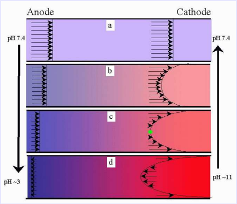
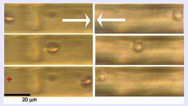
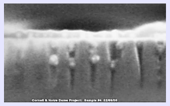
(5) Nanoshells and Nanoporous Substrates

The group is collaborating with Professor A. Ostafin on microfluidic applications of 10−nanometer gold colloids covered with specific antibodies. When electrophoretically manipulated in a micro−device, these colloids will seek out specific cancer/diseased cells, blood cells, bacteria etc within a the blood/urine sample like heat−seeking missiles. Once attached by the antibodies, the cell's hydrodynamic and (di)electrophoretic mobility changes drastically such that they can be separated and detected by the methods in section(4).







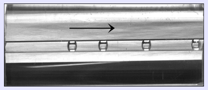
100 *nm*

Collaboration with Professor A. E. Miller has produced nano-porous substrates that can house and deliver these gold colloids in microfluidic devices. The precise anodizing condition to produce nanopores of specific demension (between 10 and 100 nm) is determined by a detailed theoretical and numerical study of the nanoporous pattern formation dynamics.

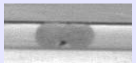
S. K. Thamida and H.−C. Chang, "Nanoscale Pore Formation Dynamics During Anodization of Aluminum," Chaos, Vol. 12, 240 (2002).

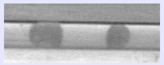
D. Crouse, Y.−H. Lo, A. E. Miller and M. Crouse, "Self−ordered pore structure of Anodized Aluminum on silicon and pattern transfer," Applied Physics Letters, Vol. 76, 49 (2000).

(6) Moving and Breaking Drops/Bubbles



500 μm





Because of capillary force drops and bubbles are difficult to be moved in a micro−channel. These problems are especially accute for electrokinetic devices when it is necessary to transport dielectric liquid drops.

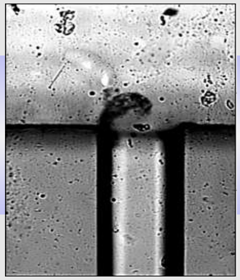
The group has employed surfactants to endow interfacial stress such that non−electrolyte drops/bubbles can be transported in microdevices. The same strategy can also be used to break micro−drops against high capillary force. We intend to use this technique to remove hydrogen bubbles generated in liquid(direct−Methanol) fuel cells.

P. Takhistov, A. Indeikina and H.−C. Chang, "Electrokinetic Displacement of Air Bubbles in Micro−Channels," Physics of Fluids, Vol. 14, 1 (2002).

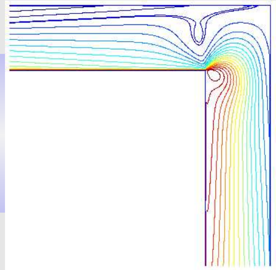
H.−C. Chang, "Bubble/Drop transport in Micro−Channels," Chapter 11, The MEMS Handbook, Editor: M. Gadelhak, CRC Press (2001).

(7) Corner Aggregation in Biochips

Colloids, Proteins and drug compounds often precipitate at micro−channel corners. The aggregate size is often large (50 microns) and cannot be explained by polarization mechanisms (DLVO and DC−Dielectrophoresis).



50 μm



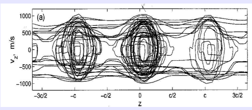
The group has discovered a long range electro−osmotic and entrainment mechanism due to field leakage that is responsible for this aggregation. Optimum channel design which minimizes aggregation is now being tested.

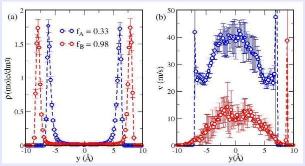
S. K. Thamida and H.−C. Chang, "Nonlinear electrokinetic ejection and entrainment and entrainment due to polarization at nearly insulated wedges," (Physics of Fluids, Accepted for Publication).

(8) Nanofluidics

In anticipation of nanoscale devices using nanotubes and nanoporous material, the group has begun to investigate fundamental transport laws at such small scales. Due to atomic and molecular interaction and because the transport time scale is comparable to the surrounding thermal bath time scale, the usual Fickian diffusion mechanism breaks down completely and new ones must be derived.

Molecular Dynamic (MD) simulations are carried out in collaboration with Professor E. J. Maginn's group.

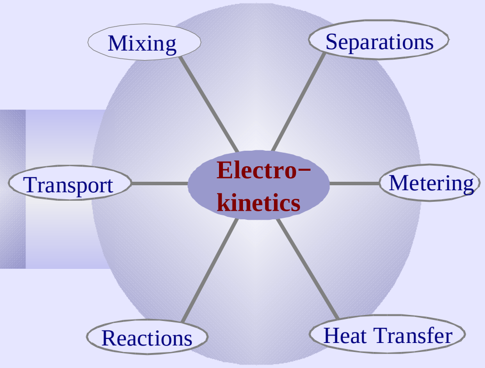




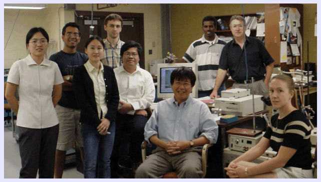
D. I. Koplevich and H.−C. Chang, "Does Lattice Vibration Drive Diffusion in Zeolite?" Journal of Chemical Physics, Vol. 114, 3776 (2001).

G. Arya, E. J. Maginn and H.−C. Chang, "Effect of Surface Energy Barrier on Sorbate Diffusion in $AlPO_{4}^{-5}$," Journal of Chemical Physics, Vol. 105, 2725 (2001).

Future Work: Micro−Fluidic Unit Operations



Research Group



Professor: H.−C. Chang,
Bayer Professor of Chemical Engineering

Research Professors: E. A. Demekhin, A. Indeikina

PhD Students: Adrienne Minerick, Sunil Thamida,
Gaurav Arya, Yuxing Ben, Ronghui Zhou

Collaborators: P. Takhistov(Rutgers), A. E. Ostafin,
D. T. Leighton, A. E. Miller, E. J. Maginn
E. Rosen, K. Oslon (Notre Dame),
S.−C. Wang(Chung−Cheng, Taiwan)
L. Chen (Penn State)

Group Website: **www.nd.edu/~changlab/**