MIXING AND GRADIENT GENERATION IN WIDE MICROCHANNELS WITH SURFACE PATTERNS

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Passive mixing is typically achieved on the microscale by driving fluid through microchannels with geometries that either (1) produce strong secondary flows or (2) split and recombined the fluid multiple times. We present a microchannel design that incorporates both of these approaches into a single channel. Our design uses oblique surface grooves on one channel wall to generate strong secondary flows at low Reynolds numbers. The surface groove pattern is inspired by the herringbone pattern of Stroock et al. [1], who demonstrate good mixing results in a channel with aspect ratio near one. We extend this approach by tiling the wall of a high-aspect- ratio channel with several parallel herringbone patterns, which generate a number of parallel counter-rotating regions in the flow. Alternating the surface patterns in the axial direction causes interaction of these parallel streams in a way that is similar to splitting and recombining multiple channels. We demonstrate this approach to passive mixing in a PDMS microchannel that is 50 μm deep and 2500 μm wide. Mixing is characterized experimentally over a range of Reynolds numbers using a phenolphthalein reaction.

The global structure of the surface groove pattern influences the interaction of parallel streams and the resulting mixing efficiency. The pattern we use is based on the concept of 'braiding' the fluid to produce topological chaos [2]. Certain braid structures are guaranteed to produce chaos in the flow, and in these cases the theory predicts a lower bound on the fluid stretching rate. We demonstrate the applicability of this topological approach with a simple model flow.

When fabricated with multiple inlets, this micromixer design can also function as a 'gradient generator'. Describe gradient generator... i.e. concentration gradient in channel cross-section downstream of the surface pattern... By varying the inlet concentrations and flowrates, the resulting concentration gradients can be customized for a desired application. This microchannel design provides an alternative to the existing gradient generator design [3].

References

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