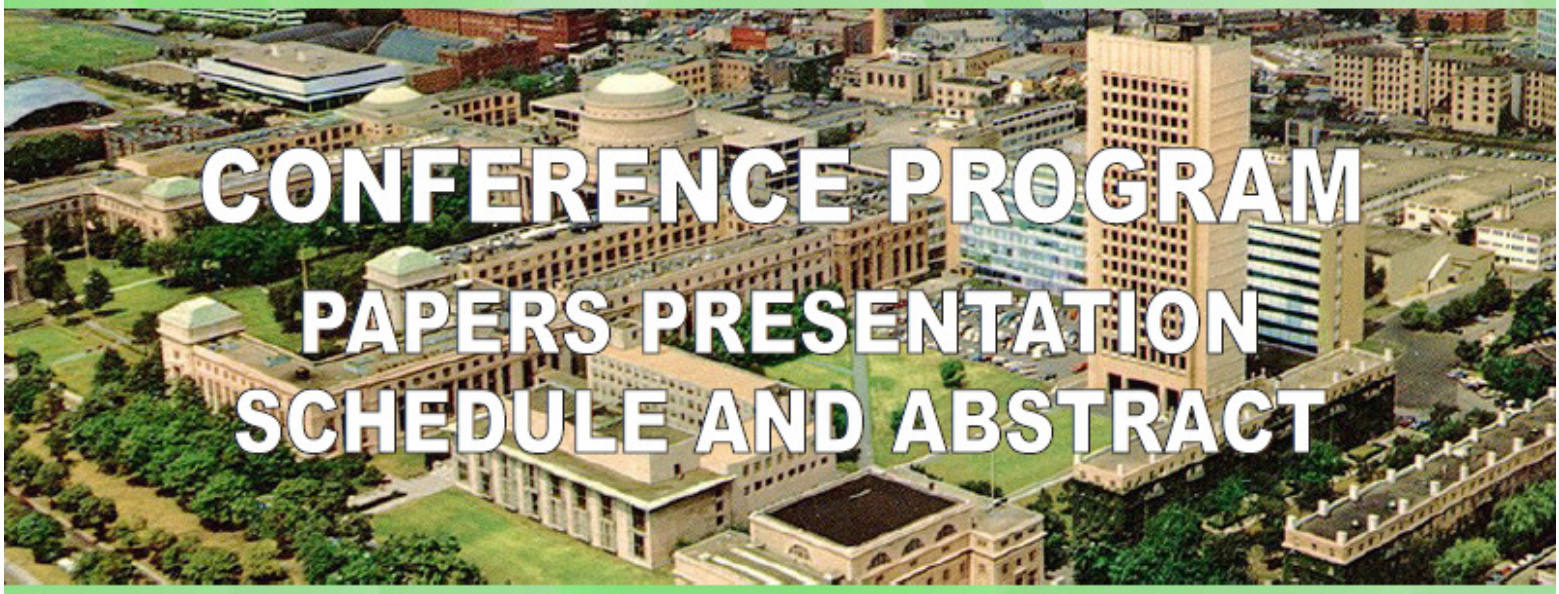
IEEE MIT URTC 2020

UNDERGRADUATE RESEARCH TECHNOLOGY CONFERENCE

October 09 - 11, 2020 | Cambridge, Massachusetts, USA (Virtual)

MEET INNOVATIVE TECHNOLOGY



CONFERENCE PROGRAM
PAPERS PRESENTATION
SCHEDULE AND ABSTRACT

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October 10, 2020 (Saturday)

Technical Paper Oral Presentation (PM Track #3)

EST 12:30pm - 2:30pm HOPIN Session Room C

Circuits, Materials, and Nanotechnologies Track, Innovative Technologies Track

Track Chair: Neil Deshmukh

➢ **12:30pm (PA20-0008)**

Aluminum-Calcium Composite Conductors: The Future of America's Power Grid

Jennifer Lew (Palos Verdes Peninsula High School)

To lower the cost of transmission line construction and increase the viability of renewable energy projects, the current research investigates the cost benefits of replacing Aluminum Conductor Steel Reinforced (ACSR) conductors with Aluminum-Calcium Composite (Al-Ca) conductors. The research modeled the conductivity of both conductors at frequencies of 0 Hz, 50 Hz, and 60 Hz. In all cases, regardless of conductor diameter, the research found that Al-Ca conductor displayed superior conductivity versus ACSR. With greater conductivity, circuits made of Al-Ca would experience less power loss from resistive heating. In addition, the research found that the superior yield strength of Al-Ca allowed for longer span lengths; consequently, a transmission circuit built using Al-Ca would require fewer support towers than the same circuit built using ACSR. As support towers can comprise as much as half of construction costs, using Al-Ca can lead to significant savings.

➢ **12:40pm (PA20-0064)**

A Tight-Binding Model for Gallium Oxide: The Newest Ultra Wide-Bandgap Semiconductor

Yifan (Frank) Zhang, Bill Liu (Cornell University)

Ga2O3, a novel ultra wide-bandgap semiconductor, shows promise for future-generation energy-efficient electronic devices. Ga2O3 presents new challenges when compared with conventional semiconductors due to the presence of polymorphs' structural phases with differing electronic and photonic properties. While modern ab initio electronic structure techniques provide a powerful description of the bulk electronic bandstructure, they become cumbersome when applied to devices and defects. To remedy the need for a compact description of the electronic structure, we develop tight-binding models derived from atomic-orbital and maximally-localized Wannier function bases to describe the valence and conduction band states of the monoclinic and rhombohedral structural phases of Ga2O3. This model accurately reproduces key features of their electronic structure, a necessary step towards the general description of the functional behaviors of Ga2O3 in heterostructures and devices. This model accurately reproduces low- and high-energy features of the conduction band as well as the bandgap.

➢ **12:50pm (PA20-0087)**

An Analog Front-End for a Photoplethysmography Patch to Monitor Respiratory Rate

Mona Elokda (Worcester Polytechnic Institute)

This paper proposes the design of an analog frontend to be used in a photoplethysmography application to detect respiration rate and transmit the information using an RF antenna. This signal can then be processed off-chip to extract respiratory rate (RR). The chip is powered using wireless power transfer through the same antenna. The design includes an RF to DC converter, an LED driver, a transimpedence amplifier, a low-pass filter, a programmable gain amplifier, and a voltage controlled oscillator. The chip is designed in TSMC 0.18 mm CMOS process. The overall power consumption is 2.46 mW from a 3.3/1.8 V source. The input RF power signal, transmitted at a frequency of 13.56 MHz, is converted to a DC voltage using a passive rectifier with a power conversion efficiency of 73.6%. The TIA has a gain of 113 dB and a bandwidth of 663 kHz. The achieved cutoff frequency of the filter is 5 Hz.

➢ **1:00pm (PA20-0092)**

Electrical Power System Design and Test for Maine's First CubeSat (MESAT1)

Joseph Patton (University of Maine)

MESAT1 is a CubeSat that was proposed by the University of Maine in response to NASA's CubeSat Launch Initiative, and in early 2020 was selected by NASA to fly aboard a NASA rocket in 2023. One of the most important factors in prolonging the lifetime of a CubeSat satellite is the design and implementation of an electrical power subsystem (EPS). The EPS is a microprocessor-based device that tracks and controls power generation, control, and distribution for all subsystems and payloads of the spacecraft. This study is the design, building, and testing of a low-cost EPS system that will safely and efficiently power the MESAT1 for the entire duration of the mission.

➢ **1:10pm (PA20-0116)**

Analysis of Lithium-Ion Battery Failure and PyBaMM's Viability in Simulating Them

Alexander Cho, Daniel Vail, Patrick Wang, Greyson Sapio (Rutgers University)

As renewable energy sources become more popular, methods of energy storage, especially lithium-ion batteries, have become essential in making renewable energy practical. Lithium-ion batteries have become particularly widespread in everyday machines such as smartphones and electric vehicles, mainly due to their power density and price. Despite their merits, lithium-ion batteries also have significant safety concerns, demonstrated by the several instances of these batteries catching fire or exploding. To ensure future battery safety, it is imperative to develop accurate testing procedures and determine the factors leading to catastrophic failure. The Oxford Mathematical Modelling Battery Group's Python Battery Mathematical Model (PyBaMM) was used to simulate these batteries in action along with experimental data from Dr. Thomas Hodson's lab at Columbia University. By comparing these different types of data and exploring each individually, it was determined that discharge rate and repeated cycling are the leading causes of thermal runaway in lithium-ion batteries. It was also determined that PyBaMM, despite showing general trends of different factors that led to combustion, was unviable in the simulation of battery explosions due to its failure to recognize explosive battery temperatures and inability to simulate both realistic thermal behavior and heat exchange between cells and the surrounding environment.

➢ **1:20pm (PA20-0149)**

A Low Cost Power Efficient Wireless Soil Moisture Sensor Network for Forest Ecosystem Monitoring

Thayer Whitney (University of Maine)

Forest ecosystem monitoring with high spatiotemporal resolution is of paramount importance for development of accurate prediction models. Current systems are bulky, use high power, and are costly to build and maintain. In this paper a novel low cost and power efficient wireless sensor network for soil moisture monitoring is proposed. This system is power efficient and low cost to enable wide spread monitoring. The proposed system was built by undergraduate students at UMaine's WiSe-Net lab under supervision of graduate students.

➢ **1:30pm (PA20-0112)**

Thermal Simulation of a CPU Based on Model Order Reduction

Kayla Ruttan (Clarkson University)

A previously developed thermal simulation technique based on model order reduction is applied to simulation of a CPU. The approach is derived from proper orthogonal decomposition (POD) that projects the physical domain onto the POD space. It has been demonstrated that the developed approach offers accurate thermal simulation of the CPU with a reduction in numerical degrees of freedom by several orders of magnitude compared to the direct numerical simulation (DNS). In addition, the technique is able to provide spatial resolution as fine as the direct number simulation for the CPU.

➢ **1:40pm (PA20-0118)**

Partial Discharge Detection by Classification of Tesla-Coil Music

Kai Shraiber (Wentworth Institute of Technology)

Partial Discharge (PD) is an electrical leakage that crosses an insulation barrier under high voltage stress. The insulation (either solid or fluid) breaks due to other types of stress such as thermal or mechanical as well. Undetected PD leads to larger faults, arc flash and substantial damages to power systems assets. Over the past decades, different techniques have been developed for PD detection based on the nature, intensity, and location of such a fault. In general, external PD falls into two major categories: a) surface discharge, and b) corona. PD induces electromagnetic and audio responses that can be used for detection. This project explores spectrum analysis of audio signals that can be used to detect and classify audible PD (surface and corona). This exploration is performed on several Tesla-coil music as well as its normal instrumentation. Tesla-coil music may have features helpful in detecting PD especially when many real-world cases of PD are not readily available for analysis. The result of this work will be used in further algorithm development to classify and detect PD events in recorded audio signals.

➢ **1:50pm (PA20-0129)**

Low Cost Vaping Detectors to Mitigate Teenage Vaping

Aarushi Pant (Westborough High School)

Youth e-cigarette use has been declared an epidemic by the US Surgeon General. E-cigarettes are addictive and detrimental to physical health, often resulting in lifelong tobacco-product usage. Originally advertised as a method for quitting smoking, e-cigarettes (a.k.a vaping devices) are now attracting millions of teenagers around the country. Initially, surveys and other research were done to gather current data on the problem. Our studies have confirmed a frightening statistic: as many as 27.5% of high school students and 10.5% of middle school students use e-cigarettes. While vaping detectors are commercially available, a key reason for high student vaping usage is that vaping detectors are prohibitively expensive. Based on our research, we have come up with a list of recommendations for vaping mitigation among youth. A major recommendation of our research includes a low cost, affordable, and reliable vaping detector that can be readily deployed in school environments.

➢ **2:00pm (PA20-0127)**

Solar Fish Drying System

Joseph W. Cordeiro (Wentworth Institute of Technology)

Sustainable economic developments in rural areas of Nepal have been organizing farmers to raise fish in ponds and sell live to local markets. Having the additional ability to dry the fish would open markets farther away and allow better product management between the timing of harvesting and selling. This project is designing a fish drying system to fabricate a prototype and test drying methods using solar radiation, heat control, and venting. Following simulation and fabrication, the drying system will be ready for testing to optimize methods for drying of fish with the goals of utilizing renewable energy and of being robust.