

Goals and Potential Impact if Successful

(Feedback) control of micro-fluidic systems such as:

- Lab-on-a-chip systems
- Conjugated polymer “conducting plastic” in bio-fluids micro actuators
- Steering of bio-particles/chemicals in micro-fluidic devices for biological screening, micro drug delivery, etc.

Create integrated systems that work in messy environments.

Require feedback on the micro/nano scale for the same reason that it is required on the macro scale: allows systems to function with large degrees of noise and uncertainty, create robust performance, accomplish complex coordinated tasks, integrated sensing/actuation.

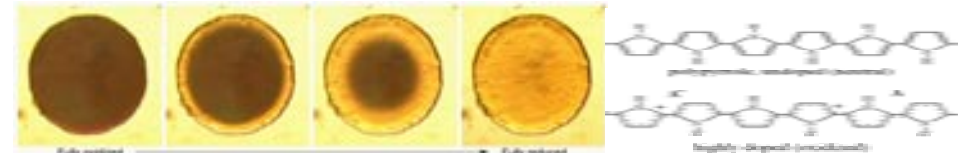
Approach and/or Accomplishments

MODELING:

- Identify dominant physical effects by intuition, theory, back-of-the-envelope analysis, experimentation, ...
- Create PDE models of dominant effects. Quantify unknown parameters by careful experiments, system identification, ..

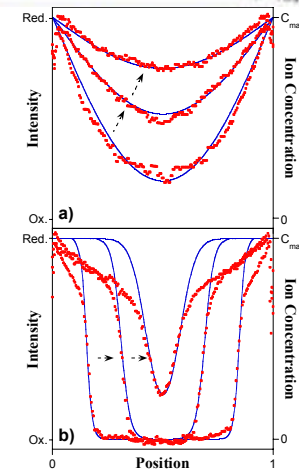
CONTROL:

- Pose practical tasks (such as split drops precisely using electrically actuated surface tension forces) as tractable mathematical problems (updated least squares control of pinch points).
- Extend/develop PDE control theory to: PDE control on changing topology, non-smooth behavior (interface control) ..

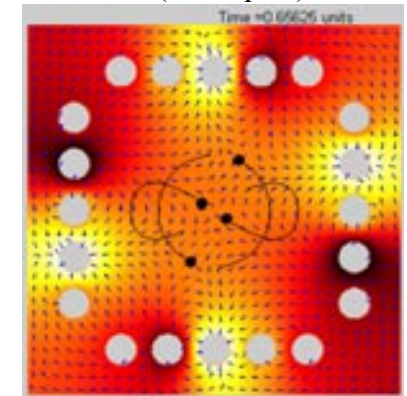


Oxidation fronts in conjugated polymer films.

Experiments (E.Smela) versus Theory (B.Shapiro)



Flow Control Micro Fluidic Tweezers (B.Shapiro)



Bottlenecks and Open Research Questions

-Modeling, analysis, and design tools appropriate for control of micro/nano systems are largely unavailable.

My lab spends the majority of its time creating control ready models and recreating tools available on the macro scale for the micro scale (such as model reduction tools).

-Communication gaps: Controls people don't speak the same language as the fabrication people who don't speak the same language as the organic chemistry people who ..

-What are the dominant physics? Given a complex bio/chemical system, how do we decide what physical phenomena really matter? Combine knowledge bases?

-System integration: Design tools. Coupling. Robust nonlinear system ID. Appropriate sensing/actuation. ...