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AES Newsletter

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Send news for the newsletter to Editor Nancy Kendrick **nancy@kendricklabs.com** or Assoc. Editor David Garfin **degarfin@sonic.net**

Contact Matt Hoelter AES Executive Director with questions about the society **matt-aes@tds.net**

Feeling *really* lazy this summer? Just make sure you're re-energized by October 16 for the AES meeting in Minneapolis!

Update from our Meeting Organizers:

The 2011 annual AES meeting will be held at the Minneapolis, MN Convention Center in conjunction with the annual meeting of the American Institute of Chemical Engineers (AIChE). As a new feature this year, AES will have parallel sessions. The AES sessions, designated Topical 3 in the AIChE schedule, consist of ten contributed sessions, one invited plenary session, one award session and one poster session, running from Monday, Oct 17 through Wednesday, Oct 19. The 2011 award session is depicted on page 4. The description of the talks in the Plenary is on page 4. The detailed program grid is presented as an insert in this newsletter and is also available at http://aiche.confex.com/aiche/2011/webprogram/T3.html. This year AES is delighted to offer on October 16 two Sunday afternoon workshops running in parallel on 2D electrophoresis and on COMSOL. The early registration deadline is August 29th; the registration form can be found at the AIChE website, http://www.aiche.org/Conferences/AnnualMeeting/index.aspx. Remember that membership in AES qualifies for the discounted membership rate and can be checked on the PDF version of the registration form. The Poster Reception is scheduled for Tuesday, Oct 18, and the AES Banquet will take place on Wednesday, Oct 19 at Hell's Kitchen. During the banquet we will have a special talk on the history and innovation at 3M, given by Dr. Tom Hanschen. Tickets for the AES banquet can be purchased along with your AIChE registration or on-site at the meeting. We look forward to seeing you there. Remember that late breaking submissions for the Poster Session will be accepted until October 1st.

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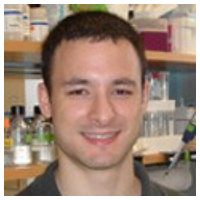

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AES 2011 Meeting Co-Chairs

Detection in Nanofluidic Channels

by Dr. Edgar D. Goluch, Northeastern University, Boston, MA

How do we know something is inside those tiny nanofluidic channels? Optical detection, and particularly fluorescent detection, is the dominant strategy for in situ monitoring in micro and nanofluidic systems, primarily utilizing fluorescent dyes, proteins, and beads to selectively visualize species and events [1]. This is an ideal approach for many experiments, but optical detection runs into problems when the analyte of interest is about the same size as the fluorescent tag.

For certain systems specialized fluorescent dyes have been identified that only minimally interfere with the target analyte, such as intercalating dyes used to visualize DNA and pH sensitive dyes that map proton gradients. Specific markers, though, do not exist for every species, nor will it be practical to develop them. Also, attaching any sort of marker to small molecules, such as hormones or sugars, will significantly affect their transport and can also affect their uptake and function in living systems.

Therefore, there is a significant need for developing label-free strategies for the slew of biomolecules and nanoparticles that researchers would like to study in micro and nanofluidic channels. The exciting development, though, is that some very interesting physics takes place at the nano scale that will lead to new analytical techniques and extend the capabilities of existing ones [2]. A few approaches are described here.

Surface plasmon resonance (SPR) [3] and surface enhanced Raman scattering (SERS) [4] are label-free techniques that rely on nanoscale phenoma. The detection mechanism exploits electronic interactions between the target species and the plasmons emitted by a gold, silver, or copper surface. These plasmons extend approximately 100 nm above the surface, allowing detection of molecules that reside in that space. SERS is particularly interesting because it provides a chemical fingerprint of the target molecule.

The most established label-free detection modality for micro and nanofluidics is electrochemical [5]. Extensive cell and particle counting and characterization has been done with impedance cytometry [6]. Impedance-based measurements are also routinely employed for DNA detection in nanopores and nanochannels [7].

Our group employs amperometric detection to determine the concentration of redox-active molecules, such as pyocyanin, in nanofluidic channels. The sensors we use are unique in that they contain two working electrodes inside a nanofluidic channel spaced approximated 100 nanometers apart. When a redox-active molecule enters the channel, it accepts an electron at one electrode and donates it at the other, as seen in Figure 1. It can repeat this process thousands of times before leaving the channel because it only takes a few microseconds for a molecule to diffuse between the two electrodes, while, on average, it takes a second to traverse the length of the channel. This type of device was recently shown to be able to detect when a single ferrocene molecule enters and leaves the sensor area inside the nanofluidic cavity [8]. The limitation of this approach is that it is constrained to redox-active molecules and it is difficult to discern between different molecular species. None-the-less, bioanalytical measurements are possible with these devices in controlled environments [9, 10].

Overall, there are a growing number of ways to investigate the contents of nanofluidic channels, but the lab-on-a-chip community is still quite a bit away from demonstrating a universal label-free detection device.

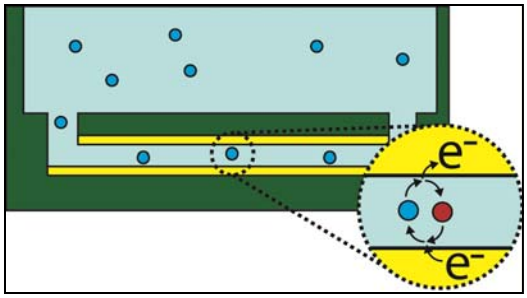

Figure 1. Principle of device operation. Redox-active molecules undergoing Brownian motion are repeatedly oxidized and reduced at two parallel electrodes inside of a nanofluidic channel that is several micrometers long, leading to a measurable current. Height and length dimensions are not drawn to scale.

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High Resolution and Real-Time Micro Particle-Image Velocimetry for Microfluidics Applications

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Introduction: Particle-image velocimetry (PIV) is a flow-measurement technique having many uses in microfluidics[1–10]. PIV works via a comparison of images taken at different times of a flowing stream of densely seeded particles. Usually, cross-correlation math[1] is used to estimate a two-dimensional histogram of particle displacement[2] between images for one or more locations within an image. The signal-to-noise ratio of this statistically derived 'histogram' scales ideally with the square root of the number of measurements, N (# pixels x # frame-pairs) used to construct the histogram. The histogram is broadened by the finite image size of particles, Brownian motion, Zeta-potential variations, spatially irresolvable flow gradients (out-of-plane parabolic flow) spatially resolvable flow gradients (if spatial averaging), and flow unsteadiness (if time-averaging). Originally developed in the 1980s for macroscale flows, in 1998 PIV was adapted into a technique by Santiago et al. for measuring steady fluid flow in microfluidic devices[3]. Called micro-PIV, this adaptation typically flood-illuminates a microchannel to excite fluorescently labeled ~100–1000-nm particles, captures particle-fluorescence images through microscope optics, and records or processes arrays of image pairs on a computer to produce measurements of velocity. Some applications process histograms further to extract parameters such as unresolved parabolic flow and temperature from Brownian motion[4]. Micro-PIV applications in microfluidics[2-10] include high-resolution velocity-field imaging[2,4] and real-time velocity sensing[9,10].

High Resolution Velocity Field Imaging: If the flow is steady, PIV can produce accurate, single-pixel-resolution[2], diffraction-limited flow field images, which are useful for characterizing devices and comparing theory and experiment[4]. For example, Fig. 1a, shows theoretical and PIV-measured electrokinetic flow fields in a microchannel containing an array of 93-µm circular posts on 200-µm centers. Fringes are contours of constant speed (24.5 µm/s) and measurements differ from the ideal flow by ~2 µm/s out of a peak of 320 µm/s, mostly due to surface flaws. These PIV measurements were processed from a 30-second video from a standard NTSC camera of 200-nm particle fluorescence through a 10x DIN microscope with a blue-LED ring illuminator, a system similar to LabSmith's SVM340™. Each histogram was constructed with N = 3600 (2 x 2-pixel x 900 frames). Reference-quality PIV does not require expensive cameras or imaging systems, but it does require 1) large N, 2) sophisticated processing software to optimize dynamic range and ignore flaws such as particle aggregates, and 3) tenacity.

Real Time Micro-PIV: On the other end of the spectrum, PIV is useful as a real-time velocity sensing technique. PIV-based software probes can be "rapidly prototyped" to automate a control loop that would otherwise be hand-tweaked. PIV probes and intensity probes, which track intensity within user-defined regions, can trigger real-time actions, such as changing voltages or flow rates, moving to the next step in a sequence, etc. Configurations can be edited, saved, and opened like any document, so control-system conceptualization and testing is fast and inexpensive. For example, Figure 1B shows real-time velocity-vector and intensity probes of a 5 µl/min pressure-driven microchannel flow processed using LabSmith's uScope™ software. Every 16 ms, probe measurements are captured, processed, displayed, and recorded.

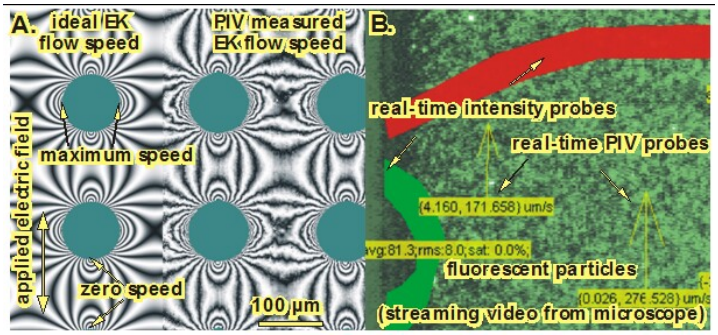

Figure 1. *A. High resolution micro-PIV experiment obtained by processing a 30-second video of fluorescence from 200 nm green-yellow Fluospheres™ in an electric field of 2 V/mm applied top to bottom, from a standard NTSC camera. B. Real-time micro-PIV experiment. Pressure driven flow (5 ul/min) was used with a 500 nm diameter Fluosphere™ seeded solution at pH 7 in a 1 mm wide by 100 um deep microchannel in a Topas chip. Taken with a LabSmith SVM340™ synchronized video microscope black and white camera. Both A. & B. used a 10X DIN objective and blue LED illuminator.*

Conclusions: Micro-PIV can eliminate uncertainty and save development time for researchers and engineers. Using off-line processing, high-resolution flow-field imaging can detail flows and reveal device issues. Real-time software probes provide a low-cost "rapid-prototyping" alternative for developing microsystem sensors and closed-loop controls. Micro-PIV can accelerate microfluidic system prototyping and refinement, key steps for capitalizing a startup and commercializing a technology.

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Join AES in the celebration of its first Award Session in Honor of Professor Kelvin H. Lee on Wednesday Oct 19 in room 101 E of the Minneapolis Convention Center!

This is the first Award Session of AES and it will honor the people who have made significant contributions to electrophoresis and to AES, and whose work is well known in both the engineering and biology communities. Awardees will receive a commemorative plaque and a lifetime membership to AES. The 2011 Awardees are:

- **Professor Kelvin H. Lee**, Chemical Engineering, University of Delaware, KHL@udel.edu
- **Dr. Nancy Kendrick**, Kendrick Laboratories, Inc, nancy@kendricklabs.com
- **Professor Larry I. Grossman**, Molecular Medicine and Genetics, Wayne State University lgrossman@wayne.edu

History First Award Session of the American Electrophoresis Society (3:15 PM)	**Lawrence I. Grossman**, Wayne State University **David E. Garfin**, American Electrophoresis Society
The Importance of Electrophoresis In Protein Analysis: From Sandefjord and Wild Dunes to Minneapolis (3:45 PM)	**Kelvin H. Lee**, Department of Chemical Engineering, University of Delaware
Optimization of Sample Preparation for Two-Dimensional Protein Electrophoresis (3:15 PM)	**Kristin N. Valente**, Leila H. Choe, Abraham M. Lenhoff and Kelvin H. Lee, Chemical Engineering, University of Delaware
Control In Microfluidic Devices (4:45 PM)	**Mark A. Burns**, Chemical Engineering, University of Michigan
Effective Separations: The Key for Proteomics (5:15 PM)	**Phillip C. Wright**, ChELSI Institute, Department of Chemical and Biological Engineering, The University of Sheffield

Award session program available at: http://aiche.confex.com/aiche/2011/webprogram/Session17408.html

Absolutely do *not* miss the AES Plenary Session on Monday Oct 17 in room 101 D of the Minneapolis Convention Center, featuring five notable speakers!

Diffusionless Particle Separation In Coherent Arrays of Flow Perturbers (3:15 PM)		**Eric B. Cummings** **MaxOut Renewables** **ecummings@labsmith.com**
On-Chip Sample Preparation and Nucleic Acid Profiling Using Isotachophoresis (3:45 PM)		**Juan G. Santiago** **Mechanical Engineering, Stanford University** **juan.santiago@stanford.edu**
Acoustically-Driven Microcentrifugation (4:15 PM)		**Leslie Y. Yeo, Micro/Nanophysics Research Laboratory** **Monash University** **leslie.yeo@monash.edu**
Subcellular Complexity, An Electrophoretic Perspective (4:45 PM)		**Edgar A. Arriaga** **Department of Chemistry** **University of Minnesota** **arriaga@umn.edu**
Applications of Micro Free Flow Electrophoresis (5:15 PM)		**Michael T. Bowser** **Department of Chemistry** **University of Minnesota** **bowser@umn.edu**

This year, AES is pleased to team up with the journal ELECTROPHORESIS to publish a special proceedings issue highlighting selected manuscripts associated with work presented in at the AES Annual Meeting. See http://www.aesociety.org/meetings/2011/ for details.