

# WIN

2018-2019

## ANNUAL REPORT

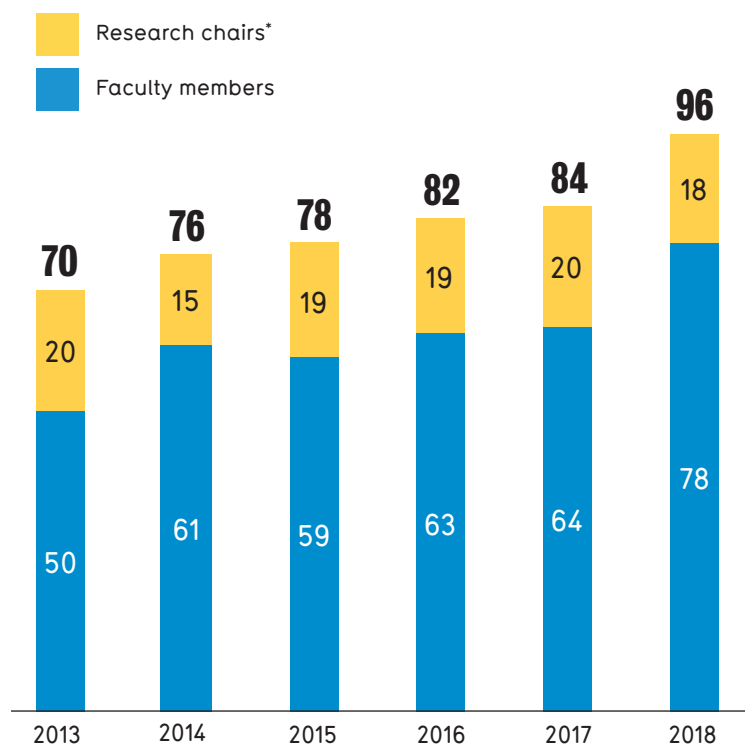


UNIVERSITY OF  
**WATERLOO**



# OUR PEOPLE

Growth of WIN membership since 2013

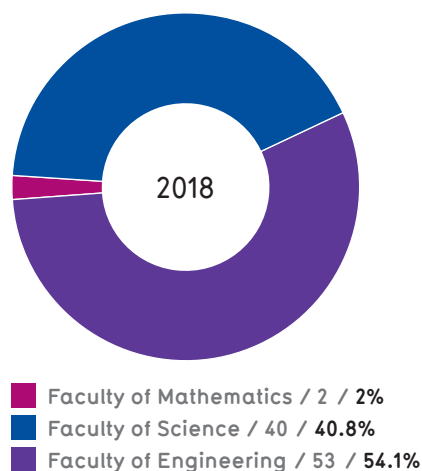
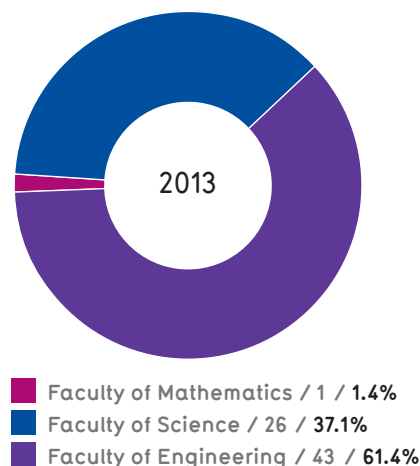


\* faculty members who hold either an NSERC Canada Research Chair (Tier 1 or Tier 2), a University Chair or a WIN Endowed Chair position.

**18** research chairs  
in 2018

**96** faculty members  
in 2018

WIN members by Faculty



# SCHOLARLY TALKS

**3** distinguished lectures

**21** seminars

**1** innovation seminar  
May 2018

**3** industry seminars  
in 2018

---

## 9 DEPARTMENTS

- › Biology
- › Chemistry
- › Chemical Engineering
- › Electrical & Computer Engineering
- › Applied Mathematics
- › Mechanical & Mechatronics Engineering
- › Systems Design Engineering
- › Pharmacy
- › Physics

---

## RESEARCH

**5,477**

papers published

since 2008, Scopus source data

**131,310**

citations

since 2013, Scopus source data

---

## NANOFELLOWSHIPS

**11** rounds of  
nanofellowship  
competitions

**42** nanofellowships  
awarded  
(2018-2019)

**394** nanofellowships  
awarded  
since 2008

---

## INTERNATIONAL

**22** international  
partners in  
twelve countries

**23** International publications  
from WIN-initiated  
partnerships

# A MESSAGE FROM THE **EXECUTIVE DIRECTOR**

It has indeed been an exciting year for Waterloo Institute for Nanotechnology (WIN) as our members and staff were engaged in putting together the five-year renewal document for the Institute, approved by the Senate. We have a strong mandate in place for WIN taking it to the next level for another five years. We are collectively committed to ensure that the research conducted at WIN not only creates economic benefits but also has important impact in our society, particularly aligning our research outputs with United Nations Sustainable Development Goals (UNSDGs).

WIN has embarked on a number new initiatives such as the WIN Rising Star Award, WIN Research Leaders Gala and an advancement committee “Engage WIN” committed to connecting the excellent science and innovation conducted by our researchers to diverse stakeholders. WIN has renewed commitment to integrate *Industry 4.0* and *Society 5.0* in its research mandate and include research leaders beyond science and engineering to realize the full potential of nanoscience and nanotechnology for Canada and beyond.

SUSHANTA MITRA

EXECUTIVE DIRECTOR



# STAFF AND GOVERNANCE

## WIN MANAGEMENT AND ADMINISTRATION

Sushanta Mitra	Executive Director	Charlotte Armstrong	Operations Assistant
Lisa Pokrajac	Assistant Director, Research Programs	Jisu Kwon	Financial and Office Assistant
Oleg Stukalov	Business Development Manager	Caroline Brookes	Executive Assistant

---

## BOARD OF DIRECTORS

### CHAIR

Charmaine Dean Vice-President, Research and International, University of Waterloo

### MEMBERS

Chris Backhouse	Professor, Electrical and Computer Engineering, University of Waterloo
Rina Carlini	President, Optimal Innovation Group Inc.
Lora Field	Team Leader, Cleantech and Advanced Manufacturing Branch, Ontario Investment Office
Karin Hinzer	Professor, Electrical and Computer Engineering, University of Ottawa
Holger Kleinke	Professor, Chemistry, University of Waterloo
Bob Lemieux	Dean, Faculty of Science, University of Waterloo
Sushanta Mitra	Executive Director, Waterloo Institute for Nanotechnology, University of Waterloo
Linda Nazar	Professor, Chemistry, University of Waterloo
Carolyn Ren	Professor, Mechanical and Mechatronics Engineering, University of Waterloo
David Sinton	Professor, Mechanical and Industrial Engineering, University of Toronto
Pearl Sullivan	Dean, Faculty of Engineering, University of Waterloo
Michael Tam	Professor, Chemical Engineering, University of Waterloo
Shirley Tang	Associate Dean Research, Faculty of Science, and Professor, Chemistry, University of Waterloo

---

## WIN INTERNATIONAL SCIENTIFIC ADVISORY BOARD

### CHAIR

John Thompson Senior Associate Vice-President, University Research

### MEMBERS

Fernando Galembeck	Professor, Universidade Estadual de Campinas, Brazil
Kazuhito Hashimoto	President, National Institute for Materials Science (NIMS), Japan
Iain Klugman	President and CEO, Communtech, Canada
Eugenia Kumacheva	Professor and Canada Research Chair in Advanced Functional Materials, University of Toronto, Canada
Richard Martel	Professor and Canada Research Chair in Electrically Conductive Nanostructures and Interfaces, Université de Montréal, Canada
Sushanta Mitra	Executive Director, Waterloo Institute for Nanotechnology, University of Waterloo

Ajay Sood	President, Indian National Science Academy, Professor, Indian Institute of Science, India
Chen Wang	Director General of National Center for Nanoscience and Technology, China
Sir Mark Welland	Head of the Nanoscience Centre at the University of Cambridge and Master of St Catharine's College Cambridge, England
Albert van den Berg	Distinguished Professor, University of Twente and Scientific Director of MESA+, Netherlands

## SPACE COMMITTEE

### CHAIR

Michael Pope	Assistant Professor, Department of Chemical Engineering, Faculty of Engineering
--------------	---

### MEMBERS

Charlotte Armstrong	Operations Assistant
Chris Kleven	QNC Facility Technician, Provost
Vivek Maheshwari	Professor, Department of Chemistry, Faculty of Science
Sushanta Mitra	Executive Director, Waterloo Institute for Nanotechnology
Scott Nicoll	Manager, Space Planning, Provost

## HEALTH AND SAFETY COMMITTEE

### CHAIR

Tom Dean	Director of Technical Operation, Department of Chemical Engineering
----------	---

### MEMBERS

Charlotte Armstrong	Operations Assistant
Dhananjai Borwankar	Senior Safety Officer, Safety Office
Chris Kleven	QNC Facility Technician, Provost
Roberto Romero	Electronics and Instrumentation Technologist, Health, Safety and Environment Co-ordinator, Institute for Quantum Computing (IQC)
Leonardo Simon	Professor, Department of Chemical Engineering
Chris Wilson	Professor, Institute for Quantum Computing

## SPECIAL PROJECTS AND RESEARCH COMMITTEE (SPARC)

### CHAIR

John Thompson	Senior Associate Vice-President, University Research
---------------	--

### MEMBERS

Bernie Duncker	Professor and Associate Vice-President of Interdisciplinary Research, Faculty of Science
David Clausi	Professor and Associate Dean Research, Department of Systems Design Engineering, Faculty of Engineering
Lisa Pokrajac	Assistant Director, Research Programs, Waterloo Institute for Nanotechnology
Shirley Tang	Professor and Associate Dean of Science Research, Faculty of Science
Zbig Wasilewski	Professor, Department of Electrical and Computer Engineering, Faculty of Engineering

# A MESSAGE FROM THE CHAIR OF THE BOARD OF DIRECTORS



Since the term ‘nanotechnology’ was first coined in the 1970’s, the field has come a long way in what it can achieve. Nanotechnology is ubiquitous in our daily life, be it in touch-screen displays of our cellphones to the way data is read from a computer’s hard drive.

As WIN enters into its 12th year of operation, it is to be commended for its fine work in promoting nanotechnology research excellence and advancing our reputation as a world leader in nanoscience and nanotechnology by bringing together various disciplines in a truly interdisciplinary fashion. WIN as a research institute is doing an excellent job providing community for its members, promoting cross-discipline connections, and serving as a window to the broader public by increasing engagement on nanoscience and nanotechnology.

In this past year, WIN has also defined its mission to affect societal impact and provide a sustainable future. With WIN’s restructured theme areas of Smart and Functional Materials, Connected Devices, Next Generation Energy Systems, and Therapeutics and Theranostics, WIN has aligned its research focus with the United Nations Sustainable Development Goals (UN SDG) seeking solutions to ensure good health (SDG 3), clean water and energy (SDGs 6 and 7), industry and innovation (SDG 9), smart communities (SDG 11) and climate action (SDG 13).

In this rapidly expanding and evolving field, the relevance of nanotechnology has only increased over the last decade. Nanotechnology’s power will continue to grow within the coming decades to tackle these very critical global challenges.

I would like to extend my sincerest congratulations to Sushanta Mitra and his team at WIN for their exceptional efforts and successes over this past year. As WIN carries on its work as a University Centre, it will continue to drive key initiatives in nanotechnology research and development for a sustainable and just society. I look forward to seeing what WIN can achieve in the next five years, striving to meet the demands of *Industry 4.0* and *Society 5.0* well into the 21st century.

DR. CHARMAINE DEAN

VICE PRESIDENT, UNIVERSITY RESEARCH



# SCHOLARLY OUTPUT

## *Publications, Citations and Impact*

WIN members have an impressive record of publications in reputable scientific journals, with an equally impressive number of citations.

### BIBLIOMETRIC ANALYSES

In 2018, WIN championed bibliometric analyses within the University of Waterloo through the use of tools such as SciVal and Scopus (Elsevier). In this way, WIN can identify key strengths based on global comparative indices such as field-weighted citation impact (FWCI\*) and collaborations. The FWCI is calculated based on all publications by WIN members taking into account all categories of peer-reviewed journals.

#### Total Publications, Citations and Collaborations

2013 to 2018, based on SciVal (Scopus) data

GROUP	PUBLICATIONS	CITATIONS	FWCI*	COLLABORATIONS		
				NATIONAL	INTERNATIONAL	INDUSTRY
WIN Members (total)	3,177	44,775	1.67	264 (8.3%)	1,489 (46.9%)	126 (4%)
Smart and Functional Materials	2,028	31,049	1.68	159 (7.8%)	966 (47.6%)	69 (3.4%)
Connected Devices	1,538	15,968	1.32	119 (7.7%)	710 (46.2%)	60 (3.9%)
Next Generation Energy Systems	1,070	22,597	2.29	71 (6.6%)	506 (47.3%)	61 (5.7%)
Therapeutics and Theranostics	1,094	14,789	1.55	94 (8.6%)	482 (44.1%)	19 (1.7%)

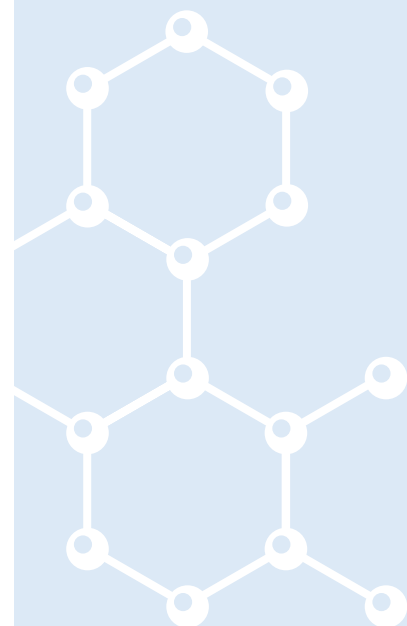
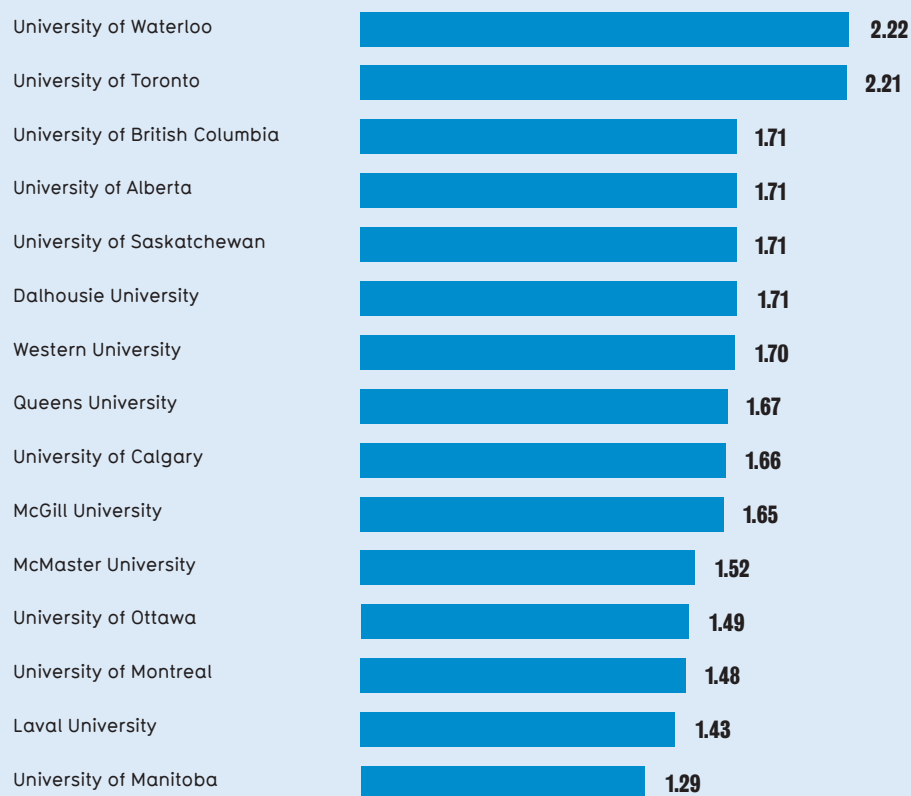
\*FWCI: Field-weighted citation impact compares the number of citations received by a researcher with the average number of citations received by all other similar publications indexed in the Scopus database (i.e. a score of 1.44 means the publications have been cited 44 per cent more times than average)



# SCHOLARLY OUTPUT

## FWCI Nano-Journals Canada U15 Comparison

NanoScience and Technology\* Journals Metrics UWaterloo compared to Canada U15



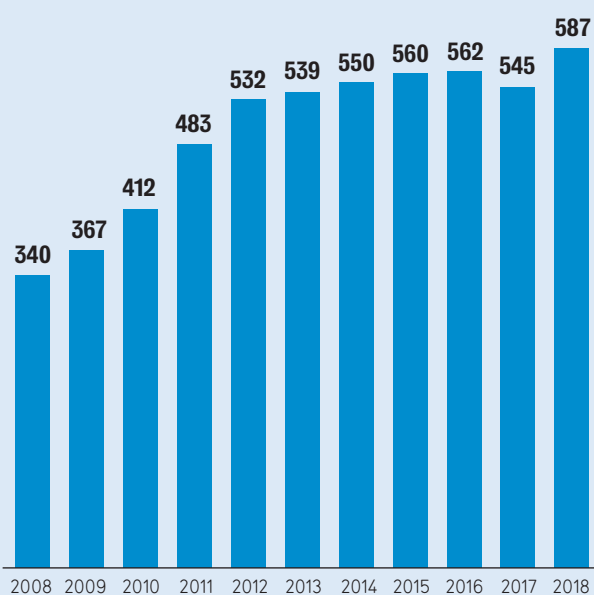
INSTITUTION	SCHOLARLY OUTPUT	CITATION COUNT	FWCI	COLLABORATIONS	
				INTERNATIONAL	INDUSTRY
University of Waterloo	2,121	42,324	2.22	59.2%	4%
University of Toronto	4,538	85,525	2.21	61.2%	4.1%
U of British Columbia	2,829	44,672	1.71	63.5%	2.8%
University of Alberta	2,658	40,893	1.71	54.3%	2.3%
U of Saskatchewan	1,010	16,061	1.71	66.7%	1.7%
Dalhousie University	655	10,386	1.71	55.1%	4.4%
Western University	1,220	18,057	1.7	52.5%	3.1%
Queens University	755	10,807	1.67	56.7%	3.3%
University of Calgary	1,322	19,872	1.66	57.9%	3.9%
McGill University	2,795	41,180	1.65	60.9%	4.1%
McMaster University	1,642	22,099	1.52	56.6%	4.9%
University of Ottawa	1,433	19,990	1.49	57.1%	2.5%
University of Montreal	1,610	21,705	1.48	60.2%	3.4%
Laval University	1,085	14,883	1.43	57.3%	4.1%
University of Manitoba	714	8,253	1.29	66.8%	1.7%

## FWCI Nano-Journals International Nanotechnology Leaders Comparison

NanoScience and Technology\* Journals Metrics UWaterloo compared to International universities with strong nanotechnology research programs



## WIN Publications by Year

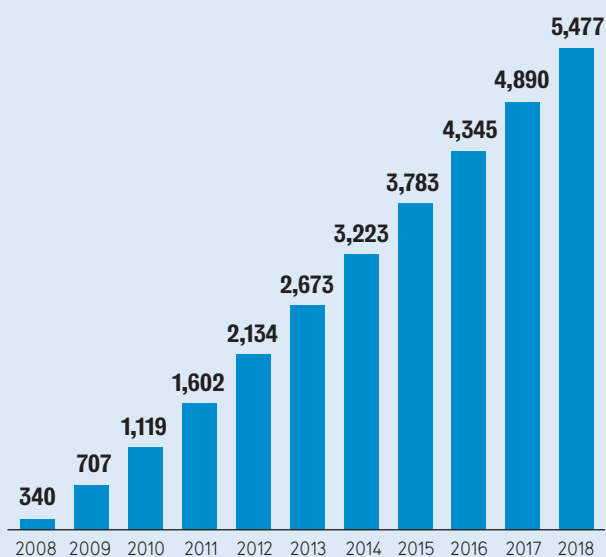


## WIN Publications in High Impact Factor Journals

Nature Energy	46.86
Science	41.06
Nature Nanotechnology	37.49
Energy and Environmental Science	30.07
Progress in Materials Science	23.75
Advanced Energy Materials	21.90
Advanced Materials	21.89
Journal of the American Chemical Society	14.05
ACS Nano	14.29

SCHOLARLY OUTPUT	CITATION COUNT	FWCI	# PUBLS TOP 10 PERCENTILE (%)
565	2,156	1.61	32.2

## Cumulative WIN Publications



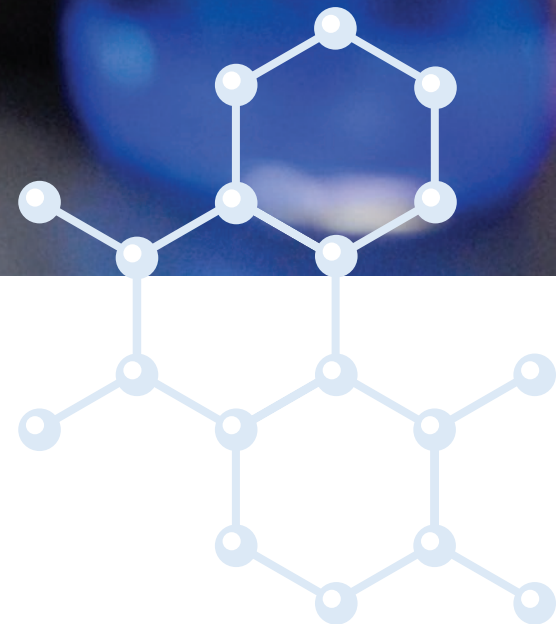
## Most Frequently Selected Journals for WIN Papers

ACS Applied Materials and Interfaces	19
Langmuir	15
Advanced Energy Materials	10
Physical Review B	9
Chemistry – A European Journal	8
Macromolecules	8
Energy and Environmental Science	6
Nature Communications	7
Advanced Materials	7

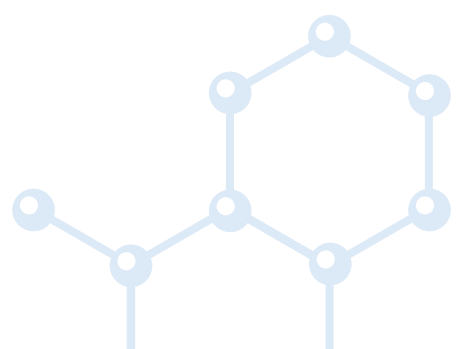
\*NanoScience and Technology Journals: compiled list of top 60 journals in materials and nanoscience on the basis of impact factor by Scopus.



DR. LINDA NAZAR, University Professor and Canada Research Chair Solid State Energy Materials



SELECTED 2018  
**RESEARCH  
HIGHLIGHTS**



## SMART AND FUNCTIONAL MATERIALS

Dr. Holger Kleinke's group (Chemistry and Physics) reported a very promising composite material for thermoelectric energy conversion and described its detailed crystalline structure (J. Am. Chem. Soc. 2018140278578-8585).



Dr. Michael Tam's group produced a new nano-porous aerogel materials based on nature-inspired cellulose nanofibrils and demonstrated its high efficiency in removing metal ion contaminants from water (Carbohydrate Polymers, 2019, Pp. 404-412).



## CONNECTED DEVICES



AI approaches are improving the output of analytical devices. Dr. Karanassios' group published a book chapter describing use of Artificial Neural Network algorithms for correction of spectral interference in miniature spectrophotometers (In: Advanced Applications for Artificial Neural Networks, 2018).



Dr. Mitra's group demonstrated an application of AI-driven mobile application for testing water quality in the field (Editor's choice, J. Electrochem. Soc. 2019).

## NEXT GENERATION ENERGY SYSTEMS

Groups of Drs. Linda Nazar and Zhongwei Chen continued producing outstanding research in the areas batteries. In the paper published in Nature Energy, Dr. Nazar's group proposed tuning structures of electrolytes to simultaneously solve anode and cathode challenges for Li-S batteries. Dr. Chen's group reported the use of naturally abundant molecule to suppress degradation of sulfur electrodes (Nature Communications, 2018).



Two collaborating WIN members, Drs. Dayan Ban and Eihab Abdel-Rahman, developed a nano-structured mechanical energy harvesting device based a combination of ZnO nanowires and nano-sheets. The work was done in collaboration with an Ontario-based aerospace company, whose interest is to develop self-powered wireless sensors for aircraft predictive maintenance.



## THERAPEUTICS AND THERANOSTICS

Two WIN members, Dr. Roderick Slavcev and Shawn Wettig, co-edited the book entitled *Nanomedicine: Gene Delivery, Imaging and Evaluation Systems*, published by Springer in 2018. Through a publication in Nature Scientific Reports early in 2019, Dr. Emmanuel Ho's group demonstrated a new nanoparticle-based gene therapy approach in preventing sexually transmitted bacterial infections (Scientific Reports, V9, 1306 (2019)). Dr. Scott Hopkins co-authored a seminal paper with researchers from Sciex, a major manufacturer of mass spectrometers, and the pharmaceutical company Pfizer, published by Nature Communications in 2018. This publication describes a novel ultrasensitive, rapid methodology for pre-screening of drug candidates and predicting their molecular properties.





# MISSION AND OBJECTIVES

All the research conducted by WIN members is divided into four thematic areas. WIN organizes events and activities thematically. Each thematic group has its lead and co-lead (except Smart and Functional Materials group which has an advisory committee), who serve as advisors to WIN staff and also facilitate communication within the theme.



## SMART AND FUNCTIONAL MATERIALS

characterization, 2D and quantum materials, quantum dots, CNT, biomaterials, additive manufacturing



## CONNECTED DEVICES

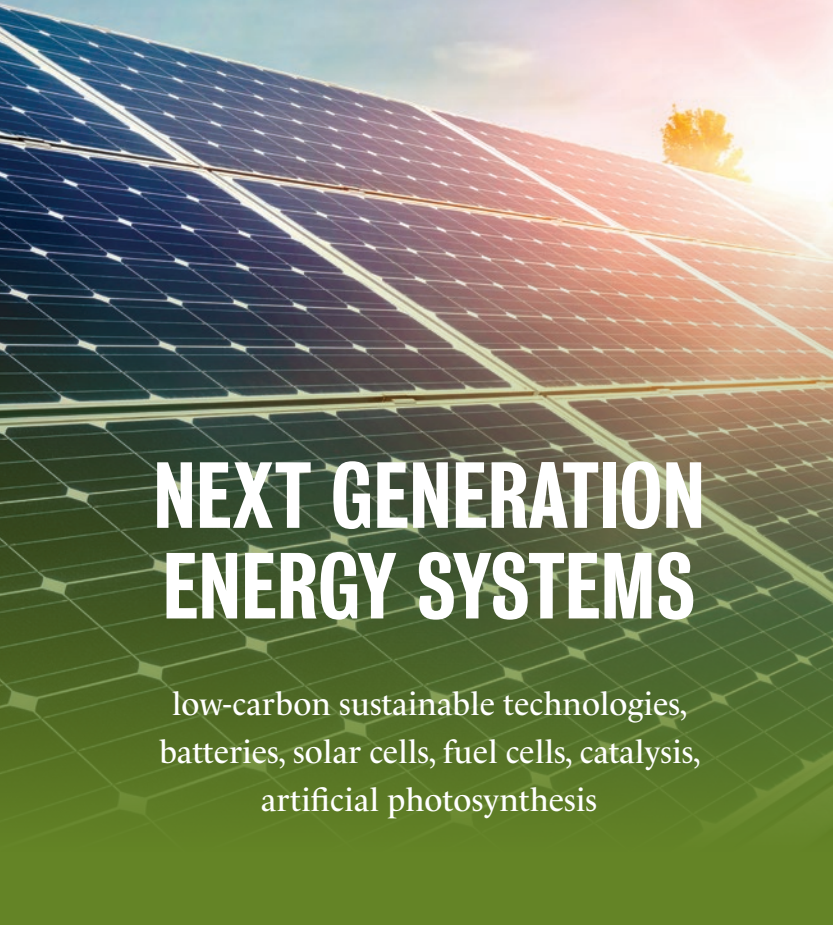
sensors, MEMS/NEMS, flexible electronics, wearable devices, LoC, IoT and AI for sensors, human-machine interface

## MISSION

*Serve WIN members to enable them to be successful in research, innovation, and scholarship.*

## OBJECTIVES

- › Promote research, technology development and innovation in key areas of nanotechnology
- › Stimulate recruitment and retention of the best and brightest research talent
- › Facilitate multidisciplinary research and collaboration
- › Partner with leading universities and institutes in nanotechnology around the world
- › Foster industry partnerships and commercialization
- › Manage the “nanotechnology” space, facilities and infrastructure in the Mike & Ophelia Lazaridis Quantum-Nano Centre (QNC)
- › Provide inputs towards the undergraduate and graduate curriculum in nanoengineering through active participation in the curriculum committees by WIN members
- › Facilitate access to the state-of-art nanofabrication and characterization facilities across the campus



## NEXT GENERATION ENERGY SYSTEMS

low-carbon sustainable technologies, batteries, solar cells, fuel cells, catalysis, artificial photosynthesis



## THERAPEUTICS AND THERANOSTICS

targeted drug delivery, tissue engineering, minimally invasive treatment of disease, immunotherapy, medical imaging

# THEME LEADS AND CO-LEADS



## SMART AND FUNCTIONAL MATERIALS

This group is by far the largest and most diverse in terms of research areas, and therefore it organizes itself via a group of seven faculty members serving as a committee:

- › **Michael Tam** (ChE) – Dr. Tam received his PhD degree from Monash University in Australia in 1991, held full professor position at Nanyang Technological University, Singapore, and then joined UWaterloo in 2007. His most recent research interests are novel chemistries and applications of cellulose nanocrystals.
- › **Hany Aziz** (ECE) joined University of Waterloo in 2007 as Industry Research Chair in OLED Displays. After receiving his PhD degree from McMaster University in 1999, Dr. Aziz worked as a Research Scientist at Xerox Research Centre of Canada for eight years.
- › **Boxin Zhao** (ChE) received his PhD from McMaster University in 2004. His research involves adhesion phenomena on the nanoscale and biomimicry.
- › **Chris Backhouse** (ECE) received his PhD in 1992 at the University of British Columbia. He worked in industry to develop large-scale microchips for use in the Human Genome Project, followed by the development of genetic analysis instrumentation. He joined University of Waterloo in 2011 after serving as a professor at the University of Alberta for 12 years.
- › **John Honek** (Chem, cross-appointed with Pharmacy) received his PhD in 1984 at McGill University and joined the University of Waterloo in 1986 in the Department of Chemistry. Working at the interface of chemistry and biochemistry, John's research involves applying chemical and biochemical principles and techniques to the problems of protein and enzyme structure/function, and their applications for bionanotechnology in medicine.
- › **Yuning Li** (ChE, cross-appointed with Chemistry) obtained his PhD from the Japan Advanced Institute of Science and Technology (JAIST) in 1999, after which he worked in both academic and industrial environments, including Xerox Research Centre of Canada. Dr. Li joined the University of Waterloo in 2010. Currently Dr. Li's lab focuses on the development of printable electronic materials including polymer semiconductors, polymer conductors, polymer binders, and various nanomaterials for thin film transistors (flexible displays, RFID tags, smart labels, sensors, and wearable electronics), photovoltaics (solar cells and photodetectors), and batteries (lithium batteries).
- › **Carolyn Ren** (MME) received her PhD from the University of Toronto in 2004, and shortly after joined the University of Waterloo. Her research involves development of advanced microfluidic devices, which are the basis for lab-on-chip applications in healthcare (e.g., point-of-care diagnostics) and real-time water quality monitoring.





## CONNECTED DEVICES

- › **Vassili Karanassios** (Chem) joined the University of Waterloo more than 20 years ago. He is founding member of WIN. Vassili's research group develops portable analytical tools for spectrochemical environmental analysis
  - › **Na Young Kim** joined the University of Waterloo in 2016 from Apple Inc., where she worked on developing small display products. She received her PhD from Stanford University in 2006. Her research involves developing elements of semiconductor quantum processors and devices using exotic nanomaterials.
- 



## NEXT GENERATION ENERGY SYSTEMS

- › **Linda Nazar** (Chem, cross-appointed to ECE) joined the University of Waterloo over 20 years ago, and holds a Tier 1 Canada Research Chair in Solid State Energy Materials. She authored over 300 research papers, review articles and patents.
  - › **Eihab Abdel-Rahman** (SDE) joined the university in 2006 from Virginia Polytechnic. His research has resulted in discovery of new phenomena in microelectromechanical systems (MEMS) and the development of new radio frequency switches, micro-mass sensors, micro-power generators, atomic force microscopy techniques, and a micro-gyroscope.
  - › **Michael Pope** (ChE) joined the University of Waterloo in 2014 from Vorbeck Materials Corporation, a Li-S battery company. Prior to that he received a PhD from Princeton University. His research interests involve utilization of large-area graphene monolayers for improving performance of supercapacitors and batteries, studying electrocatalytic effects in porous electrode systems and for development of graphene-based water treatment membranes.
- 



## THERAPEUTICS AND THERANOSTICS

- › **Karim Karim** (ECE) received a PhD from the University of Waterloo in 2002. Karim was a faculty member at Simon Fraser University between 2003-07, after which he joined the University of Waterloo. His research focuses on advancing the field of medical imaging using X-rays, which has led to over 15 patents and 100 research publications.
- › **Alfred Yu** (ECE) received PhD degree from the University of Toronto, started his independent academic career at the University of Hong Kong, and relocated to the University of Waterloo in 2015. He carries out research in ultrasound imaging using nanomaterials as contrast agents.

# SOCIETAL IMPACT OF RESEARCH

The discoveries by our scientists and engineers are fundamentally changing our world and helping solve some of humanity's most pressing issues.

Why is nanotechnology important? It is about creating new materials and improving ways of manufacturing products. To be more efficient, better, stronger, and cheaper. Also improving the economy, environment and society.

To achieve societal impact and sustainable future, WIN has now mapped its thematic areas with the United Nations Sustainable Development Goals (SDGs).

## WIN THEMATIC AREAS:



**SMART AND FUNCTIONAL MATERIALS**

INNOVATION AND INFRASTRUCTURE

CLEAN WATER AND SANITATION

GOOD HEALTH AND WELL-BEING



**CONNECTED DEVICES**

CLEAN WATER AND SANITATION

INNOVATION AND INFRASTRUCTURE

SUSTAINABLE CITIES AND COMMUNITIES

## UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS:



SUSTAINABLE CITIES AND COMMUNITIES



CLIMATE ACTION

**NEXT GENERATION  
ENERGY SYSTEMS**



AFFORDABLE AND  
CLEAN ENERGY

**THERAPEUTICS  
AND THERANOSTICS**



GOOD HEALTH  
AND WELL-BEING

# INTERDISCIPLINARY RESEARCH FUNDING PROGRAM

# PROJECT UPDATE HIGHLIGHTS

## Hydrophobic Engineering of Nanodimensional Protein Capsules for Therapeutics

- › John F. Honek  
Department of Chemistry
- › Ken Stark  
Department of Kinesiology



The ability to encapsulate, protect and deliver bioactive hydrophobic compounds to target cells is a quintessential goal for bionanotechnology as it relates to therapeutic delivery. The majority of scientific reports in this area have focused on the “easier” delivery of hydrophilic drugs to target cells, resulting in important contributions to drug delivery strategies. Nevertheless, the design of a protein nanoparticle containing a hydrophobic protein cavity would be a major contribution, as these particles could encapsulate and protect hydrophobic drugs or nutrients yet be capable of cellular targeting through the application of established protein surface modifications.

This project focuses on the hydrophobic engineering of the internal hydrophilic cavity of a spherical capsule protein (12 nm) in order to develop novel drug delivery nanoparticles, as well as controllable host-guest molecular platforms. Specifically, the controllable encapsulation of entire hydrophobic assemblies, such as micelles, composed of fatty acids and lipids, within the internal protein shell is being explored. The project has developed strategies to successfully encapsulate lipid systems within the cavity of these capsule proteins and is exploring the structure and function of these assemblies and the types of co-components (fluorescent probes, hydrophobic drugs).

## A novel theoretical framework for the prediction of non-equilibrium systems: A combinatorial approach

- › Luis Ricardez Sandoval  
Department of Chemical Engineering
- › Ricardo Fukasawa



This study aims to develop a new innovative alternative approach that can perform the dynamical evolution of non-equilibrium film growth model. The key idea of the proposed study is to formulate a mathematical combinatorial optimization model which minimizes the thermodynamic energy of the system and controlled by kinetic constraints. This approach holds advantages over kinetic Monte Carlo (kMC) algorithms in that it can provide deterministic optimal solutions which does not require to use random parameters to determine the future reaction to happen as it is performed in the kMC method. The energy of the system is calculated based on the lattice-gas Hamiltonian model which includes both atom-atom interaction and atom-substrate interaction. This enables the model to provide information on the shape of multi-layer film growth: Frank-van der Merwe mode, Volmer-Weber mode and

Stranski-Krastanov mode. By including kinetic constraints, the developed model can exactly depict each steps of the dynamical evolution of non-equilibrium systems. The obtained solution of the model provides information on the energetically favorable states still controlled by kinetic constraints. To demonstrate the applicability of the developed model, a case of epitaxial film growth is considered. The proposed study holds its novelty in that (1) it provides evolution trajectory information of a non-equilibrium system by combining thermodynamic and kinetic constraints, (2) it provides an alternative method for random reaction selection compared to kMC, (3) it includes both atom-atom interaction and atom-substrate interaction which are not considered in the kMC method. The proposed model is formulated as a mixed integer linear program solved using CPLEX.

# GHTS



## An innovative new micro-CT system for cardiovascular imaging research

- › Karim S. Karim  
Department of Electrical and Computer Engineering
- › Peter Levine  
Department of Electrical and Computer Engineering
- › Robin Duncan  
Department of Kinesiology



GOOD HEALTH  
AND WELL-BEING

## Imaging tissue samples by STEM and development of nanofluidic platforms for in-liquid (S)TEM imaging of biospecimens

- › Germán Sciaini  
Department of Chemistry
- › Michaela Devries-About  
Department of Kinesiology



GOOD HEALTH  
AND WELL-BEING

Micro-computed-tomography (m-CT) scanners take pictures inside the body non-invasively, providing information on progressive diseases like cancer and heart disease that is critical for diagnosing people and targeting treatments. Most of the research that leads to these discoveries is done in mice that have the same organ systems as humans, and develop many of the same diseases. Although there are some m-CT systems available for scientists to use with mice, they aren't practical since they cost too much, they use very high levels of radiation that cause mutations disrupting research, and they produce low-resolution pictures that lack detail needed for studying things like hardening of the arteries, or cancer cell invasion. To solve these problems, University of Waterloo engineers (Karim and Levine) built an innovative new m-CT scanner that takes super-high-resolution pictures, uses only low-dose radiation, and can be made in

It is well spread in the electron microscopy (EM) community the sample preparation procedure to image tissue samples (fixation, dehydration, embedding, microtoming and staining), as well as the fact that the sample is no longer pristine after this treatment. In addition, it is important to highlight that mainly the last step is not environmentally friendly. As a first stage in this research, samples were collected from human muscle fibers and the standard sample preparation protocol was followed with them, but staining was avoided. After optimizing the EM condition, high quality images were observed; dark field detector (Z contrast) in STEM mode showed high contrast.

Canada for a fraction of the cost of current m-CT systems. However, before researchers, and eventually doctors, will use it, it needs to be optimized and validated. Working together, engineers from the Karim and Levine Labs and biomedical researchers from the Duncan Lab have captured detailed images from mice, including pictures of the soft and hard tissues in a paw, and images of the vascular network running through a kidney. These images are exciting not only because of their quality, but also because they were captured without using any contrast agents, which are toxic to animals and people. Thus, this project demonstrated that this new m-CT technology not only matches, but exceeds the capabilities of current technology, which means that it could provide a safer, better imaging modality if scaled up for use in humans. This is the subject of current collaborative work.

In order to push even more the limits of biospecimen image capabilities towards the native environment, a nanofluidic system was developed for in-liquid EM studies of drop-casted biological samples and a loading station. All nanofabrication steps were optimized at the University of Waterloo. This invention led to a provisional US patent application via WatCo. A fixation step before cutting might be required depending on tissue properties. A new collaboration was established with a nanofluidic expert and TEM holders for in-situ measurements were machined and are getting ready for use.

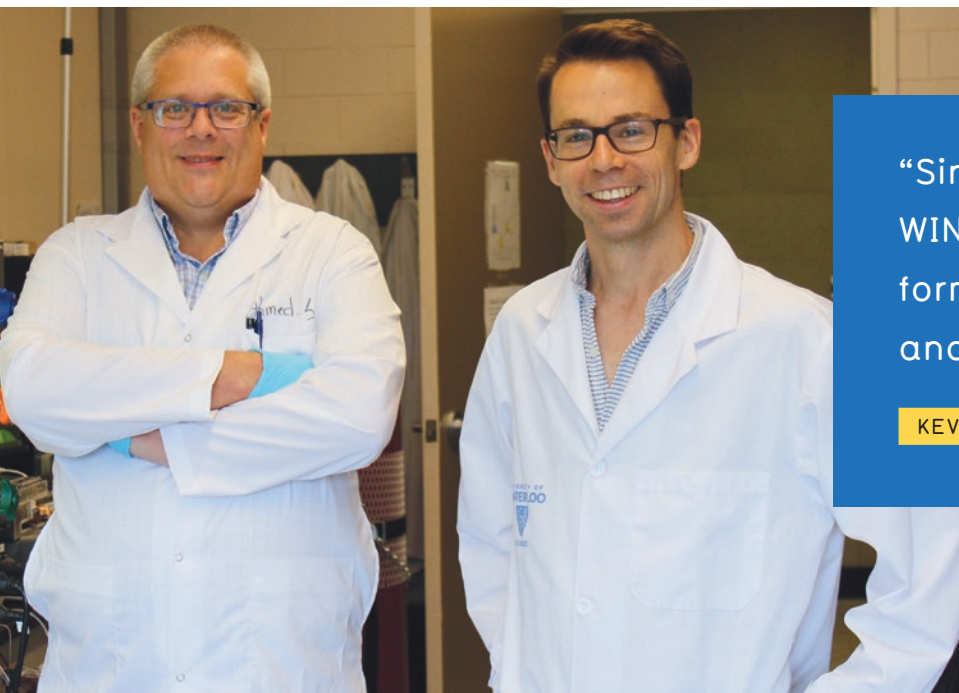
# WIN CHAMPIONING INTERDISCIPLINARY RESEARCH



This innovative project has been awarded \$250,000 over two years from the New Frontiers in Research Fund – Exploration Grant in 2018. This Tri-Agency government program recognizes early-career researchers conducting game-changing projects, using unconventional approaches.

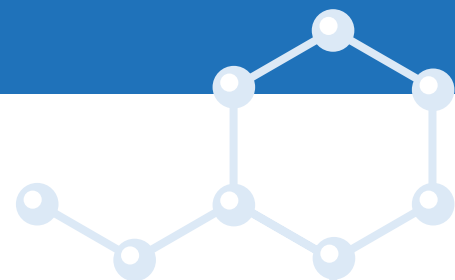
Traditional cancer therapies such as chemotherapy and radiotherapy have serious side effects and are often ineffective. This has led to the development of more precise and non-invasive “theranostic” (therapeutic and diagnostic) techniques for imaging and treating tumors. These techniques use external agents, typically nanoparticles or small molecules, which are injected into tumors. In photoacoustic imaging, for example, light pulses are directed at the tumor. The agent absorbs the light and generates heat, causing thermoelastic expansion and the emission of ultrasonic waves that can be measured by a detector. This allows tumors to be imaged and precisely targeted with therapeutic techniques, such as photothermal and photodynamic therapies, in which the injected agent absorbs light and generates heat and oxygen, respectively, to kill nearby cells. The requirements for these theranostic agents are numerous. They must be biocompatible and stable, selectively accumulate in tumor cells, effectively absorb light and convert it to heat and sound, and effectively kill cancer cells. Ideally they could also facilitate drug delivery and other imaging techniques, but individual nanoparticles or molecules are not currently capable of performing all of these roles.

In this project, a new approach is being taken to develop multifunctional theranostic agents with highly controllable shape and composition. Solutions containing flakes of 2D materials that are promising theranostic agents are irradiated using a laser. The laser breaks the flakes into smaller pieces, forming 2D nanoparticles with diameters that are controlled by the irradiation time. The laser is polarized to induce a strong, directional electric field, such that the nanoparticles can align and bond in the field to form nanorods of the 2D materials, allowing theranostic agents with different aspect ratios to be produced. Different 2D materials are being studied to optimize the photothermal properties, and molecules that improve biocompatibility and accumulation in tumors are being incorporated into the agents. The biocompatibility, stability, cellular uptake, photothermal conversion efficiency, and in vitro anticancer activity of the nanorods will be studied as a function of their shape and composition, enabling the discovery of better theranostic agents to fight cancer.



“Since coming to Waterloo in 2015, WIN has been my primary channel for forming collaborations, both inside and outside of the University.”

KEVIN MUSSELMAN



# SPOTLIGHT ON BIOLOGY IN NANOTECHNOLOGY



## *Why is Nanotechnology and Nanoscience important in biology?*

Nanotechnology in biology and applications in medicine enables new devices and therapies to help detect, diagnose and treat disease in one step. Making repairs at the cellular level, delivering light, heat, drugs and other therapeutic agents to specific areas. Saving valuable time and countless lives.

WIN is happy to welcome two researchers from the department of Biology in 2018 – Professors David Rose and Todd Holyoak, joining Moira Glerum – helping to find the causes of and also the treatments for many common diseases. Diabetes, heart disease, cancer, and many age-related afflictions are among the most common.

Regenerative medicine addresses repair, regeneration and/or replacement of damaged organs or tissues via combination techniques.

### **The future of personalised healthcare: tailored to the specific needs of individual patients**

#### **PREDICTION**

ID at-risk patients at the earliest possible moment

#### **DIAGNOSIS**

Early, accurate and sensitive diagnosis

#### **TREATMENT**

Targeted and specific treatment

#### **MONITOR**

Tracking and ensuring it is effective

# RESEARCH BREAKTHROUGH

There are many proteins that aid in COX assembly. Professor Glerum was the first to identify many of these so-called COX assembly factors in yeast, which in turn facilitated the identification of the molecular bases for a number of different COX deficiencies in patients by molecular and medical geneticists.

**Moira Glerum**, from the Department of Biology, is our resident expert on mitochondria and their function in metabolism. Moira has been interested in mitochondria and their function for several decades. She saw the importance of their role in human health long before it became a 'hot topic', especially in genetic and inherited disease. As mitochondria are the energy 'power stations' for our cells, when things go wrong with them it affects the body in profound ways. Inherited mitochondrial disease can be present at birth or at any age and affect almost any part of the body, often including the brain and central nervous system, muscles and heart. Mitochondrial dysfunction is the cause of serious afflictions such as Leigh syndrome and Friedreich ataxia, as well as often being found in association with other serious illnesses such as cancers, Alzheimers and other neurodegenerative diseases. Dr. Glerum's research is dedicated to understanding the molecular basis for inherited diseases that affect the function of mitochondria, the primary energy producers in cells. One of the key enzymes found in mitochondria is cytochrome c oxidase

(COX), a large transmembrane protein complex involved in electron transfer and proton transport across the mitochondrial inner membrane that contributes to the synthesis of cellular energy in the form of ATP. A problem in COX function can cause acute effects, and among the many primary mitochondrial diseases, those involving COX dysfunction are thought to be the most frequent. Understanding the multiple roles of proteins involved in assembly of the COX enzyme complex in mitochondria can provide insights into inherited mitochondrial diseases, as well as some of the more common neurodegenerative diseases. Because yeast cells are an excellent model for studying COX function and assembly, studies by Dr. Glerum and her trainees and collaborators have provided fundamental advances to our understanding of inherited COX deficiencies in humans. Her research also contributes to advances in lab-on-chip technologies that enable detection of dysfunctions at the cellular level; understanding these biological functions on a molecular level will facilitate and eventually enable personalized medicine.









The research in **David Rose's** laboratory in the Department of Biology is focused on the human enzymes that recognize and act upon carbohydrates. These enzymes play key roles in multiple aspects of health and disease, including deriving glucose from components of our diets, such as starch and sucrose, and in the synthesis of glycoproteins (proteins that consist of carbohydrates as well as amino acids).

One specific project addresses how carbohydrates in our diets (especially starches) are turned into fuel for the body in the form of glucose. This process is key to nutritional health and also to brain development, in particular. Malfunction of these enzymes, the intestinal-glucosides, leads to serious food intolerances, diabetes and other conditions.

Rose and collaborators are investigating ways carbohydrate digestion can be regulated to mitigate and control the body's

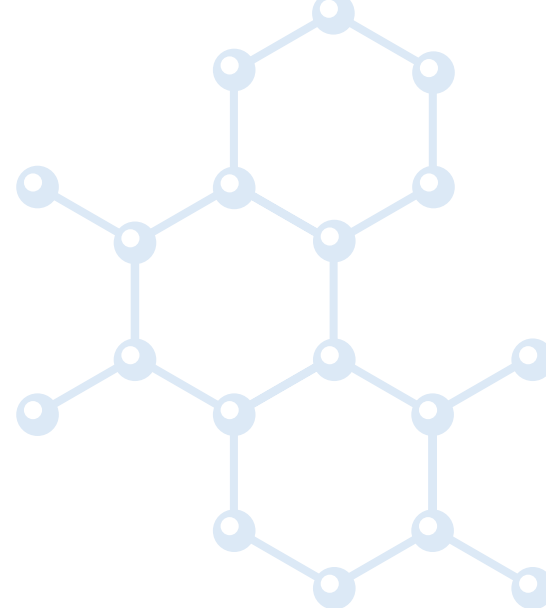
glycemic response. The focus has been on sucrose, which is almost universally present in our diet, and residual polysaccharides from starch, also a very common component of our diet, which contain multiple glucose monomers linked together.

Research into this class of enzymes contributes to fundamental human nutrition; however, it also has potential impact in other areas. Food Science investigates how we digest different types of food, and how that affects our metabolism. With the rise in popularity of plant-based foods, we ingest many varied polysaccharides and we know little about how they are all processed. In Biomedical Science, these enzyme activities are linked to regulation of blood glucose levels and are relevant to many serious conditions such as diabetes and obesity. In addition, they are directly linked to many food intolerances, such as lactose and sucrose intolerance. These can lead to significant, sometimes debilitating conditions in children and adults.



**Todd Holyoak** is an expert in the dynamic aspects of the enzyme structure-function relationship, or “conformational plasticity” in enzymology and how these dynamic aspects of enzyme structure can be altered/influenced to alter and enzyme function. Currently, the Holyoak lab is exploring the structure-function relationship in several diverse enzyme families with a current focus upon the GTP-dependent phosphoenolpyruvate carboxykinases (PEPCK) and the IgA1 protease family of bacterial proteins.

PEPCK is an important cataplerotic enzyme, essential to maintaining blood glucose levels in humans and other mammals; flux through PEPCK contributes to the fasting hyperglycaemia seen in patients with both Type 1 and Type 2 diabetes, and has been postulated to be a factor in other significant biological processes such as cancer and aging. While his work is focused upon the basic principles



of the structure-function relationship, these studies may also contribute to the ability to regulate PEPCK in the treatment of disease and biological disfunction.

Human immunoglobulin A1 (IgA1) is an antibody that plays an important role in the immune protection of mucous membranes. Due to this fact, it is not surprising that infectious microbes generate IgA1 proteases that cleave the protective IgA1 antibodies which can lead to disease as a result of the initial bacterial colonization of the mucosa. Professor Holyoak with collaborator and WIN member Professor Scott Taylor from the Department of Chemistry are collaborating on the project, “Structural Studies of Bacterial IgA1 Proteases”, which may lead to the development of novel antibiotics for common but serious infections caused by the bacteria that produce IgA1 proteases.

While its protective role is essential to human health, IgA1 is also associated with several autoimmune disorders, including celiac disease, IgA vasculitis, and Berger’s disease. Also known as IgA1 nephropathy, Berger’s disease occurs when IgA1 deposits in the kidneys resulting in inflammation and eventual kidney failure. Presently there is no cure for the disease however, it has been demonstrated that IgA1 proteases may represent an effective treatment strategy. Professor Holyoak and his team are working to better understand IgA1 protease structure and function with the ultimate goal being the ability to design novel IgA protease enzymes for use in the treatment of diseases resulting from aberrant IgA1 deposition such as IgA nephropathy.

# ENGAGING THE FACULTY OF MATHEMATICS

Nanotechnology greatly benefits from mathematical disciplines such as data science, informatics and computational modeling, assisting with theoretical and experimental approaches to designing materials with novel physical and chemical characteristics, optimizing device design, and predicting behaviour of complex biological-pharmaceutical systems.

WIN is proud to have three outstanding researchers from the Faculty of Mathematics as part of its membership, including Professor Zoran Miskovic (WIN member since 2008), and most recently Professors Anita Layton and Mohammad Kohandel, each from the Department of Applied Mathematics.





“What’s happening here in Waterloo is truly special, from theory to experiment and beyond.”

—  
—  
—



## ZORAN MISKOVIC

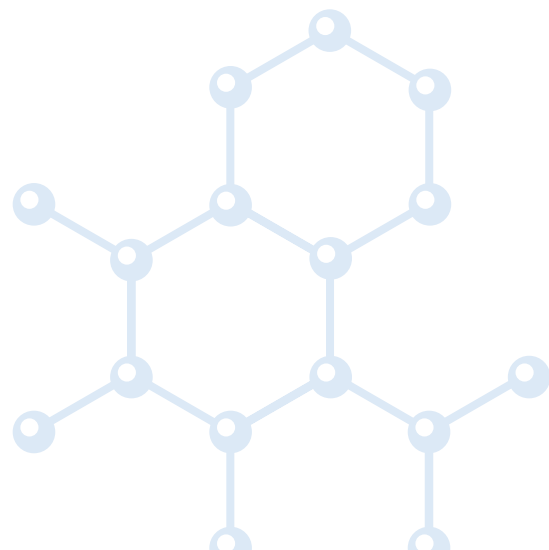


Professor Zoran Miskovic's group focuses on mathematical modeling and computer simulation of physical processes in nano-sized structures interacting with surrounding materials and external probes. The group's work has recently evolved in two main directions: nano-photonics and nano-plasmonics, and electrochemistry. In the first domain, Professor Miskovic explores the excitation of plasmon and phonon polaritons, as well as transition radiation, induced by the response of two-dimensional materials (such as graphene) to fast charged particles. This work is of interest for applications for a new generation of particle detectors, novel sources of terahertz radiation, and electron microscopy of plasmonic metasurfaces, among others. In the second domain, Professor Miskovic explores the role of the quantum capacitance of a graphene electrode when interfaced with an aqueous solution or an ionic liquid. This work develops the macroscopic and microscopic physics of graphene-based field-effect transistors to provide the theoretical framework for the advancement of graphene-based biochemical sensors, nanoporous supercapacitors, and more.

## ANITA LAYTON



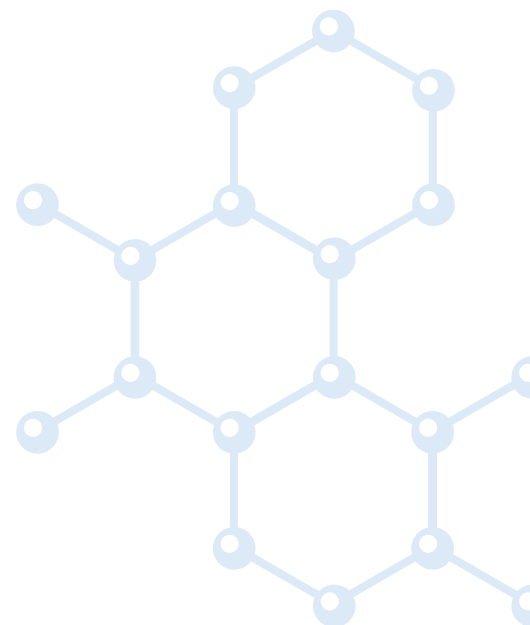
In 2018, Professor Anita Layton was named Canada 150 Research Chair for her work in mathematical biology and medicine, with \$350,000 per year for seven years to support research on mathematical and computational modelling of blood flow dynamics and kidney function. Her work is at the interface of applied mathematics, computation, and biological science, which has directly and positively impacted clinical healthcare.





Professor Mohammad Kohandel has also contributed a great deal to the field of mathematical modelling in cancer biology. His group utilizes analytical and computational approaches to study cancer heterogeneity and plasticity both of which are thought to be complicating factors in treatment. Heterogeneity, or how cancer tumours are made of several different types of cells, and plasticity – when stem cells in the tumour change, make it very difficult to treat and often the cancer become resilient and continues to grow. Professor Kohandel also works on the development and application of quantum nanosensors for biomedical applications. A particular application is cancer biology, where quantum nanosensors are used to monitor the outcome of chemotherapy immediately after drug administration.

Professor Kohandel also investigates tumour micro-environments and the vascular network to determine new potential cancer treatments. Cancer cells can ‘hi-jack’ healthy blood vessels to create its own nutrient supply to grow, and insights into these mechanisms can improve treatment options to address these factors, such as combination therapies, trans-dermal treatments, and novel nanoparticle-based drug delivery for chemotherapies.



WIN aims to attract more exceptional researchers in mathematics to help bridge disciplines to meet fundamental research goals and provide solutions to real-world problems.

# UNDERGRADUATE NANOTECHNOLOGY ENGINEERING

The Nanotechnology Engineering Program operates from the Mike & Ophelia Lazaridis Quantum-Nano Centre in the heart of Waterloo's main campus. With its two 120-seat lecture theatres, suite of teaching labs and collaborative interdisciplinary atmosphere, it's an inspiring setting for students working towards their Bachelor of Applied Sciences degree.

Soon to celebrate its 15th anniversary, the University of Waterloo's undergraduate Nanotechnology Engineering (NE) Program has gained a reputation for educating the next generation of leaders in the new frontier of nanotechnology.

## NANOTECHNOLOGY EXPERTISE

Offered collaboratively by the departments of Chemical Engineering, Electrical and Computer Engineering, and Chemistry, this unique program is co-located with the Waterloo Institute for Nanotechnology in the Mike & Ophelia Lazaridis Quantum-Nano Centre, where students study in advanced facilities surrounded by an active research culture.

Known for its rigorous academic training, the NE Program gives students broad exposure to a variety of subjects. As they progress through a carefully designed multidisciplinary curriculum, they acquire knowledge and hands-on expertise in four main areas: nano-engineered materials, nano-electronics, nano-biosystems and nano-instrumentation.

While studying chemical and electrical engineering, chemistry, materials science, quantum physics and biotechnology,

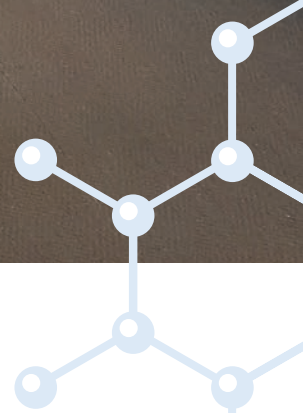
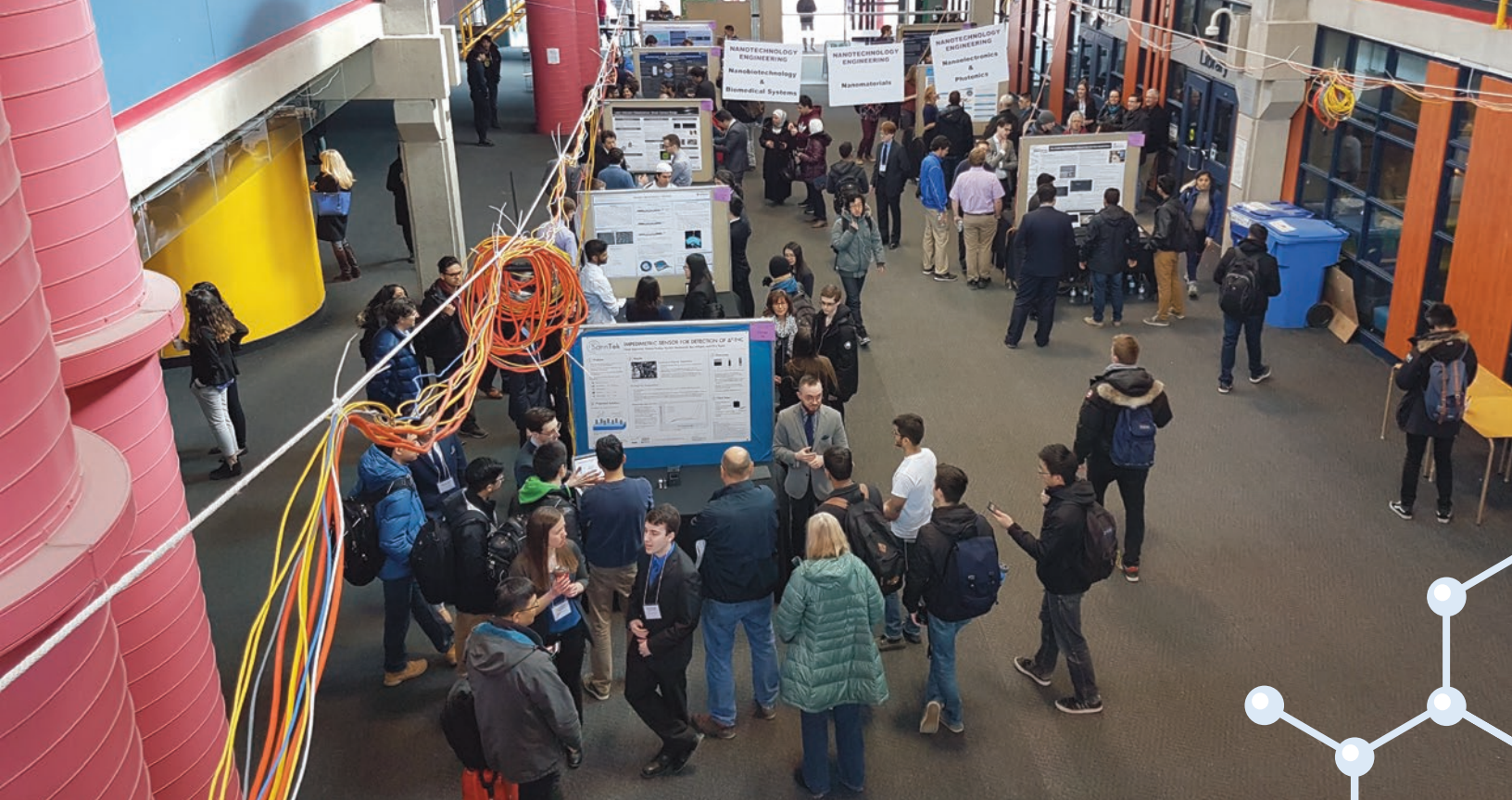
NE students develop a foundational knowledge of multiple disciplines; learn a wide range of complementary abilities, including analysis, creativity and logical thinking; and gain specific technology-driven experience.

## CO-OPERATIVE EDUCATION

NE students' unique collection of skills and attributes make them an excellent fit for employment in many sectors, and they put them to work through University of Waterloo's world-class co-operative education program. During their co-op work terms, students participate in a variety of roles, often making notable contributions to their employers.

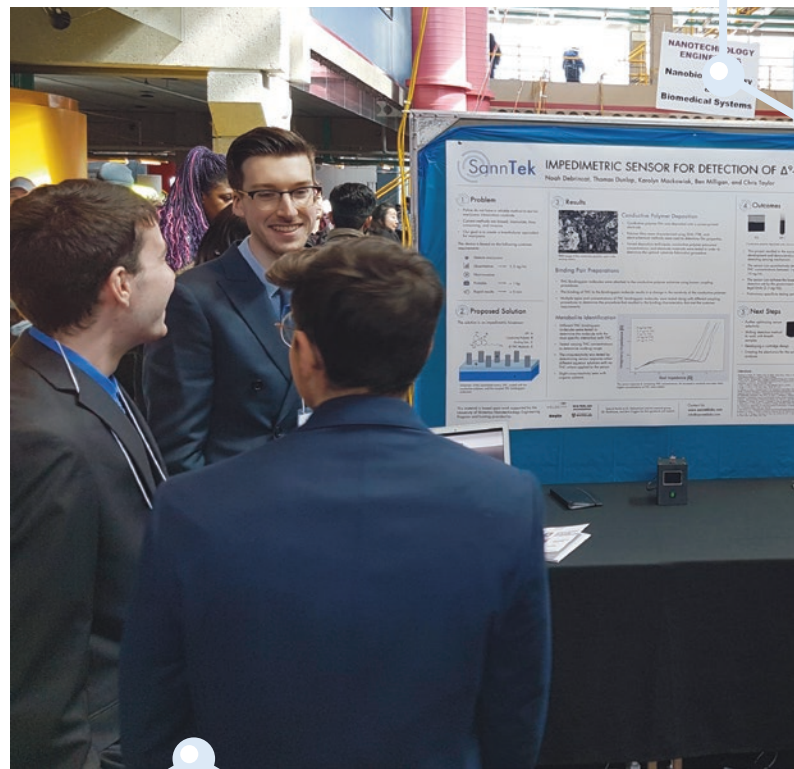
Every term, NE students apply their broad skillset towards complex tasks at electronics and novel materials companies in the Waterloo Region and beyond. Some of them, including Alchemy, Nicoya and NeRV, to name a few, were founded by NE graduates. In addition, many of WIN's international and industry partnerships include co-op placement opportunities for NE students. In Spring 2018, for example, NE students gained hands-on research experience during their co-op work term at Soochow University in Suzhou, China. Other





students honed their research skills at National Institute for Materials Science in Tsukuba (NIMS) in Japan, and Massachusetts Institute of Technology (MIT) and Harvard University in the US, to name a few.

To find out how your business or research lab could also benefit from the many and varied skills of an enthusiastic, motivated NE student, please contact Jenn Coggan, at [jcoggan@uwaterloo.ca](mailto:jcoggan@uwaterloo.ca)



# COLLABORATIVE NANOTECHNOLOGY GRADUATE PROGRAM

Launched in 2010, the Collaborative Graduate Nanotechnology Program allows students to pursue a master's or doctoral degree in nanotechnology in one of six departments: Chemistry, Physics, Chemical Engineering, Electrical and Computer Engineering, Mechanical and Mechatronics Engineering, and Systems Design Engineering.

Core course modules address foundational elements of nanotechnology, while a wide range of nanotechnology elective courses allow students to customize their education and broaden their perspective. In addition, all graduate students are encouraged to pursue intellectual exchanges among themselves, faculty and industry by attending WIN distinguished lectures and faculty seminars.

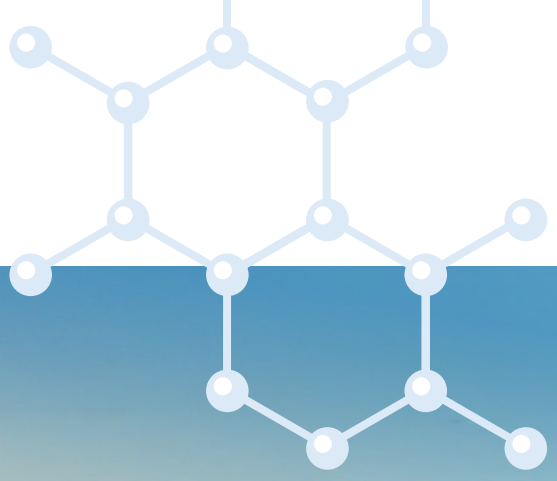
In the QNC, WIN houses 88 masters students, 97 doctoral students, and 35 postdoctoral fellows (PDF). Between 2013 and 2018, approximately 515 graduate students were supervised and co-supervised by WIN members in the QNC alone. Even more graduate students and post-doctoral fellows have been supervised by WIN members in their home departments. Each term, WIN provides a welcoming environment for new graduate students and PDFs by managing key allocation and supporting the Waterloo Institute for Nanotechnology Graduate Student Society's extracurricular activities.

## WINGSS

Since its inception in 2014, the Waterloo Institute for Nanotechnology Graduate Student Society (WINGSS) has increased networking and collaboration among the 200+ graduate students pursuing nanotechnology research across the Faculties of Science and Engineering.

WIN promotes this club via financial support (approximately \$10,000 CAD in total since 2014) and collaboration, including event planning, facilitation and promotion. For example, WIN's financial and administrative support for the annual WINGSS Career Night has been instrumental in bringing industry, government and academic personnel to participate in a panel geared toward nanotechnology graduate students. This event helps current and future students discover all the possibilities offered by the nanotechnology field.







WIN provides significant funding to attract and retain graduate students in the form of scholarships made possible from a generous donation from Douglas Fregin, a co-founder of BlackBerry. Interest from the \$10.5M endowment has provided funds for the scholarships in nanotechnology with each unit of the fellowship valued at \$10,000.

The nanofellowships are awarded to outstanding students conducting nanotechnology research through an annual competition open to international, permanent residents and Canadian students. This scholarship program is designed to recruit students from external Canadian and international universities, as well as retain exceptional talent from UWaterloo's undergraduate science and engineering programs.

## 2018-2019 RECIPIENTS

- › Marcus Abramovitch
- › Kiana Amini
- › Hassan Askari
- › Matthew Courtney
- › Ya-Ping Deng
- › Alicia Dubinski
- › Run Ze Gao
- › Xiguang Gao
- › Gilliam Hawes
- › Khaled Ibrahim
- › Kavish Kaup
- › Navjot Khaira
- › Se Young Kim
- › Chun Yuen Kwok
- › Hyunjae Lee
- › Yibo Lui
- › Rhiannon Lohr
- › Xiao Ming
- › Sirshendu Misra
- › Kissan Mistry
- › Hassan Moussa
- › Erika Ramos
- › Bohua Ren
- › Moslem Sadeghi Goughari
- › Ida Sadeghi
- › Elizabeth Salsberg
- › Serxho Selmani
- › Abhinandan Shyamsunder
- › Geoffrey Sinclair
- › Janine Thoma
- › Yannick Traore
- › Kai Xi Wang
- › Shirley Wong
- › Penghui Yin
- › Hyeonghwa Yu
- › Jing Zhang
- › Zijie Zhang
- › Kai Zhao
- › Yiju Zhao

CITIZENSHIP	APPLICANTS	AWARDEES
Canadian	36 (34%)	17 (42.5%)
International	63 (59%)	20 (50%)
Permanent resident	8 (7%)	3 (7.5%)
<b>Total</b>	<b>107</b>	<b>40</b>

DEGREE PROGRAM	APPLICANTS	AWARDEES
PhD	83 (78%)	34 (85%)
MASc/MSc	24 (22%)	6 (15%)

DEPARTMENT	APPLICANTS	AWARDEES
Biology	2 (2%)	1 (3%)
Chemical Engineering	33 (31%)	8 (20%)
Chemistry	20 (19%)	11 (28%)
Electrical Engineering	24 (22%)	9 (22%)
Mechanical and Mechatronics Engineering	16 (15%)	9 (22%)
Optometry	1 (1%)	-
Pharmacy	3 (3%)	2 (5%)
Physics and Astronomy	6 (5%)	-
Systems Design Engineering	1 (1%)	-
Not Specified	1 (1%)	-
<b>Total</b>	<b>107</b>	<b>40</b>

## Gender: Applicants

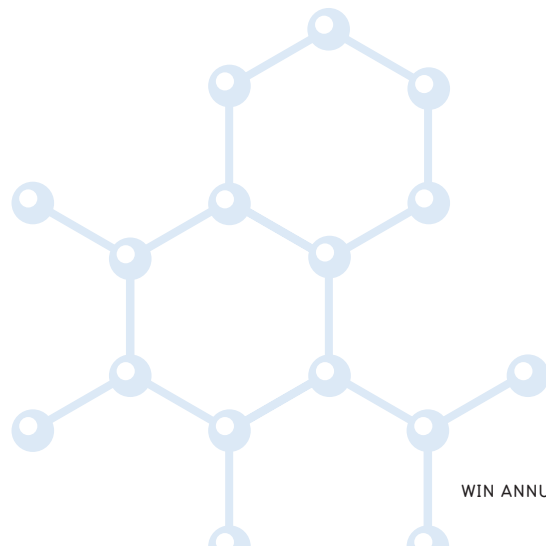


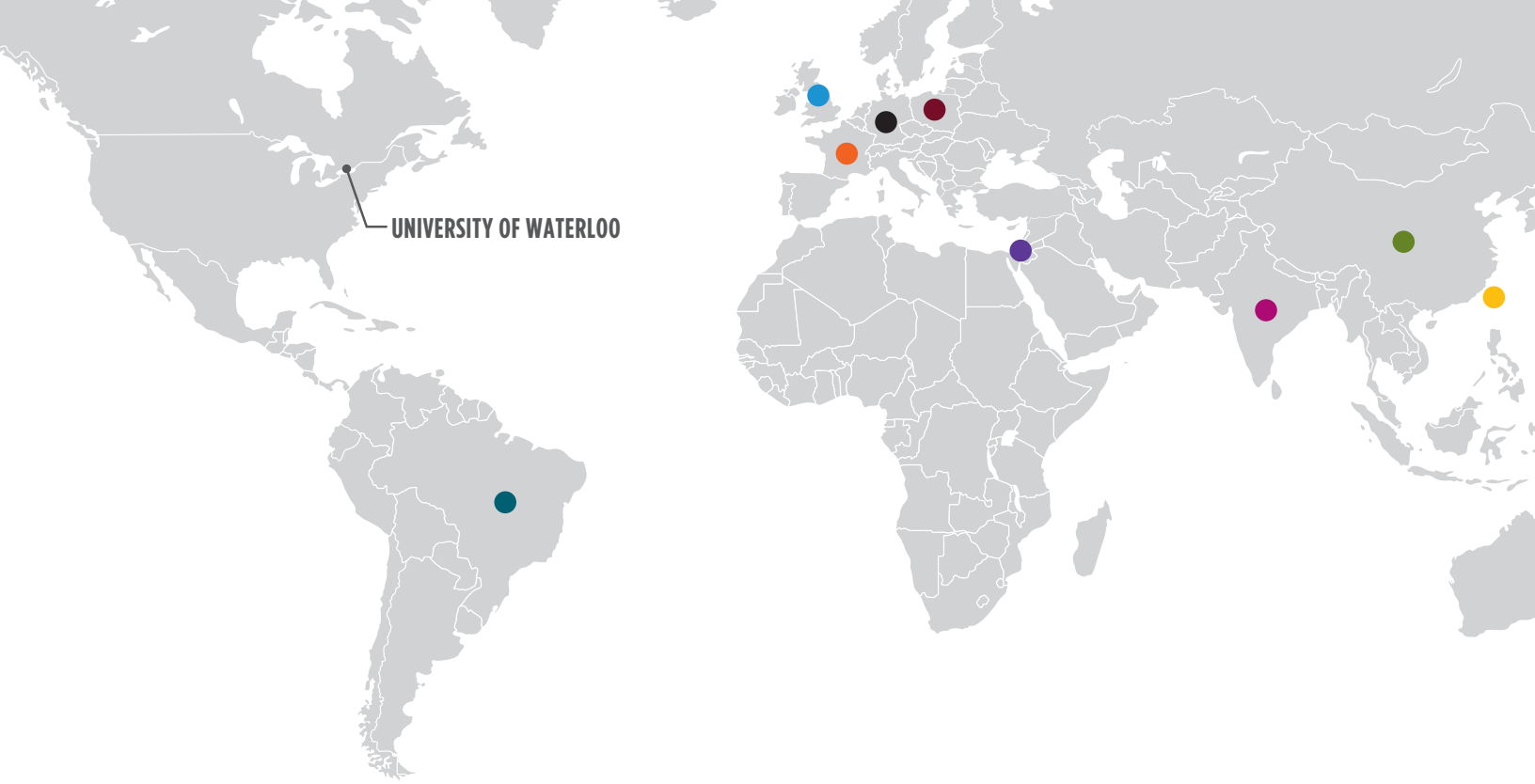
## Gender: Awardees



## WIN NANOFELLOWSHIP COMMITTEE

Created to steward the fair and optimal disbursement of funds for the annual competition and to increase transparency of the selection process Members: ADGS Engineering and Science; WIN faculty representing Deans Engineering and Science; WIN ED and ADRP.

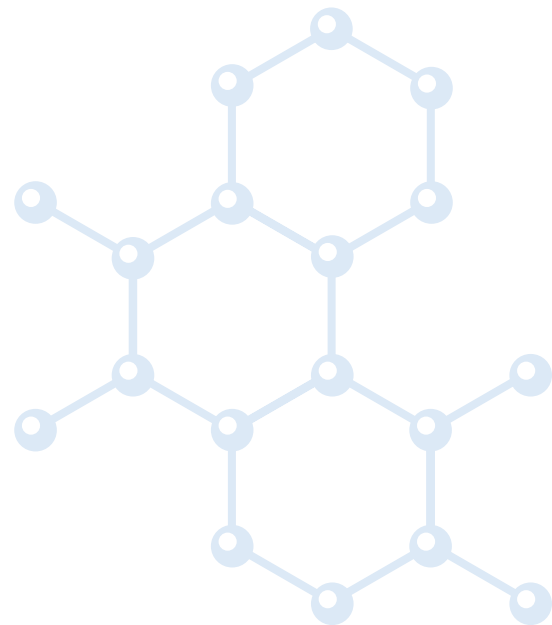




# INTERNATIONAL

It's WIN vision to be a global centre of excellence in nanotechnology and its applications.

- BRAZIL** ● Brazilian National Nanotechnology Laboratory (LNNano)
- CHINA** ● Soochow University, Suzhou (SU)  
Suzhou Industrial Park (SIP)
- FRANCE** ● Université de Bordeaux
- GERMANY** ● Center for Nano Integration Duisburg-Essen (CENIDE)
- INDIA** ● Indian Institute of Technology Bombay (IITB)  
Indian Institute of Science (IISc)  
Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)
- ISRAEL** ● Technion-Israel Institute of Technology
- JAPAN** ● National Institute for Materials Science (NIMS)
- POLAND** ● MISMap College of the University of Warsaw
- TAIWAN** ● Academia Sinica (AS)  
National Taiwan University (NTU)  
National Tsinghua University (NTHU)  
National Chiao Tung University (NCTU)  
National Cheng Kung University (NCKU)  
National Program on Nanotechnology (NPNT)
- UNITED KINGDOM** ● University of Cambridge  
University of Bristol





# CHINA

## SOOCHOW UNIVERSITY AND THE SUZHOU INDUSTRIAL PARK (SIP)

In April 2018, WIN Executive Director, Dr. Sushanta Mitra, travelled to Soochow for the first meetings with the Director of the Institute for Functional Nano & Soft Materials (FUN-SOM), Dr. Shuit Tong Lee, and the Dean of the College of Nano Science & Technology (CNST), Dr Xuhui (Jeff) Sun. As a result of the executive discussions, the SUN-WIN-SIP Joint Research and Education Institute will expand to include a competitive Postdoctoral Fellowship program to bring the world's brightest young researchers to UWaterloo and Soochow University to advance knowledge and innovation in nanotechnology.

Plans are also underway to offer 10 WIN associated startup companies a soft landing site at Nanopolis-based offices located in Suzhou. This approach will expose Canadian technology companies to the large- and emerging markets of Asia, where there is high demand for new technologies in medical and environmental sectors. The companies will benefit from engaging with prospective Chinese partners for future market entries, networking with investors and finding scale-up manufacturing partners.

## TSIEN EXCELLENT IN ENGINEERING PROGRAM (TEEP+)

The TEEP+ Summer School is co-organized by TEEP and the Center of Micro and Nano Mechanics (CMMNM) at Tsinghua University. The theme for the 2018 Summer School was “Nano-X Innovation for Sustainability” with the following themes: Nano-mechanics for sustainability; Nano-optics for sustainability; Nano-biotechnology for sustainability; and Nano-AI for sustainability. WIN researchers were invited to participate in the TEEP+ event, to help develop a dedicated program for student-led innovation. Several WIN members will travel to Tsinghua University in July to participate in this educational program.

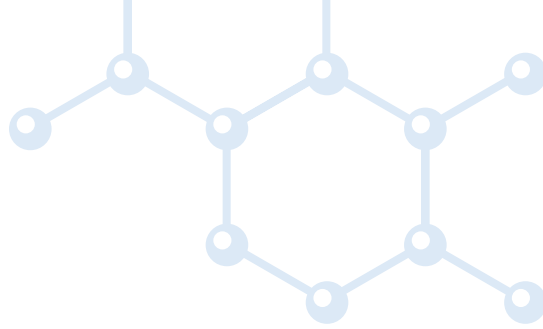
## NATIONAL CENTER FOR NANOSCIENCE AND TECHNOLOGY

WIN is fortunate to have China represented on its International Scientific Advisory Board (ISAB) by Dr Chen Wang, Director General of National Center for Nanoscience and Technology. Dr. Bai Chunli, President of the Chinese Academy of Sciences, who also delivered a WIN Distinguished Lecture in June 2017, nominated Dr. Chen Wang.

# GERMANY

## CENTER FOR NANO INTEGRATION DUISBURG-ESSEN (CENIDE)

The Centre for Nanointegration Duisburg-Essen (CENIDE) is a research institute located within the University of Duisburg-Essen (UDE). CENIDE was founded in 2005 and is considered one of the most important nanoresearch centres in Europe. Home to the unique €46M NanoEnergy Technology Centre (NanoEnergieTechnikZentrum or NETZ) and the Interdisciplinary Centre for Analytics on the Nanoscale (ICAN) the infrastructure and facilities are considered state-of-the-art, allowing for leading-edge research in fundamental and application-related development. In June 2018, a delegation of ten CENIDE members visited WIN for a three-day workshop in 2D Hybrid Nanomaterials for Production and Applications. The goal of this workshop was to identify complementary expertise on both sides for a joint DFG-IRTG/NSERC CREATE research and training proposal for the 2019-2020 funding cycle.



## JAPAN

### NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS)

Japan is a top priority for WIN, visiting the National Institute for Materials Science (NIMS) consistently every year for the past six years. Areas of common strength and vision include Electric/electronic materials, polymers and organic molecules, biomaterials, optical materials, sensors and actuators, quantum materials, and green research on energy and environmental materials.

The Co-operative Graduate Agreement between UWaterloo and National Institute for Materials Science Japan was signed in October 2018. This agreement is designed to provide a mechanism for PhD students from UWaterloo to engage in research by providing funding for living accommodations.

### KYUSHU UNIVERSITY

WIN is also affiliated with Kyushu University (KU) and its International Institute for Carbon-Neutral Energy Research (I2CNER). Research at I2CNER focuses on practical solutions to reduce carbon emissions, making it an excellent partner for WIN in the area of next generation energy systems.

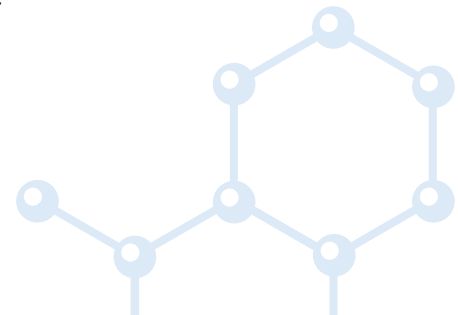
Esteemed researcher Yasuyuki Takata from the Department of Mechanical Engineering/ I2CNER visited WIN in Fall 2018 and gave a seminar lecture.

On 30th April 2019, WIN welcomed Professor Atsushi Takahara from the Institute for Materials Chemistry and Engineering and WPI I2CNER at Kyushu University as a WIN Seminar Speaker. His talk was titled, “Surface and Interface Characteristics of Polyelectrolyte Brushes”.

## TAIWAN

Taiwan represents a significant and strategic opportunity for WIN in realizing its ambition of becoming a global centre of excellence in Nanotechnology. Taiwan is considered a global powerhouse in this area, with its government recognizing Nanotechnology as a top S&T priority, and investing in tools and infrastructure (such as the National Nanodevices Laboratory) in the nation's top universities. As a result, these academic institutions have built up strong programs in fundamental nanoscience, advanced materials and nanodevices which can compete with the best in the world.

The WIN-NCKU Workshop on Nanomedicine, Medical Imaging, and Electronic Devices hosted at the QNC on August 28, 2018, with the delegation led by Professor In-Gann Chen, Director for Center for Micro/Nano Science and Technology (CMNST) accompanied by Professor Dar-Bin Shieh from the Institute for Oral Medicine and Deputy Minister of the Taiwan Ministry of Science and Technology (MOST).





# INDIA

## CENTRE FOR RESEARCH IN NANOSCIENCE AND NANOTECHNOLOGY (CRNN)

Nanotechnology is an identified priority area for Canada-India collaboration as outlined by the Canada-India Joint Science and Technology Co-operation Committee. A Memorandum of Understanding for Educational and Scientific Co-operation between WIN and the Centre for Research in Nanoscience and Nanotechnology at the University of Calcutta for joint research activities of common interest in the general fields of Nanoscience and Nanotechnology, exchange of faculty, students and information was signed in July 2018 to be in effect for a duration of five years.

# UNITED KINGDOM

## UNIVERSITY OF CAMBRIDGE

Following the WIN-Cambridge workshop in Advanced materials for Energy and Healthcare held at the University of Cambridge in July 2016, a WIN-Cambridge Seminar Series has been implemented to support collaboration and foster joint research initiatives. The first academic exchange occurred in March 2017 when Professor Arokia Nathan visited UWaterloo, for a presentation as part of the WIN Distinguished Lecture Series titled, “Transparent & Flexible Oxide Nanoelectronics”.

The second WIN-Cambridge exchange occurred in January 2018, when WIN member Prof Juewen Liu travelled to Cambridge to give a seminar, “DNA and Nanomaterials as Enzyme Mimics” and meet with prominent University of Cambridge researchers in both the Department of Bioengineering and the Department of Chemistry.

# NETHERLANDS

## MESA+ INSTITUTE

MESA+ is a renowned leader in many key fields of technology such as the physics of fluidics (ranked first in the world in this area) and has pioneered the “digital twin” platform for human health and disease prevention.

The Memorandum of Understanding for Educational and Scientific Co-operation between WIN and MESA+ University of Twente for general research collaboration, faculty and student exchange, information sharing and facilities was signed in June 2018 for a duration of five years.

## AMOLF INSTITUTE

The AMOLF Research Institute is part of the Netherlands Organisation for Scientific Research located at the Amsterdam Science Park. The research focus at AMOLF is fundamental research on the physics and design principles of natural and man-made complex matter, the creation of novel functional materials, renewable energy, green ICT and healthcare.

AMOLF faculty Dr Bruno Ehrler visited WIN in June 2018 to receive the WIN Rising Star Award recognizing his achievements in his career, and also presented at WIN’s International Frontiers in Nanoscience and Nanotechnology Symposium on June 6, 2018. This relationship will facilitate partnership and research collaboration with the institutes, and open future exciting opportunities.

# INTERNATIONAL SYMPOSIUM 2018

The first symposium held on June 6, 2018, where renowned researchers from around the world participated in the day-long conference. The conference featured keynote speakers from the international scientific community, and showcased WIN excellence in each of the key theme research areas. The agenda for the 2018 International Symposium on Frontiers of NanoScience and Nanotechnology included:

## KEYNOTE LECTURES

1. Albert van den Berg, Scientific Director, MESA+ Institute, University of Twente, Netherlands
2. David Sinton, University of Toronto
3. Carlos Bof Buffon, Brazilian Nanotechnology National Laboratory (LN-Nano), CNPEM, Brazil
4. Quanshui Zheng, Tsinghua University, China

## WIN THEME LECTURES

1. Boxin Zhao, Smart and Functional Materials
2. Vassili Karanassios and Na Young Kim, Connected Devices
3. Linda Nazar, Next Generation Energy Systems
4. Karim Karim, Therapeutics and Theranostics

## RISING STAR KEYNOTE LECTURE

Bruno Ehrler, AMOLF Research Institute, Netherlands



DR. LINDA NAZAR

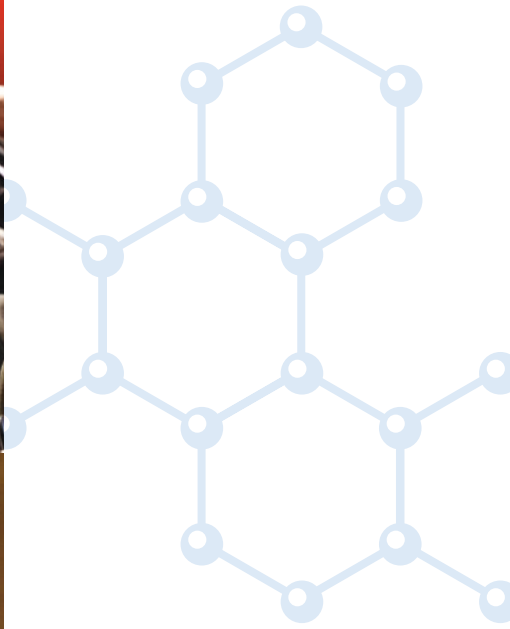




TOP  
Student Poster  
Session presentation

MIDDLE  
2018 International Symposium  
audience members

BOTTOM  
Dr Quanshui Zheng,  
Tsinghua University





WIN RISING STAR AWARD to Dr Bruno Ehrler (centre) of the AMOLF Institute in the Netherlands with WIN ED Dr Sushanta Mitra (left) and UWaterloo VP Research, Dr Charmaine Dean (right)

# WATERLOO INSTITUTE FOR NANOTECHNOLOGY

# RISING STAR AWARD

In 2018, WIN announced an international call for submissions to the WIN Rising Star Award in Nanoscience and Nanotechnology. The competition is to bring to UWaterloo a full-time early career faculty member who has received their PhD in science or engineering. This award is designed to introduce up-and-coming ‘rising stars’ in nanotechnology to WIN/UWaterloo leading to new partnerships and increase the international recognition of the research excellence at WIN.

The candidate’s research interest must align with one or more of the thematic area(s) of WIN (Smart and Functional Materials, Connected Devices, Next Generation Energy Systems, and Therapeutics and Theranostics). Along with an honorarium for \$10,000 CAD the award recipient will present a featured research seminar in the symposium. Also, the award recipient will spend two days at WIN interacting with faculty members and graduate students.

Many qualified candidates submitted applications to the competition, and early-career researcher, Dr Bruno Ehrler, Scientific Group Leader at the AMOLF Institute in Amsterdam Netherlands was chosen to receive the award for his expertise in and contribution to hybrid solar cell fabrication. Dr Ehrler gave a keynote presentation entitled “Beyond Solar Cell Efficiency Limits with Down-Conversion and Tandem Solar Cells” at the Frontiers of Nanoscience and Nanotechnology International Symposium in June 2018.

The competition was advertised widely in number of scientific outlets including the March 2018 issue of Science and was publicized among WIN’s international partners and ISAB members.



2018 WIN RESEARCH LEADERS GALA RECEPTION, June 5, 2018

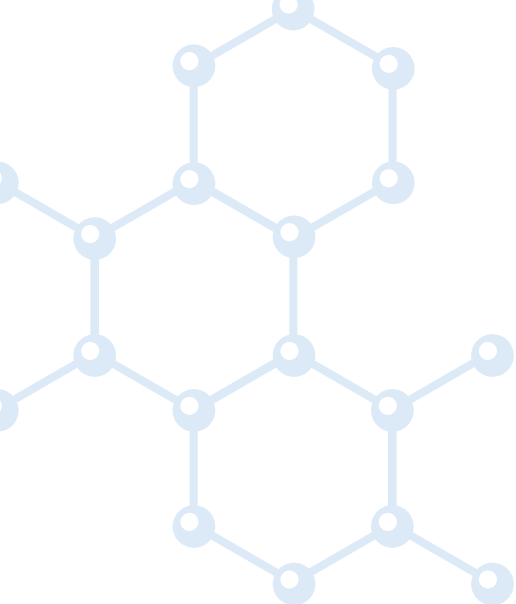
# WIN RESEARCH LEADERS GALA

As part of WIN's 10 Year Celebration, the "WIN Research Leaders Gala and Reception" was held on June 5, 2018 to recognize our outstanding researchers who have made significant contributions during the 2017-2018 fiscal year. These contributions include:

- a) Any individual or group receiving major grants with a value equal to or greater than \$500,000
- b) Major national or international awards
- c) Published books or other major scholarships and creativity

**For 2018, the following WIN members were recognized:**

- |                     |                          |                |
|---------------------|--------------------------|----------------|
| › Jonathan Baugh    | › Juewen Liu             | › Michael Tam  |
| › Zhongwei Chen     | › Adrian Lupascu         | › Adam Tsen    |
| › Kyle Daun         | › Raafat Mansour         | › William Wong |
| › Marianna Foldvari | › Kevin Musselman        | › Youngki Yoon |
| › Michel Gingras    | › Linda Nazar            | › Alfred Yu    |
| › Karim Karim       | › Janusz Pawliszyn       | › Boxin Zhao   |
| › Xianguo Li        | › Luis Ricardez Sandoval | › Norman Zhou  |



# ENGAGING INDUSTRY



## WIN INDUSTRY SERIES

In 2018 WIN started a new seminar series focused specifically for industry. Within this program, companies are invited throughout the year to give a seminar presentation at WIN. Company representatives at high levels within the enterprise are invited, such as the Vice-President of Research and Development (or equivalent). These seminars are designed to provide industry insights for our members, and have a high likelihood of future research collaborations.

The WIN Industry Seminars are accompanied by pre-arranged one-on-one meetings with faculty members whose research has strong overlap of interests with the company's R&D needs. In 2018, WIN hosted three Industry Series Seminars:

1. May 3, 2018. Jamal Zeinalov, Co-founder and CEO, Atomic Works Inc. The company develops software simulation platforms to assist in the discovery of new materials and structures on a molecular scale.
2. July 30, 2018. Michael Scott, Senior Vice-President of Product Development, BlueRock Therapeutics Inc. Dr Scott has more than 20 years of experience in the field of cardiovascular medical devices and in the stem cell therapeutics landscape. Dr Scott's R&D team focused on development of a cell therapy platform for delivery of dopaminergic neurons to treat Parkinson's disease and cardiomyocytes to treat congestive heart failure.
3. November 9, 2018. Elena Polyakova, Founder and CEO, Graphene Laboratories Inc. Dr Polyakova has co-authored papers with Nobel and Kavli prize winners. Founded in 2009, her company is a pioneer in the commercial graphene production industry.

The competition was advertised widely in number of scientific outlets including the March 2018 issue of Science and was publicized among WIN's international partners and ISAB members.



## WIN INDUSTRY WORKSHOP

To further intensify the interaction, WIN held a one-day workshop to bring academics and industry together. The topic of the event was “Nanotechnology for Advanced Manufacturing” held on October 17, 2018. There were 46 participants in total, from industry, government organizations, UWaterloo faculty and graduate students. The event featured three keynote speakers: Peter Voss, CEO and President of Shimco Inc (smart, connected shims for aerospace applications), Danny Yalcin, Smart Manufacturing Manager at Magellan Aerospace Inc (use of sensors in aerospace manufacturing), and Michaela Vlasea, Assistant Professor, Department of Mechanical and Mechatronics Engineering (overview of current state of metal additive manufacturing). The event also featured five-minute presentations from WIN faculty members and industry representatives. The event resulted in three new research partnerships. The event was financially supported by WIN and an NSERC Connect grant.

## WIN STARTUP CATALYST PROGRAM

In September 2018, WIN launched support program for nanotechnology entrepreneurs to supplement existing entrepreneurship programming at the Waterloo campus, and expose more faculty members, graduate students and postdocs to entrepreneurship. Helping new nanotechnology ventures at early stages will lead to nurturing a longer term partnership when companies grow. Below is the list of services this program provides:

- › Access to WIN’s meeting and event spaces at QNC
- › Use of the WIN name/logo in company’s marketing materials
- › Introductions to investors
- › Connections with WIN international partners
- › Facilitated access to WIN researcher expertise
- › Assistance in talent acquisition
- › Access to WIN’s Executive-in-Residence

About 10 startup companies are engaged with the program at WIN. Looking forward, WIN plans to deepen its relation on-campus Velocity program and Conrad School of Entrepreneurship and Business.

# NANOTECHNOLOGY THEME RESEARCH DAY



WIN RESEARCH DAY PANEL ON ENERGY LANDSCAPE – 2020 AND BEYOND  
(left to right) Jatin Nathwani, ED Waterloo Institute for Sustainable Energy; Lora Field, Ontario Investment Office; Paul Parker, Associate Dean Strategic Initiatives Faculty of Environment; Juan Moreno-Cruz, Professor School of Environment, Enterprise and Development; Ian Rowlands, Associate Vice President International; Arun Majumdar, Jay Precourt Professor of Energy Stanford University; Sushanta Mitra, WIN ED

## NEXT GENERATION ENERGY SYSTEMS

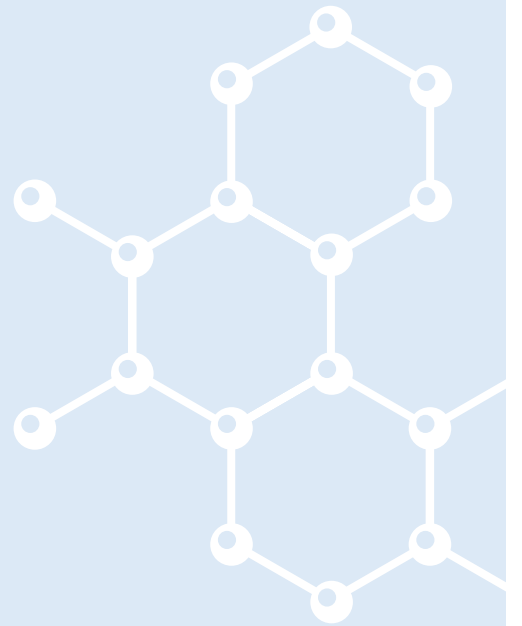
<b>Arun Majumdar</b>	“Navigating the Turbulence of the Global Energy System” WIN Distinguished Lecture
<b>Rodney Smith</b>	Asymmetry and Disorder in Heterogeneous Electrocatalysts
<b>Holger Kleinke</b>	Environmentally Friendly Materials for Sustainable Electricity Generation – Thermoelectric Magnesium Silicide-Stannides
<b>Eihab Abdel-Rahman</b>	Practical Energy Harvesting
<b>Zhongwei Chen</b>	Design and Application of Advanced Materials in Electrochemical Energy Storage Systems
<b>Jeff Gostick</b>	An Inside Look (literally) into Advanced Energy Storage Devices
<b>Linda Nazar</b>	A High energy Density Lithium-Oxygen Battery Based on Reversible Electrocatalysed Conversion of Lithium Oxide
<b>Vivek Maheshwari</b>	Stable Polymer-Perovskite composites for self-powered applications
<b>Keven Musselman</b>	Advanced nanomaterials for stable next-generation solar cells
<b>Michael Pope</b>	2D materials for Improved Electrochemical Energy Storage

### This symposium was followed by a panel discussion “Energy landscape: 2020 and Beyond”

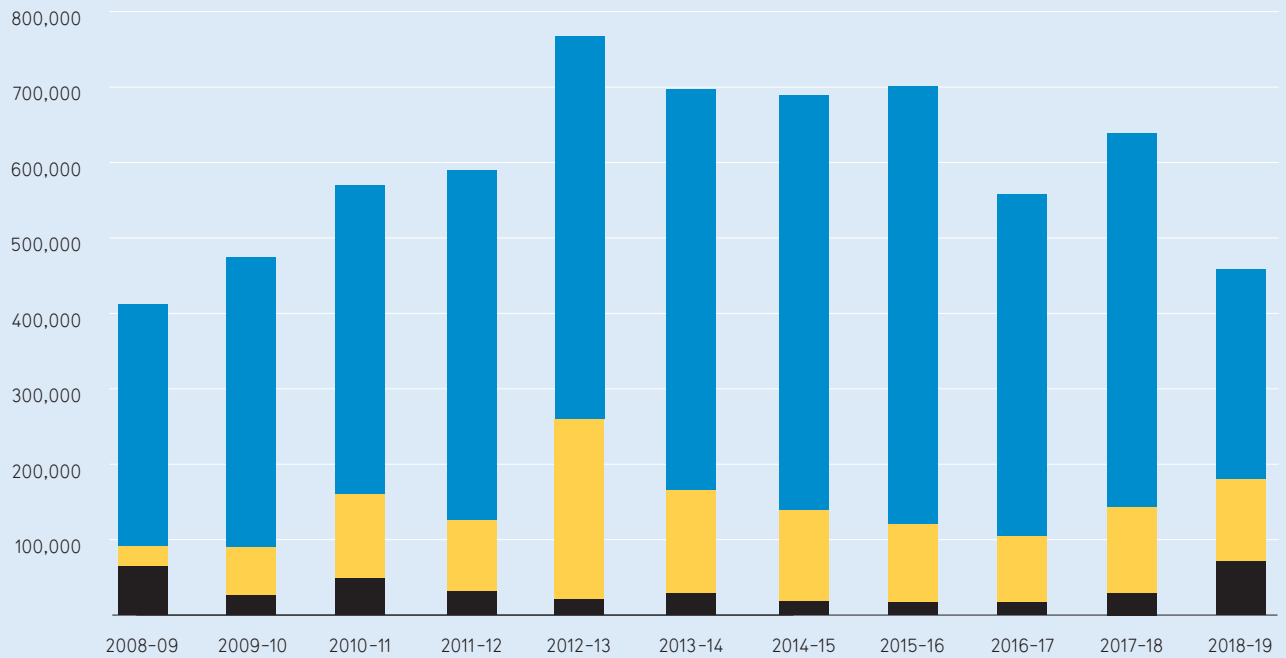
- › Moderator: Sushanta Mitra
- › Arun Majumdar: Jay Precourt Professor, Stanford University
- › Lora Field: Ontario Investment Office, Ministry of Economic Development, Job Creation and Trade
- › Juan Moreno-Cruz: Professor in Environment, Enterprise & Development and Canada Research Chair in Low Carbon Emissions
- › Jatin Nathwani: Executive Director, Waterloo Institute for Sustainable Energy
- › Paul Parker: Professor in Environment, Enterprise & Development, University of Waterloo
- › Ian Rowlands: Vice President International, University of Waterloo



# BUDGET



- Office
- Operations
- Salary



LIFE IN THE MIKE & OPHELIA LAZARIDIS

# QUANTUM-NANO CENTRE

WATERLOO INSTITUTE FOR NANOTECHNOLOGY

**3**

Lounges

**3**

Meeting  
Rooms

**200+**

Students in  
WIN section  
of QNC

**41**

Student  
Offices

**1**

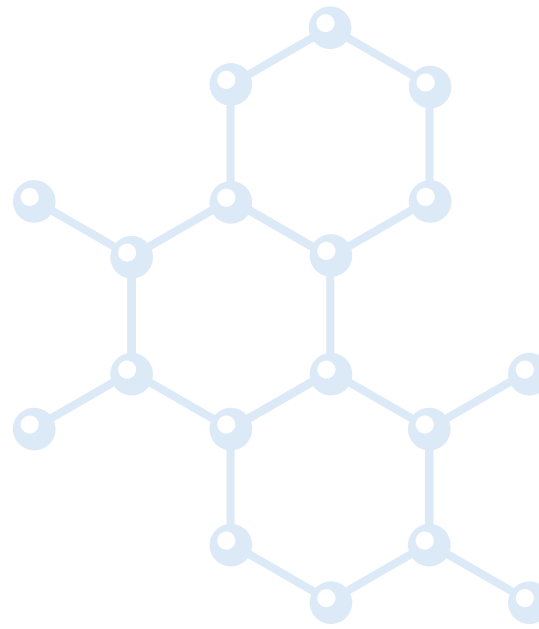
Seminar  
Room



**1**  
Rooftop  
Patio

**50**  
Laboratories

**4**  
Kitchens



WIN is responsible for managing the space and infrastructure on the “nano” side of the Mike & Ophelia Lazaridis Quantum-Nano Centre.

A sense of community is very important to everyone, and is especially significant in a multi-disciplinary research institute such as WIN. A faculty lounge was opened in October 2018 on the third floor of the QNC with a fully-equipped kitchen with Keurig coffee and tea bar, welcoming all WIN members to meet, relax, and connect with colleagues for lively discussion on the day’s current events and hot topics. This space will encourage an even tighter-knit nanotechnology community and expand interdisciplinary collaboration within WIN.

The exterior of the Mike & Ophelia Lazaridis Quantum-Nano Centre is modeled after the hexagonal structure of graphene.

UNIVERSITY OF  
**WATERLOO**



WATERLOO INSTITUTE FOR NANOTECHNOLOGY  
200 UNIVERSITY AVE. W., WATERLOO, ON, CANADA N2L 3G1



nano.uwaterloo.ca

519-888-4567