Announcing the Final Examination of Rumana Zahir for the degree of Doctor of Philosophy in Physics

Date: March 13, 2026
Time: 2:30 P.M.
Room: PSB 160/161
Rumana Zahir PhD Dissertation Defense | Meeting-Join | Microsoft Teams

Dissertation title: Bowtie Antenna-Coupled Bi_2Te_3-Sb_2Te_3 Thermoelectric Detector for THz and mm-wave Radiation

Abstract:
We explore the development of antenna-coupled thermoelectric detectors for long-wavelength radiation using sputtered Bi_2Te_3 and Sb_2Te_3 thin films. Long-wavelength detection in the infrared, millimeter-wave, and terahertz regimes is critical for sensing, imaging, and energy applications, yet many existing detectors rely on cryogenic operation, narrow spectral response, or complex material systems. In this work, we examine the feasibility of achieving reliable room-temperature long-wavelength detection using microfabricated thermoelectric thin films integrated with antenna structures. A systematic full-factorial experimental approach was employed to determine how sputtering parameters and post-deposition annealing influence the structural, electrical, and thermoelectric properties of Bi_2Te_3 and Sb_2Te_3 films. The results show that the Seebeck coefficient of sputtered Sb_2Te_3 is largely insensitive to processing variations, while film thickness and transport properties are strongly governed by deposition conditions and thermal treatment. Annealing improves crystallinity, increases grain size, and reduces resistivity, indicating enhanced electrical connectivity within the films. A key finding of this work is the identification of oxidation behavior in Sb_2Te_3 thin films. Far-infrared spectroscopy, supported by structural characterization and SIMS depth profiling, reveals that Sb-O vibrational features originate primarily from a thin buried layer at the film–substrate interface rather than from bulk oxidation. This interfacial oxidation evolves with annealing while transport properties improve, highlighting a complex relationship between microstructure, chemistry, and device performance. Optimized Bi_2Te_3 and Sb_2Te_3 films were subsequently integrated into bowtie antenna-coupled thermoelectric detectors fabricated using photolithographic processing. Electrical and photoresponse measurements demonstrate broadband operation from infrared to millimeter-wave frequencies at room temperature, polarization dependence consistent with antenna coupling, and distinct response mechanisms across spectral regimes. Together, these results establish a fabrication-tolerant framework for thermoelectric thin-film processing, clarify the role of annealing-induced interfacial oxidation, and demonstrate the feasibility of antenna-integrated thermoelectric detectors for broadband long-wavelength sensing.

Outline of Studies:
Major: Physics

Educational Career:
B.S. Physics, National University, Bangladesh
M.S. Physics, National University, Bangladesh
MPhil Physics, Chittagong University of Engineering and Technology, Bangladesh

M. S. University of Delaware

Committee in Charge:
Dr. Robert E. Peale (Chair)
Dr. Talat S. Rahman
Dr. Jing Xu
Dr. Kalpathy B. Sundaram (External Committee Member, ECE, UCF)

Approved for distribution by Dr. Robert E. Peale, Committee Chair, on February 27, 2026.

The public is welcome to attend.