Electrokinetic Flow Instabilities in Microfluidic Systems

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Microfabrication technology has enabled the application of electrokinetics as a method of performing chemical analyses and achieving liquid pumping in electronically-controlled microchip systems with no moving parts. This talk reviews progress at Stanford including novel methods for sample stacking and fundamental studies of electrokinetic flow instabilities. Field amplified sample stacking (FASS) leverages conductivity gradients as a robust method of increasing sample concentration prior to capillary electrophoresis separation. We have developed novel chip systems that can achieve signal increases of more than 1000 fold using FASS. Electrokinetic instabilities (EKI) present a major challenge to optimizing FASS devices, as well as an opportunity to achieve rapid on-chip mixing. We have developed generalized models for heterogenous electrokinetic systems for both FASS and EKI, and validated these models with experiments. This work shows that electric body forces associated with the accumulation of charge in the bulk liquid are the cause of EKI. Suppression and/or control of electrokinetic flow instabilities is directly applicable to sample stacking as conductivity-gradient-induced instabilities dramatically increase dispersion rates and thereby limit stacking efficiency.