Research Statement

I am Md Obidul Islam, currently a 4th year Ph.D. student in the department of Electrical and Computer Engineering at Old Dominion University (ODU), USA. I did my bachelor's degree in 2011 and M. S. in 2013 from the department Applied Physics, Electronics and Communication Engineering, of the University of Dhaka, a leading university in Bangladesh. I achieved the 13th highest rank out of 75 students in my B.Sc. and 10th out of 59 students in M.S. class. After finishing my M.S. degree, I joined as a Lecturer in the department of Electronic and Telecommunication Engineering at Atish Dipankar University of Science and Technology in Dhaka, Bangladesh in October 2013 where my job responsibilities were mainly teaching both theory and practical classes and preparing and evaluating exam papers. In March 2015, I switched my job and joined as a lecturer to Hamdard University Bangladesh where my job responsibilities included conducting research, perform some administrative role such as a member of project/thesis evaluation committee and student advisor along with other teaching stuffs. In February 2018, I was promoted to Assistant Professor in the same institute. After more than 5 years' experience of active teaching and research, I took leave from Hamdard University Bangladesh to pursue my Ph.D. in Electrical and Computer Engineering at Old Dominion University, Norfolk, Virginia in January 2019. My research work is going on and I am expecting to be graduate in December 2024.

At the very inception of my research during my undergrad project, I designed a low-cost Pulse Oximeter device and implemented it in laboratory. I used very common types of electronic devices (op-amp, photo diode, photo detector) to detect and process signals passing through oxygenated and deoxygenated blood. I utilized a simple microcontroller (ATMEGA 32) to detect and display the heartbeat rate and oxygen saturation level by analyzing the logarithmic ratio of two different absorption values for two different wavelengths based on Beer-Lambert law. The impacts of this research in third world countries like Bangladesh was impressive specially for its low-cost feature with reasonable accuracy and stability. In my Masters, I investigated the transient responses of planner ion sensitive Field Effect Transistor (ISFET) and cylindrical Si-NW biosensors by analytically solving the diffusion equations. I showed the faster detection by Si-NW biosensors over ISFET sensor and need for the trade-off between average response time and minimum detectable concentration for ultra-fast sensing. I also modeled the charge distribution in the ionic solvent by using Poisson-Boltzmann equation and showed that electrostatic screening and other factors in the surrounding environment such as buffer ion concentration and pH of the electrolyte solution limits the response of the device. From this research, I published one article to a peer-reviewed journal and another to an international conference. The importance of nanostructured biosensors is notable since they allow for the realization of wearable devices for the real-time monitoring of physiological parameters.

During my work at Hamdard University Bangladesh I was involved in a research group with some other faculty members and students aiming to do research in the field of nanoelectronics and thin film technology. We explored the performances of Perovskite solar cell for different structures with different electron and hole transport materials and metallization. By investigating the effects of electrical, optical, and thermal properties of materials on cell performances we optimized for suitable materials used in different layers of Perovskite solar cell. From this research we published two journal articles in 2017 and 2018 and presented another to an international conference in 2017. Also, I supervised some students for their undergrad thesis and published few articles with them. Although the research projects I worked during my master's and during working as a faculty member in Bangladesh were not funded by U.S. federal agency, these research works have major implication on the US economy and workforce. These research projects have direct impact on the U.S. manufacturing industry, U.S. energy sector, U.S. Automobile industry, U.S. Electronic chip industry, U.S. medical sector, wearable electronics sector. Note that, the U.S. federal government has recently adopted long-term plan to move U.S. manufacturing industry towards additive manufacturing.

I joined ODU as a full time Ph.D. student with graduate research assistantship in spring 2019. At the very beginning I learned various materials deposition and characterization techniques such as thermal evaporation, pulsed laser deposition, DC and RF magnetron sputtering for depositing metals and semiconductors and SEM, SEM-EDS, FESEM, AFM, XRD for surface characterization. I gained expertise on operation, maintenance and troubleshooting of ultra-fast femto-second laser and Q-switched nano-second lasers. I have designed and built optical thermometry-based experiment, time-domain thermoreflectance (TDTR) and installed a cryogenic probe station to study the thermal conductivity, thermal boundary conductance, sound speed, optical properties, and electron and phonon scattering properties in a wide array of bulk materials and thin films from cryogenic to room temperature. I have prepared thin niobium and niobium-tin samples using different deposition techniques, studied the chemical composition and structural properties of my samples using several characterization tools and made quantitative measurement of thermal and optical parameters using TDTR spectroscopy. I have presented my works in scholarly gatherings such as AVS Mid Atlantic Regional Meeting 2019 at Jefferson Lab and ESPEX 2022 at ODU. I have contributed to Snowmass Summer Study in 2021 and 2022 by publishing two white papers. I was also invited to give a talk on my work at ODU department of Electrical and Computer Engineering. One manuscript of this project is still under peer review, and we are hopeful it will create a great influence. This project was funded by II-VI Incorporated, Inc. (Grant Number: 500374-010, Grant Period: 8/1/2018 - 5/31/2020), and BSCE Systems, Inc. (Grant Number: 500429-010, Grant Period: 4/1/2020 - 3/19/2022). The thermal diffusion properties and thermal interface conductance are significant parameters in developing novel devices in the field of microelectronics, energy harvesting and photonic system. This project has direct impact on the U.S. manufacturing industry. As the size of the electronic chips made by U.S. big companies like INTEL, MICRON decreases, their power densities increase, hence they generate higher temperature and localized hotspots under operation. The path to smaller electronic Nanoscale Energy Transport chips is currently blocked by our incapability to maintain a low temperature in small scale electronics. Intensive research on Nanoscale Energy Transport is required to overcome this drawback.

In this project I studied the thermal diffusivity in Nb thin films at low temperatures which are critically important for the design of high-performance and cost-effective superconducting radiofrequency (SRF) cavities, widely used in particle accelerators. This project has direct impact on the U.S. particle accelerator facilities. The SRF cavities, currently used in particle accelerators are made from highly pure bulk niobium, have reached their performance limit and are experiencing thermal breakdown. Under high RF power operation, a low level of impurities or defects in a bulk Nb cavity can cause localized heating which, due to the poor thermal conductivity of Nb, can cause the cavity to quench to the normal state. The thermal breakdown of the superconductivity can be controlled by improving the thermal conductivity of the cavity material and thus Nb-coated Cu cavities are considered an alternative to bulk Nb for SRF cavity applications. In this project I studied the superconducting Nb thin film properties that affect the performance of a coated SRF cavity include film thickness, surface defects, grain size, and the Nb/Cu thermal interface resistance.

In September 2022, I have started working on a new project which is a Major Research Instrumentation (MRI) award given by National Science Foundation – Division of Material Research: NSF-DMR (Grant Number: 2214998, Grant Period: 9/1/2022 - 8/31/2026). The ultimate goal of this project is to develop a secondary ion mass spectrometer (SIMS) with higher sensitivity than current commercial SIMS and with better depth resolution. Current commercial secondary ion mass spectrometers use singly charged ions to remove molecules from the surface of the sample. In this project, we will be using multicharged ions (MCI) as primary ion source which can cause potential energy sputtering in addition to collisional sputtering, for the ejection of secondary ions and neutrals from the surface of a sample. The use of MCI will then enhance the ionization fraction for the secondary beam by two-to-three orders of magnitude higher than for singly charged ions and corresponding increase in SIMS sensitivity and depth resolution. I have already generated MCI beam by ablating carbon target using a Q-switched pulsed laser and tested the ion pulse using an ion energy detector.

My primary goal is to shorten the ion pulse to a few nanoseconds, select a specific charge from the MCI pulse and then focus it to less than 1 mm on the sample surface studied. I have already designed and built two Einzel lenses, one for collimating the MCI beam and the other for focusing the selected ion beam onto the sample surface, and an ion-energy analyzer to select a specific charge from the MCI signal. After successful meeting of my primary goals, I will also use the MCI beam with better control in-hand to study the interaction of multicharged ions with materials, for interface treatment by removing undesirable contamination and by improving adhesion between film and substrate and also for nanofabrication by ion implantation. This research project I am working right now and continue to work in future falls under U.S. long term scientific goals and has significant practical application in microelectronics industries. Successful development of the instrument proposed in this project will enable the chemical analysis of ultrathin layers used in nanoelectronics for high-speed computers, advanced electronic devices, and sensors. This project also has a potential implication in U.S. particle accelerator facilities. By using selective MCIs with predefined mass and energy the Nb/Cu interface could be improved with better adhesion and thereby improving the thermal boundary conductance required to overcome the issue of cavity quenching in particle accelerator and thus making Nb-coated Cu cavities as the high-performance and cost-effective alternatives for bulk Nb SRF cavities.

I have published 4 peer-reviewed journal articles and 5 articles in international conferences proceedings, contributed two white papers, presented two posters in two separate scholarly gatherings, delivered an invited talk till date and some of my ongoing research works are waiting to be published. Currently the total number of citations of my research articles is 18 (among them 14 are independent). After finishing my PhD, I plan to continue my ongoing research activities in a postdoctoral research scientist or faculty position. I believe one of these positions will help me continue my research aiming to improve the thermal and mechanical properties of thin metallic and superconducting films such as niobium and niobium-tin for application in advanced particle accelerators in the science and industrial frontiers, to contribute to microelectronics industries and to create more energy-efficient technologies and processes.