SUMMARY OF Ph.D. DISSERTATION

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Title

Combined Optical Measurements of Velocity, Ion Concentration and Zeta-Potential in Microchannel

Abstract

Microfluidic devices have been widely used for industries and are realized by miniaturizing large chemical analytical instruments and synthesizing several operations, such as transport, mixing and chemical reactions. The devices have microchannels with a width ranging from a few μm to a few hundred μm, and the flow in microchannels is controlled by several parameters, such as fluid velocities, ion concentrations and electric charge of channel wall surface, i.e. a zeta-potential. For further high-accuracy and integration of various functions, it is expected to evaluate the mixing process spatially by obtaining the above several parameters simultaneously. The objective of the present study is to develop novel combined optical measuring techniques, that is, the simultaneous measuring technique of the velocity and ion concentration, and the evaluating technique of the electroosmotic flow velocity and zeta-potential.

Chapter 1 explained significances to obtain the knowledge of flow characteristics in microspace, and the objective of the present study is described with explanations of the background and conventional measuring techniques.

Chapter 2 noted the fundamental equations for the microchannel flow, materials and fabrication techniques of microfluidic devices, and the basic knowledge of the effect of the material of the channel and the fluid properties on the microchannel flow.

Chapter 3 summarized the combined optical measuring techniques. The simultaneous measuring technique of the velocity and ion concentration was developed by combining micro-PIV and LIF with the confocal microscope to improve the depth resolution drastically. The evaluating technique of the electroosmotic flow velocity and zeta-potential was advanced by analyzing particle flow characteristics, which enables to realize two-dimensional measurements.

Chapter 4 expressed the velocity and proton concentration in mixing flow and chemical reacting flow by utilizing the simultaneous measuring technique, and the validation was confirmed by comparing with the numerical simulation. The convection of protons was evaluated by using the velocity and proton concentration data and compared with the diffusion.

Chapter 5 described the validation of the evaluating technique by the comparison with the empirical equation, and examined the electroosmotic flow fields in the microchannel made of several materials which forms the non-uniform zeta-potential.

Chapter 6 investigated the electroosmotic flow fields with the non-uniform zeta-potential formed by the surface modification patterning, and the depth-wise flow rate was estimated by using the continuous equation. These results indicate that the depth-wise velocity was generated when the surface charge is varied perpendicular to the direction of the electric field.

Chapter 7 summarized the results of the above studies and described the validation and characteristics of the measuring techniques which was developed in the present study.