Project Description

Each group of 4-3 students will give a presentation and prepare a report of a paper selected from the recent microfluidics literature. The format of the presentation and the report are summarized below. The presentation and report will be graded on the basis of the following items:

- Summarize the motivation for the microfluidic study and the application. Place the work in context by reviewing similar work in the field.
- Describe the microfluidic study - including fabrication sequence and microfluidic experiments on a particular application.
- Give an analysis of relevant chemical engineering concepts used in the paper.
- Evaluate whether or not the use of microfluidics enables investigations that could not have been done with conventional macroscopic approaches.
- Consider improvements to the microfluidic device or study. Develop a better design.
- Evaluate the overall contributions of the work by comparing to other work and macroscopic approaches.
Presentations and Reports

❖ Presentations
  • Each presentation will be 12 minutes with 3 minutes for questions. The presentation should address the items above and be prepared on overheads. Because of the short time constraint, select one (or at most two) presenters for the group.
  • The presentations will be scheduled for the last 2-3 days of the module.

❖ Reports
  • The report should follow the outline above and address all items. The report should be typed (for readability: 1 1/2 or double spaced, 1" margins on all sides, 12 pt font) and not exceed 6 pages excluding graphics, appendix, and literature cited. Include details of the chemical engineering analysis in the Appendix. If any design calculations are made in point 5, place them in the Appendix.
  • Reports are due in 66-560 March 9 by 3 pm.
Topics (1)

1. **Use of microreactors to perform difficult/hazardous liquid phase reactions.**

2. **Use of microreactors to perform difficult/hazardous gas phase reactions**

3. **Soft lithography as a method for making integrated microfluidic systems for biological applications.**
4. Microreactors incorporating solid particles for reactions and separations.

5. Hydrogels as materials for making integrated microfluidic systems for biological applications.
Topics (3)

6. **Microreactors with immobilized enzymes**

7. **Using microreactors to create emulsions and controlling reactions in dispersed liquid phases.**

8. **Find your own microreactor papers and propose a project.**
Membrane Based Gas Phase Microreactor

- Integrated heater and sensors
- Catalyst placed on under side of membrane
- Reaction energy localized to membrane
- Application: fast catalytic reactions with gas feed streams

Issues:
- Catalyst deposition
- Temperature profiles
- Heat dissipation for highly exothermic reactions
- Robustness

Cross section

Top view of SiN membrane

(I-M. Hsing, et al., 2000)

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The high heat of reaction leads to ignition and rapid temperature rise that must be controlled to avoid run-away conditions.

Ignition/extinction Behavior - Multiple Steady States

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Ignition of Reaction - NH₃ Oxidation
Effect of Membrane Design on Reactor Performance

- Microfabrication allows precise control of heat transfer for manipulation of chemical reactions
- Control of selectivity
- Access to mild oxidation conditions
- Control of mass transfer and chemical kinetics

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**Si Microreactor Fabrication Process**

Starting material:
- Si or SOI wafer
- Coat with silicon nitride

Pattern front side using IR alignment for metal lift-off and deposit Pt

Pattern and plasma etch SiN on backside to expose underlying Si

Etch Si to ~ 50 µm in KOH for easy IR alignment

Etch backside in KOH to stop on buried oxide, and etch oxide in BOE to form Si membrane

E-beam evaporate Pt catalyst in channel via shadow mask

Cut chips and bond to Al sealing plate

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Mass Transfer Characteristics

Conversion vs. Flow Rate

NO Concentration

- 2.4E-3
- 3.8E-2
- 6.2E-2

- Heater
- Membrane
- Pt Catalyst

Flow rate (sccm)

Average conversion (%)

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