Handenur Arpali, MSc. Thesis Defense in Chemical Engineering
April 23rd, 2025, at 1:00 PM Roberts Hall Room 121
Advisor: Dr. Stephan Warnat
Title: **Design and Evaluation of an Additive-Manufactured Microfluidic Device for Observing Initial Biofilm Attachment on Copper Surfaces**

ABSTRACT

The growing interest in microfluidic devices has highlighted the need for improved manufacturing methods that overcome the limitations of traditional techniques. One challenge is integrating metal surfaces into microchannels, as achieving strong and stable bonding is complex. Reliable bonding requires thorough control over surface and bonding quality. This study presents an alternative fabrication approach using double-sided pressure-sensitive adhesive (PSA) tape. Traditional methods are often expensive, time-consuming, and complex, whereas this approach enables the integration of metal surfaces while maintaining cost-effectiveness ($2.08), repeatability, optical transparency, and confocal laser scanning microscopy (CLSM)-compatible prototyping to facilitate bacterial adhesion observation.

A straight 80 µm-thick channel was selected as the optimal design among three microchannel designs for biofilm studies. The study also examines the impact of flow rate, surface roughness, hydrophobicity, and salt concentration on bonding quality. COMSOL Multiphysics® was used to visualize flow profiles and shear stress distributions across the channel. A low-cost microfluidic device was developed using PSA tape to enable bacterial attachment studies under controlled conditions. Saffman-Taylor instability was used to assess bonding quality by observing how salt concentration, flow rate, and surface finish influenced instability patterns. Although biofilm formation was not the main focus, the device is CLSM-compatible and shows potential for future biofilm studies. The fabricated device was tested under controlled flow conditions with *Pseudomonas aeruginosa* N2E2 to evaluate bacterial adhesion.

Results showed smoother surfaces, reduced instability patterns, and minimized leakage risk. Contact angle measurements confirmed that smoother and hydrochloric acid treated surfaces became more hydrophobic. Higher flow rates and salt concentrations promoted instability, reinforcing the role of viscosity in fluid behavior. Although cell adhesion was not observed on the metal surface, the successful attachment of bacteria to the cover glass indicates that the device functions effectively in enabling the observation of microbial behavior under CLSM. This outcome suggests that device orientation may have played a role. Since the bacterial strain's surface preference remains unclear, future studies should explore alternative strains to further investigate attachment behavior.

Overall, this study demonstrates a reproducible, low-cost fabrication method supporting biological integration and providing an optically transparent platform compatible with CLSM for high-resolution imaging.