Supplementary Information for

Rapid laminating mixer using a contraction–expansion array microchannel

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This file includes:

Supplementary FIGS. 1 to 4.

Text

The balance between two transport components determines whether the fluorescein isothiocyanate (FITC) stream wraps the deionized water (DIW) stream (Fig. S2). At the range of *Re* from 4.3 to 28.6, the DIW stream is wrapped by the FITC stream and located in the middle of the channel, forming alternating lamellae of FITC-DIW-FITC. At low flow rates under $Re \approx 1.4$, the intensity of the transverse component is not enough high to induce the lamination process and wrap the DIW stream with the FITC stream (Fig. S3). At higher flow rates over $Re \approx 28.6$, the intensity of the axial component is too high comparing with the transverse component, which requires more number of array units and mixing length for the increase of interfacial area (Fig. S2).

Red fluorescent polystyrene beads of 1 μm nominal diameter, which can be neglected in terms of inertial forces, were used to observe a generation of vortex by flow separation in the expansion region at a range of *Re* from 1.4 to 43.0. The bead trajectories were captured at the expansion region of the CEA microchannels, and a commercial image analyzing program (IMT i-Solution Inc., Seoul, Korea) was used to measure vortex areas induced by flow separation. The vortex areas were determined with closed lines starting from the onset of flow separation to a flow reattachment point on the channel wall (Fig. S4).

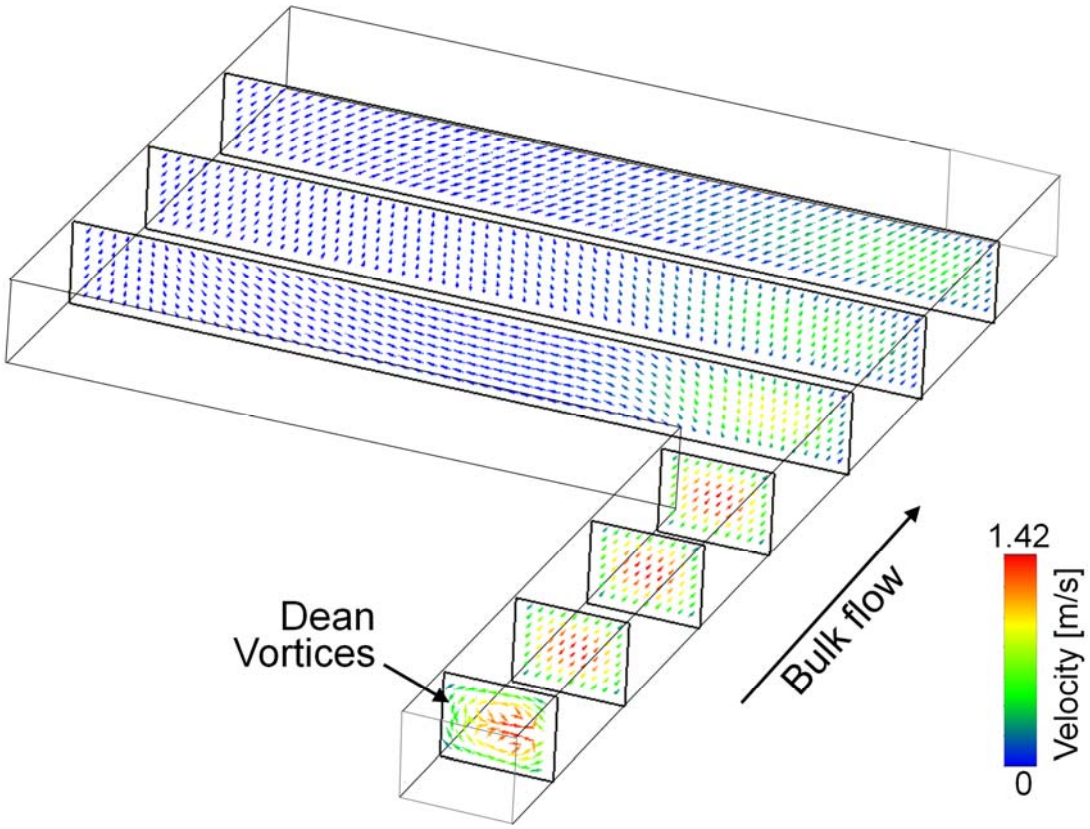

FIG. S1. Cross-sectional images of transverse velocity fields from CFD simulation. The images were captured from the entrance of the first contraction region to the end of first expansion region. Dean vortices are localized near the entrance of the contraction region and are not built in any other regions.

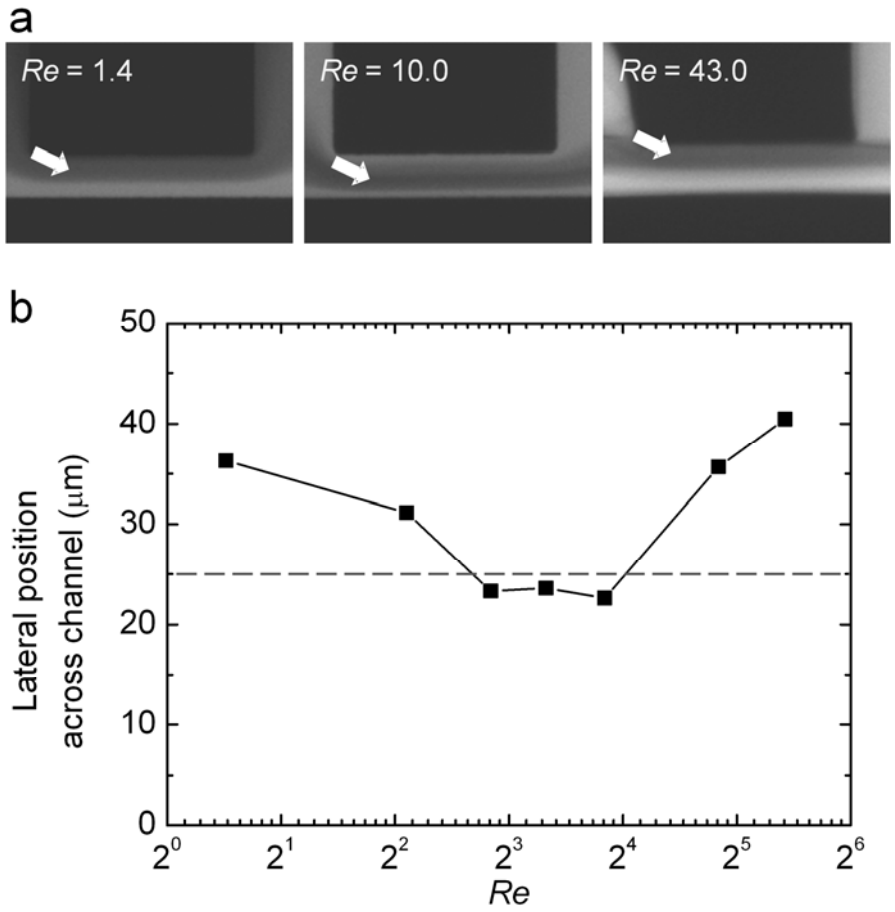

FIG. S2. (a) Micrograph showing two different streams of DIW and FITC at the sixth contraction region as an increase of *Re*. Arrows indicate DIW streams. (b) Plot of the mean lateral position of the DIW stream across the channel. The dashed line indicates the middle of the lateral position in the contraction region.

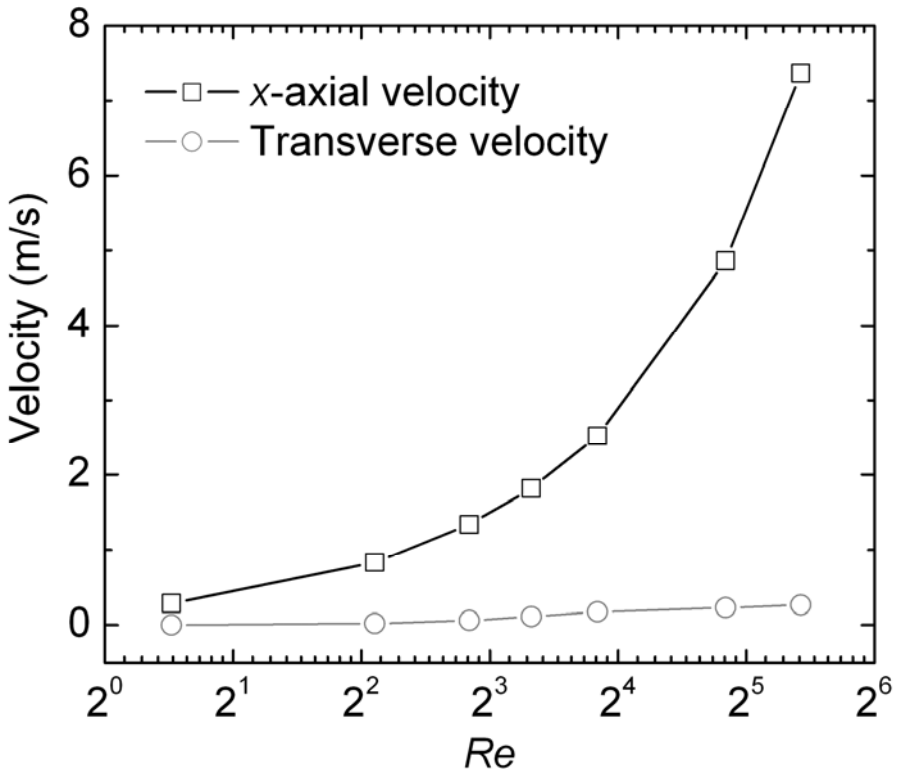

FIG. S3. Plot of the maximum *x*-axial and transverse velocity at *x*-axial position of 35 μm apart from the beginning of the second contraction region. The *x*-axial velocity increases more steeply than the transverse velocity relative to 3D lamination.

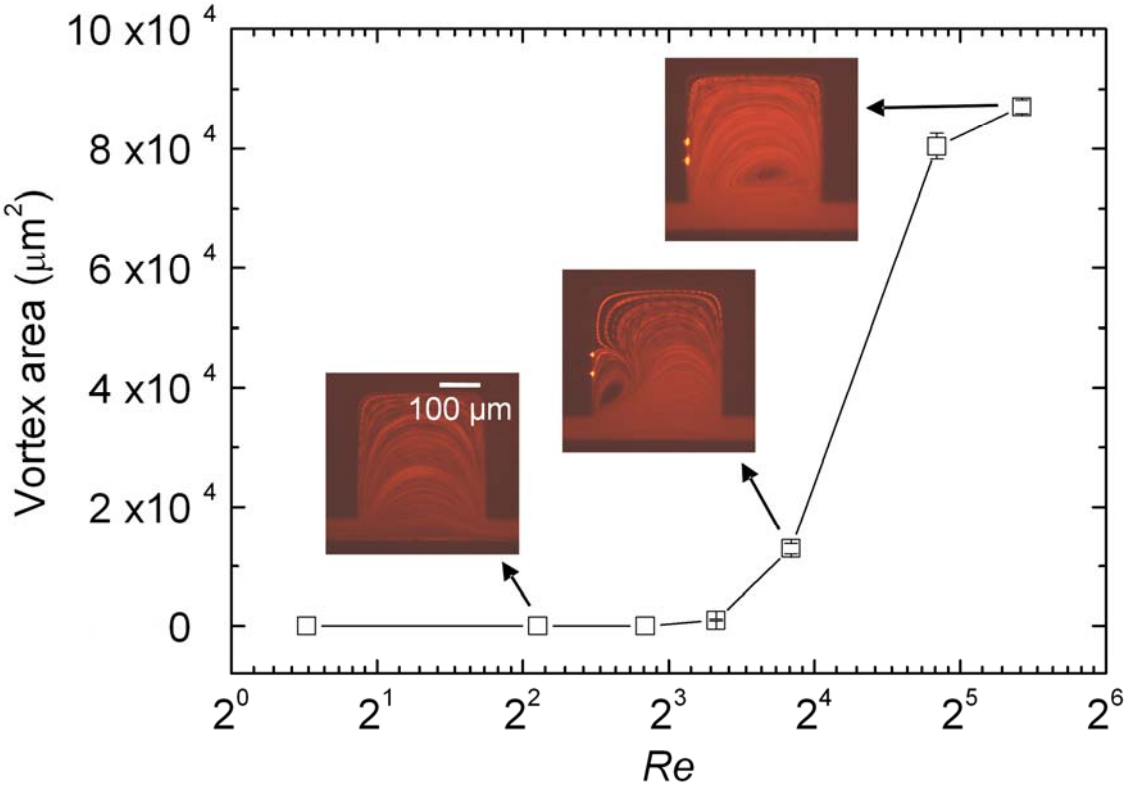

FIG. S4. Plot of vortex area as a function of *Re* in the expansion region. The insets show fluorescent microscopic images acquired at the first expansion region. A vortex by flow separation begins to be generated beyond a critical *Re* (≈14) at the entrance to the expansion region.