CLEANROOM NEWS

Process Spotlight: Ultrasonic Glass Cleaning

Glass cleaning is the single most fundamental process in liquid crystal display prototyping. The cleanliness of the substrate surface affects adhesion, thin film quality, and cell gap nonuniformity, and cleaning steps are utilized between virtually every other process step during fabrication. Although the complexity of the device and cell gap / drive voltage impact the level of cleanliness required, ultrasonic cleaning is still the predominant method for cleaning LCD glass. In this month’s process spotlight, we will discuss ultrasonic cleaning. Next month we will cover megasonic cleaning.

Ultrasonic is usually a tank-based cleaning method. A process tank is filled with fluid. This can be deionized water, to which a neutral or alkaline detergent may be added, or it can be an organic solvent (use of solvents is more typical with ultrasonic degreasers, which we will not discuss here). Attached to the tank bottom are piezoelectric or magnetostrictive transducers, which couple vibrations through the tank into the bath. Vibrational frequencies are typically 40-100 kHz for ultrasonic cleaners; the name ultrasonic is used because these are ultrasound frequencies (the upper limit of the audible range is ~20 kHz).

Fig 1. Ultrasonic Cleaning fundamentals: cavitation. Image from Fuchs, F. John, “Ultrasonic Cleaning: Fundamental Theory and Application”
Figure 1 illustrates the underlying process of ultrasonic cleaning. The ultrasonic vibrations cause pressure fluctuations as they move through the fluid. As the low pressure portion of the wave moves through the tank, it forms microscopic bubbles (voids, or vacuoles), a process called cavitation. As the high pressure portion of the wave then moves through, these vacuoles shrink and then violently collapse, or implode. The collapse of this bubble causes a high pressure jet which can generate as much as 10,000 psi of pressure, enough to dislodge very small particles from a surface (despite their small cross-sectional area). In combination with an effective detergent, this can also quickly dissolve and remove film contamination. Neutral pH detergents are most suitable if a wide range of substrate types are to be cleaned, but tends to leave a residue that must be thoroughly rinsed. Alkaline cleaners are more effective, but must be tested to ensure compatibility with each substrate type.

**Practical considerations**

In practice, many ultrasonic cleaners sweep frequencies of the transducers to minimize damage to substrates that may be caused by standing waves. This can lead to localized hot spots, which can damage sensitive substrates or films. Localized temperatures can reach thousands of degrees at the site of implosion. Though this is a very small area, with little thermal mass, it is easy to see how this has the potential to damage a substrate with patterned thin films, or a flexible plastic substrate. Sensitive substrates can be protected by decreasing intensity of the agitation, or by continually moving the parts to different positions in the bath.

The frequency used in ultrasonic cleaning will have a direct effect on bubble size (see Fig 2 below). The energy delivered will then have an effect on how many bubbles are generated. Delivery of the same energy level to a lower frequency system and a higher frequency system will lead to formation of more bubbles (but with lower bubble energy) in the high frequency system. Industrial systems that require large tanks typically use frequencies between 20 and 50 MHz, while smaller tank systems often use higher frequencies.

![Fig. 2. Bubble size vs. frequency of transducers. From “Application of Multiple Frequency Ultrasonics”, F. John Fuchs and William L. Puska](image)

The bubble size is important because of the boundary layer effect. The physical size restricts how close bubbles can get to the surface (see Fig 3 below). This limits the size of particle that can be removed by a given system. Higher frequencies allow greater penetration to the surface, but create lower energy bubbles that might not remove larger particles. The ideal situation is to have a range of frequencies that allow removal of all particle sizes. In general, as is can be deduced from Fig 3, ultrasonic cleaners are most effective at removing particles as small as 1-3 microns, but are not as efficient for smaller particles.
Modern process tanks may have multiple transducer sets to generate different frequencies, or may be capable of using the same transducers to generate multiple frequencies. This can enhance cleaning efficiency over a wide range of particle sizes.

Next month we will discuss megasonic cleaning, which is more efficient at removing submicron size contamination.

The LCDRF has a **Zenith Ultrasonics Cleaner** (which uses 80 kHz frequency) and an in-bench **Crest Ultrasonic Cleaner**. If you would like further information on these tools, or would like to arrange access, please contact Doug Bryant.

**References**


Quite a bit of useful information is available from equipment manufacturer websites:


**CLEANROOM NEWS**

There will be two new undergraduates working in the cleanroom this semester. Bill Eckert is a junior Industrial Technology major, and Pat Toothaker is a sophomore studying physics. Kevin Ballard will be working with us again this year, but Matt Wayman has transferred to another university and will not return.

Some reorganization of cleanroom floor space will take place during August and September. Dr. Jon Ruth, who is part of the FlexMatters initiative headed by John West, has already moved the **Dimatix Desktop Inkjet Printer** to the first floor teaching lab. The **ITI Inkjet Printer** and the **Spectra Apollo II Drop Watcher** will also be relocated at a future date, although this will depend upon FlexMatters securing space for these tools. In the coming months, LCDRF staff will be evaluating the status of under-utilized equipment in the cleanroom as well, with the intention of either returning them to working status, or decommissioning them.
The **ACF Bonding Station** has been relocated to the first floor, in the same room as the **MRC 603III Sputter Coater**. It has been reinstalled, and is available for use with the assistance of Dr. Bentley Wall.

**LCI NEWS**

**Upcoming Conferences**

**Symposium on “Thermotropic Biaxial Nematic Liquid Crystals”**

**Kent State University, October 27-28, 2008**

*If you are interested in submitting an abstract for poster presentation, please contact: Professor David Allender, dallende@kent.edu, phone: (330)672-0345; or contact the Organizing Committee Members.*

The field of biaxial thermotropic liquid crystals has seen a rapid resurgence with the recent discovery of its existence in bent-core, tetrapodic, and polymeric mesogens and in mixtures of rods and discs. This Symposium will assess where the field stands, identify the important questions to address, research directions to take, and provide opportunities to renew or establish productive collaborations.

There is no registration fee. Partial travel support for invited speakers and young researchers may be available. To submit an abstract contact the Symposium Chair. To apply for support, send the Symposium Chair an email with subject: “Symposium support”.

Invited Speakers:
- B. Acharya (USA), N. Clark (USA), R. Dong (Canada), H. Gleeson (UK), M. Lehmann (Germany), L. Longa (Poland), G. Mehl (UK), V. Prasad (India), S. T. Shin (Korea), E. Virga (Italy)

Organizing Committee:
- Satyen Kumar, S. Sprunt, D. Finotello, O. Lavrentovich, Q. Li, A. Jakli

**OPTO (part of SPIE Photonics West)**

**January 24-29, 2009**

**San Jose Convention Center**

**San Jose, CA, USA**

OPTO 2009 addresses the latest advances in a broad range of optoelectronic technologies and their integration for a variety of applications. Professor L.-C. Chien will chair a program on Displays and Holography.

[http://spie.org/opto.xml](http://spie.org/opto.xml)

**Past Conferences**

**Liquid Crystal Day 2008** was a real success for all involved. We’d especially like to thank the industrial exhibitors and entrepreneurial panelist who dedicated their time including Bahman Taheri (AlphaMicron), Albert Green (Kent Displays, Inc.) and LXD, Inc. To view photos, learn more and check out some of the event highlights go to: [http://www.lcd.kent.edu](http://www.lcd.kent.edu)

**Masters Defense: Lisa Green**

On September 15, CPIP Student and LCI Senior Chemist, Lisa Green, defended her master’s thesis: “Synthesis and Characterization of Photochemically Tunable Chiral Materials for Optically Addressed Cholesteric Displays”.

**LCI Recent Publications**


New Faces at LCI
Dr. Yannian Li arrived on 9/16/08 to work as a postdoctoral fellow in Quan Li's lab.

Two visiting students, Gabor Toros and Peter Salamon, from the University of Technology and Economics in Budapest, Hungary, are here for 4 months working on grant research with Tony Jakli and Jim Gleeson.

Ebru Buyuktanir (former CPIP student) is now a postdoctoral fellow in John West's lab.

LCI says farewell to Senior Chemist: Lisa Green
Lisa Green who had served as LCI’s Senior Chemist for just over one year has left to pursue a career in her native state of Michigan. We wish her the best. Green recently defended her Masters thesis. (see above story)

Recent LCI Seminars
(Note: IPP members can see videos of these and other recent seminars on the LCI Connection page of the IPP web site)

September 10: Dr. Hiroshi Yokoyama, National Institute of Advanced Industrial Science and Technology (AIST), "Nano-Craft of Liquid Crystal Surface Alignment: Theory and Implementation"

September 24: Prof. Igor Sokolov, Department of Physics and Department of Chemical and Biomolecular Science, Clarkson University, "Liquid Crystal Template Self-Assembly of Nanoporous Particles: Shape Control and the Applications"

September 26: Dr. David Siegel, Givaudan Flavors Corporation, Cincinnati, OH, "Membrane Fusion: just a passing phase"
Note: This was a joint seminar with Department of Biological Sciences.
October 6: Dr. Ivan Dozov, Vice President for Research and Development, Nemoptic, Magny les Hameaux, France, "Weak anchoring and anchoring breaking in liquid crystals: Basic Physics and Applications"

Upcoming LCI Seminars
October 15: Prof. Paul Cremer, Department of Chemistry, Texas A&M University, "Using Supported Bilayers as a Separation Matrix for Proteomics"

October 27: (Monday): Dr. A. Schönle, Department of NanoBiophotonics, Max Planck Institute, Germany, "Fluorescence Nanoscopy Through Optical Switching"

November 5: Prof. Peixuan Guo, Dane and Mary Louise Miller Endowed Chair in Biomedical Engineering, University of Cincinnati, "Single molecule detection of six pRNAs and direct observation of phi29 DNA-packaging motor with customized single molecule dual-view system”
Note: This is a joint seminar with the Department of Biological Sciences

November 19: Prof. Nongjian Tao, Department of Electrical Engineering & School of Materials Research, Arizona State University, Title: T.B.A.

December 10: Prof. Nader Engheta, H. Nedwill Ramsey Professor of Electrical and Systems Engineering, and Professor of Bioengineering, University of Pennsylvania, "Circuits with Light at the Nanoscale: Metananocircuits and Metactronics"