ALBERTA INFORMATICS CIRCLE OF RESEARCH EXCELLENCE

2005 Research Report

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This document is an excerpt from the 2005 iCORE Annual Research Report. For information or copies, please contact iCORE.

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NANOCORE
NANOSCALE ENGINEERING PHYSICS INITIATIVE

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The principal mission of Nanocore is to build upon existing strengths in nanoscale engineering physics to develop world-class expertise in selected areas of nanotechnology. Specifically, the areas can be summarized as nanofabrication methods related to thin film technology, and advanced characterization of nonequilibrium physical properties of nanosystems relevant to future ICT. The Industrial Chair Establishment (ICE) program aims to develop device applications of nanoengineered materials, with assistance from industrial partner Micralyne.

EXECUTIVE SUMMARY

The iCORE Nanoscale Engineering Physics Initiative (Nanocore) led by Drs Mark Freeman and Michael Brett has concluded its fourth year of operation, with the related effort in applied nanotechnology research strengthened through the second year of Micralyne/NSERC/iCORE Industrial Research Chair position held by Brett. The Nanocore and ICE programs are continuing to play an instrumental role in the growth of nanoscience and engineering research in Alberta. Nanocore has led the initiative to establish the University of Alberta Micromachining and Nanofabrication Facility (NanoFab), and helped to attract the National Institute for Nanotechnology to Edmonton.This development is accomplished in parallel with the training of a large number of personnel developing at the forefront of nanoscience and engineering. Continued success in recruitment of research trainees has led to an outstanding group of graduate students. Of 19 graduate students directly supervised by Brett or Freeman, 14 have been awarded major scholarships from NSERC, or Alberta Ingenuity. Brett and Freeman continue their leadership in establishment, facilitation and operation of the University of Alberta (NanoFab), having received awards over the past three years (as principal or co-investigators) of infrastructure and operating support exceeding $20M from CFI, NSERC, ASRIP, and Western Diversification. Another measure of Nanocore/ICE success is the ongoing activity in Alberta by former Nanocore/ICE trainees. Over the past two years, seven trainees have taken their skills into the growing local Alberta nanotech industry.

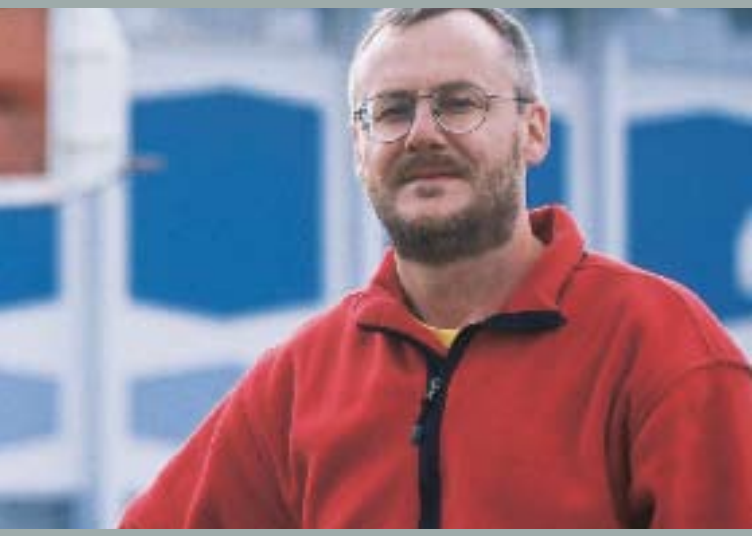
Nanocore/ICE continues to be instrumental to the evolution of Albertan and Canadian capabilities in nanotechnology. Our NanoFab, establishment of which was led by Brett and Freeman, is the best in Canada and competes in its specialties with any in the world. As a result, the NanoFab has attracted users from eight universities and six provinces, and there are already eight new ICT-related spin-off companies in Alberta that rely on the facilities for product development. Over 550 researchers have used the NanoFab equipment. Having this cluster of nanofabrication expertise nearby was an influential factor in selecting the location of the National Institute of Nanotechnology in Edmonton. Nanocore/ICE funding largely supports postdoctoral fellows, graduate students, and undergraduate research associates working on applications in nanoscience and engineering enabled by the foundational methods of nanofabrication. This support also goes beyond the principals Brett and Freeman, to seven other affiliated professors in ECE and Physics to whom incremental funding enables a significant increase in research activity, and fosters strong collaboration.

New initiatives and recognition in the last year include interim funding from Alberta Ingenuity to search for an Ingenuity Scholar in Nanofabrication, intended to bring together expertise in nanoscale engineering of soft and hard materials. Dr Freeman has spent much of his sabbatical year more firmly establishing collaboration between Nanocore and the National Institute for Nanotechnology, while developing new research efforts in the field microwave-frequency probes of microfluidic and nanomechanical systems. Dr Brett was recognized for his teaching contribu-

tions through the APEGGA "Excellence in Education Award" for 2004.

Alberta is closely connected to national developments in nanotechnology through the Nanoelectronics Program of the Canadian Institute for Advanced Research. According to Chaviva Hosek, CIAR President and CEO, the University of Alberta enjoys the highest participation in this program of any university in the world (CIAR also admits foreign associates). The Alberta members are Drs Brett and Freeman from Nanocore, and Dr Wolkow, the iCORE Chair recruited through Nanocore in 2002-03.

Former Nanocore personnel are playing key roles in Alberta nanotechnology development. PhD graduate Barb Djurfors has joined NuCryst in Sherwood Park, a firm developing nanostructured materials for health applications. PhD graduate and former Nanocore Research Associate Marek Malac has been hired by NINT as a Research Officer and group leader in charge of the excellent suite of electron microscopy tools. (Some of the electron microscopy capabilities at NINT, such as the sensitivity for electron holography, will be unparalleled in North America). Former research associate Mirwais Aktary operates the office for Raith nanolithography products in Edmonton and is developing advanced fabrication techniques through his spin-off company Applied NanoTools. Graduate student Peng Li is also a key member of Applied Nanotools. Norcada Inc. in Edmonton is leveraging the nanodevice fabrication skills of former graduate students Miro Belov and Mike Colgan through the AIIA program. PhD graduate Mary Seto has taken her expertise in microdevice processing to Micralyne. Daniel Salamon, an undergraduate student who has worked on nanofabrication for Nanocore for several years, is a Technical Officer at the National Institute of Nanotechnology. Wayne Hiebert is currently a NINT researcher seconded to the California Institute of Technology.



Michael Brett

RESEARCH PROGRAM OVERVIEW

The Nanoscale Engineering Physics Initiative and the ICE program have several interconnected themes. On the science side, the fundamental properties of the "building blocks" of future information technologies include nanomagnets and photonic crystals. Photonic crystal structures offer advanced control of the propagation of light and are a most promising technology for integrating high-level optical functionality onto chips. Conventional magnetic information storage methods have already evolved quite far into the "nano regime", and the potential for new technologies such as spin electronics and nanomagnetic logic is large. State-of-the-art nanofabrication capabilities are essential in order to make progress at the forefront of these areas, thereby establishing the second theme. For the ICE program we are also active in the engineering of real devices and the development of commercialization ready products and methods (such as fabrication of display devices and integrated nanosensors), to further the goal of spawning economic activity in Alberta in direct consequence of the Nanocore efforts. The formation of startup-company ChiralTF Devices based on the Glancing Angle Deposition (GLAD) nanofabrication process is an example of a small step in this direction.

RESEARCH PROJECTS

A primary Nanocore goal is to establish a critical mass of nanotech-related activity in the region. In their specific research and training activities, Nanocore personnel concentrate on the study of building block materials, methods, and components for nanotechnology. These developments underlie device applications in the ICE initiative.

Nanofabrication, utilizing the extensive facilities of NanoFab, continues to be a key focus of the research programs. In Brett's lab, complex structures are engineered in thin film coatings on the nanoscale utilizing the GLAD process developed and patented by Brett's team. These novel materials provide a focus and opportunities for team researchers to explore device applications where the nanoengineered structure and surface area provide advantages over conventional materials.

Recently Brett's group demonstrated fabrication of the first 3-dimensional photonic crystal in a square spiral geometry. These materials are of interest because of the potential promise in integrated optics devices, and because the square spiral architecture may offer advantages in ease of fabrication and manufacturability. A team of three graduate students (Martin Jensen, Mark Summers, and Jason Sorge) have made excellent progress in advancing our devices, by demonstration of greatly improved structural homogeneity, incorporation of intentional wave-guiding defects, and fabrication of crystals with operation close to the near infrared wavelength band utilized in optical communications.

In related optical device research, PhD student Andy van Popta and MSc student Matthew Hawkeye with collaborator Dr Jeremy Sit have developed a narrow band pass optical filter utilizing just one material but with a necessary refractive index variation engineered by variation in nanostructure. PhD student James Gospodyn provides precise characterization of these optical materials by spectroscopic ellipsometry, and Dr Doug Vick provides expertise on electrical characterization. In a fusion of optics, nanoscale engineering, and biology, graduate student Vikram Kohli and Dr Abdul Elezzabi are using ultra-short laser pulses to modify biological structure in cells.

Researching in collaboration with industrial partner Micralyne, MSc students John Steele and Shufen Tsoi, with professors Dr Jeremy Sit and Dr Jon Veinot, have demonstrated the operation of sensor devices with nanostructured surfaces that have been treated chemically or functionalized to optimize performance. For example, their humidity sensors – both optical and capacitive - afford greater sensitivity and significantly faster response than current commercial devices. Their demonstration of functionality to create hydrophobic surfaces opens the door to creation of sensors with chemical specificity.

Opportunities to apply ICT-developed nanotechnology to the energy field have been pursued by research associate Dr Greg Kiema and MSc student Doug Gish. They constructed Graetzel solar cells incorporating 20nm diameter nanofibres. These cells are based on porous nanostructured TiO_2 infiltrated with organic dye, and for efficient operation require a large TiO_2/dye interface surface area provided by nanofibres. It is hoped that photovoltaic conversion efficiencies can be improved by this approach.

Recent developments in nanofabrication in Brett's lab include nanostructure control of polymer materials of interest in plastic microdevices, fabricated in a templating process by PhD student Anastasia Elias, in collaboration with Dr Kees Bastiaansen of the Technical University of Eindhoven and Dr Dick Broer of Philips. PhD student Peter Hrudey has developed luminescent chiral materials, a potential component for more efficient polymer displays. Dr Maria Stepanova, with Dr Steven Dew, has developed new process to fabricate metal dots, networks, and nanowires on non-metallic substrates. Each of these processes brings new flexibility and control to nanomaterials engineering.

In Physics, there has been good progress in studies of new materials for information technology applications.

Michael Brett with some research team members at the 2005 Banff Informatics Summit

Ray Egerton and Frank Hegmann have worked on growth and characterization by electron microscopy of pentacene thin films, and physical studies of properties relevant to optoelectronic applications. Al Meldrum's group is making great strides in the development of silicon nanoparticle devices for optoelectronics. "Siliconization" has become one of the most dynamic topics in photonics.

Studies of the Si(100) surface at low temperatures, initiated with iCORE Visiting Professor Michael Horn von Hoegen, have been very fascinating. The silicon dimers which form at this surface represent an ultimately small limit of an electromechanical component. Each dimer tilts into one of two stable orientations, and switching between the two states may be induced by interaction with an STM tip. The STM has inspired suggestions to use this system for information processing (a model of an analogous two-state magnetic system was long ago mapped onto this mechanical system). Our studies have highlighted the importance of interactions between the surface dimers in this process, particularly along rows of dimers. These interactions are manifest in our observation of more than two conductance states when one is probing STM-induced transformations of the surface at low temperatures. In particular, the presence of "domain walls" (in the magnetics language) within dimer chains greatly facilitates transformations within the rows that contain them, and contribute to the appearance of additional conductance states as these topological defects pass through the tunnel junction. Significant modifications to the proposals for dimer logic may be required (including the possibility of domain wall logic, as has been discussed in the magnetic context). This effort has been spear-headed by Post Doctorate Fellow Yan Pennec with critical technical assistance from David Fortin.

Mark Freeman

Our studies of magnetization dynamics in confined geometries this year concentrated heavily on the magnetic oscillation modes of structures with circular symmetry (disks and rings). Such geometries are of interest for very high-density information storage because of their "closure" (they have very little stray field). In principle this will permit a higher density than for rectangular (bar magnet) storage elements. In order to record information in such an element one must be able to control whether the magnetization circulates in a clockwise or anti-clockwise fashion. We gained insight into the reversal mechanisms of nanorings through diffraction magneto-optical Kerr effect measurements. In small disks, Xiaobin Zhu discovered a surprisingly large frequency splitting of first-order magnetic normal modes, induced by the presence of a vortex core in a small diameter orbit about the center of the disk. Another exciting development in the magnetic area was a new joint project with the National Institute of Advanced Industrial Science and Technology in Japan, to further explore switching dynamics in nanomagnets. This project now has seed funding from the New Energy and Industrial Technology Development Organization (Japan).

We continued to study the dynamic coupling in magnetic multilayers with Bret Heinrich's group at Simon Fraser University. This work is also facilitated through the Nanoelectronics program of the Canadian Institute for Advanced Research, and experimentally addresses basic questions about the control of hybrid magnetic/non-magnetic structures for use in spin electronics. Dr Won Kee Kim, a Nanocore and NSERC supported Post Doctorate Fellow working with Professor Marsiglio has been performing fundamental calculations related to the underpinnings of spin electronics, addressing such questions as, "how many electrons are needed to flip a single spin?"

Another exciting stride in our general focus area of high speed local probes has been made by Markus Walther in Frank Hegmann's laboratory, who has succeeded in coupling terahertz electroagnetic radiation (triggered by ultrashort laser pulses) onto metal-tip antennas. This work is also sponsored by the NSERC NanoInnovation Platform.

OBJECTIVES FOR NEXT YEAR

The research programs will continue to focus in three areas: improving our abilities to engineer and fabricate precise nanostructures, such as nanomagnetic building blocks or chiral (helical) photonic crystals; improving characterization techniques through the use of low temperature ultrahigh vacuum scanning tunneling microscopy (LT-STM); and developing applications of nanoengineered devices in ICT and other fields of importance to Alberta.

The capability of nanostructure engineering to provide functional materials for photonics, sensor and ICT devices will be explored, with efforts aided by the installation of a new $300k high-vacuum thin film deposition system which will provide considerable new capacity for fabrication. Combined with the facilities of NanoFab, essential tools and processes are in place for each critical step ranging from blanket thin film deposition to nanoscale patterning to device testing.

One area of research emphasis will be photonic materials and devices. Development of promising 3D square spiral photonic crystals will be extended towards fabrication of devices and waveguides, with an ultimate long term goal of demonstrating optical functionality on a chip. Chiral, birefringent and luminescent nanostructured materials will be optimized to a stage where potential application in flat panel displays can be evaluated. In these latter efforts, we will be assisted by collaborator Dr Dick Broer of Philips Research Labs, who will spend the summer of 2005 visiting Brett and his colleagues. In related photonic device work, we plan to make optical filters with improved functionality, geared to potential applications in sensor devices and electrically switched optics devices.

Improved methods of fabricating nanostructured materials will continue to be studied. Specifically it is intended to optimize the template process utilized to create novel chiral structured polymers, and to utilize these polymers in prototype devices. The modified GLAD process for fabricating 20nm diameter fibres will be utilized in applications studies where high surface area and precisely controlled nanostructure geometries are required.

A nanoengineered materials research effort, though focused on ICT fields, often presents exciting opportunities outside the direct ICT area that cannot be ignored. Utilizing ICT-derived nanofabrication has led to development of fast response humidity sensors, and progress in optimizing Graetzel solar cells. Utilizing our fast response device and nanostructure geometries, a broader range of sensor devices will be explored, with strong encouragement from the industrial partner Micralyne. The utility of nanofibres incorporated into solar cells will be evaluated to determine if further efficiency improvements are possible. Prospects for commercialization will be evaluated by Micralyne/University of Alberta spinoff ChiralTF Devices Inc.

Mark Freeman with some research team members at the 2005 Banff Informatics Summit

Focus will also be on modifying some of the techniques Freeman's group has developed for studies of micro- and nanomagnetic dynamics, for applications to nanomechanical and fluidic systems. The current world's record for the highest frequency nanomechanical resonance studied is barely above 1 GHz. This is very impressive, but it should be possible to significantly surpass this milestone using stroboscopic optical techniques. This capability will create many exciting new opportunities, including the investigation of coupling between magnetic and mechanical normal modes of oscillation in nanostructures. It may be possible to mechanically tune the damping of ferromagnets, and perhaps even to mechanically induce magnetization reversal.

Our work on microwave electrical probes of material in microfluidic environments, in collaboration with NINT and with Prof. Douglas Thomson at the University of Manitoba (and some additional interaction support from CIAR), is also expanding. An internship student, Steven Olson, has been hired through NINT to ramp up chip production for this project over the next 16 months.

We will continue our studies of magnetization dynamics in confined structures. Initially there will be an emphasis on spectroscopy of normal modes as a function of applied magnetic field. Laterally-patterned multilayers will be investigated, with specimens prepared locally and from SFU. We will work towards an expansion of the NEDO-sponsored collaboration beyond the initial seed project.

The scanning tunneling microscopy project will continue with basic studies of nonequilibrium phenomena on the Si(100) surface at liquid helium temperatures. We have begun to look at the effect of small molecule absorbates on this surface. Starting towards the end of calendar year 2005 the condensed matter physics laboratories will begin the move to new physical space in the Centennial Centre for Interdisciplinary Sciences, Phase I. We are looking forward in particular to installing our low temperature ultrahigh vacuum scanning tunneling microscope in this new environment. Our effort on spin-polarized tunneling and towards dynamics resolved at the level of individual spins by STM will commence after the move.

RESEARCH TEAM MEMBERS

Team Leaders

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Dr Michael Brett	iCORE Professor and iCORE/NSERC/ Micralyne Industrial Research Chair, Canada Research Chair	ASTech Award for Outstanding Leadership in Alberta Technology (2003) Associate Member, CIAR Program in Nanoelectronics (2002)
Dr Mark Freeman	iCORE Professor, Canada Research Chair	Associate Member, CIAR Program in Nanoelectronics (1999)

Faculty Team Members

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Dr Steven Dew	Microfabrication Process Technology	
Dr Abdul Elezzabi	Ultrafast Photonics	McCalla Professor Canada Research Chair in Ultrafast Photonics and Nano-Optics
Dr Jeremy Sit	Nanostructured Devices	
Dr Ray Egerton	Electron Microscopy of Thin Films	MSA Award
Dr Frank Hegmann	Terahertz Spectroscopy	
Dr Frank Marsiglio	Superconductivity	
Dr Al Meldrum	Nanoparticles and Nanomaterials	

Postdoctoral Fellows

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Dr Xiaobin Zhu	Ultrafast Microscopy	Ingenuity Fund Fellowship
Dr Yan Pennec	Local Dynamics at Silicon Surfaces	
Dr Jim Broughton	Supercapacitors	
Dr Greg Kiema	Microfluidic Materials	
Dr Doug Vick	Nanostructure Growth	
Dr Wonkee Kim	Quantum Mechanics of Spin Transfer to Nanomagnets	
Dr Maria Stepanova	Ion Beam Nanostructuring	
Dr Marcus Walther	Near-field Terahertz Spectroscopy	

PhD Students

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Grey Arnup	Single-shot Ultrafast Microimaging	
Miro Belov	Magnetic “Ripple Tanks”	
Jason Blackstock	Nanoscale Molecular Device Fabrication	NSERC Julie Payette
Robert Bryce	Colloids in Microfluidics	NSERC PGSD
Kristen Buchanan	Ferromagnetic Nanocomposites	NSERC PGSD, Steinhauer
Zhigang Liu	Magnetic Modes in Confined Structures	
Allan MacDairmid	Bio-inspired Macromolecular Nanowires	NSERC PGS-B
Barb Djurfors	Nanostructure Characterization	IW Killam Scholarship
James Gospodyn	Chiral Optic Ellipsometry	
Peter Hrudey	Luminescent Nanostructures	NSERC PGSD; iCORE
Anastasia Elias	Replica Nanostructures	NSERC CGSD; Ingenuity; iCORE
Martin Jensen	Photonic Crystal Devices	Ingenuity; iCORE
Andy Van Popta	Chiral Photonic Devices	NSERC CGSD; iCORE
Mark Summers	Photonic Crystal Materials	NSERC PGSD, Ingenuity, iCORE

MSc Students

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Doug Gish	Nanofibre Devices	NSERC PGSM, Ingenuity, iCORE
Matthew Hawkeye	Photonic Filters	Province of Alberta Scholarship
Jason Sorge	Photonic Crystal Wave Guides	Province of Alberta, NSERC PGSM
John Steele	Sensor Devices	NSERC PGSD
Paul Moffat		MSc

Other Team Members

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Dr Mohammed Hedayatipoor	Microwave Dielectric Measurements of Proteins	Visiting Professor
Dr Marek Malac	Electron Holography and Lithography	NINT
Dorothy Fan	Nanofabrication Control Systems	Research Associate
Nick Wakefield	Student Researcher	NSERC Summer Student
Sumudu Fernando	Summer Student Researcher	NSERC Summer Student
Tze Luck Chia	Summer Student Researcher	NSERC Summer Student
Kevin van Popta	Summer Student Researcher	NSERC Summer Student
Delphine Lagarde	Summer Student Researcher	
Cindy Blois	Summer Student Researcher	NSERC Summer Student
Stephen Yewchuk	Summer Student Researcher	
Karin Hayward	Administrative Assistant	
Ben Bathgate	Technician	
Stephenie Bozic	Nanofabrication Specialist	
Lynn Chandler	Administrative Assistant	
David Fortin	Administrator/Technical	

Nanocore Supported Graduate Students of Affiliated Researchers

	ROLE /TOPIC	AWARDS/SPECIAL INFORMATION
Shufen Tsoi	Surface Functionalization	
Vikram Kohli	Femtosecond Laser Nanobiotechnology	
Lucian Covaci	Numerical Simulations of Surfaces and Nanoscale Superconducting Devices	
Fatih Dogan	Electron-phonon Systems using DMRG Method	
Aaron Hryciw	Silicon Nanocluster Photonics	NSERC CGSD, Andrew Stewart Prize, Steinhauer
Nicole MacDonald	Silicon Nanocluster Photonics	Province of Alberta
Peng Li	Radiation Damage to Organic Compounds	
Aaron Slepkov	Nonlinear Optical Properties of Organics	NSERC PGS B
Simona Verga	Researching Nanoscale Superconductivity	
Feng Wang	Magnetic Nanoparticles	Killam Scholarship
Hui (Julie) Qian	Magnetic Nanoparticles	

COLLABORATIONS

PARTICIPANTS	PARTICIPANTS	NATURE OF COLLABORATION
PROVINCIAL		
University of Alberta: Mech Eng	Dr W. Finlay, Dr C. Lange	Fabrication of Nanoengineered Aerosol Particles
University of Alberta: ECE	Dr R. Fedosejevs, M. Taschuk, Dr Y. Tsui	Optical Characterization of Nanostructures
University of Alberta: ECE	Dr K. Westra	Nanostructured Inorganic Materials
University of Alberta: Chem Eng	Dr D. Ivey	Structural Characterization of Nanostructures
University of Alberta: Medicine	Dr J. Acker	Cell Nanosurgery
University of Alberta: Chemistry	Dr J. Veinot	Integrated Sensor Devices
University of Alberta: Chemistry	Dr J. Harrison	Fabrication of Nanopores for Microfluidics
University of Alberta: Chemistry	Dr J.B. Green	
	Dr M. McDermott	Conductive Probe Atomic Force Microscopy
University of Alberta: Physics and Chemistry	Dr F. Hegmann Dr J.B. Green Dr R. Tykwinski Dr R. Wolkow	Molecular Conductors
National Institute Nanotechnology	Dr J Buriak	Nanostructured Ge
PARTICIPANTS	PARTICIPANTS	NATURE OF COLLABORATION
NATIONAL		
Carleton University	Dr T Smy	Nanostructure Growth Modelling
McGill University	Professor P. Grutter	
University of Toronto	Dr S Clemdenning Dr I Manners	Direct-written Organometallic Nanomagnets
University of Manitoba	Dr D Thomson	Small Volume Dielectric Measurements
Simon Fraser University	Dr B Heinrich	Dynamic Coupling in Magnetic Multilayers
INTERNATIONAL		
Philips Research Corporation	Dr D Broer	Study of Nanostructure Liquid Crystal Devices
Technical University of Eindhoven	Dr K. Bastiaansen	Polymer Nanostructures and Devices
Brown University	Dr G. Crawford	Optimizing Liquid Crystals in Nanostructures
National Institute of Advanced Industrial Science and Technology in Japan	Dr Hiro Akinaga	Switching in Nanoscale Magnets
Institut fur Laser und Plasma-physik, Univ Duisburg-Essen	Dr Horn von-Hoegen	Dynamics of Electrons in Nanostructures

INTELLECTUAL PROPERTY

PATENTS	TITLE/NAME	STATUS
DE 69808653, EP1007754B(UK), EP1007754B(FR)	Glancing Angle Deposition of Thin Films	Granted prior to this year
US 5,866,204	Method of Depositing Shadow Sculpted Thin Films	Granted prior to this year
US 6,206,065	Glancing Angle Deposition with Controlled Porosity	Granted prior to this year
US 6,248,422	Shadow Sculpted Thin Films	Granted prior to this year
US 6,549,253	Optical Device	Granted prior to this year
WO9803695	Capped Porous Thin Films	Granted prior to this year
WO9906608	Glancing Angle Deposition of Thin Films	Granted prior to this year
CA 2,182,452	Shadow Sculpted Thin Films	Under review
CA 2,237,732	Glancing Angle Deposition of Thin Films	Under review
JP 2001502013	Capped Porous Thin Films	Under review
JP 2002509188	Glancing Angle Deposition of Thin Films	Under review
US 9-13453-63 USPR	Photodisruption Process For Manipulating Cells	Under review
SPINOFF COMPANIES		
Chiral TF Devices		In product development stage

Micralyne and the University of Alberta have existing agreements that protect certain IP developed in the research programs of Michael Brett. This IP includes:

- the GLAD fabrication process
- improvements to the GLAD fabrication process
- applications utilizing GLAD-fabricated materials
- hybrid liquid crystal/GLAD devices

FUNDING

Michael Brett and Mark Freeman use NSERC money (~$487K) to fund research on their team. In addition, they each hold an iCORE Professorship and a Tier 1 Canada Research Chair ($200K/year). Dr Brett also holds an iCORE Industrial Chair ($100K/year) award. This year their team received substantial funding from CFI (~$6.1M) and ASRA (~$4.9M) and as well as funds from Western Economic Diversification Canada($483K).

PUBLICATIONS

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M Stepanova, SK Dew, and D Karpuzov, "Self-Organized Metal Networks at Ion-Etched Cu/Si and Ag/Si nterfaces", *Journal of Applied Physics*, vol. 97, 2005

Manuscript submitted to *Lasers in Surgery and Medicine* entitled "Cell Nanosurgery Using Ultrashort (Femtosecond) Laser Pulses: Applications to Membrane Surgery and Cell Isolation", Vikram Kohli, A.Y. Elezzabi, & Jason P. Acker, 2004.

Manuscript submitted to *Biophysical Journal* entitled: "Reversible Permeabilization Using High-intensity Femtosecond Laser Pulses: Applications to Biopreservation", Vikram Kohli, Jason P. Acker, & A.Y. Elezzabi, 2005.

J.N. Broughton and M.J. Brett "Variations in MnO2 Electrodeposition for Electrochemical Capacitors" Accepted (March 4, 2005) by *Electrochimica Acta*.

M.O. Jensen and M.J. Brett "Square Spiral 3D Photonic Bandgap Crystals at Telecommunications Frequencies" *Optics Express,* vol. 13, 2005, pp. 3348-3354.

J.J. Steele, J. Gospodyn, J.C. Sit and M.J. Brett, "Impact of Morphology on High Speed Humidity Sensor Performance", accepted (February 15, 2005) to *IEEE Sensors*.

G.K. Kiema, M.O. Jensen and M.J. Brett, "Glancing Angle Thin Film Microstructures for Microfluidic Applications", submitted (December 3, 2004) to *Chemistry of Materials*.

P.CP. Hrudey, M. Taschuk, Y.Y. Tsui, R. Fedosejevs, and M.J. Brett, "Photoluminescent Emission Properties of Porous Nanostructured Y2O3:Eu Thin Films", submitted (October 1, 2004) to *Journal of Vacuum Science and Technology A.*

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