Graduate Studies at the Department of

Materials Science and Engineering
McMaster University



MATERIALS SCIENCE AND ENGINEERING | mse.mcmaster.ca

McMaster University
ENGINEERING

START YOUR CAREER HERE

The sky's the limit when it comes to career opportunities. Alumni of McMaster MSE's graduate programs are working in private and government research labs, managing ground-breaking projects in Canadian industry, hold academic posts at McMaster and other universities, or are working to extend the frontiers of engineering knowledge and practice in many places around the world, from Switzerland to Singapore. With its reputation for research excellence, strong industry partnerships, and world-class reputation, McMaster MSE is the perfect place to start your career.

McMASTER GRADUATES ARE EMPLOYED THROUGHOUT THE WORLD

A.E.C.L.
A.F.C.L.
ABC Group Inc.
ACL
Alberta Research Council
ArcelorMittal
ArcelorMittal Dofasco
BlueScope Steel, Australia
Bodycote, Mississauga
Bund University
CANMET, Ottawa
Carnagie-Mellon, Pittsburgh
Celestica
Daimler-Chrysler, China
Defence Dept., Singapore
Dupont, Singapore
Essar Algoma Steel
ETS, Zurich
Evraz Inc. NA
Fluor Canada,Vancouver
GE Water & Process Technologies
General Motors
Integran Technologies
Kansas State University
Kinectrics
Liburdi Engineering Ltd.
Magna
Manufacturing Research, Beijing, China
McKinsey & Company
McMaster University
MSc Ontario
MTD Corning Inc., NY
Nigerian Oil Co.
Norske Hydro, Norway
Novelis
NR, Inst. of Chemical Process & Enviromental Tech.
NRC, Vancouver
Nuvera Co., USA
Research NIMS, Tsukuba, Japan
Severstaal NA
Stats Oil, Norway
Syncrude Canada Ltd.
U.C.S.B.
University of British Columbia
University of California, Santa Barbara
University of Queensland
University of Toronto
University of Waterloo
University of Windsor
University of Western Ontario
U. S. Steel Canada
Vac Aero International
Vale Inco
Xerox
Z.T.H., Switzerland

COVER PHOTO: The new Canadian Centre for Electron Microscopy's ultra-high-resolution Titan electron microscope can image individual atoms.

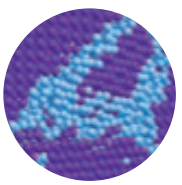
McMASTER MATERIALS SCIE

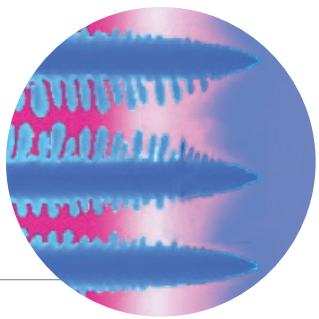
Imagine an open, innovative and collaborative learning environment that promotes new thinking and fresh perspectives; a place where positive working relationships among students, faculty, researchers, government and industry are encouraged and fostered.

Now, imagine working side by side with researchers tackling some of the most interesting, relevant and challenging problems of our age: developing technologies for creating highly-efficient, flexible solar cells; investigating metallic and semiconductor thin films that will revolutionize electronics and computing; designing biomaterials that can be used to repair blood vessels and treat cornea blindness; and exploring new ways to build light-weight, fuel-efficient automobiles.

Ranked among the top 10 materials sciences programs in North America, McMaster Engineering's *Materials Science and Engineering Department (MSE)* boasts some of the best facilities in the world, including:

- The Canadian Centre for Electron Microscopy
- The Brockhouse Institute for Materials Research
- The Steel Research Centre
- The Centre for Automotive Materials and Corrosion.





With its reputation for a student-centred, problem-solving approach to education, world-renowned faculty and research facilities second to none, McMaster is the right choice to pursue your graduate studies in materials science and engineering.

MSE RESEARCH AREAS

NANOTECHNOLOGY AND NANOMATERIALS

Using some of the most advanced electron microscopy facilities in the world, we investigate the structure and properties relationships in a range of materials:

- The nanoscale structure of fuel cell nanoparticles and battery materials are investigated by high resolution imaging and spectroscopy to determine how their shape and composition affect their properties.
- The interfaces in ferroelectric materials, quantum well and photovoltaic structures are studied with electron microscopy in order to determine their influence on the information storage performance and optoelectronic properties.



- The structure of bones and the interfaces between biomaterials and living tissues are probed to understand the process of biomineralization and the growth process of new bones around implants.



ENERGY AND FUEL CELLS

- Developing compatible interconnect materials for Pb-free thermoelectric generators.
- Developing electrically conducting ceramic coatings for high temperature fuel cells.
- Extending lifetime of sodium based high capacity Zebra batteries.
- Developing thermodynamic models for spinels and perovskites that are key components of materials for energy conversion.

SCIENCE AND ENGINEERING

AUTOMOTIVE RESEARCH

- Through research consortia such as the $46M Initiative for Automotive Manufacturing Innovation, and the newly established General Motors of Canada Centre for Automotive Materials and Corrosion, McMaster aims to become the premier university research centre in North America for the development of lightweight vehicle materials technologies.
- Collaborating with industry and government partners we are working to develop Mg alloy sheet for ultra-lightweight automotive structures, based on twin roll casting technology. This could revolutionize vehicle design and manufacture over the next few years.



- Research also extends to other materials systems and their reliability. Stress corrosion cracking of advanced automotive materials will be studied with the goal to develop new materials reliability codes that can be applied to the design of complex automotive components – an activity that will be unique in North America.
- The demand for increased fuel efficiencies to be achieved through light-weighting and the integration of new materials into complex components presents tremendous challenges that will be addressed through investigation of novel casting, forming and machining technologies.

COMPUTATIONAL MATERIALS SCIENCE

Molecular dynamics, continuum and thermodynamic modeling can provide important information about:

- Structure and properties of nanoscale materials
- Properties of interfaces and grain boundaries
- Behavior of point and line defects.

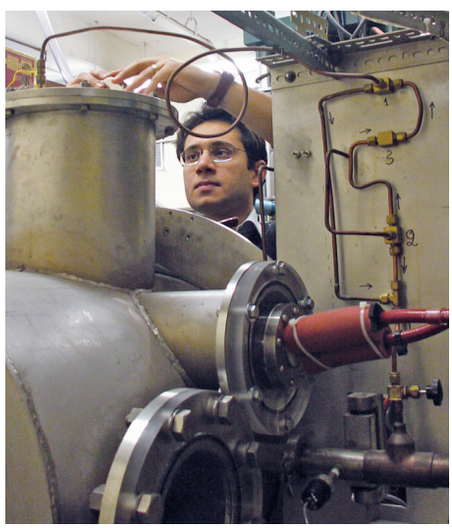


STEEL AND STEELMAKING

Electric Arc Furnace steelmaking is growing in popularity because of availability of steel scrap for recycling; this process also uses less energy and preserves natural resources. Despite its importance there has been little fundamental work on the efficiency of the process. Therefore, a large research program has been undertaken to examine various aspects such as heat transfer to scrap, the efficiency of burners and the fundamentals of slag foaming. This work is expected to benefit current operations and aid in the design of the next generation of furnaces.

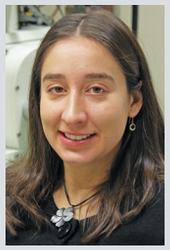
PHYSICAL METALLURGY

- Development of Compositionally-Graded Steels with unique combinations of mechanical properties.
- Experimental investigation and modeling of interfacial conditions during phase transformations.
- Thermomechanical processing of microalloyed steels.



GRADUATE STUDENT PERSPECTIVES

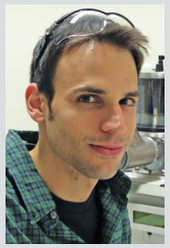
ERIKA BELLHOUSE



Galvanizing of Al-Si TRIP-Assisted Steels

"The Materials Science and Engineering Department has provided me with a positive and challenging learning environment with state of the art research facilities allowing me to grow as a researcher. I have greatly benefited from my interactions with industry through McMaster Steel Research Centre and from the opportunity to present my work to international audiences at a number of conferences."

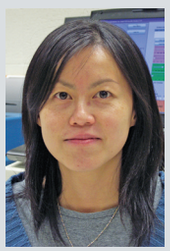
TRAVIS CASAGRANDE



The Deposition of Conjugated Polymer Functionalized Carbon Nanotube Films for Organic Solar Cell Devices

"The graduate program in McMaster's materials department is full of opportunities in the emerging fields of biomaterials, fuel cells, solar cells, computational modeling, next generation automotive materials, and the characterization of nanoscale materials, as well as being a stronghold in the traditional fields of metallurgy and material processing."

LINA GUNAWAN



The aberration-corrected TEM studies on structures of multilayered-perovskite oxides

"A splash of curiosity, a pinch of challenge, a basketful of right questions, and baking in the oven of 'graduate study' are things you need in turning imagination into science. There is no point in believing in everything you read, so why don't you prove it yourself."

NANA OFORI-OPOKU



Quantitative Multi-Phase Field Modeling of Polycrystalline Solidification

"It is a privilege to be part of the Materials Science and Engineering department at McMaster University. The opportunity to work with some of the best minds, and in one of the best departments in the field, has made all the difference in my graduate experience."

GRADUATE STUDENT PERSPECTIVES

HARITH HUMADI



A Theoretical and Atomistic Simulation Study of Solute Trapping during Rapid Solidification

"The faculty members, administrative staff, and lab techs work very hard to accommodate the needs of our students. This creates a comfortable environment for the students to get the best out of their grad school experience."

DAVID ROSSOUW



New Materials for Thermoelectric Energy Conversion from the Exhaust Heat of Automobiles

"I am less than a year into the program and already I have communicated with researchers from around the world, learned to operate state of the art equipment, shared my knowledge through teaching as a TA, and attended seminars from leaders in new and exciting fields. Graduate studies at MSE is an engaging, enriching and dynamic program, and worth serious consideration for any undergraduate student."

LEARN WHILE YOU EARN

SUMMER RESEARCH OPPORTUNITIES

Looking for an opportunity to "test drive" McMaster Engineering? A summer job working on one of these projects might be just what you need to get acquainted with graduate studies at McMaster. Our research opportunities include:

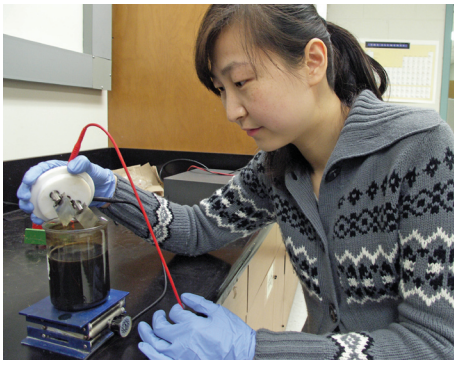
- Critical corrosion issues for storage and transport of bioethanol fuels
- Interface stability during 2D directional solidification in succinonitrile-acetone mixtures.
- pH gradient problems in bio-fuel cells
- Liquid phase organic transistors
- TEM and SEM investigation of lithium-iron-phosphate battery materials
- Characterization of hydrogen storage materials
- Electrochemical supercapacitors for hybrid vehicles
- Materials for biomedical implants
- Properties and processing of nano grain size, functionally gradient steels (tentative title)
- Molecular dynamics simulation of phase separation in Cu-Pb
- Swelling kinetics of reactive liquid metal droplets.

ELECTROCHEMICAL NANOTECHNOLOGY

Electrochemical supercapacitors

The development of hybrid and electric vehicles requires the use of efficient electrochemical supercapacitors (ES), which provide load leveling for batteries and fuel cells during starting, acceleration and braking. Electrochemical store the energy obtained from braking making it available for acceleration. ES allow significant energy savings and optimizes the operation of engines, batteries and fuel cells.

This research focuses on the development and testing hybrid supercapacitors. Electrochemical and chemical nanotechnology methods are used for the fabrication of nanoparticles, nanofibers and films of electrode materials. New techniques are used for the fabrication of composite materials containing nanoparticles, nanofibers, carbon nanotubes and conductive polymers. Advanced electrochemical facility is used for testing of supercapacitor performance, capacitance, impedance and power-energy characteristics.



Biomaterials, biomedical implants and biosensors

Hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ (HA) is an important material for bone and tooth implants, as its chemical composition is similar to that of bone tissue. Natural bone is a composite of HA and collagen fibers, containing approximately 70 wt% HA, proteins and other functional materials. Our research is focused on the synthesis of HA, and the electrodeposition of HA coatings and composite coatings containing natural biopolymers, bioactive glasses and bioceramics, drugs, antimicrobial agents and proteins. We investigate interaction of implant materials with proteins and other biomaterials. Research is focused on surface modification of shape memory alloys and other Ti alloys for application in biomedical implants and the development of functional films for application in biosensors.



CORROSION

- Spontaneous oscillatory corrosion behavior exhibited by stainless steel alloy components when in contact with hot, concentrated sulphuric acid process solutions.
- Micro-galvanic corrosion activity between intermetallic compound particles and the matrix of light weight alloy components utilized in the automotive industry.
- Environmentally-assisted cracking of carbon steel in cellulosic-derived bioethanol liquid fuel distribution and storage systems.

POLYMERS

- Non-biofouling materials
- Polymer grafting for metal corrosion protection
- Polyshell technology.

ORGANIC ELECTRONICS

- Mechanism of organic memory
- X-ray diffraction and internal atomic layer roughness
- Intrinsic degradation in organic light emitting devices.



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