CANADA RESEARCH CHAIR

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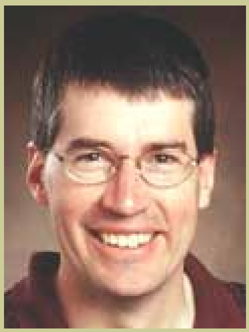
CHAIRHOLDER PROFILES



Mark R. Freeman
Canada Research Chair in Condensed Matter Physics
The University of Alberta
Tier 1 - July 1, 2001

Achievements:	E.W.R. Steacie Memorial Fellowship; Invention Achievement Award (IBM). Patent-holder
Involves:	Nanoscience and nanotechnology – the study and application of minuscule structures, with linear dimensions of tens of atoms
Research Relevance:	Magnetic science; read-write devices for information storage and retrieval; applications for the computer and recording industry

MANIPULATING THE ATOM

Miniaturization has already revolutionized technology in our world. What if science could develop ways to manipulate material at the next level – the level of a single atom?

In fact, nanoscience – the ability to study and manipulate tiny molecules that measure one-billionth of a metre – is already the topic of cutting edge discoveries and applications in physics. Mark Freeman is at the forefront of that science, where physicists are trying to understand and manipulate complex materials at the atomic level.

Nanotechnology has sweeping applications in the information technology field involving, among other things, the interaction between magnets and superconductors. Already, Freeman has worked with IBM on some of their advanced disk drive products.

Awarding Freeman this chair will enable him to continue to set the agenda in applying nanoscience and nanotechnology to applications that will be fundamental to the computer and communications industries of the future. Nanotechnology will fuel the continuing trend of smaller, faster, more capable devices and products, becoming the engine of the information and computer technology economy at the hardware level.

Freeman is already attracting top-calibre graduate students and colleagues to work with him. These researchers will be sought-after by the information technology, materials science, and engineering sectors in Canada. Already a global force in telecommunications, Canada can only benefit from developing greater expertise in nanoscience. Mark Freeman's Web site address is http://laser.phys.ualberta.ca/~freeman/.

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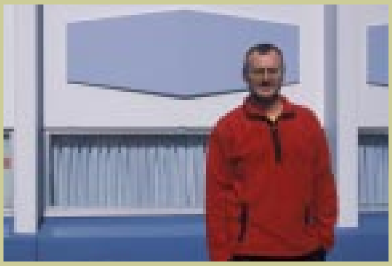

Michael J. Brett
Canada Research Chair in Nanoengineered Films
The University of Alberta
Tier 1 - October 1, 2002

Achievements:	Published over 130 refereed papers and gave numerous talks at major international conferences; awarded the Arthur G. McCalla Research Professorship and the Killam Annual Professorship; three patents issued and three patents pending on a process developed by his group
Research:	Further development of a new materials
Involves:	process, and study of the application of the material in various devices
Research Relevance:	Potential applications in nanobiotechnology and nanoelectromechanical systems

THIN FILMS BY GLAD

An innovative process was recently invented for fabricating porous, nanostructured thin films with a geometry and porosity that can be engineered to specific needs. The new process, called Glancing Angle Deposition (GLAD), does not require complex lithographic processing; rather, it utilizes computer-controlled substrate motion in conjunction with glancing incidence flux from physical vapour deposition to precisely tailor the columnar structure in thin films. This exciting process was discovered by Dr Michael Brett and his team.

These porous nanostructured thin films form a new base materials technology that has potentially broad use across many application areas, such as optics, nanobiotechnology, sensing, and nanoelectromechanical or microelectromechanical systems. Three U.S. patents have been issued for this technology, and others are pending.

As Canada Research Chair in Nanoengineered Films, Dr Brett will further develop this new materials process, dividing the work into various projects. These include periodic nanostrucutures and photonic crystals; nanostructured electrochemical devices; nanoengineered inorganic/liquid crystal devices; nanoelectromechanical systems; nanobiotechnology applications; modelling; sensor devices; and speculative and other research.

To cover such broad application areas, Dr Brett has already established effective collaborations with leading researchers and organizations, including an industry sponsor (Micralyne). He has also formed a company, ChiralTF Devices Inc., which is the primary vehicle for commercializing of GLAD. The ultimate goal of the research is not simply to license the technology, but also to establish a manufacturing facility in Alberta. This technology could have applications in optical devices for photonic and communications firms, the fuel cell industry, materials for nanosystems devices and for improved sensor devices, and optical systems such as flat panel displays.

NANOSCALE ENGINEERING PHYSICS INITIATIVE ("NANOCORE")

Dr Michael Brett
iCORE Professor
Electrical and Computer Engineering
University of Alberta

Dr Mark Freeman
iCORE Professor
Physics
University of Alberta

Dr Mark Freeman and Dr Michael Brett are both iCORE Professors of the iCORE Nanoscale Engineering Physics Initiative, jointly leading a project at the University of Alberta. iCORE has committed $500,000 per year for five years for a total of $2.5 million dollars to develop this research group.

EXECUTIVE SUMMARY

The iCORE Nanoscale Engineering Physics Initiative has concluded its second year of operation. Major research accomplishments this year included experimental demonstrations of spatial and temporal control of magnetization dynamics in mesoscopic structures (and better understanding developed through numerical simulations) and highly controlled growth of large-scale square spiral GLAD structures for photonic crystals.

Nanocore has also continued to play an instrumental role in the growth of nanoscience and engineering research in Alberta. Our efforts to attract Dr Bob Wolkow to Alberta came to fruition, and he is now installed as the senior chair targeted in our original application, and also cross-appointed as a Principal Research Officer at National Institute of Nanotechnology (NINT), a significant bonus we would not have dared predict at the time of the proposal. The "uptake" of Nanocore trainees to Alberta initiatives has begun, with Marek Malac hired by NINT, and Mirwais Aktary in negotiation with Raith Gmbh about setting up a North American office for their nanofabrication product line in Edmonton.

In granting, $8.3 million in funding for nanofabrication tools was secured from Canada Foundation for Innovation and matched by the Alberta Science and Research Investments Program. The commercialization process of GLAD is progressing with ChiralTF Devices Inc., the first Nanocore spin-off, now formulating business plans.

Within the scientific community, Brett and Freeman each made several prestigious appearances at international conferences. In professional service, a number of new appointments to national and international committees were accepted. Brett was recognized with a Canada Research Chair and Freeman received the University of Alberta Alumni Honour Award. Participation in the Canadian Institute for Advanced Research effort in nanotechnology increased, with Brett, Freeman and Wolkow now all associates of the nanoelectronics program. Brett and Freeman have each been announced as cross-appointments to the National Institute of Nanotechnology, an affiliation that should provide for future research collaboration opportunities.

RESEARCH GOALS AND OBJECTIVES

The principle 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 goals are accomplished in parallel with the training of a large number of personnel developing at the forefront of nanoscience and engineering, some of who continue upon graduation to expand the presence of this field in Alberta.

During this second year, the research groups of Nanocore principals Brett and Freeman reached steady-state size, with turnover into Alberta and other nano-initiatives already occurring. After helping to attract the National Institute for Nanotechnology in our first year, we took advantage of the confluence of iCORE, NINT, and the priority on nanotechnology within the University of Alberta to nucleate the recruitment of an iCORE Chair in nano-ICT.

As Nanocore unfolds, it is proving (as expected) instrumental in continuing the evolution of U of A capabilities in nanotechnology. Nearly one-third of Nanocore funds support personnel developing advanced nanofabrication methods in support of the other researchers. As a result, our Nanofabrication Facility is the best in Canada and competes in its specialties with any the world. The remainder of Nanocore funding largely supports postdoctoral fellows, graduate students, and undergraduate research associates working on applications in nano-science and engineering enabled by the foundational methods of nanofabrication. Continuous upgrading of infrastructure is also essential, a spectacular example of which is the showpiece $2M Raith electron beam writing tool arriving later in the year to complement the existing modified scanning electron microscope.

RESEARCH PROJECTS

The team continues to explore the potential of nanomagnetic systems. The almost unbelievable success of conventional magnetic data storage systems shows that magnetic devices miniaturize beautifully to smaller and faster scales, in many respects even better than the semiconductor devices more commonly associated with the ICT revolution of the second half of the twentieth century. The nanomagnetic universe is remarkably rich, however, and many possibilities for future devices remain to be explored. Our favourite stems from the fact that ferromagnetic materials support wave-like excitations (called spin waves or "magnons") of very short wavelengths, down to range of single-digit nanometers. The emerging area of "magnonics" aims to control the generation and propagation of these waves by means analogous to the control of light in photonic crystals. The challenge is very great owing to the exceedingly small scales, but the potential is intriguing. There is significant exploratory work to be done because the intrinsic nonlinear coupling of magnetic excitations adds an additional richness not present in the photonic system.

NANOCORE HAS ALSO CONTINUED TO PLAY AN INSTRUMENTAL ROLE IN THE GROWTH OF NANOSCIENCE AND ENGINEERING RESEARCH IN ALBERTA.

Miro Belov has begun studies of spatial control of magnetic oscillations by examining the influence of individual nanoscale pinholes patterned within a mesostructure. He is able to control the spatial pattern of oscillation and understand the nature of its damping. Sasha Krichevsky is exploring the temporal control of magnetic switching by applying two orthogonal and independently timed switching pulses in a crossed-wire magnetic random access memory geometry. His measurements add temporal and spatial dimensions to the famous Stoner-Wohlforth magnetic "switching astroid." Kristen Buchanan has discovered a very exciting giant Faraday rotation with ultrafast response in nanocrystalline magnetic composites. The mechanism is not yet understood, but appears to also be magnetic field tunable.

Advanced nanofabrication is

being pursued on a variety of fronts. Marek Malac has developed electron beam patterning on the sub-10 nm length scale in the transmission electron microscope. This is particularly promising because the TEM also allows registration to the crystallinity of the starting material in the case of a subtractive pattern transfer process. Mirwais Aktary has made great progress in sub-50 nm patterning with novel electron beam resists in the Nabity-SEM system at the Nanofab. Allan MacDairmid and Rhyan Arthur have succeeded in synthesizing protein/inorganic nanocrystal composite nanowires driven by the self-assembly of tubulin drivers into microtubules. The wires have been characterized by transmission electron and fluorescence microscopy, but electrical measurements have yet to be performed. Allan MacDairmid, Dave Fortin, and Jason Blackstock have constructed a conductive AFM add-on for a microscope of Professor Green, Chemistry.

Jason Blackstock has succeeded in developing very flat platinum nanoelectrodes for molecular electronics by template stripping of films deposited through porous membranes. In the area of advanced characterization, Marke Malac and colleagues at Brookhaven have accomplished qualitative mapping of magnetic fields from small magnetic elements, and demonstrated correspondence with simulation by Zhigang Liu.

The Marsiglio group has made advances in the study of effects of low dimensionality and surface/impurities/geometries relevant to nanoscale superconductivity. Hegmann's group, with Slepkov, Barker and Tykwinski continued their work on the nonlinear optical properties of organic materials, and began the examination of transient photoconductivity of functionalized molecular crystals. The measurements are helping to elucidate the nature of photoscitations and photoconductivity in organic materials. Meldrum's group is make rapid progress in the synthesis and characterization of light-emitting silicon nanocrystal, intended for integrated silicon optoelectronics. Michael Brett's team continues to explore the fabrication and applications of nanoengineered structures in thin films. The patented glancing angle deposition (GLAD) process is used to fabricate nanostructures with a porous chiral, post, or chevron morphology. These novel coatings are providing opportunities for team researchers to explore device applications where the structure and surface area provide advantages over conventional materials. Some of the projects are listed below.

In photonics applications, Scott Kennedy and Martin Jensen are fabricating and studying a new geometry of 3D photonic crystal, the square spiral array, which was recently proposed by collaborator Dr Sajeev John. This architecture of photonic crystal may be more readily manufactured and more amenable to intentional defect incorporation than other competing photonic crystal technologies. In related work, graduate student Andy Van Popta, with co-supervisor Dr Jeremy Sit and collaborator Dr Dick Broer of Philips Research Labs, is studying the infiltration of arrays of helical structures with optically active liquid crystals. This combination provides for an electrically switchable chiral optic medium, which has potential applications to power-efficient flat panel displays. Peter Hrudey is developing luminescent chiral materials, which are also a potential component for flat panel displays.

In a project that applies ICT technology to the energy field, Jim Broughton is utilizing the GLAD fabrication processes to develop porous electrode structures for application in supercapacitors. Such supercapacitors have been proposed as devices to provide energy load-levelling in technologies such electric cars. Graduate student Barb Djurfors, co-supervised with Dr Doug Ivey, is studying microstructural properties of the GLAD coatings in an effort to understand and optimize the charge storage mechanism.

Ken Harris and Anastasia Elias are developing new forms of nanostructured materials, specifically helically perforated membranes and films. These are fabricated by a template and casting process in a variety of materials, and Harris and Elias have demonstrated that chiral perforated thin films (or PTFs) may have superior optical properties when compared to the original chiral structures.

Research affiliates with Nanocore have been working in other exciting areas. These include: integrating tunnel diodes and other devices to fabricated remotely and radio frequency detectable tags for monitoring purposes (Jay Sulima and Dr Chris Backhouse), studying ultrafast femtosecond dynamics in semiconductors (Michael Cummings and Dr Abdul Elezzabi), and simulating and studying ion beam nanostructuring of surfaces (Maria Stepanova and Dr Steven Dew).

RESEARCH TEAM

TEAM LEADER	AWARDS
Michael Brett	Canada Research Chair in Nanoengineered Thin Films, Micralyne/NSERC Senior Industrial Research Chair
Mark Freeman	Canada Research Chair in Condensed Matter Physics, Alumni Honour Award
FACULTY TEAM MEMBERS	**TITLE**
Chris Backhouse	Affiliated Researcher
Steven Dew	Affiliated Researcher
Ray Egerton	Affiliated Researcher
Abdul Elezzabi	Affiliated Researcher
Frank Hegmann	Affiliated Researcher
Frank Marsiglio	Affiliated Researcher
Al Meldrum	Affiliated Researcher
Jeremy Sit	Affiliated Researcher

OTHER TEAM MEMBERS	RESEARCH TOPIC
Dr Marek Malac	Patterning of Permalloy Structures in Transmission Electron Microscope
Dr Mirwais Aktary	Nanolithographic Process Development
Dr Jim Broughton	Porous Electrodes for Supercapacitors
Dr Gregory Kiema	Microfluidic Devices, Carbon Electrodes
Dr Maria Stepanova	Ion Beam Nanostructuring
Dr Doug Vick	Nanostructure Growth and Modeling

POSTDOCTORAL FELLOWS	TOPIC	AWARDS
Won Kee Kim	Theory of Nanoscale Superconductivity and Magnetism	
Mark Roseman	Dynamics in Low Temperature Mesostructures	NSERC Postdoctoral Fellowship
Xiaobin Zhu	Current-driven Dynamics and Relaxation in Multilayers	

PHD CANDIDATES	TOPIC	AWARDS
Greg Ballentine	Numerical Simulation of Magnetic Dynamics	
Miroslav Belov	Spatial Control of Modal Oscillations	JDS Uniphase Scholar
Jason Blackstock	Molecular Electronics	Julie Payette Award
Kristen Buchanan	Nanocrystalline Magnetic Composites	Steinhauer, Killam Memorial Scholar and Graduate Awards
Brian Dick	Fabrication of Periodic Nanostructures	NSERC PGS-B
Barb Djurfors	Nanostructure Characterization	NSERC PGS-B
James Gospodyn	Spectroscopic Ellipsometry of Chiral Materials	
Ken Harris	Perforated Thin Films	NSERC PGS-B
Martin Jensen	Photonic Crystal Devices	Alberta Ingenuity
Scott Kennedy	Photonic Crystal Fabrication	AIXTRON Young Scientist Award, NSERC PGS-B
Sacha Krichevsky	Dynamic Switching “Astroids	
Allan MacDairmid	Bio-inspired Macromolecular Nanowires	NSERC PGS-B
Mary Seto	Mechanical Properties of Microsprings	

MSC CANDIDATES	TOPIC	AWARDS
Grey Arnup	Single-shot Ultrafast Microimaging	
Zhigang Liu	Numerical Simulation of Equilibrium Magnetization	
Mike Colgan	Graetzel Solar Cells	NSERC PGS-A
Michael Cummings	Ultrafast Carrier Dynamics in Semiconductors	
Anastasia Elias	Perforated Thin Films	Alberta Ingenuity, NSERC PGS-A
Peter Hrudey	Chiral Luminescent Coatings	NSERC PGS-A
Jay Sulima	Tunnel Diodes for Wireless Applications	
Andy Van Popta	Liquid Crystal Hybrid Devices	NSERC PGS-A, Steinhauer Award

UNDERGRADUATES	TOPIC
Rhyan Arthur	(Physics Industrial Internship) Biochemical Synthesis and Confocal Microscopy
Timmy Le	(Engineering Co-op student) Anodic Aluminum Oxide Membrane Fabrication
Lindsay Leblanc	Digital In-line Holography
Graham Nelson	Magnetic Switching from Nonequilibrium Initial State
Daniel Salamon	Glass Microfabrication

AFFILIATED STUDENTS SUPPORTED BY NANOCORE	TOPIC	AWARDS
Lloyd Barker	Time-resolved Photoconductivity of Pentacene	
Lucian Covaci	Numerical Simulations of Surfaces, Nanoscale Superconducting Devices	
Aaron Hryciw	Light-emitting Nanocrystalline Silicon	Steinhauer Award
Peng Li	Radiation Damage to Organic Compounds	
Colm Ryan	Whispering Gallery Modes in Spherical Cavities	
Aaron Slepkov	Nonlinear Optical Properties of Organics	
Simona Verga	Researching Nanoscale Superconductivity Issues	

COLLABORATIONS

Research Collaboration

Strong collaborations exist within the Nanocore program. Brett and Freeman co-supervise postdoc Mirwais Aktary in his work on sub-50 nm resolution electron beam lithography and pattern transfer. Freeman and Meldrum co-supervise PhD student Kristen Buchanan in her work on nanocrystalline composite magnetic materials exhibiting giant and ultrafast magneto-optical response. Freeman and Hegmann co-supervise MSc student Grey Arnup at work on single-shot imaging of ultrafast phenomena. Freeman is co-supporting postdoc Won Kim with Marsiglio, working on theory of nanoscale superconductivity and magnetism. Brett and Sit co-supervise Andy Van Popta who is studying chiral photonic materials.

Collaboration with Industry

Brett ended his first five-year term working with Micralyne under the Micralyne/NSERC Industrial Research Chair, and has applied (with Micralyne's support) for a further five years of funding. This research concerns device development of GLAD nanostructured materials.

Freeman and Krichevsky continued to work with Maxtor and Read-Rite on high data rate magnetic recording head characterization.

Jason Blackstock took an internship in molecular electronics at Hewlett Packard Laboratories, with the group of Stan Williams that has become famous for its work on prototype molecular random access memories in the crossbar configuration.

Multidiscipline or Multi-Institutional Partnerships

Important multidisciplinary and multi-institutional collaborations have arisen as a result of the CIAR program. One of the most compelling discoveries in magnetism in recent years has been the "spin-transfer torque" phenomenon, in which a spin-polarized electrical current at high current density carries with it a capability to re-orient magnetization via relaxation of the spin polarization that competes with or even exceeds the influence of the conventional "Oersted field" associated with the current itself. A corollary of this effect is a novel mechanism of damping (or amplification) of magnetic excitations via the passage of currents through "multilayer" geometries (in which ferromagnetic layers are separated by thin non-magnetic spacers). We are working with Simon Fraser University on magnetodynamics in multilayers. Bret Heinrich and colleagues have the ability to grow the most nearly perfect films in the world, and our time-resolved microscopy methods are suited to the study of current-driven and nonlinear response of the multilayers and of mesoscopic devices patterned from them. Within the CIAR, we also collaborate with leading theoretician Dr Sajeev John, who has highly innovative proposals for photonic crystal materials and devices.

A strong collaboration has been established with organic chemists Dr Dick Broer of Philips Research Laboratories (The Netherlands) and Dr Kees Bastiaansen of the Technical University of Eindhoven in the field of making hybrid materials composed of organic liquids or polymers and inorganic GLAD nanostructured coatings. This research is studying methods to better tailor the orientation and performance of liquid crystals in displays, and of methods to make uniquely structured polymers.

The Brett group continues to work closely with Dr Tom Smy of Carleton University, who is able to perform full three-dimensional simula-tions of the intricate structures engineered by Glancing AngleDep-osition. This simu-lation insight is essential to optimizing the GLAD structures in various applications, particularly photonics. The GLAD films also provide a good experimental verification for the 3D simulator, which may ultimately be released as a commercial product similar to the SIMBAD simulator developed by Smy, Brett and Dr Steven Dew.

IMPORTANT MULTIDISCIPLINARY AND MULTI-INSTITUTIONAL COLLABORATIONS HAVE ARISEN AS A RESULT OF THE CIAR PROGRAM.

We have begun work on biomaterials, inspired by the theoretical work of physics professor Jack Tuszynski on microtubules, and experimental results of (and assistance from) his colleagues Silke Behrens and Eberhard Unger of Forschungszentrum Karlsruhe. The work is further motivated by the view that wet nanotechnology is quite important, for instance it is perhaps the only way that the "wiring problem" will be conquered in a cost-effective manner. Graduate student Allan MacDairmid and internship student Rhyan Arthur are working on polymerization and depolymerization of tubulin, decoration with inorganic nanocrystals, and electrical characterization interfacing with microfluidics techniques. Valuable assistance has been received from U of A chemist Jed Harrison (microfluidics) and John-Bruce Green (atomic force microscopy). Frank Hegmann and Rik Tykwinski (Chemistry) maintain a strong collaboration on optical properties of organic materials.

Brett and Research Associate and chemist Dr Gregory Kiema, are studying the incorporation of GLAD nanostructures into microfluidic devices. These highly tailorable structures may have advantages over current packed bead systems used for micro--chromatography and other on-chip processes.

FUNDING

In addition to the iCORE funding of $500,000, the Nanocore project received $966,000 from Western Diversification, $8,247,533 (includes ASRIP and matching funds) from the CFI Innovation fund, and successful leveraging of iCORE funds with CIPI. As part of the Canada Research Chair appointment, Michael Brett was awarded $312,500 for an advanced Physical Vapour Deposition System. Canada Research Chair funding was $358,000, and $279,500 was received from NSERC.

Industry funding included $112,000 in cash from Micralyne, Read-Rite and Maxtor, and $232,000 in-kind from Micralyne and JDS Uniphase. Michael Brett was also awarded $237,000 from the Micralyne/NSERC Senior Industrial Research Chair.

INTELLECTUAL PROPERTY

Received or created over lifetime

1. M.R. Freeman, Method for measuring current distribution in an integrated circuit by detecting magneto-optic polarization rotation in an adjacent magneto-optic film, US Patent #5,663,652 (1997).
2. M.R. Freeman, Fiber optic probe with a magneto-optic film on an end surface for detecting a current in an integrated circuit, US Patent #5,451,863 (1995).
3. Spin-off company, Picomagnetics Inc., 1996 - 2003 (phasing out in favour of simple direct invoicing by the Department of Physics).
4. K.J. Robbie, D.J. Broer, M.J. Brett, J.C. Sit, "Optical Device," US Patent #6,549,253 (2003).
5. K.J. Robbie and M.J. Brett, "Shadow sculpted thin films," US Patent #6,248,422 (2001).
6. K.J. Robbie and M.J. Brett, "Glancing angle deposition of thin films," U.S. Patent #6,206,065, (2001).
7. K.J. Robbie and M.J. Brett, "Method of Depositing Shadow sculpted thin films," U.S. Patent #5,866,204 (1999).
8. R.R. Parsons and M.J. Brett, "Transparent, Heat Reflective, Metal Oxide Films," Canadian Patent #1,216,821 (1987).

Potential for future commercial activity

The University of Alberta Industry Liaison Office, in a partnership with Micralyne, led the creation of a new spin-off company, ChiralTF Devices Inc., which was established to commercialize the Glancing Angle Deposition (GLAD) Technology invented in Brett's lab. The company is in a business development and concept planning stage.

PUBLICATIONS

Refereed Journal Publications

1. W.K. Hiebert, G.E. Ballentine, and M.R. Freeman, “Correspondence of Experimental and Numerical Micromagnetic Dynamics in Coherent Precessional Switching and Modal Oscillations,” *Physical Review B (Rapid Communications)*, vol. 65, 2002, pp. 140404-140408.
2. G.M. Steeves and M.R. Freeman, “Ultrafast Scanning Tunneling Microscopy,” *Advances in Imaging and Electron Physics*, vol. 125, 2002, p. 195-229.
3. S. Zelakiewicz, et al., “Time-Resolved Kerr Measurements of Magnetization Switching in Crossed-Wire Ferromagnetic Memory,” *Journal Applied Physics*, vol. 91, 2002, pp. 7331-7333.
4. W.K. Hiebert et al., “Ultrafast Imaging of Incoherent Rotation Magnetic Switching with Experimental and Numerical Micromagnetic Dynamics,” *Journal Applied Physics*, vol. 92, 2002, p. 392.
5. J.N. Broughton and M.J. Brett, “Electrochemical Capacitance in Manganese Thin Films with Chevron Microstructure,” *Electrochemical and Solid State Letters*, vol. 5, 2002, pp. A279-282.
6. K.D. Harris, A. Huizinga, and M.J. Brett, “High Speed Porous Thin Film Humidity Sensors,” *Electrochem. Solid State Letters*, vol. 5, no. 11, 2002, H27-H29.
7. M. Seto, K. Westra, and M.J. Brett, “Arrays of Self-Sealed Micro-Chambers and Channels,” *Journal Materials Chemistry*, vol. 12, 2002, pp. 2348-2351.
8. K.D. Harris, A. Huizinga, and M.J. Brett, “A Simple and Inexpensive Humidity Control Chamber,” *Measurement Science and Technology*, vol. 13, 2002, pp. N10-N11.
9. D. Vick, M.J. Brett, and K. Westra, “Porous Thin Films for the Characterization of AFM Tip Morphology,” *Thin Solid Films*, vol. 408, 2002, pp. 79-86.
10. S.R. Kennedy et al., “Fabrication of Tetragonal Square Spiral Photonic Crystals,” *Nano Letters*, vol. 2, 2002, pp. 59-62.
11. M.D. Cummings, J.F. Holzman, and A.Y. Elezzabi, “Carrier Transport Dynamics in an Edge-Illuminated Photoconductive Switch,” *Journal Vacuum Science Technology A*, vol. 20, 2002, p. 1057.
12. M. Stepanova and S.K. Dew, “Discrete-Path Theory of Physical Sputtering,” *Journal Applied Physics*, vol. 92, 2002, pp. 1699-1708.
13. M. Stepanova, S.K.Dew, and I.P. Soshnikov, “Sputtering from Ion-Beam Roughened Cu Surfaces,” *Physical Review B*, vol. 66, 2002, p. 125407.
14. R. Egerton and M. Malac, “Improved Background-fitting Algorithms for Ionization Edges in Electron Energy-Loss Spectroscopy,” *Ultramicroscopy*, vol. 92, no. 2, July 2002, pp. 47-56.
15. R.F. Egerton, “The Future of EELS,” *Microscopic Microanalysis*, vol. 8 (Suppl. 2), 2002, pp. 464-465.
16. R.F. Egerton, “Application of Electron Energy-loss Spectroscopy to the Study of Solid Catalysts,” *Topics in Catalysts*, vol. 21, 2002, pp. 185-190.
17. M. Malac et al., “Exposure Characteristics of Cobalt Fluoride (CoF2) Self-Developing Electron-Beam Resist on a Sub-100nm Scale,” *Journal Applied Physics*, vol. 92, 2002, pp. 1112-1122.
18. Y. S. Yang et al., “Spin Wave Response in the Dilute Quasi-one Dimensional Ising-Like Antiferromagnet CsCo{0.83} Mg{0.17} Br3,” *Physical Review B*, vol. 65, pp. 212408-1-4.ss.
19. L. Deakin et al., “Superconductivity in Ba2 Sn3 Sb6 and SrSn 3Sb4,” *Journal of Alloys and Compounds*, vol. 388, 2002, pp. 69-72.
20. K. Tanaka and F. Marsiglio, “Microscopic Study of Inhomogeneous Superconductors,” *Journal Phys. Chem. of Solids*, vol. 63, 2002, pp. 2287-2293.
21. K. Tanaka and F. Marsiglio, “S-wave Superconductivity Near a Surface,” *Physica C*, vol. 384, 2003, pp. 356-368.
22. S. Verga, A. Knigavko, and F. Marsiglio, “Inversion of ARPES Measurements in High Tc Cuprates,” *Physical Review B*, vol. 67, 2003, pp. 054503-1-5.
23. F.A. Hegmann et al., “Picosecond Transient Photoconductivity in Functionalized Pentacene Molecular Crystals Probed by Terahertz Pulse Spectroscopy,” *Physical Review Letters*, vol. 89, 2002, p. 227403.

24. A.D. Slepkov et al., "Optical Properties of Cross-Conjugated Iso-Polydiacetylene Oligomers as Measured by UV-vis Spectroscopy and the Optical Kerr Effect," *Journal Optics. A: Pure Applied Optics*, vol. 4, 2002, pp. S207-S211.
25. R.R. Tykwinski et al., "Nonlinear Optical Properties of Thienyl and Bithienyl Iodonium Salts as Measured by the Z-Scan Technique," *Journal Optics. A: Pure Applied Optics*, vol. 4, 2002, pp. S202-S206.
26. A.D. Slepkov et al., "Ultrafast Optical Kerr Effect Measurements of Third-Order Nonlinearities in Cross-Conjugated Iso-Polydiacetylene Oligomers," *Journal Chem. Phys.*, vol. 116, 2002, pp. 3834-3840.

Accepted publications by refereed journals

1. B. Dick, M.J. Brett, and T. Smy, "Controlled growth of periodic pillars by glancing angle deposition," to be published in *Journal Vacuum Science and Technology B*, Jan/Feb 2003.
2. K.D. Harris, J.C. Sit, and M.J. Brett, "Fabrication and Optical Characterization of Template-Constructed Thin Films with Chiral Nanostructure" to be published in IEEE *Trans. Nanotechnology.*
3. K.D. Harris, et al., "Column Angle Variations in Porous Chevron Thin Films" to be published in *Journal Vacuum Science Technology A.*
4. D. Vick, T.J. Smy, and M.J. Brett, "Growth Behavior of Evaporated Porous Thin Films," to be published in *Journal Materials Research.*
5. S.R. Kennedy and M.J. Brett "Porous Broadband Antireflection Coating by Glancing Angle Deposition," to be published in *Applied Optics.*

Proceedings

1. B.C. Choi, A. Krichevsky, and M.R. Freeman, Ultrafast Magnetization Imaging, to be published in *Proceedings of the IEEE*, June 2003.
2. A. Hryciw et al., "Luminescence of Silicon Nanocrystals in SiO2: Effects of Excitation Spectrum," to be published in *Mater. Res. Soc Symp. Proc.* vol. 777.
3. M.O. Jensen, S.R. Kennedy, and M.J. Brett, "Fabrication of periodic arrays of nanoscale square helices" *Materials Research Society Symposium*, April 2002, San Francisco. Accepted (July 30, 2002) for publication in the proceedings.
4. S. R. Kennedy et al., "Fabrication of Square Spiral Photonic Crystals by Glancing Angle Deposition," *SPIE Proc. of the 10th International Symposium on Nanostructures: Physics and Technology*, St. Petersburg, Russia, in press (2002).
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2. Mark Freeman, American Physical Society Northwest Section meeting plenary talk, Banff May 2002.
3. B.C. Choi, "Dynamic Domain Configurations in Mesoscopic Thin Film Elements with Various Aspect Ratios," Magnetism and Magnetic Materials Conference, Tampa.
4. A. Krichevsky, "The Effect of Pole-tip Geometry on the Flux Rise Time of Write Heads," Magnetism and Magnetic Materials Conference, Tampa.
5. M. Belov, "Magnetization Dynamics of Internally Patterned Thin Film Microstructures: a Spatiotemporal Study," Magnetism and Magnetic Materials Conference, Tampa.

6. M.J. Brett, "Fabrication and Optical Behaviour of Chiral Thin Film Materials," Invited talk at the Society of Vacuum Coaters Annual Convention, Orlando, April 16, 2002. With invited paper in: SVC 45th Ann. Technical Conf. Proc., 2002, pp. 238-244.
7. J.C. Sit, D.J. Broer and M.J. Brett, "Control of Liquid Crystal Orientation in Optical Devices Using Porous Engineered Thin Films Grown by Glancing Angle Deposition," 19th International Liquid Crystals Conference, Glasgow, July 2002.
8. M. Malac, "Electron Beam Patterning with Carboneous Contamination Resists Below 10 nm Linewidth," 49th International Symposium of American Vacuum Society in Denver (CO).
9. M.J. Colgan, G.K. Kiema, and M.J. Brett, "Application of Nanocrystalline Structures to Photovoltaic Cells," Materials Research Society Fall Meeting, December 2002, Boston, MA.
10. B. Dick, M.J. Brett, and T.J. Smy, "Growth Studies of Periodic and Aperiodic Arrays of Posts and Helices," Materials Research Society Fall Meeting, December 2002, Boston, MA.
11. S.R. Kennedy, M.O. Jensen, M.J. Brett, O. Toader, and S. John, "Three-Dimensional Square Spiral Photonic Crystals," Photonic Nanostructures 2002, San Diego, October 25, 2002.
12. M.O. Jensen, S.R. Kennedy, and M.J. Brett, "Thin Film Chiral Nanostructures for Photonic Applications," Photonic Nanostructures 2002, San Diego, October 25, 2002.
13. B. Dick, M.J. Brett, and T.J. Smy, "Sculptured Thin Films Grown by Glancing Angle Deposition," NRC Frontiers of Integration Meeting, Edmonton, October 28, 2002.
14. M.O. Jensen, S.R. Kennedy, and M.J. Brett, "Thin Film Chiral Nanostructures for Photonic Applications," NRC Frontiers of Integration Meeting, Edmonton, October 28, 2002.
15. J.N. Broughton and M.J. Brett, "Performance of Nanostructured Thin Films in Electrochemical Capacitors," NRC Frontiers of Integration Meeting, Edmonton, October 28, 2002.
16. M.D. Cummings and A. Y. Elezzabi, "Photo-Excitation of Coherent Acoustic Phonons in InSb," 13th International Conference on Ultrafast Phenomena, Vancouver, B.C., May 2002.

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4. M.D. Cummings and A.Y. Elezzabi, "Photo-Excitation of Coherent Acoustic Phonons in InSb," *Ultrafast Phenomena XIII*, ed. R.D. Miller, M.M. Murnane, N.F. Scherer, and A.M. Weiner, Springer Series in Chemical Physics, 2002, p. 383.
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EQUIPMENT IN THE NANOFAB

Atomic Force Microscope

Electron Beam Lithography

Mini-brute Oxidation Furnace

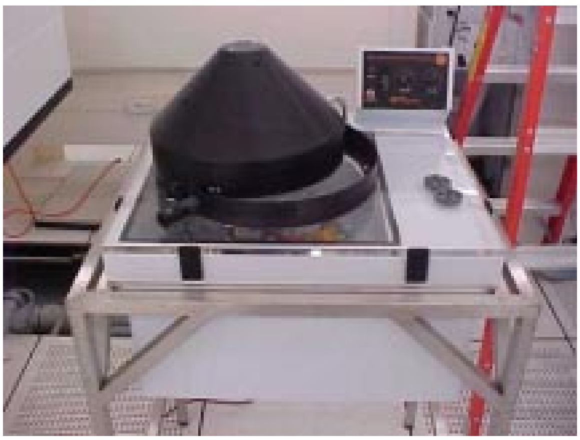
Wentworth Prober Station

Ion Mill

Aisle 3 Fume Hood

Wetdeck aisle 2

Trion Technologies PECVD



High Pressure Washer

Spectroscopic Elipsometer (VASE)

Lesker Sputter System 'Bob'

Electron Beam Evaporator Gomez