

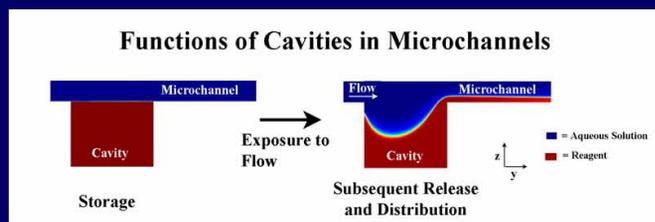
Controlling Chemical Concentrations in Microchannels using Embedded Cavities

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Introduction

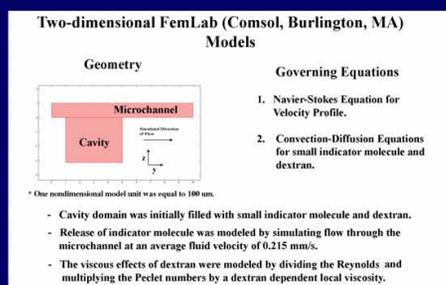
- The on-chip storage and controlled transport of chemicals and other reagents could make lab-on-a-chip systems even more fully integrated.
- We are studying the use of reagent-filled cavities in the walls of microchannels for both storage and controlled release of chemicals under flow. Here we examine controlled release under flow.



Methods

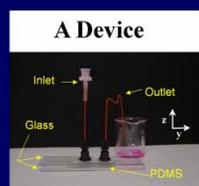
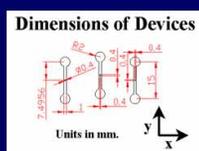
Computational Fluid Dynamics

- A model was created to explore the concentration distribution of reagent in the y- and z- dimensions during release.



Microfluidic Devices

- Devices composed of glass and PDMS that had been shaped using a double layer SU-8 mold.
- Each possessed a cavity embedded in one of its PDMS walls in one of three shapes: a square, circle, or triangle.
- Device and cavity depths were 100 μm and either 226 or 314 μm respectively.

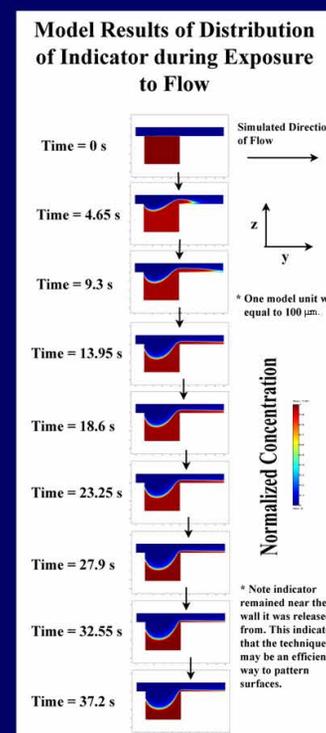


Experimental Protocol

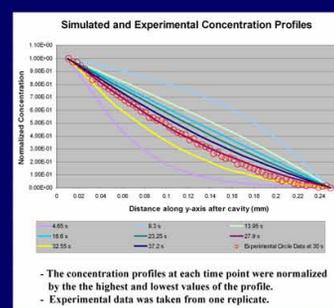
1. Cleaned and dried devices.
2. Filled cavities with a viscous dextran solution containing a fluorescent indicator manually using a pin.
3. Exposed filled cavities to flowing buffer solutions at an average fluid velocity of 0.215 mm/s.
4. Acquired fluorescent images during flow and release of indicator from cavities under a microscope.
5. Processed images.

Results

- Simulations show indicator rapidly leaving cavity at early time points compared to later ones.
- The distribution of material in the cavity varied both temporally and spatially.
- Indicator remained near the wall it was released from under the simulation conditions.
- After 37.2 s, the cavity had not been emptied.

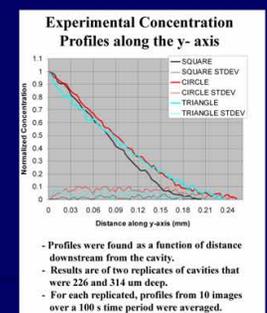
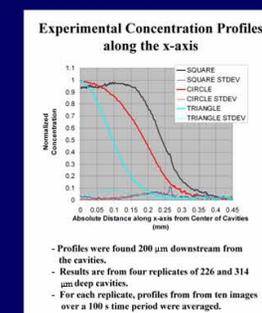
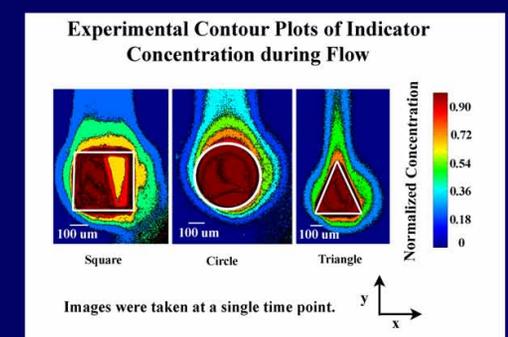


- The average concentration along the z-axis as a function of y varied over time during the simulated release (see below).
- For all time points, the concentration was highest immediately downstream from the cavity and then decreased with increasing distance from it.
- Model results compare closely with experimental data.



- Contour plots (see following) of release from cavities of three different shapes at a single time point showed unique concentration distributions for each shape.
- As shown in the contour plot and concentration profiles (see following), the concentration profile was narrowest for the triangle shaped cavity and then increased for the the circle and square shaped cavities respectively.

- The contour plot and concentration profiles along the y-dimension (right below) were consistent with modeling results.



Conclusions

- Simulations show concentration distributions vary over space and time within the microchannel during release and closely match experimental data.
- Experimental results demonstrate that the release of molecules from cavities of different shapes can be used to control the spatial distribution of molecules in a microchannel.
- The described method of spatially and temporally controlling concentrations in microchannels could be useful for the wide variety of lab-on-a-chip applications where control of chemical concentrations are needed.

Acknowledgments

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