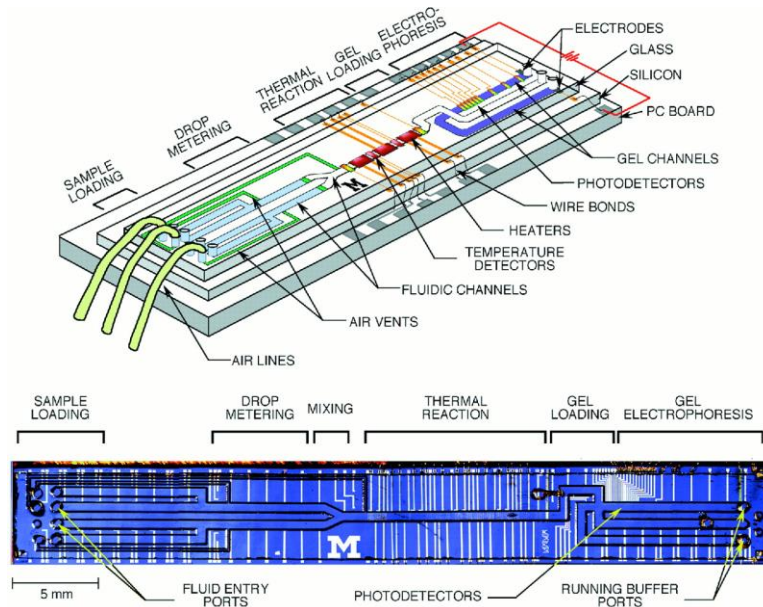


McMaster University, Department of Mechanical Engineering
ME 752: ADVANCED MEMS FABRICATION AND MICROFLUIDICS



Course Outline: Introduction, Microfabrication and micromachining, Surface and bulk micromachining, non-conventional machining, Microfluidics, Microchannels, Microvalves, MicroMixers, Micropumps, Droplet actuation, Integrated Systems.

Objective: To provide a detailed look into the various planar and non-planar fabrication methods employed for MEMS device design. To provide an in-depth look at the various methods and techniques employed for microfluidic actuation and control and its applications.

Instructor: Ravi Selvaganapathy, JHE 212B, ext. 27435, selvaga@mcmaster.ca

Term: Winter

Text: None (*course notes and research articles provided by the instructor will be used*)

Supplementary Materials and References: Research articles provided by instructor
References – Books (several of these books are course reserves for ME 752 and can be accessed through Thode library)

Microfluidics:

1. G. Karniadakis, A. Beskok, N. Aluru *Microflows and Nanoflows: Fundamentals and Simulation*, Springer 2005
2. N. T. Nguyen, S. Wereley *Fundamentals and Applications of Microfluidics*, Artech House Publishers, 2002
3. O. Geschke, *Microsystem Engineering of Lab-on-a-chip Devices*, Wiley, 2008
4. G.A. Urban, *BioMEMS*, Springer, 2012 (e-book)
5. J. Berthier, *The physics of microdroplets*, Wiley, 2012

Design:

1. Stephen D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, 2000
2. G.T.A. Kovacs, *Micromachined Transducers Sourcebook*, McGraw-Hill, 1998
3. Mohamed Gad-el-Hak, *The MEMS Handbook*, CRC Press, 2002

Microfabrication:

1. S. A. Campbell, *Science and Engineering of Microelectronic Fabrication*, Oxford University Press, 2005.
2. M. Madou, *Fundamentals of Microfabrication*, New York: CRC Press, 1997
3. M. Elwenspoek, H. Jansen, *Silicon Micromachining*, Kluwer Academic Publishers, 2001

Grading Scheme: Class Presentation & reports: 50%, Assignments: 50%

Course Contents:

- 1) **Introduction** to MEMS and Microfabrication
- 2) **Conventional Microfabrication:** Silicon based: Surface Micromachining, Bulk Micromachining, Glass Micromachining
- 3) **Non-conventional Microfabrication:** Electrodischarge machining, Laser Micromachining, LIGA, Microstamping and soft lithography, Stereo lithography, Focused Ion Beam machining
- 4) **Microfluidics:**
Microchannels: Flow in Microchannels, Fabrication methods.

Micro Mixing: Passive Mixers: Surface modification mixers, Spatial mixers, Concentration gradient generation. Active Mixers, Electrokinetic mixers, Ultrasonic mixers.

Microvalves: Passive Valves: Structural design. Active valves: Piezoelectric, Bimorph, Thermo pneumatic, Large scale integration, Thermal and pH responsive.

Micropumps: Micro-displacement pumps, Electric-field assisted pumps, Magneto-hydrodynamic pumps, Acoustic streaming (ultrasonic) pumps, Pumping based on interfacial tension, Rectified pumping, Knudsen pump.

Droplet motion: Electrowetting, Dielectrophoresis, Traveling wave methods, Droplet generation.
- 5) **Integrated Microsystems** for biological applications: Lab on chip systems, Polymerase chain reaction microchips, Immunoassay microchips, Massively parallel nucleic acid construction, DNA sequencing chips, Microfluidic interface for Mass spectroscopy, Microfluidic cell handling

STUDENT SUPPORTS

WELLNESS

Student Wellness Centre

On-Campus Support for Medical and Mental Health Concerns. Doctors and Counsellors available. Located in PGCL, 2nd Floor.

Mon-Fri 9AM-5PM 905-525-9140 ext. 27700
<https://wellness.mcmaster.ca/contact-us/>

Main St. West Urgent Care Centre

For immediate health concerns that do not require the emergency room.

690 Main St W - Mon-Sun 9AM-9PM

Emergency Rooms

For **immediate, serious** health concerns.

St. Joseph's Healthcare Hamilton
50 Charlton Ave E

McMaster Children's Hospital
Students 17 and under

Telehealth Ontario

Telehealth Ontario is a free, confidential service you can call to get health advice or information. A Registered Nurse will take your call 24 hours a day, seven days a week.

Toll-free: 1-866-797-0000 Toll-free TTY: 1-866-797-0007

Phone Lines

Good2Talk

Confidential helpline providing professional counselling, info and referrals for mental health, addiction, and well-being

1-866-925-5454

LGBT Youthline

Confidential, non-judgemental & informed LGBTQQ2SI peer support.

Sun-Fri, 4-9:30 PM, Text 647-694-4275

SACHA (SEXUAL ASSAULT CENTRE - HAMILTON AREA)

Confidential, anonymous 24-hour nonjudgmental telephone support for adults who have experienced sexual violence at any point in their lives; will provide accompaniment to hospital or police station for survivors wishing to seek medical attention or report; counselling services & public education

905-525-4162

Empower Me (Graduate Students)

24/7 accessible counselling services to empower you to thrive, crisis support, mental health and well-being services.

1-844-741-6389

Bounceback

CBT skills-building for mild to moderate depression and anxiety for people 15 or older. If accessed through self-referral, the client's primary care provider will be notified.

1-866-345-0224

INDIGENOUS STUDENTS

Indigenous Student Services

Academic & social counselling, employment aid
LRW 1010

ext. 23788

indigenous.admin@mcmaster.ca
indigenous.mcmaster.ca

INTERNATIONAL STUDENTS

International Student Services

Advising services for international students and exchange students
GH 104

ext. 24254

iss@mcmaster.ca
iss.mcmaster.ca

STUDENT SUPPORTS

ACADEMIC

Student Success Centre

Academic skills assistance, job search, volunteering
GH 110
ext. 24254
studentsuccess@mcmaster.ca

Student Accessibility Services

Disability services, assistive technology support
MUSC B107
ext. 28652
sas@mcmaster.ca

TutorOcean

Student to Student Tutoring Services
<https://mcmaster.tutorocean.com/>

FINANCIAL

Office of Student Financial aid and Scholarships

Emergency funding, government funds, OSAP assistance, scholarships, work programs
GH 120
ext. 24319
<https://registrar.mcmaster.ca/aid-awards/>

FOOD

Food Collective Centre (FKA Mac Bread Bin)

The Food Collective Centre is a service run by students dedicated to cultivating stronger food systems in the McMaster and surrounding community. (MSU Service)
macbreadbin@msu.mcmaster.ca
<https://www.msumcmaster.ca/services-directory/14-food-collective-centre>

Neighbour 2 Neighbour

Food bank, community kitchen, community counselling, help with paying for utilities, and more. Hamilton Mountain.
905-574-1334 <http://www.n2ncentre.com/>

CRISIS SUPPORT

Barrett Centre for Crisis Support

Provides a safe environment in the community and responds to the needs of individuals, 16 years of age or older, who experience a mental health crisis and do not require a hospital stay. Confidential and free services 24/7/365
24 Hour Crisis Line: 905-529-7878, Toll Free: 1-844-777-3571

COAST (Crisis Outreach and Support Team)

Hamilton's crisis line is answered 24 hours a day, 7 days a week. The COAST mobile team, consisting of a mental health worker, and a police officer, will respond to crisis calls between the hours of 8 a.m. and 1 a.m. daily.
905-972-8338

Oakville Distress Centre

Distress Centre Halton provides telephone and online support to people to better cope with crisis, loneliness, and emotional stress. Also serves the Hamilton area.
905-849-4541

Assaulted Women's Helpline

Free, anonymous and confidential telephone and TTY crisis telephone line to all women in the province of Ontario who have experienced any form of abuse. Provides crisis counselling, safety planning, emotional support, information and referrals accessible 24/7/365.
Toll-free: 1-866-863-0511 TTY: 1-866-863-7868

Crisis Resources in the GTA

The CAMH Distress Crisis Resources web page lists a number of phone lines, response teams and hospitals in the GTA.
<https://www.camh.ca/en/health-info/crisis-resources>

STUDENT SUPPORTS

OTHER

Student Assistance Plan (Undergraduate)

Psychological counseling (offered in-person, over the phone, or over secure video) and academic-life services (legal consultation, financial consultation, life coaching, nutrition consultation and wellness resources offered virtually or in-person)

<https://www.msumcmaster.ca/services-directory/36-health-and-dental-insurance/student-assistance-plan>

Ombuds Office

Advice for students, staff, and faculty regarding academic and non-academic concerns.

MUSC 210

ext. 24151

ombuds@mcmaster.ca

mcmaster.ca/ombuds

SWHAT - Walk Safe Program

The Student Walk Home Attendant Team (SWHAT) is a volunteer service within the McMaster Students Union that will walk or bus with students during the evening hours 7 days a week, in all kinds of weather! (MSU Service)

Ext. 27500

swhat@msu.mcmaster.ca

Student Support and Case Management

Student rights & responsibilities

GH 207

ext. 23845

studentconduct.mcmaster.ca

Chaplaincy Centre

Pastoral support with personal counselling and bereavement support groups.

MUSC 231

ext. 24207

McMaster Engineering Society

Support from other McMaster Engineering Students

<https://www.macengsociety.ca/>

MSU PEER SUPPORT SERVICES

MSU Maccess

Maccess is a service that aims to build and maintain a campus that celebrates, advocates, and ensures inclusivity in the area of disability. A central aspect to Maccess is the provision of peer support by trained volunteers with lived experiences with disability such as chronic illness, mental illness, mental health concerns, neurodivergence, and additional identities.

Student Health Education Centre

SHEC is a peer-run health promotion, education, and referral service for McMaster University students. SHEC focuses on engaging with students about health-related issues through performances, peer support, fundraisers, and events. The service offers peer support, anonymous and confidential pregnancy testing, a resource library, condoms, lubricant, and menstrual products. SHEC's space is located in MUSC 202.

Women + Gender Equity Network

WGEN is a service that caters to women, transfolk, people who identify outside the gender binary, and all survivors of sexual assault. WGEN provides a safe(r) space and resource library on campus in MUSC 204. Volunteers in the space offer peer support and the service also runs a support group for survivors of domestic and intimate partner violence.

Pride Community Centre

The Pride Community Centre is a service of the McMaster Students Union. We provide a contact point for McMaster students that may identify as gay, lesbian, bisexual, transgender, queer, and/or any of the other diverse identities that make up our community. We offer educational programming and access to resources of interest, as well as peer support and a physical space for students to meet and socialize with each other. As advocates for gender & sexual diversity, the PCC's mandate upholds that LGBTQ+ students are entitled to a safe and supportive campus, absent of homophobia and transphobia, where the expression of one's gender & sexual identity is welcomed and respected.