CLEANROOM NEWS

The LCI cleanroom staff has begun to revamp training materials for cleanroom users. Currently, users can access text documents that outline standard operating procedures, cleanroom protocols, and safety information. Cleanroom assistants Bill Eckert, Matt Wayman, and Pat Toothaker are editing video footage for our most common processes at this time, and will continue to add processes as the year progresses. Initial videos are expected to be completed in early September. Doug Bryant will make the materials available to users as they are completed.

A new Electro-Optic Measurement (EOM) setup has been installed by Dr. Vassili Sergan (Cal State Sacramento, formerly a visiting scientist in Dr. Phil Bos’ lab). Those who have used the existing EOM setup in Bos Lab will notice that Dr. Sergan has updated the software package to include “standard” measurement files, and made significant upgrades and improvements to the hardware. The new EOM setup is located in research carrel B.

The MRC sputter coater located on the 1st floor (“MRC Room”) will be upgraded this fall for ITO deposition. A purchase order has been placed with John Tykowski to add a pulsed DC module and third cathode to the machine. It is currently configured to deposit nickel via DC magnetron sputtering and SiO2 via RF magnetron sputtering. Additional repair work on the machine was done in August to repair damage to the computer I/O board caused by a water leak.

The substrate platen on the Asymtek A403 XY Dispenser will be modified this fall to make vacuum hold down possible for various small size substrates. Additionally, the camera illumination will be upgraded so that users can easily view fiducial markings in ITO. These modifications should be complete in early October.

If there are particular pieces of equipment that are of interest to you, or if you would like to see particular capabilities added to the room, please contact Doug Bryant.

PROCESS NOTES: SiO2 and SiOx Post Spacers for Submicron Cells
In most liquid crystal devices, the cell gap is held constant by spacer particles, which can be silica or polymer spheres, or glass fibers. This method works quite well for standard device thicknesses, say 3 to 8 microns. Spacer particles are available in 0.1 micron increments over this range, and can easily be applied by wet or dry spraying. In years past, 3 microns was typically the lower limit of spacer availability, but today spheres are available as small as one micron. Smaller sizes do prevent some challenges, as moisture and static can cause clumping of particles more easily.

Post spacers are now widely used in large area displays such as LCD televisions. Post spacers are rigid, fixed columns that are fabricated by a photolithographic process. Post spacers can be placed in the interpixel areas of a display, and eliminate light leakage. Because many of these large area devices require patterning of protrusions to align the liquid crystal domains within each pixel, it is not unreasonable to pattern spacer posts at or near the same time. Color filter plates already have organic coatings that are several microns thick, and utilizing the same processes and materials allows manufacturers to fabricate posts that are up to 5 microns thick (see ref. 1).

![Figure 1. Rigid post spacer for TFT LCD (from ref 1)](image)

Post spacers are a necessity, however, for most displays with submicron cell gaps, such as ferroelectric displays. Spacer particles are not generally available below 1 micron in size.

Post spacers can be fabricated with organic materials such as photoresist, polyimide, Dow’s cyclotene resins, or the resins used for black matrix in color filters. Being organic, these materials have thermal expansion characteristics similar to liquid crystal, and can expand and contract with temperature without forming voids in the display. However, in a prototyping setting, it can be difficult to adequately pattern thin films of these materials in submicron thicknesses with suitable thickness tolerance.

A simple method to achieve submicron post spacers is to use vacuum evaporated SiO2 or SiOx in a liftoff process (see Figure 2).
Standard photoresist materials, such as Rohm and Haas S1818, can be coated and patterned by the usual photolithographic process to leave an array of holes in the coating. The substrate can then be transferred to a vacuum deposition system to deposit a layer of SiO2 or SiOx of the desired spacer post thickness. The spacer thickness should be less than that of the resist layer, to insure that the underlying resist can be stripped off. After coating, the substrate can be rinsed with acetone to dissolve the resist layer and “lift off” the SiO2 coating on top. This leaves the spacer posts on the substrate (see Figure 3).
There are several important considerations regarding SiO2 post spacer process parameters:

1. The resist layer should be thicker than the post spacers to allow easy stripping
2. The sidewalls of the holes in the resist layers should be vertical to prevent sidewall coverage during deposition, which can cause incomplete removal
3. Evaporative processes are preferred to sputtering, as evaporation is more of a line-of-sight process, resulting in less sidewall coverage
4. Resist stripping may require ultrasonic agitation
5. UV/ozone cleaning may be required before SiO2 coating to guarantee adequate adhesion of the spacer posts—otherwise the posts may be stripped along with the resist

The LCDRF has recently used a lift-off process to fabricate devices with cell gaps of less than 0.5 microns. If you are interested in learning more about this process, or requesting services, please contact Doug Bryant.

References

LCI NEWS

Jakli’s article featured in Chemical Technology

They are a step closer to producing a new generation of energy conversion devices, using flexoelectricity, where materials, such as LCs, convert mechanical energy into electrical energy when they are flexed. Bent-core nematics (BCNs) - LCs made from banana-shaped molecules - are particularly flexoelectric but because of their fluidity, they are not robust or flexible enough to use in energy conversion devices.

To get around this problem, the team used the rubbery properties of a LC elastomer (LCE) to provide a flexible support for the BCN. By swelling the LCE with a BCN, they obtained lightweight films that preserve the pure BCN's strong flexoelectricity but in a more robust and flexible form. The new BCN-LCE material can be used over a wider temperature range than the pure BCN, increasing its viability for device application.

CPIP Faculty Members Take Lead in Organizing Upcoming SPIE Conference
Professor L.C. Chien will chair the SPIE Photonics West OPTO Symposium on Optoelectronic Materials, Devices and Applications: Emerging Liquid Crystal Technologies V at the Moscone Center in San Francisco. Prof. Hiroshi Yokoyama is serving on the program committee.

This conference will focus on current research on emissive, headmount, projection and 3-D displays as well as spatial light modulators. The keynote paper, “Resonantly-pumped optical Kerr nonlinearity in
liquid crystalline materials”, will be presented by Yuen-Ron Shen of University of California-Berkeley, on January 26.

Conference web site: http://spie.org/x13202.xml
Emerging Liquid Crystal Technologies
Advances in Display Technologies

Wei receives Farris Family Innovation Award
CPIP Professor Qi-Huo Wei has been selected as recipient of a Farris Family Innovation Award for his research project entitled, “Development and Fundamental Studies of Biaxial Colloidal Systems”. The competition for the award was very competitive, with 47 applications and only three awards.

Hicks receives IGERT grant to study liquid crystal elastomer biological sensors
Chemical Physics Interdisciplinary Program (CPIP) Student Sarah Hicks recently received a one-year, IGERT (Integrated Graduate Education and Research Traineeships) grant from the National Science Foundation. Three IGERT grants were awarded to Kent State University under Principal Investigator Professor Laura Leff of the KSU Biological Sciences Department. Hicks, who will receive a one-year $30,000 stipend, will do interdisciplinary research on a project involving environmental sensing in fresh water systems.

Under the direction of CPIP Professors Deng-ke Yang and Qi-Huo Wei, Hicks will make liquid crystal elastomers to be used as sensors of bacteria and toxin levels. She will attend the first trainee workshop from September 17-20 at Lake Lacawac in the Poconos Mountains of Pennsylvania. In addition, there will also be education outreach and business entrepreneurship components of the project.

Upcoming Events
September 24-26, 2009 – 5th International Liquid Crystal Elastomer Conference – Liquid Crystal Institute, Kent State University: http://ilcec2009.lci.kent.edu
Following the tradition of previous ILCEC in Ljubljana (2007), Cambridge (2005), Bleibach (2003) and Ebernburg (2001), the aim of the conference is to bring together physicists, chemists, mathematicians, materials scientists and engineers active in the field of liquid crystal elastomers. Experimental, theoretical, and technical results will be discussed through talks (invited and contributed) as well as poster presentations.

As part of the ILCEC, a Public Lecture, “Liquid Crystals and Rubbers: Combining Scientific Fields for New Technologies” will be given by Professor Jonathan Selinger on Saturday, September 26 at 9 a.m. in the Samsung Auditorium at the Liquid Crystal and Materials Science Building.

Recent Events
On July 8-10, the 1st NSF-OTKA Symposium for Complex Fluids was held in Eger, Hungary. See the conference web page: http://www.lci.kent.edu/crelic_ires/symposium.htm and related IRES project: http://www.lci.kent.edu/crelic_ires/index.html

Recent Seminars
September 2, Prof. Ji-Ping Huang, Department of Physics, Fudan University, Shanghai, "Physics Meets Economics: Econophysics" (click link for video in Real Media format)

Upcoming Seminars
September 16, Prof. Martin Bier, Department of Physics, East Carolina University, NC, "The Biological Significance of the Lipid Bilayer's Melting Transition"
September 23, Prof. Slobodan Zumer, University of Ljubljana & Jozef Stefan Institute Faculty of Mathematics and Physics, Slovenia, Title: T.B.A.

September 30, Prof. Scott Milner, Department of Chemical Engineering, Penn State University, PA, “Crystal-Melt Interfaces, Rotator Phases, and Nucleation in Polyethylene”

December 9, Prof. Hartmut Lowen, Institute for Theoretical Physics I - Soft Matter, Heinrich-Heine-Universitat Dusseldorf, Title: T.B.A.

Recent Talks by CPIP Faculty


Recent Publications

Prof. Antal Jakli recently published:


Prof. Oleg Lavrentovich recently published:


Prof. Jonathan Selinger recently published: 

New Faces at LCI
Donald Diehl, Senior Research Associate, joined LCI on September 1.

Postdoctoral Fellows Chris Grabowski & Gyanu Acharya will work in Professor Peter Palffy-Muhoray’s group.

Li-Mei Jin, postdoctoral fellow, will work in Quan Li’s group.

The Chemical Physics Interdisciplinary Program welcomed 13 new students this Fall. They include: Nik Glazar, William Ryan, Emine Kemiklioglu, Jia Ning Chen, Young-Ki Kim, Cuiyu Zhang, Shuojia Shi, Jie Xiang, Hsien-Hui Cheng, Shuang Zhou, Da-Wei Lee, Mikhail Pevnyi, and Jason Morvan.

On the web
CPIP Virtual E-Bookshelf
Professor Robin Selinger and CPIP Student Jun Gen have put together a list of e-books that cover topics such as liquid crystals and soft matter; statistical mechanics/phase transitions; simulation and modeling; mathematics; chemistry; optics and electromagnetism; experimental techniques; and computer programming, graphics, image processing.
Go to: http://www.lci.kent.edu/cpip_e_bookshelf.html

Lab Video
Professor Antal Jakli’s group has posted a video demonstration of Giant Flexoelectricity in Bent Core Nematic Liquid Crystals. Go to: http://realserver.lci.kent.edu/ramgen/Seminars_2009/giant_flexo.rm
(Note: You will need Real Media Player to see this video)

TECHNOLOGY TRANSFER
A grouping of Kent State University-owned patents available for licensing is featured this month. This cluster encompasses various loosely-related technologies focused on alignment options in liquid crystal (LC) displays. Companies with interests in licensing these are urged to contact the university’s Office of Tech Transfer and Economic Development (see below) as soon as possible!

PATENTS IN THIS GROUP OF DISPLAY/ALIGNMENT TECHNOLOGIES INCLUDE:

- US 5,145,999 and US 5,280,103 (KSU.209 & 209A) – Perfluoroalkylated amines and polymers made therefrom;
- US 5,118,880 (KSU.211) - Method of preparing 2-bromo-4,6-dinitromesitylene;
- **US 6,067,139 (KSU.304)** - Multi-domain stn LCD comprising fluorinated polyimide alignment layers;
- **US 5,856,432 and US 5,731,404 (KSU.305 and 306)** - Polyimide films from pyromellitic dianhydride and a bis (4-aminophenoxy) aromatic compounds as alignment layers for LC displays;
- **US 5,670,609 (KSU.307)** - Polyimide films from pyromellitic dianhydride and 2-2’-bis(perfluoroalkoxy) benzidines as alignment layers for LC displays;
- **US 5,936,691 (KSU.177)** - Method of preparing alignment layer for use in LC devices using in-situ ultraviolet exposure;
- **US 6,927,823 (KSU.188)** - Method for alignment of LCs using irradiated LC films;
- **US 6,939,587 (KSU.201)** - Fabrication of aligned LC cell/film by simultaneous alignment and phase separation;
- **US 7,075,613 (KSU.224)** - Electro-optical display with in-situ polymerized columns providing alignment and structural bond between substrates; and

For more information on these and other useful technologies for license, please contact us!
Office of Technology Transfer and Economic Development, Kent State University
[www.techtrans.kent.edu](http://www.techtrans.kent.edu) (Please visit the “For Industry” section of our website)

**Licensing Information Contacts:**
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**FACULTY PROFILE**

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**Research Interests**
- Computational materials science; molecular scale and mesoscale simulation techniques applied to both hard and soft condensed matter
- Liquid crystals: phase behavior, transport, and microstructure
- Chirality in soft condensed matter
• Fracture and deformation of crystalline solids: size effects in plasticity, dislocation dynamics and patterning, dynamic fracture

Current Research Activities
• **Modeling shape change and microstructural evolution in liquid crystal elastomers.** Co-I: Jonathan Selinger. Grad students: Badel Mbanga and Vianney Gimenez. Postdoc: Fangfu Ye (now at Urbana.) Senior collaborator: Ratna (NRL).
• **Theoretical and computational studies of topological defects in soft materials in curved geometries.** Co-I: Jonathan Selinger. Grad student: Lena Lopatina. Undergrad: Andrew Konya. Senior collaborator: Alex Travesset (Iowa State.)
• **Modeling multicomponent nucleation in the atmosphere.** Co-I: Shanhu Lee. Undergrad: Joshua Gaffen (REU student.) Project is in start-up phase.
• **Simulation studies of switching in flexible cholesteric displays.** Co-I: Sherrie Schofield-Tomschin, who is working on fashion applications of KDI’s color e-skin materials. Grad student: Vianney Gimenez.
• **Active nematics.** I have begun an exploratory simulation study of self-propelled mesogens which resemble crawling segmented worms. To date we have demonstrated an isotropic/nematic transition as a function of mesogen density. This work represents a possible future collaboration with Christina Marchetti and Aparna Baskaran.
• **Modeling plasticity in crystalline solids.** This work was begun when I worked at Catholic University. Work in similar areas continues by contractors doing research at NIST under the supervision of Dr. Lyle Levine.

Publications

Badel Mbanga
Ph.D. Candidate
Liquid Crystal Institute &
Chemical Physics Program
330-672-7999
**Long Term Interests**
Conduct research and teaching at a major University. My research will focus on using methods of statistical and computational physics to tackle complex interdisciplinary problems in soft condensed matter, biomedical sciences, and social sciences.

**Short Term Interests**
In the near future, I would like to work as a postdoctoral fellow or research scientist in a research center/institute or R&D division of a company.
The following are the areas in which I have experience and interest in doing further work.
- Simulations of soft matter (Liquid Crystals, polymers…)
- Monte Carlo simulations, Molecular dynamic simulations.
- Parallel Programming and scientific visualizations.

**Current Research Project**
Using finite element simulations to study the intricate mechanical behavior of liquid crystal elastomers under the influence of external stimuli. The goal is to bridge the gap between the microscopic theory of these materials and their engineering device applications since they pose as excellent candidates for application in artificial muscles, robotics, and microfluidics.