

Evanescent molecular tagging technique for electrokinetic effects on velocity field in the vicinity of electrolyte-glass interface

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The investigation of flow structure in the vicinity of electrolyte-glass interface contributes to control accurately the liquid flow in electrokinetic microfluidic devices, because the electroosmotic flow is governed by the ions which exists in the vicinity of the interface. The present study proposes a novel technique for investigation of nanoscale flow structure in a microchannel. The technique realizes the velocity measurement of the ion in the vicinity of the interface by utilizing the caged fluorescent dye and evanescent wave illumination of the glass wall.

Caged fluorescent dye is initially non-fluorescent because a chemical group is attached to quench the fluorescence of the dye. After irradiated by ultraviolet light, the chemical group is cleaved and the dye restored the fluorescence, known as an uncaging event. In order to excite the uncaged dye in the vicinity of the interface selectively, evanescent wave illumination is employed as shown in Fig. 1. The velocity of the uncaged dye was obtained by tracing fluorescence^[1] from the dye.

Figure 2 shows the microchannel comprised of a poly(dimethylsiloxane) (PDMS) and a 170 μm thickness borosilicate cover glass. The DMNB-caged fluorescein dextran and CMNB-caged fluorescein was prepared by dissolving in carbonate buffer at pH 9.3. The experimental setup is comprised of an inverted microscope and two types of laser as illustrated in Fig. 3. A pulsed ultraviolet laser beam was focused as a laser sheet into the microchannel cross-section for the uncaging event. A 60 \times magnification objective lens (NA = 1.45) was employed to generate evanescent wave. Evanescent wave illumination can be easily switched to epi-fluorescent illumination, i.e., mercury lamp by changing the optical path in the microscope. Fluorescence from the uncaged dye was captured by a CCD camera through the objective lens.

A comparison between the fluid flow measured by epi-fluorescent and evanescent wave illumination was carried out. In the pressure-driven flow and the electroosmotic flow (EOF), the calculated velocity profiles are plotted in Fig. 4 and 5, respectively. In the pressure-driven flow, the velocity obtained by evanescent wave illumination is much decreasing than that by epi-fluorescent illumination, while the almost same velocity was obtained by the both illumination methods in the EOF.

Evanescent molecular tagging technique enables to detect the ions in the vicinity of the interface and measure the ion velocity successfully. This technique can be applicable to the investigation of the flow structure on the order of nano meters from the channel wall.

References

[1] Yamamoto et al., 11th Int. Symp. on Appl. Laser

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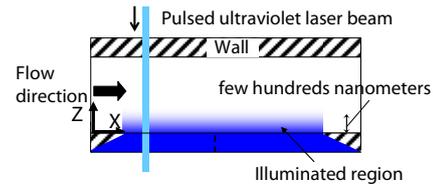


Fig. 1 Schematic concept of evanescent wave illumination.

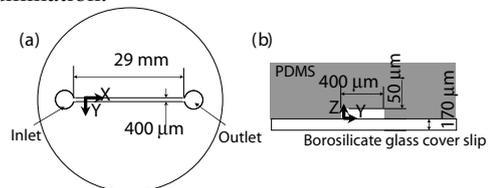


Fig. 2 Schematic illustration of the microchannel in (a) top view and (b) cross-sectional view.

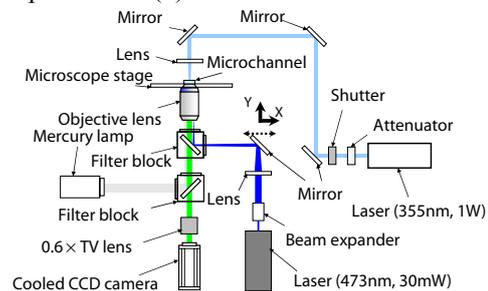


Fig. 3 Schematic illustration of experimental setup.

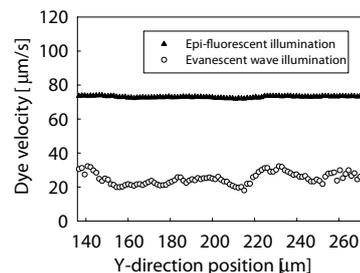


Fig. 4 Calculated velocity profile in the pressure-driven flow.

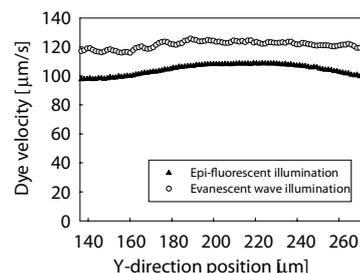


Fig. 5 Calculated velocity profile in the EOF