NRC-Waterloo Workshop on Quantum and Nanotechnologies

Featuring

NRC's Quantum Internetworking and Quantum Sensors Challenge Program!

- ✓ Thematic Knowledge Sharing
- ✓ Networking Opportunities
- ✓ Program Partnership

Nov 25, 2025

8:00 AM - 4:30 PM, QNC 0101

UNIVERSITY OF WATERLOO | WATERLOO INSTITUTE FOR nanotechnology | IQC Institute for Quantum Computing

NRC-Waterloo Workshop on Quantum and Nanotechnologies

Event Detail:

The Institute for Quantum Computing (IQC) and Waterloo Institute for Nanotechnology (WIN) are proud to jointly host this strategic workshop in collaboration with the National Research Council (NRC). This event marks a significant milestone in strengthening research partnerships and advancing Canada's leadership in quantum and nanotechnology innovation.

Purpose of the Workshop:

This workshop provides a unique platform for researchers and leaders from NRC, IQC, and WIN to:

- Identify collaborations in areas of mutual interest
- Explore joint funding opportunities through NRC programs
- Develop strategic partnerships between NRC and the University of Waterloo
- Contribute to Canada's global leadership in advanced materials, sensors, and quantum technologies

Thematic Sessions:

Reflecting WIN's interdisciplinary research strengths, the workshop features two broad thematic areas:

- Advanced Materials:
  - Applied Quantum Materials
  - Additive Manufacturing
  - Printable Electronics
- Sensors and Devices:
  - Sensors for Threat Detection/ Environment
  - Quantum Components
  - Devices and Interconnects

Workshop Highlights:

- Introduction to NRC's Quantum Internetworking Round 3 Challenge Program
- In-person participation from NRC management professionals and researchers
- Networking opportunities to foster long-term collaborations

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Agenda

Nov 25, 2025

Time	Event	Speaker
8:00 - 8:15 AM	Registration, Coffee and Networking	
8:15 - 8:35 AM	Opening Remarks: • Charmaine Dean – VICE President, Research & International, University of Waterloo • Sushanta Mitra – Executive Director of WIN • Norbert Lütkenhaus – Executive Director of IQC • Peter Mason – Director General of NRC-QN	
8:35 - 8:50 AM	NRC Challenge Programs	Aimee Gunther - Director: Quantum Internetworking Program
8:50 - 9:00 AM	Health Break	
SESSION 1A: ADVANCED MATERIALS		
9:00 - 9:10 AM	From Seed to Quantum Alliance: Building Canada's First Cathodoluminescence Platform for Quantum Materials	WIN: German Sciani
9:10 - 9:20 AM	Purified Carbon Nanotubes for Photonic Applications	IQC: Na Young Kim
9:20 - 9:30 AM	Developmental and Analytical Microscopy at QN	NRC: Mark Salomons
9:30 - 9:40 AM	Manipulating Excitonic Properties of Plasmonic Semiconductor Nanostructures	WIN: Pavle Radovanovic
9:40 - 9:50 AM	2D Quantum Materials for Broadband Electromagnetic Wave Sensing	IQC: Adam Wei Tsen

Agenda

Nov 25, 2025

Time	Event	Speaker
9:50 -10:00 AM	Materials and Methods for Generating 3D Electronics with Volumetric Additive Manufacturing	NRC: Chantal Pacquet
10:00 -10:30 AM	Health Break	
SESSION 1B: ADVANCED MATERIALS		
10:30 - 10:40 AM	Manufacture of Nanoengineered Quantum Dots and Thin Films	WIN: Kevin Musselman
10:40 - 10:50 AM	Building a Spin Qubit Ecosystem at Waterloo	IQC Jonathan Baugh
10:50 -11:00 AM	III-V MBE at the NRC: Where We've Been, and Where We're Going	NRC: Chris Deimert
11:00 -11:10 AM	Optomagnetics in Ditac Materials	WIN: Hamed Majedi
11:10 -11:20 AM	Photonic Nanowire Devices for Quantum Networks and Sensing	IQC: Michael Reimer
11:20 -11:30 AM	Transcoherent States: Optimized Atomic Control Using Quantum States of Light	NRC: Aaron Goldberg
11:30 AM -1:00 PM	Networking Lunch	
SESSION 2A: SENSORS AND DEVICES		
1:00 - 1:10 PM	Microwave Sensing for Biomedical and Environmental Applications	WIN: Carolyn Ren

Agenda

Nov 25, 2025

Time	Event	Speaker
1:10 -1:20 PM	Mechanically Detected Molecular Qubits: A New Approach to Single-Molecule Quantum Sensing	IQC: Raffi Budakian
1:20 -1:30 PM	Technology for Point of Need Environmental Measurements	NRC: Enas Osman
1:30 - 1:40 PM	Flexible Sensors Enabled by Semiconducting Polymers	WIN: Yuning Li
1:40 -1:50 PM	Quantum Sensors Based on Superconducting Quantum Devices	IQC: Adrian Lupascu
1:50 -2:00 PM	Si-based Material Platforms for Quantum Technologies	NRC: Khaled Mnaymneh
2:00 - 2:30 PM	Health Break	
SESSION 2B: SENSORS AND DEVICES		
2:30 -2:40 PM	Hexagonal Boron Nitride Strain Sensors	WIN: Aleksandar Misic
2:40 - 2:50 PM	Developing Components and Devices for Quantum Networks Using Neutral Atom Arrays	IQC: Alexandre Cooper-Roy
2:50 - 3:00 PM	Quantum Error Corrected Non-markovian Metrology	NRC: Ningping Cao

Agenda

Nov 25, 2025

Time	Event	Speaker
3:00 - 3:05 PM	Selection of DNA aptamers for biosensors	WIN: Juewen Liu
3:05 - 3:10 PM	On-chip nature-inspired trapped-ion platform for environmental monitoring	WIN: Sushanta Mitra
3:10 - 3:20 PM	Optomechanical Sensors and Frequency Converters	IQC: Bradley Hauer
3:20 - 3:30 PM	Flexible Printed Sensors using Advanced 2D MXene Materials	NRC: Ta-Ya Chu
3:30 - 3:45 PM	Health Break	
PANEL DISCUSSION		
3:45 - 4:30 PM	• **Opportunities for Collaboration** • **Q&A**	• Sushanta Mitra • Norbert Lütkenhaus • Peter Mason • Aimee Gunther • Marina Gertzvolf - Director of Quantum Sensors Program
4:30 - 4:35 PM	Wrap Up and Closing Remark	Panel Members
4:35 - 5:30 PM	Reception, 2nd Floor at IQC	

NRC Presenters

Ningping Cao

Research Officer
Digital Technologies

Quantum Error Corrected Non-markovian Metrology

Quantum metrology aims to maximize measurement precision on quantum systems, with a wide range of applications in quantum sensing. Achieving the Heisenberg limit (HL)--the fundamental precision bound set by quantum mechanics--is often hindered by noise-induced decoherence, which typically reduces achievable precision to the standard quantum limit (SQL). While quantum error correction (QEC) can recover the HL under Markovian noise, its applicability to non-Markovian noise remains less explored.

In this work, we analyze a hidden Markov model in which a quantum probe, coupled to an inaccessible environment, undergoes joint evolution described by Lindbladian dynamics, with the inaccessible degrees of freedom serving as a memory. We derive generalized Knill-Laflamme conditions for the hidden Markov model and establish three types of sufficient conditions for achieving the HL under non-Markovian noise using QEC.

Additionally, we demonstrate the attainability of the SQL when these sufficient conditions are violated, by analytical solutions for special cases and numerical methods for general scenarios. Our results not only extend prior QEC frameworks for metrology but also provide new insights into precision limits under realistic noise conditions.

NRC Presenters

Ta-Ya Chu

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Flexible Printed Sensors Using Advanced 2D MXene Materials

Wearable sensors, including chemical, physical, and biological sensors, have attracted a lot of attention due to the significant market demand in healthcare and robotics. Additive manufacturing with advanced materials enables innovation for sensor applications with novel 2D materials. Further development with sustainable and environmentally friendly materials for wearable sensors has great potential to advance technology in Canada. The development of advanced 2D materials MXene with additive manufacturing for wearable sensors aligns with the NRC's research and innovation priorities. It supports the strategic priority through material development to sensing applications. The University of Waterloo has strong research capabilities in nanotechnology and materials science, and the potential collaboration in material synthesis and surface functionalization can accelerate development and contribute to Canada's leadership in wearable technology research. Solution-processable MXene development for sensors are potential opportunities for wearable sensors development between NRC and the University of Waterloo.

Chris Deimert

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

III-V MBE at the NRC: Where We’ve Been, and Where We’re Going

The NRC’s V90 MBE system grew its first structure back in 2002. Its first decade saw the growth of myriad quantum and photonic devices, from quantum well infrared photodetectors to 2-dimensional electron gases, to record-breaking THz quantum cascade lasers. More recently, the focus steered towards mid-infrared photonics: complex interband cascade lasers and quantum well lasers based on quaternary and quinary alloys. 2026 will mark a new era, with major upgrades to the power and control systems that will improve reliability and unlock new capabilities. Where will this take us? From THz/mid-IR devices to more fundamental studies, the future looks bright.

NRC Presenters

Aaron Goldberg

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Transcoherent States: Optimized Atomic Control Using Quantum States of Light

Every time you manipulate matter using light, your quality diminishes due to residual light-matter interactions. What if you could avoid that by tailoring the quantum properties of your light? I will explain our techniques to do just so, followed by discussions on potential enhanced magnetic resonance imaging and enhanced generation of resources like Schrodinger cat states that are imperative for quantum sensing and beyond.

Khaled Mnaymneh

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Si-based Material Platforms for Quantum Technologies

Silicon-based material platforms offer promising pathways for scalable quantum technologies due to their compatibility with existing CMOS infrastructure. SiGe heterostructures enable high-mobility two-dimensional electron gases and precise control over spin-orbit coupling, making them ideal for hosting spin-based qubits with long coherence times and tunable interactions. Meanwhile, silicon nitride (SiN) has emerged as a robust photonic platform, particularly for integrated quantum optics. SiN ring resonators exhibit low propagation losses and high quality factors, supporting efficient photon routing and frequency conversion essential for quantum communication and photonic quantum computing. Together, SiGe and SiN platforms represent complementary approaches toward hybrid quantum systems that integrate spin qubits with photonic interconnects.

NRC Presenters

Enas Osman

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Technology for Point of Need Environmental Measurements

The Detection and Automation department develops sensors, actuators, and device platforms that generate new knowledge and deliver value in real-world environmental sensing applications. We draw on extensive expertise in analytical chemistry, device fabrication, sensor testing and integration, micro- and nanofabrication, and engineering to address challenges. Through strong partnerships and collaborative efforts, we provide relevant and impactful technology solutions that address the needs of Canadians.

Chantal Pacquet

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Materials and Methods for Generating 3D Electronics with Volumetric Additive Manufacturing

Volumetric additive manufacturing (VAM) is a newly developed polymer 3D printing technique that uses tomographic projection to print all-at-once enabling objects to form orders of magnitude faster than traditional vat polymerization 3D printing methods. This technique also has the unique ability to print over top of an existing structure, a method we term overprinting. We propose to use this printing platform in an unconventional way – to 3D overprint a pattern of a functional polymer overtop of an existing object and subsequently metallized the newly printed pattern to produces 3D printed conductors. This presentation will introduce volumetric additive manufacturing, highlight challenges of printing with VAM and the development of photoresins and printing requirements needed to generate high resolution 3D electronics

NRC Presenters

Mark Salomons

Research Officer
NRC-Quantum and Nanotechnologies Research Centre

Developmental and Analytical Microscopy at QN

Overview of Advanced Characterizations in QN with a focus on the NRC-WIN collaboration.

IQC - Presenters

Jonathan Baugh

Professor
Department of Chemistry
Building a Spin Qubit Ecosystem at Waterloo

Raffi Budakian

Professor
Department of Physics and Astronomy

Mechanically Detected Molecular Qubits: A New Approach to Single-Molecule Quantum Sensing

Alexandre Cooper-Roy

Research Associate, Senior Technical Lead, Quantum Simulation
Transformative Quantum Technologies
Developing Components and Devices for Quantum Networks Using Neutral Atom Arrays

Bradley Hauer

Assistant Professor
Department of Electrical and Computer Engineering
Optomechanical Sensors and Frequency Converters

IQC - Presenters

Na Young Kim

Associate Professor
Department of Electrical and Computer Engineering

Purified Carbon Nanotubes for Photonic Applications

Adrian Lupascu

Associate Professor
Department of Physics and Astronomy

Developing Networks of Quantum Sensors and Clocks Using Atom Arrays for Defense and Environment

Michael Reimer

Associate Professor
Department of Electrical and Computer Engineering

Developing Networks of Quantum Sensors and Clocks Using Atom Arrays for Defense and Environment

Adam Wei Tsen

Associate Professor
Department of Chemistry

2D Quantum Materials for Broadband Electromagnetic Wave Sensing

WIN - Presenters

Juewen Liu

Professor
Department of Chemistry

Selection of DNA aptamers for biosensors

AAptamers are single-stranded nucleic acids that are highly useful for designing biosensors. They were obtained by using a combinatorial selection method called SELEX. Most of the previous aptamer selections were performed using immobilized target molecules and the binding studies often relied on heterogeneous assays or gold nanoparticle based assays. We articulate the importance of homogeneous binding assays. Currently, many new DNA aptamers were selected using immobilized DNA library and this method is called capture-SELEX. We studied the effect of target concentration in aptamer selection and found that a lower target concentration is more favorable for the selection of aptamers with higher affinities. In addition, a longer incubation time is also favorable. The effect of pH and salt concentration was further studied, and a lower pH led to faster enrichment of aptamers for kanamycin. This research provides fundamental insights into aptamer selections and has led to the generation of many high affinity aptamers for metal ions and small molecules.

Yuning Li

Professor
Department of Chemical Engineering

Flexible Sensors Enabled by Semiconducting Polymers

Flexible, printable sensors based on semiconducting polymers are emerging as key components for wearables, smart packaging, and environmental monitoring. Despite advantages in mechanical flexibility and low-cost, solution processing, conventional polymer sensors often suffer from limited sensitivity, poor selectivity, and inadequate long-term stability. This presentation highlights our recent advances in the rational design of semiconducting polymers that address these limitations, enabling high-performance temperature and chemical sensing (e.g., NO_2, CO, and alcohols) in both chemiresistive and organic field-effect transistor (OFET) formats. We demonstrate how molecular engineering, tuning frontier energy levels, hydrogen-bonding capacity, porosity, and solvent compatibility, translates into enhanced transduction, stability, and processability. The resulting materials deliver robust performance while remaining scalable and environmentally compatible, positioning these platforms for broad adoption in next-generation flexible and wearable technologies

WIN - Presenters

Hamed Majedi

Professor
Department of Electrical and Computer Engineering

Optomagnetics in Ditac Materials

Abstract: Optomagnetics—the generation of effective magnetic fields by circularly polarized light—enables ultrafast generation of magnetic fields. I will present a quantum framework for optomagnetics in Dirac material. I will then discuss our results on microwave-driven inverse Faraday effect in high-Tc superconductors, where circularly polarized microwaves create tunable condensate magnetization and helicity-odd Kerr/Faraday responses. Finally, I will outline our cryogenic setup designed to quantify optomagnetic fields.

Sushanta Mitra

Executive Director, WIN
Professor,
Department of Mechanical and Mechatronics Engineering

On-chip nature-inspired trapped-ion platform for environmental monitoring

In nature, the asparagine–proline–alanine (NPA) motif of Aquaporins enables water molecules to pass in a single file due to extreme confinement. This confinement can be created by parallel sheets of 2D materials like graphene. In this work, we first show, through Molecular Dynamics simulations, how such van der Waals architecture can be engineered to trap ions like Na+ and Cs+ within a linear chain of water molecules. Consequently, we present the device prototype where this confinement is achieved by patterning nanometer-scale channels on graphene with electron beam lithography and reactive ion etching. Further, we highlight practical challenges in realizing such a device. Furthermore, we highlight that the proposed platform with on-chip integrated photonics and gating architecture can manipulate ions, whereby subtle shifts in fluorescence spectra can enable the detection of trace contaminants, for example, charged aerosols in the atmosphere. Consequently, the proposed embodiment holds promise as a quantum sensing platform.

WIN - Presenters

Aleksandar Misic

Graduate Researcher
Department of Electrical and Computer Engineering

Supervisors:

Eihab Abdel-Rahman

Professor
Department of Systems Design Engineering

Mustafa Yavuz

Professor
Department of Mechanical and Mechatronics Engineering

Hexagonal Boron Nitride Strain Sensors

Hexagonal Boron Nitride (hBN) has recently emerged as a leading platform for room-temperature single-photon emitters (SPEs) at due to its wide band gap and photostability. As a chemically stable, 2D Van der Waals material it is compatible with integrated quantum photonic. It is mechanically robust and can withstand significant strain, which in turn modulates the wavelength of emitted photons. It has been experimentally shown that strain can tune the band gap in hBN defect centers. However, controlled strain induction in hBN remains experimentally challenging and is not yet scalable for integrated applications. We propose a method using microelectromechanical systems (MEMS) to control in strain hBN and use the composite as a highly sensitive strain sensor. Chemical vapour deposition (CVD) is used to grow hBN on off-shelf silicon atomic force microscopy (AFM) probes to fabricate micro cantilever resonators. hBN glasses are also mechanically transferred onto perforated silicon nitride substrates to fabricate membrane resonators. These resonators are characterized using laser vibrometery before and after fabrication steps. Annealing and femtosecond laser pulses will be used to engineer the photon emitters in the hBN layer at target locations. The emitters are verified and characterized using a confocal microscope and a Hanburry-Brown Twiss interferometer to measure the second order autocorrelation function, with excitation from two lasers for off resonance repumping. This effort will lead to opto-electro-mechanical integration of single photon emitters in silicon photonics which has applications in quantum sensing and quantum computing.

WIN - Presenters

Kevin Musselman

Associate Professor
Department of Mechanical and Mechatronics Engineering

Manufacture of Nanoengineered Quantum Dots and Thin Films

This talk will provide a survey of my group's efforts to manufacture highly tunable nanoparticles and thin films for a variety of applications. We use femtosecond-laser synthesis to control the size, structure (e.g., core-shell), and surface functionalization of nanoparticles and quantum dots of 2D materials. Defect engineering of these 2D nanoparticles makes them efficient photothermal agents for applications such as photothermal cancer therapy and solar water evaporation. Surface functionalization makes them effective materials for gas sensing and fluorescent chemical sensing. Our group specializes in spatial atomic layer deposition (SALD), a high-throughput, scalable, open-air version of ALD. We have designed and built the first three SALD systems in Canada, capable of coating small wafers or roll-to-roll substrates at tens of meters per minute. We can deposit a range of conformal metal-oxide films by SALD, dope them, and form layered nanolaminate thin-film structures, as well as gradient films for combinatorial studies and devices. We are developing SALD films for perovskite solar cells and gas sensors and are commercializing SALD vapor-barrier coatings for sustainable consumer packaging. These nanoparticle, quantum-dot, and thin-film architectures can be tuned to provide important (electro)optical functions for quantum systems.

WIN - Presenters

Pavle Radovanovic

Professor
Department of Chemistry

Manipulating Excitonic Properties of Plasmonic Semiconductor Nanostructures

Understanding fundamental principles that govern interactions between different intrinsic degrees of freedom (charge, spin, orbital, and lattice) or quasiparticles (e.g., exciton, plasmon, phonon, and magnon) in materials of reduced dimensions may result in unconventional approaches to non-volatile information transfer and processing, high-density multi-state memory storage, and ultrasensitive and selective sensing technologies. Our research program aims to develop different multifunctional nanostructured materials for photonics and quantum technology applications, and investigates the correlations between their structural, optical, electronic, and magnetic properties. In this presentation I will discuss our work on the functional property corelations in plasmonic semiconductor nanostructures, and possible applications of these materials for information and sensing technologies. I will particularly focus on magneto-optical studies of these materials. Specifically, using magnetic circular dichroism (MCD) spectroscopy we demonstrated robust exciton polarization in a range of plasmonic semiconductor nanostructures enabled by the angular momentum associated with the cyclotron motion of free charge carriers in an external magnetic field. This phenomenon allows for a new way of realizing charge carrier polarization in semiconductor nanomaterials. Given their strong surface-dependent MCD response, 2D plasmonic semiconductor nanostructures (e.g., certain MXene phases) represent an attractive platform for the design of highly sensitive and selective magneto-optical sensors. If time permits, I will also briefly discuss out recent results on diluted magnetic semiconductors based on transition-metal-doped metal halide perovskite nanostructures and their application in semiconductor spintronics.

WIN - Presenters

Carolyn Ren

Professor
Department of Mechanical and Mechatronics Engineering

Microwave Sensing for Biomedical and Environmental Applications

Microwave sensing differentiates materials based on their electrical properties such as dielectric constant. It has been demonstrated for simultaneous sensing and heating of nanoliter-sized aqueous droplets carried by oil streams and circular tumor cells in whole blood droplets carried by oil streams. By functionalizing their surfaces, microwave sensors can be exploited for disease diagnosis and environmental monitoring. Examples include detection of the COVID-19 virus, postoperative anastomotic leakage, E. coli in drinking water and microplastics in water systems.

WIN - Presenters

German Sciani

Professor
Department of Chemistry

From Seed to Quantum Alliance: Building Canada’s First Cathodoluminescence Platform for Quantum Materials

This presentation highlights the evolution of a WIN–NRC seed collaboration into a five-year, $1.5M NSERC Alliance Quantum partnership between the Ultrafast Electron Imaging Lab (UeIL, University of Waterloo), the Developmental and Analytical Microscopy (DAM) group at the National Research Council (NRC), and Hitachi High-Tech Canada (HTC). Led by Germán Sciaini (UeIL) and Mark Salomons (DAM), the partnership is developing CanCL—an advanced cathodoluminescence (CL) platform for nanoscale characterization of light-emitting quantum materials.

CanCL is being integrated into NRC’s high-resolution Hitachi S5500 and Waterloo’s Ontario Battery and Electrochemistry Research Centre (OBEC) Hitachi SU8700 microscopes. Combining hyperspectral detection, time-correlated photon counting, and photon-coincidence interferometry, it will enable sub-meV spectral and sub-nanometre spatial resolution—revealing the optical signatures of single-photon quantum emitters in 2D materials, quantum dots, and heterostructures. By embedding CL in high-resolution SEMs this initiative bridges a major gap in quantum materials characterization.

The project will expand NRC’s analytical capabilities, strengthen HTC’s product portfolio, and train over 50 highly qualified personnel through the 2D-MATURE program. By uniting academic, government, and industry partners, this collaboration is laying the foundation for advances in quantum communication, computation, and materials design—solidifying Canada’s leadership within the National Quantum Strategy.