimental measurements conducted by a joint Australian/Dutch team working on FEL related programs. This project aims to develop a fundamental new approach to the theory of LDSS interactions with the FEL field and at relating theoretical results to those obtained very recently from our measurements.

Set up a prototype unit with operation systems of Wollongong model high Tc superconducting electrical fault current limiter

Years funded: 1999
Amount funded: $5,000
Chief Investigator: JX Jin

As electrical power systems grow in capacity, the fault current level has increased. It is thus very necessary to develop a new type of fault current limiter (FCL) which cannot be built using conventional conductors. A novel FCL developed by the applicant(s) using a high Tc superconductor (HTS) provides a new opportunity to protect and maintain present power systems. Successful implementation of such a device will save billions of dollars in upgrading the existing power systems. The preliminary study and design of the HTS FCL has been named by the most famous overseas HTS group the "Wollongong Model" HTS FCL. As HTSs gradually make inroads into electrical engineering, it is a significant step to build such a complete unit, both for research purposes and for commercial demonstration. A kW rated unit will be set up with a simulated operation system. The study also covers the feasibility for industry applications.

Relationship between superconductivity and antiferromagnetism in Ca-Ba-Cu-O oxide

Years funded: 1999
Amount funded: $5,000
Chief Investigator: P Mikheenko

The aim of the project is the development of a simple route for synthesis of $CaBa_2Cu_3O_x$ and related Ca-Ba-Cu-O compounds at normal pressure to make them suitable for technological use. In our procedure, the superconducting phase appears on the antiferromagnetic background, and the analysis of the relationship between superconductivity and antiferromagnetism is able to give a key to the mystery of high temperature superconductivity. Another important element of high temperature superconductivity - two dimensionality - will be analyzed in combination with antiferromagnetic behaviour. The suitability of Ca-Ca-Cu-O compounds for power applications will be tested by analysis of critical current mechanisms and pinning behaviour.

Electronic transport in modulated electronic nanostructures

Years funded: 1999
Amount funded: $7,500
Chief Investigator: C Zhang

This proposal is concerned with electronic transport in a particular type of nanostructure: two-dimensional electronic systems under a periodic modulation potential. Such a periodic potential can be either electrical or magnetic. This system presents one of the most interesting and challenging problems in physics, mathematics and computer simulation techniques. Our plan is to carry out theoretical analysis and numerical modelling on the dynamical properties of these new materials under a wide range of conditions (e.g. electron concentration, disorders, temperature, electric and magnetic field, etc) which will ultimately lead to a full understanding of the physics of these systems. For a system under a strong periodic potential, the fractal structure has so far blocked study of the dynamical properties. This is the problem we wish to confront.

OTHER RESEARCH PROJECTS

DEET

Target Institutional Links Program

Investigation of Metal-Nickel Hydride Alloys for the use of energy storage

Years funded:	1996/7	1997/98	1998/99
Amount funded:	$100,000	$40,000	$29,000
Chief Investigator:	SX Dou, H.K. Liu		
Partner Investigator:	I Uehara (Japan) YS Zhang, JX Wang (PRC)		
Assoc. Investigator:	D. Bradhurst		
Postgrad. Students:	A. Howes, L. Sun, J. Chen		

The objective of the project is to investigate nickel-metal hydride alloys for incorporation into rechargeable batteries characterised by high energy density and low cost. These will play an increasingly important role in the energy industry and will be achieved by bringing together internationally recognised experts in this field from Japan, China and Australia to conduct collaborative research work. The research project described in this proposal is at the forefront of the rapidly developing field of nickel-metal hydride (Ni-MH) materials and will enhance the R&D capacity of the universities. Its success would significantly contribute to the growth of Ni-MH materials science and technology, enhancing Australian manufacturing capability in metal hydride batteries. These products would be very attractive for applications such as electric vehicles and telecommunications. The Ni-Metal alloys also have potential to replace Ni-Cd alloys and so prevent proliferation of Cd in the environment.

DIST

Bilateral

Processing of Bi-based high Tc superconducting powders for tape technology

Chief Investigator:	SX Dou

Doping of Ag-alloy sheath of Bi-HTS wires

Years funded:	1997	1998	1999
Amount funded:	$7,100	$7,100	$7,100
Chief Investigator:	SX Dou		
Partner Investigator:	R Togano (Japan)		
Assoc. Investigator:	YC Guo		

AINSE

Uranium doping & neutron irradiation of Ag/Bi-2223 superconducting tapes for improved critical current density

Years funded:	1999
Chief Investigator:	SX Dou
Partner Investigator:	J. Boldeman
Postgrad. Students:	D. Milliken

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

Postgraduate Research Award - 1999

Years funded: 1999
Amount funded: $5,500
Postgrad. Students: D. Marinaro

Australian Academy of Science

Scientific Exchange with Germany

Years funded: 1999
Amount funded: $5,700
Chief Investigator: W. Xu

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 collaborative between IMR-CAS and ISEM-UoW is to investigate nickel-metal hydride rechargeable batteries with a view to high 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.

Terahertz emission and absorption in low dimensional systems

Years funded: 1999
Amount funded: $6,100
Chief Investigator: C. Zhang

Recently electron optics and transport in terahertz-drive low-dimensional systems (LDS) has received a great deal of attention both in the condensed matter physics community and in the optoelectronics community. Advances in technology have made possible study of the novel electron transport in the terahertz regime. In this work we will study nonlinear transport and electron optics in LDS under a terahertz field. This is a new field of study because the usual linear response theory breaks down in LDS in the high frequency regime. From the fundamental physics point of view, this work will provide a new understanding of light-matter interaction in anisotropic systems of reduced dimensionality. From the practical point of view, the result of this work is of paramount importance in developing new opto-electronic devices such as far-infrared radiation generators, modulators and detectors.

Interaction of electrons and coherent-phonons in semiconductor systems

Years funded: 1999
Amount funded: $5,700
Chief Investigator: W. Xu

Coherent phonons (or coherent lattice vibration) are a source of high-frequency ultrasound (f~100 gigahertz) with a pure frequency, which can be used to realise a device known as the SASER-the acoustical analogue of a LASER. Recently, the generation and detection of coherent-phonon emission in semiconductor systems (SSs) have been successfully achieved by, eg, the host institution. In this project, I propose a theoretical study on the interaction between electrons and coherent-phonons, which plays a key role in affecting the propagation of coherent phonon waves in SSs, in conjunction with experimental work conducted and proposed in the host institution.

University of Wollongong

University Research Council, ISEM Performance Indicators

Years funded: 1999
Amount funded: $155,000
Chief Investigator: S.X. Dou, H.K. Liu, P. Fisher, C. Zhang
Assoc. Investigator: M. Ionescu
Postgrad. Students: D. Marinaro, A. Howes, D.Q. Shi

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

Research Progress

Research progress is highlighted by a number of short summaries on selected topics.

High Temperature Superconductivity

Small Angle Grain Boundary in $YBa_2Cu_3O_y$ Superconductor, **Int. J. Mod. Phys. B** 13, 2285, (1999)
W.M. Chen, J. W. Huang, S. S. Jiang Y. C. Guo, H. K. Liu and S. X. Dou

Electron diffraction spots splitting into three is an unusual phenomenon. Based on the analysis of crystal structure, the splitting is believed to be due to some neighbouring crystal cells grown along a small angle ¦È, rather than along a parallel direction as in the general case. When a crystal grows along two neighbouring boundaries meeting at a small angle, the distance between the two boundaries increases as well. When the distance between the two boundaries becomes as large as a cell constant, a new cell will grow in the site, which is called an edge dislocation. According to the geometric relation in reciprocal space, small angle grain boundaries can be calculated from the corresponding splitting spots. In this work, two small angles ¦È are determined to be -2.5¡ã and 3.0¡ã, respectively. Obviously, the grain with small angle grain boundaries has a curved surface, and the curvature of the surface is determined by the density of the edge dislocation. The corresponding parameters of the edge dislocation are calculated. Both the edge dislocation and the growth of neighbouring cells along a small angle represent a growth mechanism of $YBa_2Cu_3O_y$, and this mechanism is responsible for the curved grain surface.

Angular Distribution Of Crystal Grains In Polycrystalline Bi-2223/Ag Tape, **J. Supercond. 12** 421 (1999)
W.M. Chen F. Wang, S.S. Jiang, Y.C. Guo, H.K. Liu and S.X. Dou

Grain alignment in Bi-2223/Ag superconducting tapes was investigated by measuring critical current density, J_c(T), in an applied magnetic field (*H//ab* and *H//c)*. Based on the Bean model, the magnetization intensity $M(T,H)$ was determined from the data of $J_c(H,T)$. The upper critical field, H_{c2}, for H parallel to the *ab* plane and *c*-axis was then theoretically calculated from $M(H)$. Based on the fact that the ratio of $H_{c2(H//ab)}$ to $H_{c2(H//c)}$ depends on the angle θ between the *ab* plane of grains and the broad surface of the tape, the orientation distribution of grains was determined. The calculated results showed that *ab* planes of grains in Bi-2223/Ag tapes may have an orientation angle at any value between $75^\circ > \theta > -75^\circ$. Few grains can have an angle in the region of $75^\circ > /\theta/ > 85^\circ$ and no grain can orient with its *ab* plane perpendicular to the broad surface of the tape. This means that in polycrystalline Bi-2223/Ag tapes grains tend to have certain preferential orientation, but do not tend to form a perfect orientation. The distribution of grain orientations has a significant effect on critical current density (J_c) and J_c behaviour in applied magnetic fields.

Critical current density and flux pinning of Bi-(Pb)-Sr-Ca-Cu-O Superconductors, **Science and Technology Advancing into the New Millenium,** Peoples Education Press, Ed. J. Sun 352-367 (1999)
S.X. Dou

High critical current density (J_c) is essential for most large-scale applications of high temperature superconductors (HTS). In addition to the weak link problem, weak flux pinning is a major cause for the rapid decline of J_c with magnetic field at high temperatures. Through intensive research over the past eleven years the weak pinning problem has been partially overcome and the J_c has reached a level approaching the requirements for some commercial applications. A number of techniques by which effective pinning centres can be introduced to improve flux pinning in Bi(Pb)SrCaCuO high temperature superconductors are reviewed. Fission tracks induced by using a combination of uranium doping and thermal neutron irradiation act as effective pinning centres in Ag-clad Bi-based superconducting tapes, resulting in one order of magnitutde of enhancement of J_c(H//ab) in fields greater than 3T and 60 times enhancement of J_c(H//c) in 0.7T at a U-doping level of 0.15%. Anisotropy was reduced 23 times in 0.5T at U-doping level of 0.6%. Also, in comparison with fast

neutron cascades, the Ag radioactivity induced by neutron irradiation including ^{235}U, such as we used, is presently 100 times lower than is found using neutrons without U, and will ultimately be at least 400 times lower. This technique has proved to be the most promising one by far for applications in high temperature superconducting tapes. Spiral grown Bi-2212 crystals have been obtained for the first time using KCl as flux. Enhanced flux pinning in the spiral grown crystals was observed, compared with crystals grown by a layer-by-layer mechanism. Flux pinning in Ag-clad Bi-based tapes is stronger than in single crystals. In comparison with hot deformation processed tapes, cold processed tapes show improved flux pinning whereas hot deformation significantly improves grain connectivity. These results indicate that the defects induced by mechanical deformation act as pinning centres in Bi-based materials and are responsible for the improvement in flux pinning.

Critical Role of Phase Transformation During Processing of Ag/Bi:2223 Tapes, **IEEE Trans. Appl. Supercond. 9(2), (1999) 2436-2439** (1999)
S. X. Dou, R. Zeng, X. K. Fu, Y. C. Guo, B. Zeimetz, H. K. Liu , T. Beales and M. Apperley

Phase transformation during the final stage of HTS materials processing was investigated through quenching and normal cooling in a specially-designed two-step sintering process for Ag\2223 tapes. It was found that the phase assemblage in the final tape was determined by the equilibrium composition at the sintering temperature and also from phase transformations which occurred on cooling. A two-stage sintering procedure in the final thermal cycle was found to be effective in transforming the liquid (or amorphous) phase and residual 2201 into 2212 and 2223. However, the annealing temperature during the final step is critical to the final phase assemblage. The optimal annealing temperature of the second step in the two-step process was around 825°C, where all the low T_c phases and impurities were at a minimum. Annealing at temperatures below 810°C, resulted in a substantial increase in 3221, and a lower J_c. Annealing above 825°C led to a large 2212 fraction with a small amount of 2201 because of insufficient time to convert these phases into 2223 as occurs with normal cooling.

High Temperature Bi2223/Ag Superconducting Tapes Doped With Ultra-Fine SiC Particles
Y. C. Guo, H. K. Liu, S. X. Dou, Y. Tanaka and T. Kuroda

The effects of ultra-fine SiC on the properties of Bi2223 superconductors was investigated by doping into Bi2223 precursor powders with SiC particles and fabricating the mixtures into silver-sheathed tapes. The tapes were then heat treated by a thermomechanical process and characterised by XRD, SEM/EDX and electrical and magnetic measurements. The main results obtained are as follows:

1. SiC doping lowered the melting temperature of Bi2223 precursor powders. Consequently, the optimum sintering temperature for the tapes made from the SiC doped powders was lower than that of undoped tapes.

2. Bi2223 formation was not affected by SiC doping up to 1.00wt%. However, doping with ≥2.00wt% SiC resulted in incomplete Bi2223 formation. SiC existed mainly as dispersed, discrete fine particles in the tapes doped with small amount of SiC (0.15wt%), but agglomerated into larger non-superconducting particles for larger amounts (e.g. 2.00wt%).

3. A small amount of SiC doping (0.15wt%) increased the tape's critical current (I_c) by ~20% as a result of enhancement in core density, grain alignment and grain connectivity. However, a larger amount of SiC doping decreased I_c due to the formation of large non-superconducting phases and incomplete Bi2223 phase formation.

Uranium Doping of (Bi, Pb)$_2$Sr$_2$Ca$_2$Cu$_3$O$_x$/Silver Superconducting Tapes, **9th International Workshop on Critical Currents, 7-10/7/99, Wisconsin, USA, 153-154** (1999)
Y.C. Guo, B.. Zeimetz, J. Horvat S.X. Dou, A. Gandini, R. Weinstein, Y. Ren, R. Sawh, S Tönies and H..W. Weber

Uranium oxide (^{235}U) up to 0.6wt% was added to Bi-2223 powders by mixing fine UO_4 particles and superconductor precursor powders. The mixed powders were fabricated into silver sheathed Bi-2223 tapes and the effect of UO_4 on the properties of the composite tapes was investigated. XRD analyses and AC susceptibility measurements showed that neither the Bi-2223 formation nor the critical temperature (T_c) were detrimentally affected by doping with UO_4. However, transport measurements showed that UO_4 doping lowered the critical current (I_c) slightly, e.g. I_c decreased by ~ 12% when 0.6wt% of UO_4 was added to the Bi-2223/Ag tapes.

Positive in-plane and negative out-of-plane magnetoresistance in the overdoped high-temperature superconductor $Bi_2Sr_2CaCu_2O_{8+x}$ **Physical Review B-Condensed Matter. 59(17)** 11179-11182, (1999)
G. Heine, W. Lang, X.L. Wang and S.X. Dou

The in-plane and out-of-plane magnetoresistances of moderately overdoped $Bi_2Sr_2CaCu_2O_{8+x}$ single crystals have been studied, from T=5 K to T=100 K, with the magnetic field oriented perpendicular and parallel to the current, respectively. The in-plane magnetoresistance is positive, the out-of-plane magnetoresistance negative, and their temperature variations depend on the orientation of the magnetic field. A recent theory for superconducting order parameter fluctuations is extended to the interaction of carrier spins with the magnetic field. The anomalous, anisotropic magnetoresistance can be well described by a unique set of physical parameters, which were found to correspond to estimates from the normal-state transport properties.

In-plane and out-of-plane magnetoresistance in $Bi_2Sr_2CaCu_2O_{8+x}$ with various carrier densities, **Journal of Low Temperature Physics.** 117 (5-6):1253-1257, (1999)
G. Heine, W. Lang, X.L. Wang and S.X. Dou

The in-plane and out-of-plane magnetoresistance of $Bi_2Sr_2CaCu_2O_{8+x}$ single crystals was investigated in magnetic fields of 12 T, oriented parallel to the c axes. Crystals with different carrier concentrations, corresponding to the underdoped, optimally doped, and overdoped region of the phase diagram of high-temperature superconductors, were prepared by variation of the oxygen content. Above the critical temperature, the magnetoresistance is positive for in-plane and negative for out-of-plane currents in all samples. Using recent theories for superconducting order-parameter fluctuations, the in-plane magnetoresistance can be well described for all samples. Only the out-of-plane magnetoresistance of the underdoped crystal shows distinct deviations from the theoretical predictions and appears to be influenced by the 'pseudo-gap'.

Role of the density-of-states superconducting fluctuations in the in-plane and out-of-plane transport properties of $Bi_2Sr_2CaCu_2O_{8+x}$ single crystals, **Physica C.** 318:596-599, (1999)
G. Heine W. Lang X.L. Wang S.X. Dou

We report transverse (B perpendicular to j) and longitudinal (B parallel to j) in-plane (j parallel to lab-plane) and out-of-plane (j parallel to c-axis) magnetoresistance measurements on underdoped, optimally doped and overdoped $Bi_2Sr_2CaCu_2O_{8+x}$ single crystals. The measurements were performed in the temperature range from slightly above Tc to 200 K and in magnetic fields up to 13 T. The in-plane magnetoresistance (MR) is positive for all temperatures, magnetic fields and different doping levels. Near T-c, the in-plane MR is dominated by thermodynamic fluctuations, but at higher temperatures a smooth transition to the MR of normal-stale quasiparticles takes place. In sharp contrast, the out-of-plane MR is negative for all temperatures and orientations of the magnetic field. We interpret this unconventional behaviour in the framework of the superconducting fluctuation theory, taking into account different weights of the Aslamazov-Larkin and single-carrier density-of-states contributions.

Vortex pinning in heavily Pb-doped Bi2212 crystals **Physica C 324, 211** (1999)
J. Horvat, X.L.Wang and S.X.Dou

Magnetic vortex pinning processes were studied for heavily Pb-doped Bi_{2-x} $Pb_xSr_2CaCu_2O_y$ crystals. The atomic ratio of Bi to Pb atoms was 1.66:0.34, as obtained by EDS. The hysteresis loops of the crystals exhibited a very pronounced secondary peak effect, in the temperature range $20K < T < Tc$. Jc_0 at T=0.3Tc was 75 kA/cm^2, several times higher than for a pure Bi2212. The current-dependence of the activation energy was obtained from magnetic relaxation measurements at different temperatures. Temperature scaling U~(1-(T/Tc)2) was employed. Fitting of the activation energy by the interpolation formula $U(J)=Uc[(J_0/J)m - 1]$ gave m=0.33 and 0.1 for the fields at the secondary peak and away from the peak, respectively. This shows that variable range hopping processes define the magnetic relaxation at the secondary peak, whereas single vortex pinning was obtained at higher fields. It was concluded that increased c-axis coupling with Pb-doping contributed to the increased pinning in both field ranges. The nanometer-size laminae, observed in heavily Pb-doped Bi2212, were likely to be responsible for the variable range hopping processes at the secondary peak. The nanometer-size amorphous regions were most probably responsible for the increased pinning at higher fields.

Reduction of the a.c. losses in Ag sheathed PbBi2223 tapes with twisted filaments,
Physica C 325 77-82 (1999)
T. Hughes, F. Darmann, J. Horvat and S.X. Dou

Measurements of the total a.c. losses in an applied parallel a.c. magnetic field are measured for tapes with twisted and untwisted filaments. These measurements were undertaken using suitable pickup loops and a lock in amplifier. For all frequencies (37Hz-200Hz) and field amplitudes (<45mT) the tape with untwisted filaments behaved as if its filaments were fully coupled. For this situation the total losses can be estimated using Beans model for a 1D slab and assuming that the tape acts as a monoblock. In contrast the tape with twisted filaments of pitch 10mm, behaved as if the filaments were fully decoupled. However the coupling current losses were significant over all ranges measured. The total losses in the tape could be estimated by adding the filament losses to the coupling current losses. The filament losses were calculated using Bean's model for a slab with dimensions of an individual and the coupling current losses predicted from existing theory for a tape geometry in parallel to the field.

A High Gradient Magnetic Separator Fabricated Using Bi-2223/Ag HTS Tapes, **IEEE Transactions on Applied Superconductivity (9) No. 2,** 394-397 (1999)
J.X. Jin, S.X. Dou, H.K. Liu, R. Neale, N. Attwood,G. Grigg and T. Beales

Bi-2223/Ag HTS wire provides a new opportunity to build an HTS magnet for use in a high separation efficiency, low operational cost, high gradient magnetic separator. A magnet has been designed using HTS wires and the results analyzed for use in this application. The magnet configuration consisted of 12 units and generated a 3 T magnetic field. The suitability of the Bi-2223/Ag HTS wire for this application was analyzed with consideration of its critical transport current density, conductor filling factor, and magnetic field distribution.

***Critical Current Degradation Caused by Winding Process of Bi-2223/Ag HTS Wire in the Form of a Coil,* IEEE Transactions on Applied Superconductivity, (9) No. 2,** pp. 138-141 (1999)
J.X. Jin, S.X. Dou, H.K. Liu T. Hardono, C. Cook and C. Grantham

High Tc superconducting (HTS) $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$ Ag-clad wire in the form of a coil or a winding has potential for practical applications. This HTS wire has strong magnetic field-dependent and mechanical strain-dependent critical currents, so that it consequently faces a severe problem of critical current degradation when it is used in the form of a coil. To design a winding with this conductor, the critical current degradation due to the magnetic fields and the winding process has to be identified. This is important in order to optimize an appropriate coil winding procedure using this HTS wire.

A specially designed non-inductive sample has been made with a $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$ Ag-clad 27-filament wire, and the critical current degradation, which is caused by the magnetic field generated and the mechanical winding procedure used to form the coil, has been separated into two factors accordingly and discussed in this paper.

Comparison of Pinning Behavior in Bi-2223/Ag Tapes with Various Preparation Processing, **Physica C 312,** 71-77 (1999)
J. N. Li, H. K. Liu and S. X. Dou

Transport and magnetization J_c was measured at various temperatures for different groups of Bi-2223 tapes, which were prepared by using various processing routes (direct cooling, step cooling and pressing). In spite of quite different J_cs in these samples, the field and temperature-dependent pinning force can be well described by a unique scaling law except for a single lower temperature measurement, which suggests that the pinning mechanism for these samples is approximately the same. It was found that, in this system, the main limitation of the pinning force is due to the plastic deformation of the flux line lattice in the highest field range. For the direct-cooled sample, the irreversibility field was lower compared to the step-cooled samples, which leads to a lower J_c from both transport and magnetization measurements. The electrical connection along the traverse direction was improved in the pressed samples, which resulted in a larger magnetization J_c.

Study of the magnetic phase transition in $La_{0.7}$ $Ca_{0.3}$ MnO_3 using a magneto-optical method, **Applied Physics Letters. 74(20)** 3014-3016, (1999)
Z.W. Lin, J.W. Cochrane, G.J. Russell, X.L. Wang, S.X. Dou and H.K. Liu

The colossal magnetoresistive material, $La_{0.7}$ $Ca_{0.3}$ MnO_3, which has the perovskite structure, has been investigated by means of a magneto-optical method. Analysis of the magnetic field distributions within this material under applied perpendicular fields clearly showed that the sample was paramagnetic above the Curie transition temperature Tc and ferromagnetic below it. The field distributions were also studied as a function of decreasing temperature through Tc. The results show the microscopic magnetic transition process as the material changes magnetic phase.

Effect of Cryogenic Deformation on Microstructure & Critical Current Density in Ag/Bi-2223 Tapes, **IEEE Trans. Appl. Super. 9** (2) 2726-2729 (1999)
H.K. Liu, Q.Y. Hu, Y.C. Guo, J. Horvat, X.Z. Liao, and S.X. Dou

In order to improve the grain alignment and density of HTS materials, a deformation technique carried out at low temperatures, such as liquid nitrogen temperature, has been developed. It was found that cryogenic deformation improved the grain connectivity, alignment, Ag/core interface and critical current density. These benefits may be attributable to the increased extent of mechanical deformation. As a result of cryogenic conditions, the hardness of the silver sheath, in particular was significantly increased during mechanical deformation, , allowing for a much larger load to be applied during the deformation process. The maximum J_c appeared at a 20% reduction rate for cryogenically processed tape while it appeared at a 15% reduction rate for normally processed tape. TEM studies revealed that in addition to a large increase in basal plane dislocations in the cryogenically pressed tapes, compared with tapes pressed at room temperature, small angle c-axis twist grain boundaries also increased significantly. A high density of edge dislocations with dislocation lines parallel to the c-axis is found at these boundaries which may be responsible for the observed enhancement in flux pinning.

Phase transformation and liquid phase conversion during the final processing of Bi-2223/Ag PIT tapes and their influence on critical current density **Physica C 325** (1999) 70-76 (1999)
H.K. Liu, R. Zeng, X.K. Fu and S.X. Dou

The phase transformations during the final processing step of Bi-2223/Ag PIT tapes and its effect on the critical current density have been investigated. In order to determine the phase composition during the final cooling process, tapes were quenched at temperatures between 700 and 845°C at the end of a two-step process. On cooling, the liquid phase was converted to either an amorphous phase, superconducting or impurity phases, depending on the cooling step. The optimal annealing temperature to convert the liquid to 2223 was found to be 825°C. At annealing temperatures higher than 825°C, the liquid phase was converted to 2212, 2223 and amorphous phase on cooling. Between 825°C and 800°C, if any liquid phase was present in the tape, it converted to 2212 and other phases. 2223 decomposed into 3221 and other phases below 800°C. The composition of phases formed during cooling had a significant effect on grain connectivity and flux pinning in the tapes. The residual liquid phase was largely responsible for weak links, substantially reducing J_c.

Surface barrier controlled order-disorder transition in Bi2223/Ag tapes, **Physica C 325** 83-90 (1999)
P.N. Mikheenko, B. Zeimetz and S.X. Dou

We report on the surface barrier controlled order-disorder transition in Bi2223/Ag tapes. Contrary to the expected 3D-2D transition, the vortex solid is always 3D-like Josephson-dominated. The only transition in the solid state is the order-disorder transition caused by point defects with the *ab*-plane diameter ≈ Å. Bi2223/Ag tape can be considered as a uniform superconductor with a vortex phase diagram whose order-disorder line reflects a change in the anisotropy parameter γ from 3.4 at low T to ≈ 50 at high T.

Softening of Bi2212 crystals and growth mechanism of Bi2212 and Bi2201 grown at the KCl flux surface, **Superconductor Science & Technology.** 12(2):77-80, (1999)
X.L. Wang, H.K. Liu, X.Z. Liao and S.X. Dou

A comparative study was carried out on observation of the growth mechanism of Bi2212 and Bi2201 crystals grown at the surface of a KCl flux by using optical microscopy and XRD. The growth of Bi2212 crystals is typically spiral mediated, while Bi2201 crystals always grow layer-by-layer. We observed that the Bi2212 crystals grown on a KCI surface at 800-840 degrees C are soft and can be bent freely. No softening was observed for the Bi2201 crystals. The generation of screw-dislocations can be caused by the coalescence of softened crystals. It is suggested that the formation of single, double and multiple spirals in the Bi2212 crystals can be explained by the softening of the Bi2212 crystals. TEM studies revealed abundant dislocation networks in the softened Bi2212 crystals.

Effect of short processing time on Bi-2223 phase formation kinetics and critical current in Bi-2223/Ag tape, **IEEE Trans. Appl. Supercond. 9** (2) 2734-2737 (1999)
R. Zeng, H.K. Liu, T. Beales and S.X. Dou

Bi-2223 volume fraction and the critical current (I_C) in Bi-2223/Ag tapes exhibited maximum values ($f_{2223\ max}$ and I_{Cmax}) versus sintering time; on further heating the Bi-2223 phase decomposed and the Ic would be decreased. The total time to reach I_{Cmax} is defined as t_c. Based on the investigation of the effect of processing on Bi-2223 phase formation kinetics, an optimal processing technique to substantially reduce the processing time in Ag-sheathed Bi-2223 tapes was introduced in this paper. It was found that, after 10-15h sintering, the Bi-2223 phase formation rate decreased. Intermediate procedures using a quench, pressing or rolling and then rapid heating can avoid unnecessary Bi-2223 phase decomposition and recovery, decrease the diffusion distance and substantially reduce the sintering time in Bi-2223/Ag tapes. The t_c was reduced to 30h, even 20h, and Jc reached 40-50 kA/cm^2 for multifilamentary tapes. Our results indicated that Pb distribution in the precursor powder plays an important role in fast phase formation. Fabrication of high Jc tapes in a short time is desirable for scaling up production of Ag/Bi-2223 tapes.

Development of long length Bi-based/Ag tapes and experimental magnets, **IEEE Trans. Appl. Supercond. 9** (2) 2605-2608 (1999)
R. Zeng, H.K. Liu, T. Beales and S.X. Dou,

Long lengths of multifilamentary superconducting Bi-2223/Ag tapes (up to 250m) made with the "powder-in-tube" (PIT) process have been successfully prepared on a laboratory scale. A reproducible critical current density of between 12,000~18,000A/cm^2 in the long length tapes has been achieved using the optimal reduction in the flat-rolling procedure and the standard flat-rolling method as the intermediate deformation between sintering periods. Several coils have been fabricated from sections of the long length tape, using the co-wound react-and-wind (R&W) procedure for double pancake-shaped coils and the wind-and-react (W&R) procedure for solenoidal pancake shaped coils. Each coil was fabricated by co-winding three tapes on a 30mm-diameter mandrel. An experimental magnet was designed and constructed by stacking coils together. Dimensions and parameters of this magnet are as follows: height, 105mm; winding ID, 32mm; OD, 120mm; total number of turns, 1068. Total conductor length in the magnet was ~870m. The coils were connected in series and then tested at 77K. The field constant at mid-plane of the magnet, determined by introducing a Hall probe in the bore of the magnet, was ~105Gs/A and it generated 0.24T magnetic field at 77K. A detailed investigation of the J_c-B properties and J_c-strain characteristic of the Bi-2223 tapes as designing parameters and properties of the test magnet have been carried out.

Fabrication and Properties of Some Ag-Alloy Sheathed Bi-2223 tapes, **IEEE Trans. Appl. Supercond. 9** (2) 2710-2713 (1999).
R. Zeng, Y.C. Guo, Y. Tanaka, J. Horvat, M. Ionescu, T.P. Beales, M. Apperley, H.K. Liu and S.X. Dou

Mono and multifilamentary powder-in-tube tapes with sheaths of Ag, $AgCu_{0.02}$, $Ag(AgCu_{0.02})$, $AgAl_{0.25}$, $Ag(AgAl_{0.25})$, $AgNi_{0.25}Mg_{0.25}$, $AgTi_{0.25}Mg_{0.25}$, and $AgTi_{0.25}$ alloys have been fabricated and their physico-chemical properties and effect on the phase formation of Bi-2223 determined. Alloying was found to have a significant effect on phase formation of the Bi-2223 phase and was linked to the alloying elements reactive to oxygen, Cu < Ni < Al < Mg < Ti. Multifilamentary tapes, composed of an inner Ag sheath and an outer Ag alloy sheath showed no such effects. The resistivity and mechanical properties of the various Ag alloys used as sheathing materials are also reported on and their possible use in improving the performance of PIT tapes.

High electrical performance Ag-sheathed Bi-2223 multifilamentary tapes prepared by an optimised PIT processing route, **IEEE Trans. Appl. Supercond. 9** (2) 2730-2733 (1999).
R. Zeng, P. Yao, B. Zeimetz, T. Beales, H.K. Liu and S.X. Dou

An optimised PIT processing route is introduced and discussed. The procedure was obtained from experiments investigating the effect of processing on microstructure, and subsequently on Jc in PIT tapes. At 77K and self-field, the highest Jc performance of 51,000A/cm^2 has been obtained for 69-filament tapes. High critical current samples with Ic=108A and Jc=36,000A/cm^2 have been measured at 77K and self-field for 361-filament tapes. Our results indicated that Jc is influenced by Pb distribution in Pb-2212, phase composition for the precursor powder, the deformation reduction rate, and the core thickness. Intermediate processing (cooling, deformation and heating) between thermal-mechanical cycles and finally cooling procedures also play an important role in Bi-2223 phase purity and achievement of high electrical performance in the tapes.

Battery Group

***An Electrometric Method for Evaluation of the Corrosion of Lead Alloy*,**
Journal of Power Sources 77 56-63(1999)
W. H. Boctor, S. Zhong, H. K. Liu and S. X. Dou

In an electrometric method, the lead electrode is subjected to electrolyte and temperature conditions, as well as various states of polarization that simulate the service of lead/acid batteries. The resulting corrosion layer is first reduced to lead sulphate then to sponge lead.

A linear relation is observed between the weight of the corroded lead and the surface area of the sponge lead after cathodic reduction of the corrosion layer. This surface area is determined by measuring the time required to cover the lead completely again with lead sulphate at a specified current density and standardized conditions, irrespective of the test solution and test temperature.

The results are very reproducible. The application of the electrometric method proves to be effective for the evaluation of lead-antimony-arsenic alloys in a wide range of sulfuric acid concentrations and at temperatures between 25 and 60 °C. The study also suggests that the recommendation to reduce the acid's relative density (rel. dens.) in lead/acid batteries operated in tropical climates may be harmful to battery life.

***Improvements in the electrode properties of nickel-metal hydride cells,* J. New Mat. Electrochem. Systems, 2** 39-44 (1999)
J. Chen, D.H. Bradhurst, S.X. Dou and H.K. Liu

Nickel hydroxide and Zr-based Laves phase alloy electrodes were investigated in order to prepare nickel-metal hydride batteries with high energy density and long cycle life. The nickel hydroxide powders coprecipitated with the additives $Ca(OH)_2$, $Co(OH)_2$ and $Zn(OH)_2$ were used as the active materials of nickel hydroxide electrodes. The addition of these additives improved the electrode utilisation. The nonstoichiometric $Zr(V_{0.1}Mn_{0.25}Co_{0.05}Ni_{0.6})_{2.1}$ alloy was first annealed at 950°C for 12 hours and then treated in an ultrasonic cleaner containing 1M KF + 0.02M KH_2PO_2 solution for 1 hour at the temperature of 20°C.

It was found that the properties of the alloy electrode such as the activation, discharge capacity and high-rate discharge capability were greatly improved by the treatment because of the formation of a new surface layer.

***The effect of $Zn(OH)_2$ addition on the electrode properties of nickel hydroxide,* J. Mater. Res., 14** 1916-1921(1999)
J. Chen, D.H. Bradhurst, S.X. Dou and H.K. Liu.

Nickel hydroxide powders currently used in the positive electrode of nickel-metal hydride (Ni-MH) batteries require cobalt or cobalt oxides to make them viable and attractive. As a step towards eliminating the cobalt-containing materials, spherical nickel hydroxide powders coprecipitated with $Zn(OH)_2$ were prepared by a spraying technique. These powders, which have a higher tapping density and a much smaller pore volume than conventional powders, were used as the active materials of nickel hydroxide electrodes.

The effects of the $Zn(OH)_2$ additions on the electrode properties, such as percentage utilization and cycle life, were studied, and the relationship between the electrode performance and the formation of γ-NiOOH was investigated. The cycle life was increased because there was less electrode swelling due to much reduced formation of γ-NiOOH.

Nickel hydroxide as an active material for the positive electrode in rechargeable alkaline batteries. **J. Electrochem. Soc., 146** (10) 3606-3612. (1999)
J. Chen, D.H. Bradhurst, S.X. Dou and H.K. Liu

Spherical nickel hydroxide powders coprecipitated with the additives of $Ca(OH)_2$, $Co(OH)_2$ and $Zn(OH)_2$ were prepared through a spraying technique. These powders, which have a higher tapping density and a much smaller pore volume and crystallite size than conventional powders, were used as the active materials of nickel hydroxide electrodes. The effects of the $Ca(OH)_2$, $Co(OH)_2$ and $Zn(OH)_2$ additions on the electrode properties, such as charge-discharge, reversibility of the electrode reaction and cycle life, were studied. The relationship between the electrode swelling and the formation of γ-NiOOH was also investigated. The results show that nickel hydroxide powders having a smaller crystallite size show better electrode characteristics such as lower overpotential, higher plateau discharge potential, and higher capacity. The utilization of the active material in the electrodes illustrates that for general use, it is better to add Co^{2+}, while for a wider temperature range, it would be better to consider the addition of Ca^{2+}. The cycle life of the electrode containing Zn^{2+} was improved, almost certainly because there was less electrode swelling due to much reduced formation of γ-NiOOH.

Mg_2Ni-based hydrogen storage alloys for metal hydride electrodes, **J. Alloys & Compounds, 293-295** 675-679(1999)
J. Chen, P. Yao, D.H. Bradhurst, S.X. Dou and H.K. Liu.

$Mg_{2-x}M_xNi$ (M=Ti, Ce; x=0, 0.1, 0.2) and $Mg_2Ni_{1-y}N_y$ (N=Mn, Co; y=0, 0.1, 0.2) were prepared by a powder metallurgical sintering technique. The effects of the element substitutions and the ball-milling of the alloy, with or without nickel powder, on the alloy properties were investigated by X-ray diffraction, transmission electron microscopy and the Malvern particle size analyser. Three types of alloys, un-ball-milled, ball-milled without nickel powders and ball-milled with the addition of nickel powders, were used as the active material of metal hydride electrodes. Electrochemical measurements show that ball-milling the alloy with or without nickel powders is an effective method for increasing the discharge capacity and cycle life of the alloy electrode because of the changed phase structure and surface behaviour.

Improvement of the performance of Mg-based alloy electrodes, **Materials Science Forum Vols. 315-317,** (1999) 545-551
H.K. Liu, J. Chen, L. Sun, D.H. Bradhurst and S.X. Dou

Rechargeable batteries are finding increased application in modern communications, computers, and electric vehicles. The Nickel-Metal Hydride (Ni-MH) battery has the best properties overall. In order to increase the energy density of the Ni-MH battery, it is necessary to improve the negative (metal hydride) electrode properties. In this paper it is reported that with a combination of modifications to the alloy composition and new methods of electrode preparation, discharge capacities of 630mAh/g, 672mAh/g, 680mAh/g, 756mAh/g, 778mAh/g and 780mAh/g were achieved at a discharge current density of 50mA/g for Mg-based alloy electrodes. These encouraging results indicate that the kinetics of the hydriding/dehydriding reactions of Mg-based alloy electrodes can be greatly improved by the processes of ball-milling and chemical coating.

The electrode properties of $Mg_{1.9}Al_{0.1}Ni_{0.8}Co_{0.1}Mn_{0.1}$ Alloy by mechanical grinding with Ni powders, **Electrochem. And Solid. State Lett. 2** (4) 164-166 (1999)
L. Sun, H.K. Liu, D.H. Bradhurst and S.X. Dou

A modified magnesium alloy of composition $Mg_{1.9}Al_{0.1}Ni_{0.8}Co_{0.1}Mn_{0.1}$ was prepared by mechanical grinding with Ni powder for periods up to 120 h. The resulting structures of the $Mg_{1.9}Al_{0.1}Ni_{0.8}Co_{0.1}Mn_{0.1}$ alloys were found to be amorphous. Electrodes made of the modified $Mg_{1.9}Al_{0.1}Ni_{0.8}Co_{0.1}Mn_{0.1}$ alloys had large discharge capacities. At a discharge current rate of 50 mA/g, the capacity was 630 mAh/g after 50 h of mechanical grinding and 510 mAh/g after 120 h of mechanical grinding.

***The effect of Co addition of Mg_2Ni alloy hydride electrodes prepared by sintering and followed by ball milling*, J. New Mat. For Electrochem. Systems 2** 211-214 (1999)
L. Sun, G.X. Wang, H.K. Liu, D.H. Bradhurst and S.X. Dou

In this paper we investigated the effect of Co addition on Mg_2Ni alloy hydride electrodes prepared in two different ways: 1) by ball milling (BM) Mg_2Ni alloy prepared by sintering a mixture of Mg and Ni powders with Ni or Co powders; and 2) by ball milling $Mg_2Ni_{0.6}Co_{0.4}$ alloy prepared by sintering a mixture of Mg, Ni and Co powders with Ni powders. The results show that the sintered Mg_2Ni alloy ball-milled with Ni or Co powders can achieve an amorphous structure. The $Mg_2Ni_{0.6}Co_{0.4}$ alloy ball-milled with Ni powders for 60 hours can also achieve an amorphous structure. The formation of an amorphous alloy structure is a key factor in order in obtaining high initial discharge capacities. The addition of Co to amorphous Mg_2Ni alloys can increase their crystallisation temperature and alter the initial discharge capacity but the Co adidtion has no effect on their cycle life. Increasing the ball milling time is an effective method of obtaining further improvements in the initial discharge capacity of Mg-based alloys.

***Mg_2Ni hydride electrodes prepared by sintering and subsequent ball milling with Ni powders*, J. Alloys and Compounds 293-295,** 536-540 (1999)
L. Sun, P. Yao, H.K. Liu, D.H. Bradhurst and S.X. Dou

Mg_2Ni alloy electrodes were manufactured by a powder metallurgical technique followed by ball milling with Ni powders. The discharge capacities of the electrodes were significantly improved by ball milling. An amorphous structure is a key factor in achieving high discharge capacities. Other effective methods include increasing the ball milling time and changing the ratio of ball to sample weight.

***Spinel $Li[Li_{1/3}Ti_{5/3}]O4$ as an anode material for lithium ion batteries*, J. Power Sources 83** 156-161 (1999).
G.X. Wang, D. Bradhurst, S.X. Dou and H.K. Liu

The spinel $Li[Li_{1/3}Ti_{5/3}]O_4$ compound was synthesised via a solid-state method, and its electrochemical performance in lithium ion cells was examined. Lithium ions intercalate into and deintercalate from $Li[Li_{1/3}Ti_{5/3}]O_4$ with high reversibility. The spinel $Li[Li_{1/3}Ti_{5/3}]O_4$ demonstrated a very stable structural characteristic for lithium ion insertion and extraction without passivation on its surface. The spinel $Li[Li_{1/3}Ti_{5/3}]O_4$ as an anode material was coupled with $LiCoO_2$ and $LiMn_2O_4$ as cathodes to construct lithium ion cells. These cells provide 2.4~2.5V operating voltage and do not raise the safety concerns associated with using lithium metal or carbon anodes.

***Improvement of electrochemical properties of the spinel $LiMn_2O_4$ using a Cr dopant effect*, Solid State Ionics 120** 95-101 (1999).
G.X. Wang, D. Bradhurst, H.K. Liu and S.X. Dou

A series of $LiCr_xMn_{2-x}O_4$ spinels were synthesised by the Pechini method which enables dopant Cr ions to occupy Mn sites homogeneously. Neutron diffraction and EDS analysis confirmed that Cr ions do occupy 16d sites (octahedral intestial) evenly in the spinel structure. The Cr dopant effect improves the cyclic performance of spinel $LiMn_2O_4$ electrodes and decreases the self-discharge rate substantially. Cyclic voltammetry and AC impedance spectroscopy were employed to characterise the reactions of lithium insertion into and extraction from $LiCr_xMn_{2-x}O_4$ electrodes. It was found that a thicker surface layer was formed on the surface of a pure $LiMn_2O_4$ electrode than on a $LiCr_{0.1}Mn_{1.9}O_4$ electrode.

Electrochemical performance of orthorhombic $LiMnO_2$ in lithium ion batteries, J. New Mater. for Electrochem. Sys. **2**, 215-219 (1999).
G.X. Wang, L. Sun, S. Zhong, P. Yao, D. Bradhurst, S.X. Dou and H.K. Liu

Two types of orthorhombic $LiMnO_2$ of different stoichiometry were synthesised using a solid-state reaction at high temperature. Their electrochemical performance is dependent on the synthesis conditions. It was found that a few charge/discharge cycles were necessary to activate the electrochemical reactivity of o-$LiMnO_2$, which is related to the transformation from the orthorhombic phase to a spinel-like phase. AC impedance spectroscopy confirmed this phenomenon, which showed that initially the charge-transfer resistance (R_{CT}) for the o-$LiMnO_2$ electrode is much larger than that for the electrode in the charged state. A maximum discharge capacity of 180-190 mAh/g was achieved for the o-$LiMnO_2$ electrode.

Structure characterisation and lithium insertion in $La_{0.33}NbO_3$ perovskite, **Solid State Ionics**, 124 37-43 (1999)
G.X. Wang, P. Yao, D.H. Bradhurst, S.X. Dou and H.K. Liu

The A-site $La_{0.33}NbO_3$ perovskite was prepared by a solid-state reaction at high temperature. A superstructure was observed in both the XRD and electron diffraction patterns of $La_{0.33}NbO_3$, which is related to the ordering of La^{3+} ions and vacancies in the A sites. The $La_{0.33}NbO_3$ was used as the cathodic materials in lithium cells. Approximately 67% lithium can be electrochemically inserted into the La per formula $La_{0.33}NbO_3$, which confirms the structural analysis. The kinetic process of lithium sites in insertion/extraction in $La_{0.33}NbO_3$ electrodes was determined by electrochemical impedance spectroscopy (EIS). The charge-transfer resistance (R_{CT}) decreases and the diffusion coefficient increases with lithium insertion into the $La_{0.33}NbO_3$ structure.

Electrochemical study on orthorhombic $LiMnO_2$ as cathode in rechargeable lithium batteries,
J. Appl. Electrochem. 29 1423-1426 (1999).
G.X. Wang, P. Yao, S. Zhong, D.H. Bradhurst, S.X. Dou and H.K. Liu

Orthorhombic $LiMnO_2$ was synthesised via a solid-state reaction. Its electrochemical properties as the cathode in lithium batteries were examined. It was found that initially a few cycles are necessary to activate the electrochemical reactivity of o-$LiMnO_2$, which is related to the transformation from the orthorhombic phase to a spinel-like phase. A maximum discharge capacity of 180-190 $mAhg^{-1}$ for o-$LiMnO_2$ electrodes was achieved. An electrochemical impedance spectroscopy (EIS) study showed that the charge-transfer resistance (R_{CT}) for the initial o-$LiMnO_2$ electrode is much larger than that for the o-$LiMnO_2$ electrode in the charged state. O-$LiMnO_2$ electrodes demonstrated better cyclic performance than those made of the spinel $LiMn_2O_4$ directly synthesised by a solid-state reaction.

$LiAl_\delta Ni_{1-\delta}O2$ solid solutions as cathodic materials for rechargeable lithium batteries,
Solid State Ionics, 116 271-277 (1999).
G.X. Wang, S. Zhong, D.H. Bradhurst, S.X. Dou and H.K. Liu

Layered $LiAl_\delta Ni_{1-\delta}O_2$ solid solutions were synthesised for use as electrodes via a solid-state reaction at 750 °C under an oxygen stream. Single phase $LiAl_\delta Ni_{1-\delta}O_2$ compounds were obtained. The structural integrity of the electrode could be preserved via an inert Al^{3+} dopant effect to prevent the overcharge of the electrode, which is beneficial for long cycle life of the cell. The $LiAl_\delta Ni_{1-\delta}O_2$ electrode delivered approximately 150-160 mAh/g discharge capacity between 3-4.3V, which is similar to $LiNiO_2$. A.C. impedance spectroscopy was employed to characterise the kinetic parameters of $LiAl_\delta Ni_{1-\delta}O_2$ electrodes in lithium cells combined with the GITT technique. It was found that the Al^{3+} dopant effect could decrease the charge-transfer resistance (R_{CT}) and increase the Li-ion diffusion coefficient.

Rare earth element (La) doped $LiNiVO_4$ as a cathode material for secondary lithium ion cells, **Mater. Sci. Forum, Proc. Rare Earth 98,** 25-30/10/98, Fremantle, Australia, 105-112, (1999).
G.X. Wang, S. Zhong, D. Bradhurst, S.X. Dou and H.K. Liu

A series of doped La_δ-$LiNiVO_4$ inverse spinels were synthesised by chemical precipitation. Their electrochemical properties as cathodes in lithium cells were examined. La doped and undoped LiNiVO4 electrodes demonstrated high voltages of around 4.8V. It was found that the rare earth element lanthanum when used as a dopant effect can improve the capacity of $LiNiVO_4$ slightly. The kinetic parameters were determined using a.c. impedance spectroscopy.

Carbon materials and the effect of pre-lithiation treatment on sugar carbon for the Li-ion battery, **New Materials for Electrochemical Systems 3rd International Symposium,** July 4-8, 1999 Montreal, Canada.
J. Wang, G.X. Wang, S. Zhong,, P.Yao, H.K. Liu, D.H. Bradhurst and S.X. Dou

Some carbonaceous materials have specific capacities of about twice that of the theoretical limit capacity of lithium intercalated graphite (LiC_6) and some commercial products using hard carbon-type anodes present a cycle-life performance superior to those using graphite-type anodes. However, the reversible capacities and the rate capacity of hard carbon-type materials seem to be lower than those of graphite-types. In order to reduce the irreversible capacity, a pre-lithiation treatment method was investigated in this study. A hard carbon-type material was synthesized under an optimized carbonizing process and then a pre-lithiation treatment was applied. This hard carbon powder was well mixed with a lithium salt, such as Li_2CO_3 or $LiNO_3$ or LiOH and was then subjected to a solid-state reaction. Powder XRD measurements performed on these carbon materials with and without the pre-lithiation treatments showed no change in the amorphous carbon patterns. Changes in morphology and microstructure of the hard carbon after the pre-lithiation treatment were observed by SEM examinations. Cyclic voltammetry (CV) and galvanostatic charge/discharge methods were used to examine the effects of the pre-lithiation treatment on the electrochemical performance and the reversible capacity of the carbon anodes.

An Anode Material with Pervoskite Structure for Rechargeable Li-Ion Batteries, **New Materials for Electrochemical Systems 3rd International Symposium,** July 4-8, 1999 Montreal, Canada.
S. Zhong, G. X. Wang, J. Wang, D. H. Bradhurst, S. X. Dou and H. K. Liu

A conductive ceramic, barium metaplumbate ($BaPbO_3$), has been synthesized by solid-state reactions for use as an anode in lithium-ion batteries. The electrochemical characteristics of the electrode were tested in ethylene and diethyl carbonate (EC-DEC) solutions of $LiPF_6$ versus Li metal in test cells. During cycling, the material showed voltage plateaus between 0.2 V and 0.6 V versus Li, demonstrated a gravimetric discharge capacity of about 110 mAh g^{-1} and a volumetric capacity of 960 mAh cm^{-3}.
Two phases, $BaPbO_3$ and PbO, were found in compositions containing excess PbO. The free PbO in the fired bodies was found in the experiment to react with the lithium and form a new compound, probably a Pb-Li alloy, which was unstable and caused an intensive capacity fading. Single phase $BaPbO_3$, which was obtained by an increase in the calcining temperature and the partial pressure of O_2 in the ambient air, presented an improved capacity and a stable pervoskite structure. Cyclic voltammograms suggest that the insertion and de-insertion of Li ions proceed in the voltage range from 0.01 to 1.2 V versus Li/Li^+.

Quantum Point Contact in a Magnetic Field: Far-infrared Resonant Heating Observed in Photoconductivity, **Applied Phys. Lett. 75, 20,** 3150-3152 (1999)
R.J. Heron, R.A. Lewis, B.E. Kane, G.R. Facer, R.G. Clark, A.S. Dzurak, N.E. Lumpkin, R.P. Starrett, D.G. Rickel, L.N. Pfeiffer and K.W. West

We report on the far-infrared photoresponse of a quantum point contact device fabricated on a top-gated GaAs/AlGaAs heterostructure. The top-gated architecture avoids the disorder built into conventional modulation-doped structures. We observe a distinctive far-infared magneto-photoresponse. This depends on the wavelength of the radiation and on the carrier density, which is controlled by the gate voltage. We conclude by comparison with transport data that the oscillations observed in photoconductivity and which are centred around the cyclotron energy arise from the resonant heating of electrons by the far-infrared radiation.

Non-Linear Processes Induced in a 2DEG by Intense Terahertz Radiation, **Proc. 24th Int. Conf. Physics of Semiconductors,** 2-7/8/99 Jerusalem
P.M. Koenraad, R.A. Lewis, L.R.C. Wauman, C.J.G.M. Langerak, W. Xu and J.H. Wolter

The magneto-photoconductivity of a two dimensional electron gas in the temperature range of 4.2-180 K and in magnetic fields up to 14 T has been measured. Under THz irradiation, provided by the Free Electron Laser for Infrared experiments (FELIX), we studied the cyclotron resonance, magneto-phonon resonance, magneto-photon-phonon resonance and dynamic processes in the magnetoconductivity. Cyclotron resonance was observed at all temperatures up to 180 K and magneto-phonon resonance was observed above 100K. The recently predicted magneto-photon-phonon resonance was however not observed. The THz irradiation induced dramatic depopulation and repopulation effects in the two dimensional electron gas.

Response of a 2DEG to Intense THz Radiation in High Magnetic Fields, **Proc. Physical Phenomena at High Magnetic Fields Conf.** 24-27/10/98 Tallahassee, Florida, USA, 642-643
R.A. Lewis, P.M. Koenraad, L.R.C. Waumans, H.P.M. Pellemans, C.J.G.M. Langerak, W. Xu and J.H. Wolter

Intense THz radiation has been found to induce both a photovoltage and a photocurrent in a 2DEG sample. The behaviour of these has been examined as a function of magnetic field. The photovoltage varies with magnetic field at low fields. The photocurrent shows both rapid, non-resonant response and a slower, resonant response to THz radiation. No evidence has been found for a proposed anisotropy in resistivity under intense, polarised THz fields.

Optical Investigation of $La_{1-x}Ca_xMnO_3$ and $La_{1-x}Li_xMnO_3$, **Aust. J. Phys. 52,** 197-203 (1999)
R.A. Lewis, A.D. Martin, X.L. Wang and S.X. Dou

An optical study has been made of $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.8}Li_{0.2}MnO_3$ in the infrared spectral region (100 cm^{-1} to 4000 cm^{-1}). The transmission of all samples is negligible. The photoconductive response is also unmeasurable. The data reported are therefore restricted to reflectivity measurements. At room temperature, both materials exhibit similar 'bending' and 'stretching' phonon modes, associated with the MnO_6 octahedra, at ~330 and ~580 cm^{-1}, respectively. The 'external' phonon mode observed at ~170 cm^{-1}, corresponding to the (La,Ca/Li) cations beating against the MnO_6 octahedra, is slightly shifted between the two materials, as would be expected on the basis of the different compositions. At elevated temperature (~600°C) the intensity of the light reflected decreases across the infrared spectrum, and the 'stretching' mode moves to lower energy.

Spectroscopy of Acceptor States Associated with Landau Levels of Germanium, **Phys. Stat. Sol. (b)** 215, 143 (1999)
G. J. Takacs and P. Fisher,

The advent of Fourier spectroscopy with its large bandwidth, coupled with state-of-the-art detectors and high-field superconducting magnets, has permitted the complexity of the "Landau oscillations" associated with acceptor states in Ge to be explored in more detail than was possible previously [1, 2]. The present results exhibit very rich spectra at fields beyond ~4 T, revealing dichroic effects for **B**||<100> and <111> for boron. The intense "Landau lines" originally observed [1] using unpolarized radiation and low fields are now found to separate into several features while new, weaker lines appear. The excited states of the more prominent lines can be associated with a number of the calculated [3] parent Landau levels; the correlations obtained do not agree with those previously presented [4]. Some of these identifications have been made possible from our detailed knowledge of the Zeeman behaviour of the acceptor ground states [5]; this enables the symmetries of the Coulomb-related final states of the Landau transitions to be identified. The classifications obtained confirm the nature of the Landau levels to which the Coulomb states belong.

Effect Of Electron Thermalisation On Thermionic Cooling In A Single Barrier Structure, **Proc. Electrochemical Soc.** PV99-11, 255 (1999)
C. Zhang and R. A. Lewis

One of the important problems in multilayer thermionics is related to the thermalisation of hot electrons in the electrodes and in the barrier region. Thermalisation may occur directly via the electron-phonon interaction, or indirectly via the electron-electron interaction. In semiconductor heterostructures at room temperature, the LO phonon plays a crucial role in thermalising electrons. In this work we study the thermalisation of electrons in a single barrier structure by taking into account the electron-phonon interaction. The relaxation is dependent on the lattice temperature of each electrode. Because the rate of thermalisation increases exponentially with the temperature and thermalisation in the barrier region only affects the emission current from the hot electrode, the reduction of thermionic emission for the hot electrode is greater than that for the cold electrode. As a result, we find that the theoretical thermal efficiency can increase due to thermalisation.

Invited Talks & Conference Presentations

Small Angle Grain Boundary in YBa_2Cu_3Oy Superconductor	Cryogenic Engineering Conference and International Cryogenic Materials Conference, Montreal 12-15 July 1999,	W.M. Chen, J.W. Huang, S.S. Jiang, S.X. Dou, H.K. Liu and Y.C. Guo
Orientation Distribution of Grains in Bi-2223/Ag Polycrystal Tapes	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	W.M. Chen, F. Wang, X.X. Yao, Y.C. Guo, H.K. Liu and S.X. Dou
Current Limiting Mechanism in the Silver/Bi2223 Tapes Processed with Various Techniques Using Magneto-optical Imaging	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA, 7-10 July 1999	S.X. Dou, H.K. Liu, R. Zeng, A. Polyanskii and D. Larbalestier
Effect of U-Doping on Flux Pinning and Radioactivity in Silver-Bismuth-2223 Tapes using Thermal Neutron Irradiation	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	S.X. Dou, B. Zeimetz, Y.C. Guo, J. Horvat, R. Weinstein, R. Sawh, Y. Ren, S. Tonies, C. Klein and H. Weber
Synthesis And Magnetic Properties Of Pervoskite $La_{1-x}Ca_xMn_{0.9}Li_{0.1}O_3$	IUMRS-ICAM'99, Beijing, China 13-18 June 1999	F. Gao, X. L. Wang, P. Mikheenko, V. Rouessac, H. K. Liu and S. X. Dou (oral)
A New Method to Fabricate Bi-2223 Current Leads	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	X.K. Fu, V. Rouessac, Y.C. Guo, H.K. Liu and S.X. Dou
High Temperature Bi2223/Ag Superconducting Tapes Doped with Ultra-fine SiC Particles	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	Y.C. Guo, H.K. Liu, S.X. Dou, T. Tanaka and T. Kuroda
Uranium Doping of $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$/Silver Superconducting Tapes	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA, 7-10 July 1999	Y.C. Guo, B. Zeimetz, J. Horvat, S.X. Dou, A. Gandini, R. Weistein, Y. Ren, R. Sawh, S. Tonies and H.W. Weber
Phase Formation in Melt Textured Bi-2212 in the Presence of Uranium Oxide	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	M. Ionescu, J. Boldeman and S.X. Dou
Critical Current Density in Ion Implanted Bi-2212 Crystals	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA, 7-10 July 1999	M. Ionescu, J. Boldeman, S. Gong and S.X. Dou

Photocurrent and photovoltage induced in a 2DEG under intense, pulsed, THz radiation	23rd ANZIP Condensed Matter Physics Meeting, Charles Sturt University, Wagga Wagga, 2-5 February 1999	R A Lewis, P M Koenraad, H P M Pellemans, L R C Waumans, C J G M Langerak, W Xu and J H Wolter
Thermalisation of hot electrons and thermionic cooling in a single barrier structure	196th Meeting of the Electrochemical Society, Honolulu, Hawaii, 18-20 October 1999	R A Lewis and C Zhang
Comparison of Ag/Bi-2223 tapes processed with and without hot-pressing and post-annealing"	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	H.K. Liu, A. Polyanskii, R. Zeng, P. Yao, V. Rouessac and S.X. Dou
Comparison of Differently Processed Ag/Bi-2223 Tapes Using Magneto-Optical Imaging	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA7-10 July 1999	H.K. Liu, R. Zeng, S.X. Dou, A. Polyanskii and D.C. Larbalestier
Phase Decomposition and Transformation During Final Processing of Bi-2223/Ag PIT Tapes and its Influence on Critical Current Density	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	H.K. Liu, R. Zeng, X.K. Fu, P. Yao and S.X. Dou
Comparison of the Silver/Bismuth-2223 Tapes Processed with or Without Hot-Pressing Using Magneto-Optical Imaging	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	H.K. Liu, R. Zeng, V. Rouessac, S.X. Dou, A. Polyanskii and D.C. Larbalestier
The effect of Co addition on Mg_2Ni alloy hydride electrodes prepared by sintering and followed by ball milling	3rd International Symposium on New Materials for Electro-chemical Systems 4-8 July 1999 in Montreal	L. Sun, G.X. Wang, H.K. Liu, D.H. Bradhurst and S.X. Dou Presented by H.K. Liu
Influence of Irradiation on the Superconducting Properties of Uranium-Doped $Bi_2Sr_2Ca_2Cu_3O_x$- Tapes	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	S. Tönies, C. Klein and H.W. Weber, B. Zeimetz, Y.C. Guo, S.X. Dou, R. Sawh, Y. Ren and R. Weinstein
Enhancement of Critical Current Densities by Thermal Neutron Irradiation of Uranium-doped BiSCCO-2223 Tapes	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA, 7-10 July 1999	S. Tönies, C. Klein, H.H. Weber, B. Zeimetz, J. Horvat, S.X. Dou, R. Sawh, Y. Ren and R Weinstein
Electrochemical performance of orthorhombic $LiMnO_2$ as cathode in lithium ion batteries	3rd International Symposium on New Materials for Electro-chemical Systems, Montreal, 4-8 July 1999	G.X. Wang, L. Sun, S. Zhong, P. Yao, D.H. Bradhurst, S.X. Dou and H.K. Liu
Carbon materials and the effect of pre-lithiation treatment on sugar carbon for the Li-ion battery	3rd International Symposium on New Materials for Electro-chemical Systems, Montreal, 4-8 July 1999	J. Wang, G.X. Wang, S. Zhong D.H. Bradhurst, H. K. Liu and S. X. Dou

An anode material with pervoskite structure for rechargeable li-ion batteries	3rd International Symposium on New Materials for Electro-chemical Systems, Montreal, 4-8 July 1999	S. Zhong, G.X. Wang, J. Wang, D.H. Bradhurst, M. Ionescu, S.X. Dou and H.K. Liu
Effect of grain connectivity on the magnetoresistance in Ca, or Li doped lanthanum manganites	IUMRS-ICAM'99, Beijing, China 13-18 June 1999	X.L. Wang, P. Gehringer, Wolfgang Lang, H.K Liu and S.X. Dou
Enhanced flux pinning by Fe point defect in $Bi_2Sr_2CaCu_{2-x}Fe_xO_{8+d}$ single crystals	IUMRS-ICAM'99, Beijing, China 13-18 June 1999	X.L. Wang, J. Horvat, G.D. Gu, K.K. Uprety, H.K. Liu, and S.X. Dou
Large enhancement of peak effect induced by Pb doping in Bi2Sr2CaCu2O8+d single crystals	IUMRS-ICAM'99, Beijing, China 13-18 June 1999	X.L. Wang, J. Horvat, H.K. Liu, and S.X. Dou
Increase in J_c and Irreversibility Field, Decrease in Anisotropy and Lowered Radioactivity in BiSCCO 2223 Irradiated by U Fission	9th International Workshop on Critical Currents, University of Wisconsin, Madison, USA, 7-10 July 1999	R. Weinstein, A. Gandini, Y. Ren, R. Sawh, D. Parks, Y. Guo, B. Zeimetz, S.X. Dou, S. Tonies, C. Klein and H.H. Weber
Controlled Intermediate Quenching and its Effect on Microstructure and Critical Current Density	Cryogenic Engineering Conference and International Cryogenic Materials Conference 12-15 July 1999, Montreal	R. Zeng, P. Yao, J. Horvat, H.K. Liu, T.P. Beales and S.X. Dou
Nonlinear transport in a low dimensional system	City University of New York, 24 September 1999	C. Zhang
Phonon generation in quantum wells	Stevens Institute of Technology, New Jersey, USA, 14/10/1999	C. Zhang
Transport and optical properties in quantum fractal systems	BICCP summer school of computational physics, Beijing, 13/07/1999	C. Zhang

Seminars by Visiting Scientists

11/1/99	Dr SC Chen Shanghai Institute of Technical Physics	*Photothermal Ionization spectroscopy of shallow impurities in semiconductors*
27/1/99	Dr V Minasyan Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna	*Superconducting Bosons in Superconductors*
29/1/99	Dr EW Collings Ohio State University	*Aspect ratio dependence of effective transverse matrix resistivity in multifilamentary HTSC/Ag strands*
4/2/99	Dr T Sakai Osaka National Research Institute, Osaka, Japan	*Recent Developments in Nickel-Metal Hydride Batteries*
12/3/99	Dr M Das Australian National University	*Density functional approach: Understanding structure and properties of matter*
25/8/99	Prof Koung-An Chao Lund University, Sweden	*Novel semiconductor THZ laser: Physics and applications*
26/8/99	Dr M Das Australian National University	*Metroscopic electronic transport and fluctuations*
21/10/99	A/Prof Q Deng Institute of Metal Research, Chinese Academy of Sciences	*Study of hydrogen storage alloys in IMR*
25/10/99	Dr Gordon Donaldson TIP Division, CSIRO	*Applications of SQUIDS to non-destructive evaluation and biomagnetism*
17/12/99	Dr DL Shi University of Cincinnati, USA	*A Study on the Grain Texturing Mechanism of YBCO Film on a Silver Alloy Substrate through Peritectic Solidification*

Refereed Publications – 1999

High Temperature Superconductivity Program

- T.P. Beales, F. Darmann, R. Zhao and J. Horvat, "Grain connectivity in Ag-sheathed powder-in-tube Bi-2223 high-temperature superconducting tapes with different filamentary structures", *J. Mater. Sci. Lett.* **18**, 525-528 (1999).
- W.M. Chen, J.W. Huang, S.S. Jiang, Y.C. Guo, H.K. Liu and S.X. Dou, "Small angle grain boundary in $YBa_2Cu_3O_y$ superconductor", *Int. J. Mod. Phys. B.* **13**, (17) , 2285-2290 (1999).
- W.M. Chen, S.S. Jiang, Y.C. Guo and S.X. Dou, "Development of twins in $Yba_2Cu_3O_y$ superconductor", *J. Supercond.* **12** (2), 421-426 (1999).
- S.X. Dou, "Critical current density and flux pinning of Bi-(Pb)-S-Ca-Cu-O Superconductors", *Science & Technology Advancing into the New Millenium*, Peoples Education Press, Ed. J. Sun, 352-367 (1999).
- S.X. Dou, R. Zeng, X.K. Fu, Y.C. Guo, J. Horvat, H.K. Liu, T. Beales and M. Apperley, "Critical role of phase transformation during processing of Ag/Bi:2223 tapes", *IEEE Trans. Appl. Supercond.* **9** (2), 2436-2439(1999).
- X.K. Fu, V. Rouessac, Y.C. Guo, P.N. Mikheenko, H.K. Liu and S.X. Dou, "Bi-2223 bar current leads fabricated by the combination of cold isostatic pressing and hot-pressing", *Physica C* **320**, 183-188 (1999)
- Y.C. Guo, Y. Tanaka, T. Kuroda, S.X. Dou and Z.Q. Yang, "Addition of nanometer SiC in the silver-sheathed Bi2223 superconducting tapes" *Physica C* **311**, 65-74 (1999).
- T.J. Green and W. Xu, "Far-infrared laser generation from an optically pumped single quantum well structure", *Proc. Conf. Optoelectronic & Microelectronic Mater. & Devices*, Perth, Australia, 14-16/12/98, 131-134 (1999)
- T Hardono, C. Cook and X.K. Fu, "Performance of a bulk superconducting plate carrying transport currents exposed to AC and DC field" *Proc. AUPEC Conf*, 375-379 (1999)
- G. Heine, W. Lang, X.L. Wang and S.X. Dou, "Role of the density-of-states superconducting fluctuations in the in-plane and out-of-plane transport properties of $Bi_2Sr_2CaCu_2O_{8+x+}$ single crystals", *Physica C* **317-318**, 596-599 (1999).
- G. Heine, W. Lang, X.L. Wang and S.X. Dou, "Positive in-plane and negative out-of-plane magnetoresistance in the overdoped high-temperature superconductor $Bi_2Sr_2CaCu_2O_{8+x}$", *Phys. Rev. B*, 11 179 - 1182 (1999).
- J. Horvat, X.L. Wang and S.X. Dou, "Vortex pinning in heavily Pb-doped Bi2212 crystals", *Physica* C **324**, 211-219 (1999).
- T. Hughes, F. Darmann, J. Horvat and S.X. Dou, "Reduction of the ac losses in Ag sheathed PbBi2223 tapes with twisted filaments", *Physica C* **325**, 77-82 (1999)
- J.X. Jin and S.X. Dou, "Development of High TC Superconductors for Engineering Applications", *Science & Technology Advancing into New Millenium*, Peoples Education Press, Ed. J. Sun, 368-382 (1999).
- J.X. Jin, S.X. Dou, T. Hardono and C. Cook, "Novel AC loss measurement of High T_c superconducting long wire", *Physica C* **314**, 285-290 (1999).
- J.X. Jin, S.X. Dou, H.K. Liu, R. Neale, N. Attwood, G. Grigg, T. Reading and T. Beales, "A high gradient magnetic separator fabricated using Bi-2223/Ag HTS tapes", *IEEE Trans. Appl. Supercond.* **9** (2) 394-397 (1999).

- J.X. Jin, S.X. Dou, H.K. Liu, T. Hardono, C. Cook and C. Grantham, "Critical current degradation caused by winding process of Bi-2223/Ag HTS wire in the form of a coil", *IEEE Trans. Appl. Supercond.* **9** (2) 138-141 (1999).
- J.N. Li, H.K. Liu and S.X. Dou, "Comparison of pinning behaviour in Bi-2213/Ag tapes with various preparation processing", *Physica C* **312**, 71-77(1999).
- Z.W. Lin, J.W. Cochrane, G.J. Russell, X.L. Wang, S.X. Dou and H.K. Liu, "Study of the magnetic phase transition in $La_{0.7}Ca_{0.3}MnO_3$ using a magneto-optical method", *Appl. Phys. Lett*, **74** (20), 3014-3016 (1999).
- H.K. Liu, Q.Y. Hu, X.Z. Liao, Y.C. Guo, J. Horvat and S.X. Dou, "Effect of cryogenic deformation on microstructure and critical current density in Ag/Bi-2223 tapes", *IEEE Trans. Appl. Supercond.* **9** (2) 2726-2729 (1999).
- H.K. Liu, R. Zeng, X.K. Fu and S.X. Dou, "Phase transformation and liquid phase conversion during the final processing of Bi-2223/Ag PIT tapes and their influence on critical current density", *Physica C* **325** 70-76 (1999).
- P. Mikheenko, B. Zeimetz and S.X. Dou, "Surface barrier controlled order-disorder transition in Bi2223/Ag tapes", *Physica C* **325** 83-90 (1999).
- D.C. Sinclair, J.M.S. Skakle, F.D. Morrison, R.I. Smith and T.P. Beales, "Structure and electrical properties of oxygen-deficient hexagonal $BaTiO_3$", *J. Mater. Chem.* **2**, 1327-1331 (1999).
- X.L. Wang, H.K. Liu, X.Z. Liao and S.X. Dou, "Softening of Bi2212 crystals and growth mechanism of Bi2212 and Bi2201 grown at the KCl flux surface", *Supercond. Sci. Tech.* **12** 77-80 (1999).
- W. Xu, "Dielectric function of an electron gas under intense laser radiation in quantizing magnetic fields", *Phys. Rev. B* **59** (16) 10869-10876 (1999).
- W. Xu, "Magneto-plasmon modes in a terahertz-driven electron gas", *J. Phys. Cond. Matter,* **II**, L355-L361 (1999).
- W. Xu "Magneto-plasmon modes in a semiconductor under intense terahertz laser radiation", *Proc. Conf. Optoelectronic & Microelectronic Mater. & Devices*, Perth, Australia, 14-16/12/98, 333-336 (1999)
- W. Xu, "Nonlinear transport and optical properties in a GaAs/Al/GaAs heterostructure under linearly polarised intense terahertz laser radiation", *Proc. Conf. Optoelectronic & Microelectronic Mater. & Devices*, Perth, Australia, 14-16/12/98, 329-332 (1999)
- W. Xu, P. Vasilopoulos, C. Zhang and R.A. Lewis, "Collective excitation in a semiconductor under free-electron laser radiations", *Proc. 24th Int. Conf. Of the Physics of Semiconductors (ICPS24)*, Editor D. Gershoni, Singapore, World Scientific, Article 1029 - CD no page nos (1999).
- Z.Q. Yang, X.D. Su, G.W. Ziao, Y.C. Guo, S.X. Dou and F.R. de Boer, "Flux-pinning enhancement in Ag-sheathed Bi-2223 tapes by nanometer-SiC addition", *Physica C* **325**, 136-142 (1999).
- B. Zeimetz, H.K. Liu and S.X. Dou, "General design formula for tapered, conduction-cooled current lead utilizing high temperature superconducting tapes", *Supercond. Sci. Tech.* **12** 181-183 (1999).
- R. Zeng, Y.C. Guo, Y. Tanaka, J. Horvat, M. Ionescu, T.P. Beales, M. Apperley, H.K. Liu and S.X. Dou, "Fabrication and Properties of Some Ag-Alloy Sheathed Bi-2223 tapes", *IEEE Trans. Appl. Supercond.* **9** (2) 2710-2713 (1999).
- R. Zeng, H.K. Liu, T. Beales and S.X. Dou, "Development of long length Bi-based/Ag tapes and experimental magnets", *IEEE Trans. Appl. Supercond.* **9** (2) 2605-2608 (1999.

- R. Zeng, H.K. Liu, T. Beales and S.X. Dou, "Effect of short processing time on Bi-2223 phase formation kinetics and critical current in Bi-2223/Ag tape", *IEEE Trans. Appl. Supercond.* **9** (2) 2734-2737 (1999).
- R. Zeng, P. Yao, B. Zeimetz, T. Beales, H.K. Liu and S.X. Dou, "High electrical performance Ag-sheathed Bi-2223 multifilamentary tapes prepared by an optimised PIT processing route", *IEEE Trans. Appl. Supercond.* **9** (2) 2730-2733 (1999).
- R. Zeng, B. Ye, J. Horvat, Y.C. Guo, B. Zeimetz, X.F. Yang, T.P. Beales, H.K. Liu and S.X. Dou, "Significantly enhanced critical current density in Bi-2223/Ag multifilamentary tapes by hot pressing", *IEEE Trans. Appl. Supercond.* **9** (2) 2742-2745 (1999).

Battery Program

- W.H. Boctor, S. Zhong, H.K. Liu and S.X. Dou, "An electrometric method for evaluation of the corrosion of lead alloys", *J. Power Sources* **77** 56-63 (1999).
- J. Chen, D.H. Bradhurst, S.X. Dou and H.K. Liu, "Nickel hydroxide as an active material for the positive electrode in rechargeable alkaline batteries", *J. Electrochem. Soc.* **146** (10) 3606-3612 (1999).
- J. Chen, D.H. Bradhurst, S.X.Dou and H.K. Liu, "The effect of $Zn(OH)_2$ addition on the electrode properties of nickel hydroxide electrodes", *J. Mater. Res.* **14** (5) 1916-1921(1999).
- J. Chen, D.H. Bradhurst, S.X. Dou and H.K. Liu, "Improvements in the electrode properties of nickel-metal hydride cells, *J. New Mater. for Electrochem. Sys.* **2** (1) 39-44 (1999).
- J. Chen, P. Yao, D.H. Bradhurst, S.X. Dou and H.K. Liu, "Mg_2Ni-based hydrogen storage alloys for metal hydride electrodes" *J. Alloys & Compounds* **293-295**, 675-679 (1999).
- H.K. Liu, J. Chen, L. Sun, D. Bradhurst and S.X. Dou, "Improvement of the performance of Mg-based alloy electrodes" *Mater. Sci. Forum,* **315-317**, 545-551, (1999).
- L. Sun, G.X. Wang, H.K. Liu, D. Bradhurst and S.X. Dou, "The effect of Co addition on Mg_2Ni alloy hydride electrodes prepared by sintering and followed by ball milling", *J. New Mater. for Electrochem. Sys.* **2** 211-214, (1999).
- L. Sun, H.K. Liu, D. Bradhurst and S.X. Dou, "The electrode properties of $Mg_{1.0}Al_{0.1}Ni_{0.8}Co_{0.1}Mn_{0.1}$ alloy by mechanical grinding with Ni powders", *Electrochem. & Solid State Lett.* **2** (4) 164-166 (1999).
- L. Sun, P. Yao, H.K. Liu, D.H. Bradhurst and S.X. Dou, "Mg_2Ni hydride electrodes prepared by sintering and subsequent ball milling with Ni powders", *J. Alloys & Compounds* **293-295**, 536-540 (1999).
- C.Y. Wang, P. Yao, D.H. Bradhurst, H.K. Liu and S.X. Dou, "Surface modification of Mg_2 Ni alloy in an acid solution of copper sulfate and sulfuric acid", *J. Alloys & Compounds*, **285** 267-271 (1999).
- G.X. Wang, D. Bradhurst, S.X. Dou and H.K. Liu, "Spinel $Li[Li_{1/3}Ti_{5/3}]O_4$ as an anode material for lithium ion batteries", *J. Power Sources* **83** 156-161 (1999).
- G.X. Wang, D. Bradhurst, H.K. Liu and S.X. Dou, "Improvement of electrochemical properties of the spinel $LiMn_2O_4$ using a Cr dopant effect", *Solid State Ionics* **120** 95-101 (1999).
- G.X. Wang, L. Sun, S. Zhong, P. Yao, D. Bradhurst, S.X. Dou and H.K. Liu, "Electrochemical performance of orthorhombic $LiMnO_2$ in lithium ion batteries", *J. New Mater. for Electrochem. Sys.* **2**, 215-219 (1999).
- G.X. Wang, P. Yao, D.H. Bradhurst, S.X. Dou and H.K. Liu, "Structure characterisation and lithium insertion in $La_{0.33}NbO_3$ perovskite", *Solid State Ionics*, **124** 37-43 (1999).

- G.X. Wang, P. Yao, S. Zhong, D.H. Bradhurst, S.X. Dou and H.K. Liu, "Electrochemical study on orthorhombic $LiMnO_2$ as cathod in rechargeable lithium batteries", *J. Appl. Electrochem.* **29** 1423-1426 (1999).
- G.X. Wang, S. Zhong, D.H. Bradhurst, S.X. Dou and H.K. Liu, "$LiA_\delta Ni_{1-\delta}O2$ solid solutions as cathodic materials for rechargeable lithium batteries", *Solid State Ionics*, **116** 271-277 (1999).
- G.X. Wang, S. Zhong, D. Bradhurst, S.X. Dou and H.K. Liu, "Rare earth element (La) doped $LiNiVo_4$ as a cathode material for secondary lithium ion cells", " *Mater. Sci. Forum,* **315-317**, 105-112, (1999).

Solid State Physics Program

- R.J. Baker, P. Fisher, C.A. Freeth, M.A. Horniman, D.S. Ryan, G.J. Takas, R.E.M. Vickers and A.D. Warner "Zeeman spectra of group III acceptors in Germanium", in The Physics of Semiconductors, *Proc. 24th Int. Conf. of the Physics of Semiconductors (ICPS24)*, Editor D. Gershoni, Singapore, World Scientific, Article 1365 - CD no page nos (1999).
- R.J. Heron, R.A. Lewis, R.G. Clark, R.P. Starrett, B.E. Kane, G.R. Facer, N.E. Lumpkin, D.G. Rickel, L.N. Pfeiffer and K.W. West, "Terahertz photoconductivity of 2D electrons in top-gated semiconductor structures", *Proc. 24th Int. Conf. of the Physics of Semiconductors (ICPS24)*, Editor D. Gershoni, Singapore, World Scientific, Article 605 - CD no page nos (1999).
- R.J. Heron, R.A. Lewis, P.E. Simmonds, R.P. Starrett, A. V. Skougarevsky, R.G. Clark and C.R. Stanley, "Central-cell corrections for Si and S in GaAs in a strong magnetic field", *J. Appl. Phys.* **85** (2) 893-896 (1999).
- R.J. Heron, R.A. Lewis, B.E. Kane, G.R. Facer, R.G. Clark, A.S. Dzurak, N.E. Lumpkin, R.P. Starrett, D.G. Rickel, L.N. Pfeiffer and KW. West, "Quantum point contact in a magnetic field: Far-infrared resonant heating observed in photoconductivity", *Appl. Phys. Lett*, **75**, (20) 3150-3152 (1999).
- P.M. Koenraad, R.A. Lewis, L.R.C. Wauman, C.J.G.M. Langerak, W. Xu and J.H. Wolter, "Non-linear processes induced in a 2DEG by intense terahertz radiation", Proc. 24th Int. Conf. Of the Physics of Semiconductors *(ICPS24)*, Editor D. Gershoni, Singapore,World Scientific, Article 1042 - CD no page nos (1999).
- R.A. Lewis and M. Henini, "Zeeman spectroscopy of the Be acceptor in GaAs to intermediate fields", *Solid State Commun.* **112** 25-29 (1999).
- R.Z. Lewis, P.M. Koenraad, L.R.C. Wauman, H.P.M. Pellemans, C.J.G.M. Langerak, W. Xu and J.H. Wolter, "Response of a 2DEG to intense THz radiation in high magnetic fields", *Proc. Phys. Phenomena at High Magnetic Fields III*, 24-27 October 1998, Tallahassee, Forida, USA, 642-643 (Ed. Z. Fisk, I. Gor'kov and R. Schrieffer, World Scientific, Singapore (1999).
- R.A. Lewis, A.D. Martin, X.L. Wang and S.X. Dou, "Optical investigation of $La_{1-x}Ca_xMnO_3$ and $La_{1-x}Li_xMnO_3$", *Australian J. Physics*, **52**, (1) 197-203 (1999).
- G. Takacs and P. Fisher, "Spectroscopy of acceptor states associated with Landau levels of Germanium", *Physica Status Solidi* (B), 143-148 (1999).
- C. Zhang and R. Lewis, "Thermalisation of hot electrons and thermionic cooling in a single barrier structure", *Proc. Of Advanced Luminescent Mater. & Quantum Confinement Symp.*, 18-20/12, Hawaii, USA, 130-136 (Ed. M. Cahay, S. Bandyopadhyay, D.J. Lockwood, N. Koshida, J.P. Leburton, M. Meyyappan and T. Sakamoto, The Electrochemical Society, Pennington, NJ(1999)

Equipment & Facilities

ISEM facilities contain six laboratories with a floor space of 400m^2 with modern facilities for processing and characterisation of HTS and energy storage materials; materials processing and a full range of materials characterisation.

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

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

- University of Queensland, (Prof DR Mackinnon)
- RMIT, (Prof PJK Paterson)
- CSIRO, (Dr N Saviddes, Dr K Müller)
- University of NSW, (Profs G. Russell, C Grantham, Dr B Gleeson, R. Ramer)
- ANSTO, (Dr ER Vance),
- Australian National University, (Dr M Das)
- University of Melbourne, (DN Jamieson)
- Griffith University,(Dr S Myhra)
- Curtin University (Prof DY Li and Dr I Low)
- Queensland University of Technology, (Dr PD Killen)
- University of Technology, Sydney, (Profs J Smith and JN Bell)
- James Cook University (Prof. J. Mazierska)
- Monash University, (Dr S Ringer, Dr YB Cheng)

Materials Processing Facilities

- Freeze Drier, Lyph-Loch 4.5, 4.5l/24h
- Spray Drier, GA-32, ~100g/h
- Attrition Mill, 01-HD, 0-600rpm
- Planetary Mill, Pulverisette 5, 0-300rpm, agate
- Drawing Bench, 8m, fixed die, 11.5kW,
- 0-100cm/s
- Bull Block, 22cm diameter
- Rolling Mill, 2x60mm flat and square rollers, 5cm/s
- Rolling Mill, 2x25mm supported rollers, 5cm/s
- Swagging Machine, 15-1mm diameter
- Hydraulic Press, 10t – 100t
- More than 30 various furnaces

Thin Film Deposition Facility

- Excimer Laser, ComPex301, 9W, 10Hz, 248nm
- Thin Films Deposition Chamber, 18" diameter, with high vacuum system

Materials Characterisation

- DTA/TG, Setaram 18-92, 1750°C; DSC, TA300, -170°C +600°C
- Particle Size Analyser, Mastersizer S, 0.05-900μm
- XRD for Single Crystals
- SEM, Stereoscan 440, with EDS and EBSP
- TEM, J2000FX1, with EDS
- AFM, Nanoscope IIIa
- XRD, PW1050, 3kW; XRD Texture, PW1078, 3kW
- XRD, M18XHF, 18kW, Cu rotating anode, with HT 2000°C camera

Physical Property Characterisation

- PPMS, PPMS1, 2-400K, 0-9T DC field
- VSM, MagLab, 2-400K, 0-12T DC field
- DC Superconducting Magnet, 0-8T, 5-300K
- Various Electronic meters, HP and Keithley;
- Lock-in Amplifier, SR510; Lock-in Amplifier, SR830DSP
- Function Generator, DS340; Digital Oscilloscope, TDS320
- Electromagnet, HSV-4H1, 2T, 100mm pole diameter
- Electromagnet, 3473-70, 2T, 150mm pole diameter
- Five power supplies (HP and Keithley) 0-900A
- Digital Teslameter, DTM-132, with Hall Probe; Fluxmeter, 916
- Cryogenic Temperature Controller, ITC4, 0-500K
- He Recovery System, $10m^3$, Bauer K100,1001/min

Chemical Property Characterisation

- Cyclic Voltammograph, BAS CV-27
- Scanning Potentiostat, M326; Potentiostat, M363
- Impedance Analyser, M6310
- Power Supply, DCS 20-50, 0-20V, 0-50A
- Four Channels Data Collection System, MacLab/4e
- Eight Channels Data Collection System, MacLab/8
- Automatic Battery Charge/Discharge, DC5-C, 16 channels
- Controlled Atmosphere System (Glove Box), OP7
- Temperature Controlled Water Bath, F10-MF

Research Grant Funds - 1999

Australian Research Council Grants

Large

S.X. Dou	Microstructure and Critical Current in Bi-HTS	$59,000
S.X. Dou	Growth Mechanism and Flux Pinning in Spiral Grown HTS Crystals	$60,000
H.K. Liu	Cryogenic Deformation and High T_c Phase Evolution	$60,000
W. Xu	Optical & electric generation of far-infrared laser emission from semiconductor quantum well system	$59,000

Small

C. Freeth, R. Vickers	Micro raman spectroscopy of high temperature superconductors	$5,000
A. Rozenfeld	Solid state detector for nanodosimetry on radiation oncology modalities	$8,000
J. Horvat	Inter-grain links in well-oriented high-temperature superconductors	$5,000
W. Xu	Nonlinear optoelectronic properties of low-dimensional semiconductor systems under intense terahertz laser radiation	$5,000
J.X. Jin	Set up a prototype unit with operation systems of Wollongong model high Tc superconducting electrical fault current limiter	$5,000
P. Mikheenko	Relationship between superconductivity and antiferromagnetism in Ca-Ba-Cu-O oxide	$5,000
C. Zhang	Electronic transport in modulated electronic nanostructures	$7,500

Fellowship

H.K. Liu	SRF, "Processing and Critical Current Density of HTS Tapes"	$108,000
Y.C. Guo	APDA, "Silver Alloy Sheathed HTS Wires"	$59,000

Strategic Partnerships with Industry – Research & Training (SPIRT)

S.X. Dou, T. Beales & E.W. Collings	Effective Transverse Resistivity of Bi-HTS tapes	$89,279
S.X. Dou, H.K. Liu, L. Lam and D. Rand	Bi-polar Electrode Materials and Design for Electric Vehicles Lead-Acid Battery	$73,000
S.X. Dou and H.K. Liu	High Gradient HTS Magnetic Separators	$92,000
H.K. Liu & M. Apperley	Reduction of Heat Leak in HTS Current Leads	$79,738
J. Horvat & M. Ionescu	Substrate for Large area YBCO Film Deposition by Laser Ablation	$21,000

Research Infrastructure Equipment and Facility Fund (RIEF)

S.X. Dou, H.K.Liu and G. Russell	Multi-layer Thin Film Deposition Facility Using Pulse Laser Ablation	$640,000
J. Horvat	AC Power Supply (Pool 2)	$40,000

International Researcher Exchange Program (IREX)

S.X. Dou and T. Hughes	Study of AC losses in Multifilamentary Ag-sheathed PbBi-2223 Tapes with Twisted Filaments	$59,192
W. Xu	Nonlinear transport and optical properties of semiconductors	10,300
		$1,550,009

Australian Academy

S.X. Dou, Q. Deng	Exchange program with Chinese Academy	**$2,000**

Australian Institute of Nuclear Science & Engineering

D. Marinaro/ Dou	Special Postgraduate Award	$6,550
S.X. Dou	Thermal Neutron Irradiation of Ag/Bi-2223	$2,050
B. Zeimetz	Hot Isostatic Pressing of HTS	$1,200
M. Ionescu	Insitu Phase Transformation of Bi-2223	$4,020
		$13,820

Industry Grants

Metal Manufacturers Ltd	$75,000
Alphatech International Ltd	$30,000
Zhuhai Taiyi Ltd	$30,000
	$135,000

University of Wollongong Support

ISEM Performance Indicators	$155,000
ISEM Quantun Assessment	$90,000
ISEM Management Fund	$75,000
Director's Costs	$139,000
Scholarships (OPRS, UPA & APA)	$215,000
	$674,000

$2,374,829