



FIG. 3: Photomicrograph of unstable flow in the second expansion for a concentration of 64 ppm high molecular weight (18×10^6 Da) polyacrylamide polymer added. It is apparent that large instabilities are excited that display a dominant scale set by the microchannel. Dashed outlines indicate field of view and microchannel outline; the 160 μm long solid line indicates where the space-time diagram slice was taken for the expansion regions. The instabilities in the constriction regions can also be seen here at the sides of the image; regions are centered for data collecting.

the limited bandwidth visual evidence (see Fig. 3) that large scale instabilities dominate the instability spectrum. The lack of enhanced diffusion confirms that small scale instabilities below the camera resolution are not excited to a significant extent.

Finding the first moment mixing index, M1, for concentrations of 0 ppm, 32 ppm, and 64 ppm as the fluid moves downstream reveals that absolute mixing is reduced in viscoelastic solutions relative to the polymer-free sample; Fig. 7. We also observe an increase in the rate of change in mixing downstream for viscoelastic solutions. By looking at the flow at different constriction units ($N=2, 4, 8$) the mixing length is calculated and we find a mild decrease with raising polymer concentration; the mixing length reduces from 4.5 for 0 ppm to 4.2 for 32 ppm and finally 3.2 for 64 ppm. For diffusion from an ideal sharp 2D interface [28] changing viscosity simply shifts calculated M1 by a constant for our parameters, indicating that the change in mixing length can be attributed to the action of instabilities.

For an uniform microchannel we calculate [28] M1 values roughly twice as large as we observe for polymer-free solutions in our channels corrugated with constriction/expansions. This enhanced mixing has been previously observed for electro-osmotic flows through con-