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Electrokinetic 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. Electrokinetics involves the interaction of solid surfaces, ionic solutions, and electric fields. Electric fields can be used to generate bulk fluid motion (electroosmosis) and to separate charged species (electrophoresis). Microfabrication technology has enabled the application of electrokinetics as a method of performing chemical analyses and achieving liquid pumping in electronically-controlled microsystems with no moving parts. This seminar reviews progress at Stanford including methods for sample stacking in capillary electrophoresis assays 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 electrophoretic separation. A major challenge to achieving robust, high-efficiency FASS is the role of electrokinetic instabilities (EKI) generated by a coupling of electric fields and ionic conductivity gradients. This coupling results in electric body forces in the bulk liquid that can generate instabilities. Suppression and/or control of electrokinetic flow instabilities is critical as they dramatically increase dispersion rates and thereby limit stacking efficiency. We have identified the key physical mechanisms in EKI; developed generalized models for electrokinetic systems; and validated the models with experiments. We have applied this understanding to the development of chip systems that achieve signal increases of more than 20,000 fold using FASS. This stacking ratio is over 200 times larger than previous on-chip FASS devices.