266d Mass Transport to Boundaries and Mixing in Microfluidic Systems

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Microfluidic systems are generally characterized by laminar, axial flow and slow, purely diffusive mixing in the cross section, resulting in poor bulk mixing and limited mass transport to boundaries. Methods have been developed to produce transverse flow to efficiently mix fluid in the bulk of a microchannel, but little attention has been given to the use of these flows to enhance mass transfer from the bulk to the channel walls. I will present a numerical study of the effect of mixing on transport to reactive boundaries in the context of surface based microreactors (e.g. fuel cells, biochemical analyses, sensors).

Mass transfer simulations are performed using passive tracer particles to model reactive solute molecules. These particles are traced down the length of the reactor and collisions with the reactive wall are marked. The effect of mixing in the cross section is quantified in terms of an axial Nusselt number as well as an overall flux to the reactive boundary. This allows for evaluation of the enhancement produced by a transverse flow relative to the Graetz-Nusselt result. Several transverse flow geometries that are physically feasible through lithographic patterning of the channel floor are considered and compared. A boundary layer analysis is used to explain the enhancement to transport resulting from transverse flow. Finally the features of a flow that are vital to improving transport to boundaries are discussed in hopes of enabling the development of efficient microreactors.