Photonics Innovation Centre Presents:

REG Ceremony

September 2, 2021

1:00 PM – 2:30 PM

Research Expansion Grant

The Research Expansion Grant (REG) is a student-led grant for upper year PhDs in UofT Engineering. The grant strives to support multidisciplinary projects related to the field of photonics. The awards of $10,000 for each winner are funded by the Photonics Innovation Centre (PIC).

The winners of the REG 2021 cycle are:
Hadeel Mohammad
Mohamed Elsayed
Prajay Shah
Katelyn Dixon

Program

Opening Remarks

[1:00] Gligor Djogo, REG Committee

Talk Schedule

1:10 – 1:30	“**Controlling protein interactions using Terahertz and optical frequencies**” *Hadeel Mohammad*
1:30 – 1:50	“**Micromachines driven by optoelectronic tweezers**” *Mohamed Elsayed*
1:50 – 2:10	“**New methods to examine neuronal excitability in deep brain regions**” *Prajay Shah*
2:10 – 2:30	“**Width-graded ultrathin plasmonic resonator arrays for broadband visible and infrared field enhancement**” *Katelyn Dixon*

Closing Remarks

[2:30] Professor Li Qian (ECE); Director, Photonics Innovation Centre

Winner Abstracts

Hadeel Mohammad

is currently a ECE PhD Candidate. Her research interests include Nanonetworks, Terahertz Intra-body Communication as well as Molecular Communication. Hadeel completed a research internship at the Ultra-broadband Nanonetworking Lab, University at Buffalo, USA in 2016. In 2017, she joined the Photonics Summer School organized by KAUST and conducted research in the Communications Theory Lab. She worked as a Research Associate in the Healthcare Engineering Innovation Center, Khalifa University until August 2018. She is also the vice-chair of the IEEE Toronto Communications Chapter.

Controlling protein interactions using Terahertz and optical frequencies

One of the most prominent applications of nanodevices involves cutting-edge diagnostic and therapeutic techniques utilizing bio-nanomachines. Specifically, in-vivo wireless nanosensor networks (iWNSNs) have emerged to provide fast and accurate disease diagnosis and treatment. These networks are expected to operate inside the human body in real-time while establishing reliable wireless transmission between biosensors. Among the biological structures found in the human body, protein molecules are heterogeneous chains of amino acids; they perform their biological function by coiling and folding into a distinct three-dimensional shape. Proteins exhibit vibrational spectral features in the THz and optical frequency regimes, corresponding to functionally relevant modes. These modes provide information about protein conformational change, ligand binding and oxidation state. Hence, our research is concerned with controlling molecular interactions involving proteins using the THz and optical frequency bands. The basic premises of this work involves a nanoantenna that can target distinct vibrational modes of the protein to induce a functional conformal change. By inducing such stimuli, biochemical and biomechanical activities can be carried out in a controlled manner. Propagation between the nanoantenna and the protein occurs in a blood vessel constituting of several nanoscale and microscale elements. For that, we will use electromagnetic (EM) wave theory to develop a channel model that captures the THz and optical spectral features and account for the properties of tissues in these bands. Knowledge from communication and information theory will also be used to design metrics that will guide experimenters into understanding the sensitivity of intra-body interactions along with quantifying the amount of information the protein signaling pathway carries. The field of biophotonics acts as a gold mine of ideas, discoveries, and innovations. We hope through our work to spark research into the EM and optical based control of protein networks.

Mohamed Elsayed

joined the Wheeler lab September 2018 as a PhD student in Biomedical Engineering. Mohamed is an electrical engineer by background and prior to starting his PhD he worked and published in various research topics, including FPGAs, microfluidics, nanophotonics. Mohamed is an author or co-author on 12 journal papers, 20 conference papers and 1 book chapter.

Micromachines driven by optoelectronic tweezers

I will introduce light-driven micromachines made up of multiple components working together that rely on optoelectronic tweezers (OET). Using a "micro-gear" as a unit component, will I demonstrate new functionalities, including a micro "missile-launcher" that enables 3D particle trajectory control, multi-component micro-gear trains that serve as torque- or velocity-amplifiers, and micro-rack-and-pinion systems that serve as microfluidic valves, with potential applications in microrobotics, micromanipulation, and microfluidics. I will also give a brief overview about my plans in developing this technology as a cell sorter for 2 applications: (1) Isolate rare sperm cells from sexual assault samples, (2) Isolate rare stem cells from tissue dissections. I will describe how successful execution of these projects will involve strong collaboration with experts in various fields, including photovoltaics, artificial intelligence, machine vision, stem cells and forensics.

Prajay Shah

Is a MD/PhD student at the University of Toronto, and currently in his final year of his PhD with Dr. Taufik Valiante. He eceived a BSc (Honors) from the University of Calgary in 2017, where he studied the responses of neural stem cells after brain injury. His PhD research now focuses on studying the mechanisms of seizures and epilepsy using calcium imaging and optogenetics in the mouse brain.

New methods to examine neuronal excitability in deep brain regions

Recently developed genetic technologies (optogenetics) have enabled for light-based stimulation of neurons in the brain. This experimental ability has raised a need for novel photonics tools for precise light delivery to deep brain regions. In our project, we develop and deploy novel silicon-based integrated photonics probes that allow for simultaneous micro-scale light delivery and electrophysiological recording from the brain. The combination of electrical recording and fine photostimulation enables high resolution tests of neuronal network excitability in the deep brain regions across healthy and diseased states.

Katelyn Dixon

is a 4th year PhD student at U of T supervised by Profs. Nazir Kherani and Naomi Matsuura. Her research is focused on the design and fabrication of plasmonic nanostructures for multiwavelength light trapping and their applications in early-stage disease detection through Raman spectroscopy. In 2019 she completed a research fellowship at Lawrence Berkeley National Lab's Berkeley Synchrotron Infrared Structural Biology program and in September 2021 will be beginning an internship at the Quantum Valley Ideas Lab in Waterloo, ON.

Width-graded ultrathin plasmonic resonator arrays for broadband visible and infrared field enhancement

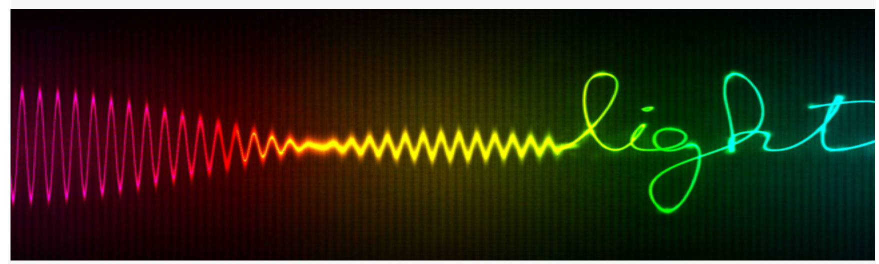
Light incident on nanoscale plasmonic devices generates surface plasmon polaritons (SPPs) which resonate and propagate within the structure. When SPPs meet the resonance conditions of these nanostructures they produce significant enhancements in the local electromagnetic field, a phenomenon known as light trapping. Furthermore, tuneable broadband field enhancement can be produced by combining nanostructures with different resonant wavelengths into a single device. These plasmonically enhanced fields have promising applications in molecular sensing, nonlinear optics, super-resolution optics and field-enhanced catalysis. However, many plasmonic devices currently used for these applications lack precise control over the spatial and spectral field enhancement profile and cannot provide sufficiently high field enhancements. Additionally, the fabrication of devices which produce enhancement in the infrared (IR) range remains a significant challenge due to the high aspect ratio resonators required.

Here we report on a versatile, analytical design paradigm for broadband light trapping in nanogroove arrays which is adaptable for operation in both the visible and IR regimes. We couple this design technique with fabrication through multilayer thin-film deposition and focused ion beam milling, which enables the realization of unprecedented feature sizes down to 5 nm, corresponding extreme normalized local field enhancements up to 10^3, and aspect ratios as high as 600:1. We demonstrate the versatility of this technique by fabricating devices with enhancement profiles optimized for the visible and the IR. Broadband field enhancement is demonstrated in these structures through visible and infrared spectroscopy, and is corroborated via optical simulations. Additionally, we explore the impact of various groove geometries and array formations to elucidate the physical mechanism of the light localization and to optimize the spatial and spectral field enhancement profiles.

Katelyn Dixon, Arthur O. Montazeri, Liang Chen, Moein Shayegannia, Stefano Cabrini, Hoi-Ying Holman, Naomi Matsuura, and Nazir P. Kherani

Future Events

Check out more events at the PIC website photonics.utoronto.ca and subscribe to our listserv to be updated on events and news.



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