

# ALCOM Update

NSF Science and Technology Center for Advanced Liquid Crystalline Optical Materials

Consortium of Kent, Case Western Reserve, and Akron

VOL. 8, No. 1

JUNE 1998

## From ALCOM labs to the marketplace: A technology for improved LC displays

Liquid crystal technology continues to grow throughout the world; it has become the dominant flat panel display technology because of its low power consumption. Research continues to increase LCD performance, particularly to improve the viewing angle of displays.

Thin-film transistor active matrix displays offer the advantages of high information content, color capability, broad gray scale and fast response. TN displays have been extensively used in televisions, lap-top computers and information-re-

lated displays. A major drawback of this technology is the narrow range of viewing angles. When used in avionics and surgical visual instrumentation wide viewing angle is essential.



Prof. Stephen Cheng (2nd from left) with his research group (l-r) Bret Calhoun, Ian Mann, and Fuming Li

One way to improve the viewing angle of a liquid crystal display is to add a negative birefringence compensation film.

Early methods for forming compensation films include vapor deposition of small molecules which proved to be expensive, slow, and environmentally sensitive, and stretching of polymer films which proved difficult to control uniformly.

Frank Harris and Stephen Cheng (University of Akron) in collaboration with Jack Kelly, Deng-Ke Yang, and Phil Bos (Kent State University) developed negative birefringence retardation films based on a series of soluble, segmented rigid rod polymers which can be spin coated using ordinary organic solvents.

Negative birefringence results when thin films are cast from solution, causing

**Technology**, continued on page 4

## Phase Separation workshop held at Courant Institute

by Peter Palffy-Muhoray

The mission of ALCOM's Heterogeneous Structures Project is to study phase separation and other processes which produce heterogeneous liquid crystal materials and to understand the relation between morphology and physical properties and response. To further this mission, an informal workshop brought together ALCOM researchers and colleagues from other universities, industry, and govern-

ment laboratories.

In addition to the ALCOM university consortium of Kent, Case Western Reserve, and Akron, participating institutions included New York University, UCLA, UC Santa Barbara, NIST, and IBM.

The ALCOM/CIMS/NIST Workshop on Phase Separation was held April 25-26, 1998, at the Courant Institute of Mathemat-

**Workshop**, continued on page 2

## RESEARCH NOTES

### White Reflective Displays from Polymer-Stabilized Cholesteric Textures

Reflective liquid crystal displays are ideal for portable systems because of their very low power consumption. Chien's group (Julie Cho and Dr. Nathalie Leroux) reports a white reflective display using the polymer-stabilized cholesteric texture technology.

The new system is prepared by photopolymerizing a small quantity of a chiral monomer in a cholesteric host. The polymerization is carried out at the homeotropic texture of the cholesteric host under an applied field. After the polymerization, the chiral polymer network phase separates into micron-size twisted pillars (Fig. 1) which provides additional chirality and influences the

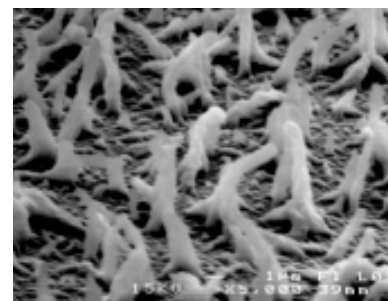


Fig. 1. SEM Photo

pitch and orientation of helical axes of the cholesteric liquid crystal.

The optical responses of a white reflective PSCT cell are studied using a spectrometer under diffuse lighting conditions. A red mixture which Bragg reflects the wavelength of 695 nm (a) is added with a chiral monomer (3.5%), resulting in a blue reflected color having the wavelength of 450 nm (b). The

**Notes**, continued on page 5



## FROM THE DIRECTOR

# A busy spring for ALCOM

by John L. West

ALCOM researchers had a productive spring, presenting 27 papers at the May SID meeting in Anaheim, CA; offering a week long short course in early June; and bringing on-line the new clean room and display pilot line in the LCI. Rohm and Haas, National Semiconductor, and Eastman Kodak joined our Industrial Partnership Program, bringing total membership to 31.

We have just balloted three new technologies resulting from ALCOM research. We wrapped up the spring with a mini-retreat which gave ALCOM principal investigators an opportunity to share our research and ideas.

We are pleased to announce that an industrial partner, Kent Displays Incorporated,

won the prestigious product of the year award from *Electronics Products* magazine.

Moving into summer we are looking forward to the 17<sup>th</sup> International Liquid Crystal Conference where ALCOM principal investigators, postdoctoral fellows, and graduate students will give over thirty oral and poster presentations. During the summer we will continue to explore ways of continuing ALCOM after this round of NSF funding ends in January 2002. Later this summer we will announce a fall or winter ALCOM symposium.

Have an enjoyable and productive summer and I hope to see you in Strasbourg.

## Workshop, from page 1

cal Sciences, New York University.

The two-day meeting consisted of seventeen participants including faculty, research scientists, and graduate students. The aim of the meeting was to coordinate research efforts by establishing common perspectives and goals, and to identify key areas for future work.

Informal presentations covered a wide variety of topics ranging from polymerization reactions and photochemistry through experiments probing phase separation and the response of heterogeneous liquid crystalline materials to theory, modeling and numerical simulations, as well as information management for the project (<http://cpip.kent.edu/PSP>).

New phenomena, such as electric and optical field effects on phase separation, and new experimental and numerical techniques were also described. Discussions were held during and after the presentations.

The workshop banquet, sponsored by CIMS, was held Saturday evening and provided an informal setting for further discussions. The workshop concluded Sunday af-



Workshop participants: (seated l-r) S. Hudson, S. Glotzer, A. Liu, A. Lapena; (2nd row) P. Palffy-Muhoray, W. E. P. Taylor, T. Kyu, G. Held, L. Bartolo, C. Muratov, R. Nyquist; (3rd row) F. Otto, B. Taheri, D. Yang, R. Ennis, and C. Snively.

ternoon by underlining research priorities for the project.

The informal setting and the enthusiasm of participants from diverse backgrounds made this workshop most stimulating and enjoyable. New collaborations and the exchange of information resulting from the workshop are expected to contribute to the progress of research in the Heterogeneous Structures Project.

For more information contact Peter Palffy-Muhoray ([mpalffy@cpip.kent.edu](mailto:mpalffy@cpip.kent.edu)), Sharon Glotzer ([glotzer@ctcms.nist.gov](mailto:glotzer@ctcms.nist.gov)) or Steve Hudson ([sdh6@po.cwru.edu](mailto:sdh6@po.cwru.edu)).

# ALCOM

NSF Science and Technology Center  
for Advanced Liquid Crystalline Optical Materials  
Consortium of Kent, Case Western Reserve and Akron

Director - J.L. West

Associate Director - J.L. Koenig

## ALCOM PIS

Kent State University

D.W. Allender, L. M. Bartolo, P.J. Bos,  
L.-C. Chien, P. Farrell, D. Finotello,  
J.E. Fulghum, E.C. Gartland,  
J.R. Kelly, S. Kumar, O.D. Lavrentovich,  
M.E. Neubert, P. Palffy-Muhoray, A. Ruttan,  
S. Sprunt, R.J. Twieg, J.L. West, D.K. Yang

University of Akron

S.Z.D. Cheng, F.W. Harris, T. Kyu

Case Western Reserve University

W.L. Gordon, S.D. Hudson, A.M. Jamieson,  
J.L. Koenig, J.B. Lando, J.A. Mann,  
R.G. Petschek, C. Rosenblatt, D.E. Schuele,  
K.D. Singer, P.L. Taylor, S.Q. Wang

John Carroll University

M.R. Fisch

## ALCOM Advisory Board

Dr. P.E. Cladis, Advanced LC Technologies  
Dr. Noel Clark, University of Colorado  
Dr. J. William Doane, Kent Displays Inc  
Dr. Paul Drzaic, Electronic Ink  
Dr. Curtis W. Frank, Stanford University  
Dr. William Glenn, Florida Atlantic University  
Dr. Sharon Glotzer, NIST  
Dr. Anselm Griffin, U. of Southern Mississippi  
Dr. Glenn Held, IBM  
Dr. Juergen Pohlmann, Department of Defense  
Dr. Y.R. Shen, UC Berkeley  
Dr. George W. Smith, GM Research Labs  
Dr. Sukant Tripathy, U. of Massachusetts Lowell  
Dr. Bruce Winker, Rockwell International

ALCOM Industrial Partner Liaison

Dr. Bahman Taheri

ALCOM Education Project Coordinator

Dr. Maxwell I. Godfrey

ALCOM Newsletter Editors

Elaine Landry and Brenda Buck

ALCOM is a periodic publication of the NSF  
Science and Technology Center for  
Advanced Liquid Crystalline Optical Materials  
Mailing Address: Liquid Crystal Institute  
Kent State University, Kent, OH 44242-0001  
Tel: (330) 672-2654; Fax: (330) 672-2796  
e-mail: [brenda@scorpio.kent.edu](mailto:brenda@scorpio.kent.edu)

## New photoaligning materials subject of international ALCOM collaboration

**D**r. Yuri Reznikov from the Institute of Physics of the Ukrainian National Academy of Science is visiting the Liquid Crystal Institute for a six-month research collaboration with ALCOM principal investigators. Reznikov, John West (KSU) and Chuck Rosenblatt and Ken Singer from Case Western Reserve University (CWRU) are researching and developing new photoaligning materials and then studying the light-induced orientation effects in liquid crystal cells with these materials.

Dr. West is the host scientist for Dr. Reznikov's visit, sponsored by the ALCOM Visiting Scientist program and a grant from the U.S. Civilian Research and Development Foundation.

"It is a privilege for me to have the opportunity to work closely with Yuri for this extended period," said West. "He is full of ideas for new research directions."

The light-induced orientational effect is being studied as a more efficient method for aligning materials than rubbing where consistency is difficult to achieve. Currently, the research area of light induced orientation effect is important in liquid crystal science and technology because it has the ability to eliminate problems specific to rubbing. Dust and static electricity are two problems created with the rubbing technique that can destroy a liquid crystal display. Neither of these factors is present using the light induced orientation effect.

The ALCOM center offers Reznikov the opportunity to draw on expertise from the Liquid Crystal Institute as well as CWRU. Reznikov works with West on research and development of new photoaligning materials and then collaborates with Professor Rosenblatt (CWRU) to test the surfaces using a birefringent

technique. These studies will then be supported by Professor Ken Singer (CWRU) using the second harmonic generation technique.

Dr. Reznikov anticipates the collaboration will reveal interesting effects in liquid crystals such as controlling liquid crystal properties by the action of light on the aligning surface. It is hoped that these discoveries will prove useful in real applications leading to use in manufacturing.

He has studied light induced orientation effects for ten years and is a co-author of a patent on the technology.

"I came to conduct research at the LCI because it is a really famous institute," said Reznikov, "but also because the atmosphere at

the LCI is very friendly. It is very easy to interact with scientists in different areas. It is my sincere pleasure to be here at LCI."

This is not the first visit to Kent for Dr. Reznikov. He visited the LCI in 1993 and has returned four times to collaborate with ALCOM scientists.

Reznikov said that other scientific centers may be able to conduct the same research but it is difficult to find the cooperation and friendly atmosphere that he has found through the ALCOM Center.

Dr. Reznikov is head of the Crystals Department at the Institute of Physics, Ukrainian National Academy of Science. He earned a Ph.D. in 1984 and a Doctor of Science in 1994 from the Institute of Physics.

If you would like more information on Dr. Reznikov's research, he may be contacted at the LCI until August 1, by phone: (330) 672-3999 ext. 333 or e-mail: [yuri@lci.kent.edu](mailto:yuri@lci.kent.edu).



"High Resolution Electron Microscopic Investigation of the Frustrated Packing of a Semiflexible Liquid Crystalline Polyester," H.-T. Jung, S.D. Hudson, R.W. Lenz, *Macromol.* **31**, 637 (1998).

"Finite Element Analysis of the Landau-de Gennes Minimization Problem for Liquid Crystals," T.A. Davis, E.C. Gartland, Jr., *SIAM Jnl. Num. Analysis* **35**, 336-362 (1998).

"Measurements of Kleinman-Disallowed Hyperpolarizability in Conjugated Chiral Molecules," S.F. Hubbard, R.G. Petschek, K.D. Singer, N.D'Sidocky, C. Hudson, L.C. Chien, C.C. Henderson, P.A. Cahill, *J. Opt. Soc. Amer B* **15**, 289-301 (1998).

"Modeling Relaxation Processes in Poled Electro-Optic Polymer Films," R.D. Dureiko, D.E. Schuele, K.D. Singer, *J. Opt. Soc. Am. B* **15**, 338-350 (1998).

"Critical Behavior of a Smectic-A to Nematic Phase Transition Imbedded in a Random Network of Voids," S. Qian, G.S. Iannacchione, D. Finotello, *Phys. Rev. E*, **57**, 4305-4315 (1998).

"Unipolar Electro-Optic Effect in a Nematic Cell," V.G. Nazarenko, R. Klouda, O.D. Lavrentovich, *Phys. Rev. E* **57**, R36-R38 (1998).

"Topological Defects in Dispersed Liquid Crystals, or Words and Worlds Around Liquid Crystal Drops," O.D. Lavrentovich, *Liq. Cryst.* **24**, 117-125 (1998).

"Tilted Photoalignment of a Nematic Liquid Crystal Induced by a Magnetic Field," D. Andrienko, Y. Kurioz, Y. Reznikov, C. Rosenblatt, R. Petschek, O.D. Lavrentovich, D. Subacius, *J. Appl. Phys.* **83**, 50-55 (1998).

"Crossing of Disclinations in Nematic Slabs," T. Ishikawa, O.D. Lavrentovich, *Europhys. Lett.* **41**, 171-176 (1998).

"Mechanism of Unidirectional Liquid-Crystal Alignment on Polyimides with Linearly Polarized Ultraviolet Light Exposure," M. Nishikawa, B. Taheri, J.L. West, *Appl. Phys. Lett.* **72**, 2403-2405 (1998).

# Kent Displays receives prestigious product of the year award

*Electronic Products* magazine selects several products of the year from among thousands of new products introduced. The selections are based on significant advances in technology or its application, a decided innovation in design, or a substantial gain in price-performance. Among those selected this year is the KDS Infosign reflective cholesteric LCD module from Kent Displays, Inc.

The KDS Infosign is a cholesteric LCD (ChLCD), capable of generating a digital image that can last for months, even years, after the power is removed.

Signage such as transportation systems, airport flight schedules, and theatre billboards will benefit from this technology because of its low energy consumption and the ability to quickly change the information displayed using computers.

A display can go for a period of months without a recharge of batteries, and can be radio addressed from a PC. The display, therefore, is portable and does not need to be tethered to the wall with AC power cords or cables to the computer.

The reflective display does not require backlighting or polarizers. Readability is excellent in sunlight or low light at any angle.

The technology used for the Infosign was pioneered at the Liquid Crystal Institute (LCI) at Kent State University. Through collaboration with the LCI, Kent Displays has expanded their ChLCD technology considerably in the areas of electronic drive, materials, color, and response time. The advanced ChLCD builds on the strengths

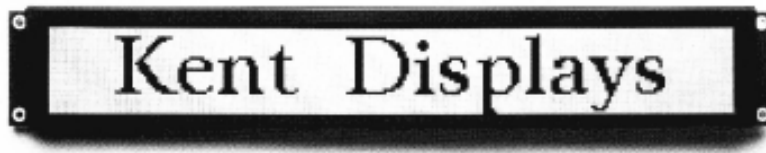
effits provided through the ALCOM Industrial Partnership Program such as access to the new clean room facility.

According to Joel Domino, chief financial officer of Kent Displays, "Our alliance with the Liquid Crystal Institute is a tremendous advantage. We make use of their R&D facilities and get outstanding technical support."

The mission of Kent Displays is to provide ChLCD products that will allow greater information content to be available to anyone, anywhere. Their manufacturing philosophy is focused on fabricating products to provide the highest quality and most reliable delivery to their customers.

The company is committed to maintaining their technical advantages by devoting considerable resources to the improvement of product performance and versatility. Beginning in 1996, one-half of their technical resources were dedicated exclusively to R&D efforts.

Kent Displays joined the ALCOM Industrial Partnership in 1993.



The KDS 3077-xxx Infosign reflective cholesteric liquid crystal display (ChLCD)

of LCD technology and eliminates the disadvantages of power usage and viewing angle. Power is required only to change the information displays.

At the heart of Kent Displays is a group of display professionals with over 75 years of cumulative experience. Additionally, the company works closely with LCI researchers and takes advantage of the many ben-

## Technology, from page 1

the linear chains of the polymer to orient randomly in the plane of the film. The linear chains form an orientationally ordered polymer with a negative order parameter (see Fig. 1). The magnitude of the negative birefringence is controlled by adjusting the chain linearity and backbone stiffness.

The Akron research team has developed commercially viable synthetic routes for these materials. The new negative birefringence film can therefore be produced on a large scale at a reasonable cost.

Kent researchers modeled and measured the optical performance of devices utilizing these negative birefringence retardation films. They demonstrated that while these films widen the viewing angle of liquid crystal displays, they do not improve the gray scale performance of LCDs at wide viewing angles. Modeling work predicts that gray scale will be improved when the optic axis of the polymer film is tilted at an angle to the normal. This prediction has spawned ALCOM research to develop such films us-

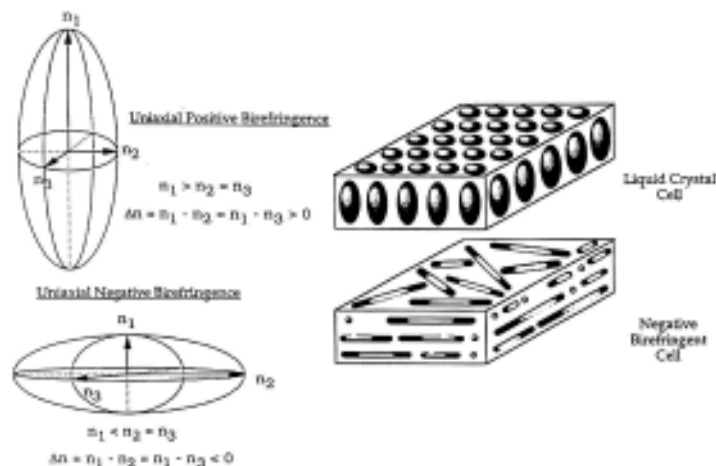


Fig. 1 Optical principle of the NW-TN-LCD with a UNB compensator

ing photopolymerizable discotic liquid crystals.

ALCOM researchers began work on this problem following an ALCOM symposium on *Novel Liquid Crystal Materials and Optical/Electro-Optical Effects* held November, 1991. ALCOM researchers developed the technology quickly and effec-

tively through teamwork. The technology was offered for licensing to ALCOM Industrial Partners within 18 months.

"This progress is a typical example of cooperation between the Liquid Crystal Institute and the University of Akron," according to Dr. Stephen Z.D. Cheng (UA).

"Dr. Fuming Li, a postdoctoral fellow in my laboratory, conducted a majority of the Akron portion of the research on the problem. We couldn't have solved the problem without the collaborative efforts within the ALCOM Center."

## ALCOM participates in K-12 science fair

ALCOM's ongoing commitment to K-12 Education involves students of all ages by providing demonstrations and lessons showing how liquid crystals touch their lives. Elementary school children learn that liquid crystals are found in soap bubbles, something with which they can identify. High school students learn about the physics of controlling liquid crystals with electricity.

As part of the continued effort to educate students, ALCOM participated in the Portage County Science Fair, "Destinations in Science," held at Kent State University, March 7, 1998. In addition to the presentations by students, participants and their

parents attended various demonstrations involving liquid crystals, physics, and chemistry.

Dr. Max Godfrey, ALCOM Education Project Coordinator, demonstrated the unique properties of liquid crystals and showed how liquid crystal technology impacts our lives.

Mr. Doug Bryant, Display Engineer at the LCI, gave students and parents a view through PDLC switchable windows into the new clean room. He explained how the equipment works and how important clean room technology is to the liquid crystal display industry.

## Liquid crystals short course held at Kent

*Liquid Crystals: Materials and Display Devices*, was the topic of an ALCOM short course held at the Liquid Crystal Institute, June 2-5, 1998. The course was taught by university faculty with active research and a minimum of ten years experience in the areas covered by their lectures. Speakers included D.W. Allender (Kent Physics Dept.), P.J. Bos (LCI), J.R. Kelly (LCI), C. Rosenblatt (CWRU Physics Dept.), John L. West (LCI), and Deng-Ke Yang (LCI)

The three and one-half day course consisted of four morning lectures and three afternoon laboratory sessions. In the labs, participants experienced hands-on construction of small liquid crystal cells demonstrating the principles of polymer dispersed liquid crystals (PDLC), twisted nematic (TN), supertwisted nematic (STN), and electrically controllable birefringence (ECB).

Short course participants represented government laboratories and companies from the United States, Mexico, and Israel.



(above) Participants learn how to fabricate PDLC cells.



Phil Bos, short course chair (right), shows participants how to evaluate a STN device.

Detailed information on the course content is available on the web at: <http://alcom.kent.edu/ALCOM/ALCOM.html>.

For information on future short courses send your complete mailing address to [brenda@scorpio.kent.edu](mailto:brenda@scorpio.kent.edu).

Notes, from page 1

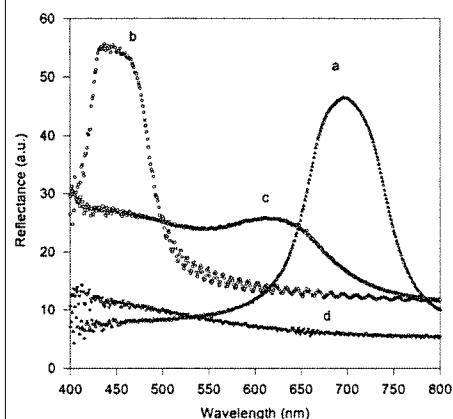


Fig. 2

PSCT Bragg reflects the visible spectrum (c) at planar texture, and absorbs the incoming light (d) at focal conic texture (Fig. 2).

The response of the bistable PSCT display to voltage pulses is shown in Fig. 3 where (a) is the response to a voltage pulse from the planar texture and (b) is the response to a voltage pulse from the focal conic texture. With a 40 ms bipolar square pulse voltage smaller than 20 V ( $V_1$ ), the display stays at the planar texture. When the voltage is increased to 40 V ( $V_2$ ) the display switches to a focal conic texture. By increasing the voltage above 61 V ( $V_4$ ) the display switches to a homeotropic texture and then relaxes to the planar texture.

The display is easy to fabricate and suitable for portable reflective displays.

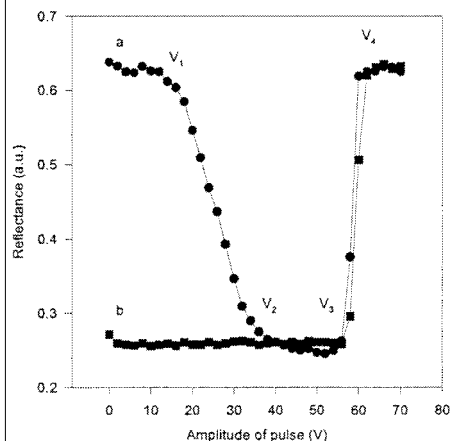


Fig. 3

## DEGREES, APPOINTMENTS & RECOGNITION

**H.-T. Jung**, Ph.D., Case Western Reserve University, February, 1998.

**Sandra S. Keast**, M.S. in Chemistry from Kent, December 1997. Keast was a Senior Chemist in Dr. Neubert's lab and worked on ALCOM research projects since its inception in 1991. She had been at KSU more than eleven years. Keast is now a chemist at Eli Lilly Drug Company in Indianapolis, IN, where she designs the synthesis of and prepares new drugs.

### SID Recognition

- J. William Doane - Jan Rajchman Prize
- William Glenn - Fellow of the Society

## IN BRIEF

### ALCOM paper highlighted by APS

A publication involving scientists from all three ALCOM universities was recently chosen by the American Physical Society as a selected article on their web site, "Physical Review Focus." Articles are selected from *Physical Review Letters* and reviewed on-line. The article review from May 22, 1998 can be found at: <http://publish.aps.org/FOCUS>.

The article, "Kinetics of Phase Transition in an Anticlinic Liquid Crystal Induced by a Uniform Temperature Field: Growth in One Dimension," by X. Y. Wang (UA), J.-F. Li (CWRU), E. Gurarie (CWRU), S. Fan (UA), T. Kyu (UA), M.E. Neubert (KSU), S.S. Keast (KSU) and C. Rosenblatt (CWRU) appears in *Phys. Rev. Lett.* **80**, 4478 (1998).

## CALENDAR

**AM-LCD 98**, July 9-10, 1998  
Tokyo, Japan.

Japan Society of Applied Physics  
International workshop on Active-Matrix liquid crystal displays

**17th International LC Conference**  
July 19-24, 1998  
Strasbourg, France

**8th International Topical Meeting on Optics of Liquid Crystals**  
September 27 - October 1, 1999  
Humacao, Puerto Rico  
<http://web.uprr.pr/olc99>

## Web Sites

### ALCOM Home Page

<http://alcom.kent.edu/ALCOM/ALCOM.html>

### Liquid Crystal Institute, KSU

<http://www.lci.kent.edu>

### Dept. Macromolecular Science, CWRU

<http://k2.scl.cwru.edu/cse/emacs/>

### Department of Physics, CWRU

<http://erebus.phys.cwru.edu/phys/physdept.html>

### Polymer Science, University of Akron

<http://www.polymer.uakron.edu/>

### On-Line Polymer Liquid Crystal Tutorial

<http://plc.cwru.edu>

### Experiment at a Distance

<http://olbers.kent.edu/alcomed/Experiment/eo.html>

### Optics of Cholesteric Liquid Crystals

<http://alcom.kent.edu/~tik/choles.html>

### ALCOM Education Home Page

<http://olbers.kent.edu/alcomed/k12.html>



# ALCOM

NSF Science and Technology Center for  
Advanced Liquid Crystalline Optical Materials  
Consortium of Kent, Case Western Reserve, and Akron

Liquid Crystal Institute  
Kent State University  
P.O. Box 5190  
Kent OH 44242-0001