Prof. Hsien-Hung Wei

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Research Interests

My research interests are in the area of complex fluids, emphasizing the use of integrated theoretical, experimental, and computational approaches in exploring the small-scale physics and their applications. Specific topics include microhydrodynamics, electrokinetically-driven micro/nanofluidics, and single molecule manipulation and detection.

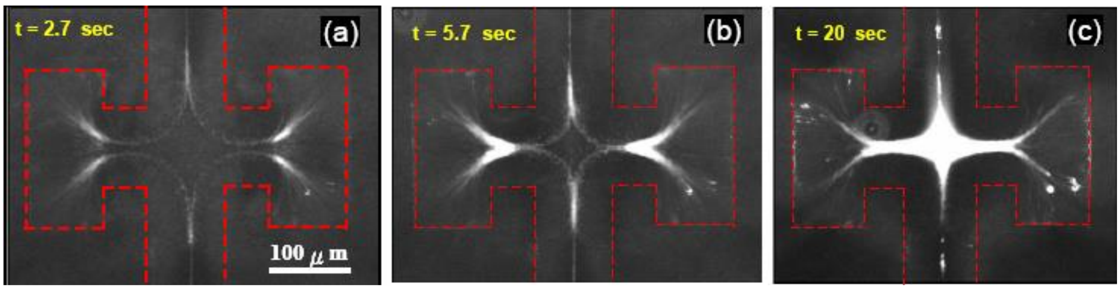
Representative Publications

1. Y.-C. Liao, Y.-C. Li, and **H.-H. Wei**, Drastic changes in interfacial hydrodynamics: Slip-intensified film thinning, drop spreading, and capillary instability, ***Physical Review Letters***, **111**, 136001 (2013).
2. **H.-H. Wei** and J.-S. Jan, Self propulsion and dispersion of reactive colloids due to entropic anisotropy, ***Journal of Fluid Mechanics***, **657**, 64-88 (2010).
3. S.-F. Hsieh and **H.-H. Wei**, Entropic trap, surface-mediated combing, and assembly of DNA molecules under submicrometer interfacial confinement, ***Physical Review E***, **79**, 021901 (2009).
4. S.-F. Hsieh, C.-P. Chang, Y.-J. Juang, and **H.-H. Wei**, Stretching DNA with electric fields beneath submicron interfacial constriction created by a closely fitting microdroplet in a microchannel, ***Applied Physics Letters***, **93**, 084103 (2008).
5. J.-R. Du, Y.-J. Juang, J.-T. Wu, and **H.-H. Wei**, Long-range and superfast trapping of DNA molecules in an ac electrokinetic funnel, ***Biomicrofluidics***, **2**, 044103 (2008).

Research Highlights

1. Rapid Electrokinetically-Driven Molecular Trapping for Enhancing Detection Sensitivity

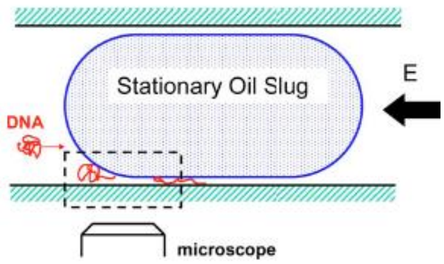
We design a new microfluidic platform for rapid trapping of biomolecules such as DNA. It involves a uniquely designed asymmetric electrode geometry to generate a structured AC electrokinetic funnel capable of collecting molecules distantly. Together with other AC effects such as dielectrophoresis and dipole-dipole attraction, this platform is able to concentrate DNA at the picomolar level with 100-fold concentration enhancement within less than a minute, greatly promoting the ability to capture and detect dilute biological samples.



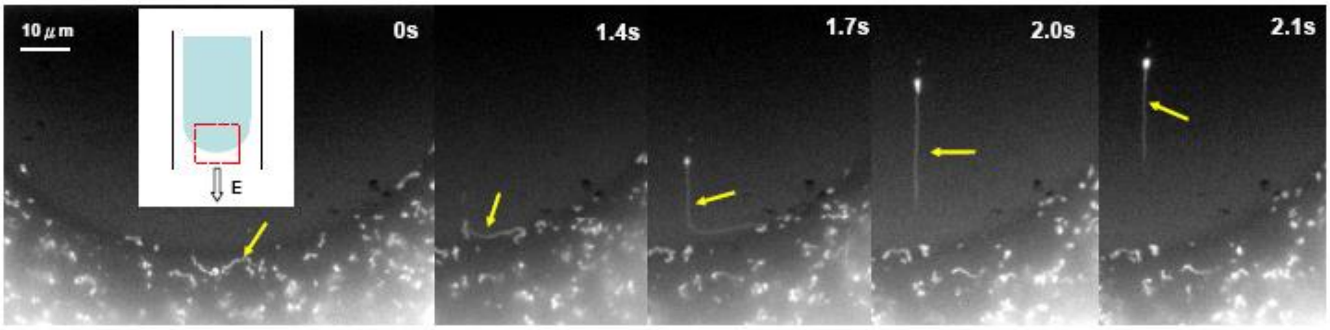
Sequential images showing rapid of trapping of DNA molecules by head-on streaming generated by asymmetric AC polarization.

2. Dynamic Stretch and Assembly of DNA Molecules within Interfacial Confinement

A new microfluidic platform is devised for stretch and manipulation of DNA molecules. The central feature here involves a submicron film created by a readily prepared closely fitting microdroplet in a microchannel. This film can not only serve as a natural confinement for rendering conformation changes of DNA, but also greatly magnify applied force fields for stretching DNA. What is more important is that a diversity of manipulations such as entropic trap/escape and stretching can be realized using this platform, which could have potential applications to DNA separation. Also because of the interactions between DNA and the underlying substrate, this platform further offers the advantages of conducting molecular combing and directing assembly of DNA molecules.



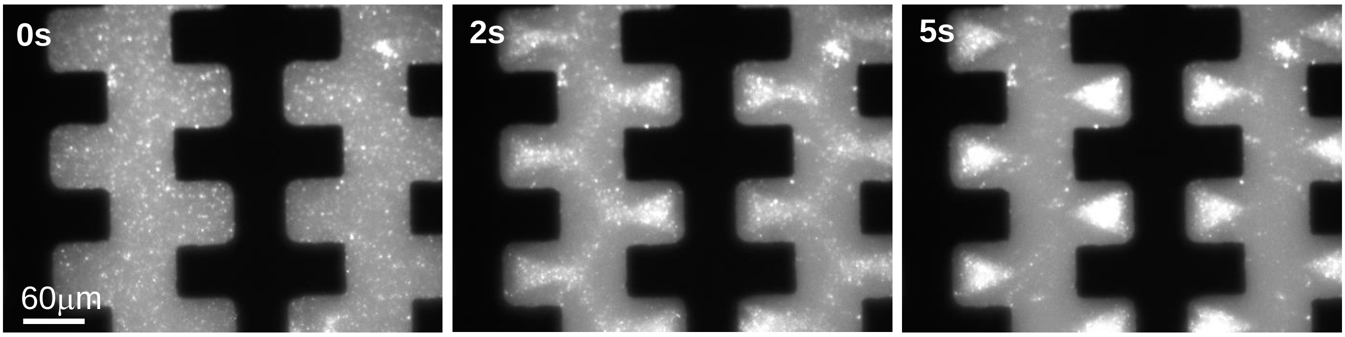
Stretching DNA beneath a closely fitting microdroplet in a microchannel.



Observed stretch dynamics of a single DNA molecule beneath the meniscus of a closely fitting microdroplet.

3. Trapping Nanoparticles by Giant Dipole Moments

It is well known that convectional dielectrophoresis (DEP) is inefficient to trap nanoparticles because of the quadratic dependence of the DEP mobility on the particle size. We develop a new AC electrokinetic scheme to overcome this limitation. The strategy involves the addition of micron-sized particles to form larger clusters by DEP, creating enormous dipole moments capable of trapping the surrounding nanoparticles. This technique can also be applied to trap biomolecules (e.g. ssDNA) for enhancing target molecular sensing and detection.



Sequential images for AC trapping of illuminated quantum dots assisted by the clustering of micron-sized particles.