Project: Investigation of a potential cost-effective surface-activation treatment for the bonding of PDMS microfluidic chambers to glass

Supervisor(s):
Dr. Tamie Poepping

Location:
PAB136

Project description:
The proposed project will investigate and quantify a low-cost and accessible method for bonding polydimethylsiloxane (PDMS) to glass, a critical step in the fabrication of microfluidic devices. Conventional bonding approaches, such as oxygen plasma treatment, require specialized equipment and infrastructure that may be cost-prohibitive for small laboratories, educational institutions, and resource-limited settings. The goal of this project is to validate and optimize an alternative surface modification technique to provide reliable bonding strength and durability without the need for expensive instrumentation. Bonding quality will be systematically evaluated through leak testing, burst pressure measurements, and long-term device stability under flow operation.

By developing and validating a low-cost bonding method, this project will lower the barrier to entry for microfluidic research and education, enabling broader participation in fields such as point-of-care diagnostics, lab-on-a-chip technologies, and environmental monitoring. Ultimately, the outcomes will contribute to democratizing access to microfluidic fabrication techniques, fostering innovation in both academic and low-resource environments.

Skills and/or experience required:
Comfortable with hands-on building and experimental work; programming experience for data analysis.

Project: Low-cost Soft-tissue Testing Device

Supervisor(s):
Dr. Maria Drangova & Dr. David Holdsworth, Medical Biophysics & Robarts Research

Location:
Robarts Research Institute

Project Description:

One of the challenges in biomedical training programs in low- and middle-income countries is the high cost of laboratory equipment that is required during training. For example, biomedical engineering programs typically require access to material testing systems, such as indentation testers to characterize low-modulus materials and soft-tissues. While these devices are commercially available, even a small unit is typically over $50,000 CAD, making it difficult or impossible to incorporate into training programs.

Our group has developed a low-cost soft-tissue testing device, which is based on common-off-the-shelf mechanical components and open-source software control using a common microcontroller (Raspberry Pi Pico). The device has been developed but additional electronics development is needed to streamline production and ease of assembly. The ultimate goal of this project is an open-source product that can be widely distributed in low-resource settings.

Skills and/or experience required:

Demonstrated experience with microelectronics, circuit board design, Arduino IDE, Python required. Students who have completed second or third year courses in Electrical Engineering, Mechatronic Systems Engineering, Mechanical Engineering, or Computer Engineering, Medical Biophysics or Physics and have the required background in working with microelectronics should apply.

Project: Development of testing a low-cost qualitative PCR (qPCR) system

Supervisor(s):
Dr. Tamie Poepping & Dr. David Holdsworth

Location:
Robarts Research Institute, Centre for Medical Imaging & Technology & Physics & Astronomy Building, PAB136

Project description:

Analytic instrumentation for biomedical research is typically too expensive for low-resource settings, limiting research capacity. However, recent developments in ultra-miniature optical instrumentation provide the opportunity to re-think some types of lab equipment, such as quantitative PCR (qPCR) systems. Like many lab instruments, qPCR depends on accurate measurement of weak fluorescent signals, and a new generation of low-cost, low-power miniature spectrometers may provide a solution for epi-fluorescent acquisition during qPCR thermal cycling.

The selected student will be expected to participate in:

- investigating the performance of a 14-channel spectrometer (AS7343, Osram) as a candidate for a data acquisition module in a low-cost qPCR system using a programmable microcontroller (Raspberry Pi Pico);
- developing and testing a multi-well configuration;
- testing spectrometer performance and compatibility with a thermal cycler.

Skills and/or experience required:

- Basic knowledge of electric circuitry is required.
- Programming experience (C/C++, python) would be an asset but not required.

Project: Low-Cost Smart Toothbrush for Children Living with Neuro-developmental challenges in Low-Resource Settings

Supervisor(s):

Dr. James Lacefield, Faculty of Engineering & Schulich School of Medicine & Dentistry

Location:

Robarts Research Institute

Project Description:

This project was suggested by our partners in the Department of Dental Sciences at the University of Nairobi, Kenya. Studies in high-income nations demonstrate that using a smart toothbrush to guide brushing technique and promote brushing habits can improve the oral health of people facing neurodevelopmental challenges, but sophisticated commercial toothbrushes are unaffordable even for upper-middle-class families in sub-Saharan African nations. The goals of this project are to design a device that provides capabilities comparable to a commercial smart toothbrush at < 25% of the cost and is effective when used by children under the supervision of their caregivers with minimal coaching from dental care professionals.

The current prototype employs inertial measurement units (IMUs) to track the position and orientation of the brush-head. An ESP32-S3 microcontroller in the brush handle collects IMU data that is transferred to a laptop for input into a machine learning model that analyzes the user's brushing performance. Brushing performance metrics include position and orientation of the brush head, time spent in brushing each region within the mouth, and contact pressure between the brush head and the teeth estimated using a Hall effect current sensor measuring the current drawn by the brush's motor.

A student joining this project will complete the design and fabrication of a mechanical assembly to rotate the brush-head and will continue the development of an AI algorithm to assess brushing efficacy. A research ethics protocol for a pilot patient study of usability will also be devised with guidance from faculty members in the Schulich School of Dentistry.

Skills and/or experience required:

Experience with computer-aided design and 3D printing of small mechanical components. Experience with, or strong interest in learning, tiny machine learning (also known as edge AI) methods to implement AI algorithms efficiently on a microcomputer processor.