

# ALCOM Update

NSF Science and Technology Center for Advanced Liquid Crystalline Optical Materials

Consortium of Kent, Case Western Reserve, and Akron

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DECEMBER 1998

## ALCOM Center holds workshop on banana-shaped liquid crystal molecules

An informal ALCOM workshop was held November 10 in the Samsung Auditorium at the Liquid Crystal Institute on the topic of banana shaped molecules in liquid crystal phases of fluids. The goal of the workshop was to acquaint researchers with the structure, behavior and properties of these fascinating new materials, and to identify promising related research topics.



The program consisted of a brief introduction by Professor Peter Palffy-Muhoray (Kent State University) followed by overview lectures on the chemistry and physics of the materials by Prof. L.-C. Chien (Kent State University)

and Alfred Saupe (Professor Emeritus, KSU).

Following the overviews, presentations of recent experimental results were given by Prof. Noel Clark (University of Colorado, Boulder) and Dr. Antal Jáklí (Hungarian Academy of Sciences).

Following the talks, a great deal of enthusiastic discussion took place, including mini-presentations by participants. The informal atmosphere proved helpful in exchanging information; discussion continued throughout dinner at the Schwebel Garden Room on the Kent campus.



Participating in a panel discussion at the workshop are (l-r): A. Jakli, A. Saupe, N. Clark, and R. Petschek

More than sixty people participated in the workshop, including ALCOM principal investigators, visiting scientists, post-doctoral fellows, and graduate and undergraduate students from the three ALCOM universities.

## Pilot manufacturing line nears completion

Visitors to the Liquid Crystal Institute's LCD Research Facility are seeing a very different picture from that of last Spring. A functional pilot manufacturing line is nearly complete, although a large amount of work still lies ahead.

Users can now begin with a full sheet of glass and complete all processing through cell filling and sealing. Additional process capabilities are being added in the coming months, including a combination rub/dry ultrasonic module from Hornell Automation. Baseline processes are available for several machines, but are still being completed for most.

The following equipment is now available for use: Air Control wet benches, Samco

UV/Ozone cleaner, Brewer spincoater, ORC UV exposure system, Nissha printer, Reynoldstech hotplate, Blue M ovens, Asymtek XY dispenser, Fujioka dry spacer sprayer, Fujioka plate aligner, VPI glass scribe, and TNP Instruments laser repair station.

The Nissha and Fujioka equipment were set up with the assistance of Mr. Scott Worthington while others were set up by LCI personnel Roy Miller, Forrest Nicholson, and Jason Chonko.

The first test of the line took place in April when an A4 size cholesteric display was needed for a DARPA contract. Hugh Wonderly, Display Engineer, was largely responsible for the fabrication of this proto-

type. During Summer, the prototype display subsystems were delivered to DARPA.

The LCI is now getting ready for the first use of the pilot manufacturing line by an industrial partner. For the last six months, engineers and technicians from both LCI and industry have been working together to install equipment and work out infrastructure details including the design of carriers and tooling.

*Pilot Line continued on page 2*

ALCOM Update newsletters with color photos are available on the world wide web at:  
[www.lci.kent.edu/newsletters.html](http://www.lci.kent.edu/newsletters.html)



## FROM THE DIRECTOR

by John L. West

Happy New Year! In addition to the coming of the New Year, this time of year provides a logical point for evaluation, review and planning for the coming year. ALCOM has submitted annual reports on Center activities to our sponsors in Washington and Columbus. In November and December, the Operations Committee reviewed the research of principal investigators and proposed new areas of "high-risk research."

High-risk research is the theme for the upcoming ALCOM annual retreat. We have refined this theme to investigations of responsive materials. At the retreat we will conduct sessions on 3-D holography, mechanically responsive materials, chemical sensors and light emitting diodes. We will identify specific research areas where the unique, multi-disciplinary strengths of ALCOM will put us in the lead. We will also assess how these new areas of research will complement and blend with the current ALCOM projects.

The retreat's high-risk research theme is timely and appropriate. ALCOM has established a solid reputation in research, educa-

tion and industrial outreach. Having established this reputation, it is appropriate that we take the lead and assume the risk of striking out in new directions while continuing our well-established research programs. This is an investment in our future. I fully expect that new research conducted next year will define new directions for liquid crystal science and place ALCOM in a strong position to compete for funding in the next decade.

My ultimate dream is that these new areas of basic research will spawn new applications and industries, once again demonstrating the relevance of basic research and the value of science and technology centers. A lofty goal, but a good way to start the new year. I look forward to working together to make this dream a reality.

### Pilot Line from page 1

In February, an ITO deposition system custom-built by General Vacuum, Inc., will be installed in the W.M. Keck Foundation Cleanroom. The e-beam evaporator will also be capable of coating other materials such as aluminum, chromium, and silicon dioxide.

ALCOM Industrial Partners interested in using the facility or companies interested in joining the Industrial Partnership Program should contact Dr. Phil Bos at (330) 672-2511 or e-mail: pbos@kent.edu.

## ALCOM symposium on chiral materials and applications to be held in February

Chiral materials and applications will be the topic of an ALCOM symposium scheduled for February 18-19, 1999. The one and one-half day symposium will begin at 8:00 a.m. Thursday at the Sheraton Suites, Cuyahoga Falls, Ohio.

Co-chairs for the symposium are Dr. John L. West, Director, Liquid Crystal Institute, and Professor Robert J. Twieg, Department of Chemistry, Kent State University.

Invited speakers include: John Goodby, University of Hull, "Chirality at the Extremes in Liquid Crystals", Mark Green, Polytech Institute of New York, "The Amplification of Chirality and Other Studies in Chiral Synthetic Polymers Lead to New Points of View and New Materials", Nobuyuki Kobayashi, Minolta, Japan, "Reflective Color Cholesteric LCDs: The Relationship Between Chemical Structures of LC Materials and Characteristics of LCDs", Robert P. Lemieux, Queens Univer-

sity, "Induction of a Ferroelectric Smectic C\* Liquid Crystal Phase Using Atropisomeric Dopants", and Andre Persoons, University of Leuven, "Nonlinear Optics, Chirality, Supramolecular Organization: A World of Twisted Symmetries."

A poster session will cover chiral materials as well as other areas of ALCOM research.

A forum on chiral materials and applications will be held following talks on Friday morning. Attendance is limited to ALCOM members, industrial partners, and those specifically invited to attend.

If you would like more information on the symposium, please contact John West (tel: 330-672-2654; johnwest@scorpio.kent.edu) or Bob Twieg (tel: 330-672-2791; rtwieg@lci.kent.edu).

Web site: <http://alcom.kent.edu/ALCOM/symposia.html>

## ALCOM

NSF Science and Technology Center  
for Advanced Liquid Crystalline Optical Materials  
Consortium of three Northeast Ohio universities:  
Kent, Case Western Reserve and Akron

Director - J.L. West

Associate Director - J.L. Koenig

### ALCOM PIs

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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. Wang

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#### Case Western Reserve University

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R.G. Petschek, C. Rosenblatt, D.E. Schuele,  
K.D. Singer, P.L. Taylor, S.Q. Wang

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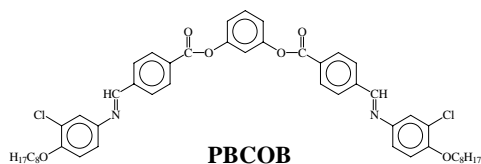
# Researchers study formation of double-twisted helix in banana-shaped liquid crystals

Chong-Kwang Lee and Liang-Chy Chien

Although classical thermotropic liquid crystals are commonly composed of rod-like molecules, many liquid crystals exhibit conventional molecular structures. Currently, one of the most interesting molecular architectures of a liquid crystal is a banana-shaped molecule with a bend in the middle of the mesogenic unit.

Several groups such as Voländer, Matsunaga, Niori, Weissflog, Clark, and Jákli, have reported that banana-shaped molecules exhibit ferroelectricity which is attributed to the polar packing of molecules with  $C_{2v}$  symmetry when the banana-shaped molecules are packed in the same direction. They exhibit antiferroelectricity when packed in the opposite direction. The existence of such a mesophase depends on the length of the rigid core of molecules as well as the magnitude of bend and its position.

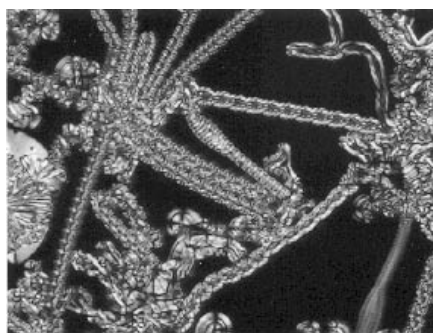
The structure and flexibility of the angled segment are also important. In the banana-shaped molecular system reported here, 1,3-phenylene bis[4-(3-chloro-4-n-octyloxy-phenyliminomethyl) benzoate] (PBCOB), both left and right-handed helical domains are spontaneously formed in the smectic phase even though the constituent molecules are achiral (see figure below). The formation of the helical domains observed in banana-shaped molecular systems is unique because it occurs in a fluid system in which molecular interaction is weak and thermal fluctuation is extensive.



It is worth noting that mixing chloro-substituent and non-chloro-substituent banana-shaped molecules results in the appearance of a wide miscibility gap and enlargement of the range of the switchable banana phase. The presence of a lateral chloro-substituent in the Schiff's base moi-

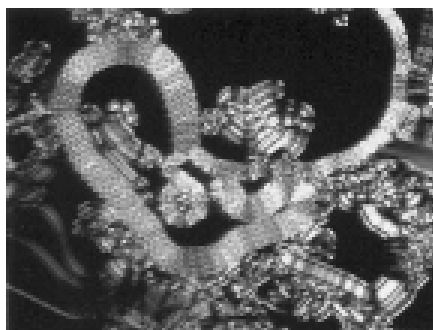
ety prevents the regular stacking of molecules and results in lowering of the switchable banana phase.

Figures 1(a) and 1(b) show the optical micrographs of PBCOB in the phase transition from the isotropic to switchable banana phase. Upon cooling from isotropic melt, the switchable banana phase appears in several forms such as double-twisted helices, filaments and fan-shaped textures. They tend to transform into fan-shaped textures with a fringe pattern showing a helical structure, although the system contains only achiral molecules.



(a)

Fig. 1. Optical micrographs in the switchable banana phase of PBCOB on cooling from the isotropic melt. (a) The switchable banana phase initially appears as double-twisted helices. They tend to transform into fan-shaped textures with a fringe pattern. (b) Simultaneously, the homeotropic domains begin to occupy the space between double-twisted helices.



(b)

"Nematic Order in Polymer-Stabilized Liquid Crystals," R.E. Kraig, P.L. Taylor, R. Ma, D.-K. Yang, *Phys. Rev. E* **58**, 4594-5597 (1998).

"Freedericksz Transition in Antiferroelectric Liquid Crystals and Cooperative Motion of Smectic Layers," X.Y. Wang, T. Kyu, A.M. Rudin, P.L. Taylor, *Phys. Rev. E* **58**, 5919-5922 (1998).

"Application of Real Time Mid-Infrared FTIR Imaging to Polymeric Systems. 1. Diffusion of Liquid Crystals into Polymers," C.M. Snively, J.L. Koenig, *Macromol.* **31**, 3753-3755 (1998).

"High-Resolution Electron Microscopic Investigation of Frustrated Packing of a Semiflexible Liquid Crystalline Polyester," H.-T. Jung, S.D. Hudson, R.W. Lenz, *Macromol.* **31**, 637-643 (1998).

"Alignment of Liquid Crystals on Polyimide Films Exposed to Ultraviolet Light," J.-H. Kim, S. Kumar, S.-D. Lee, *Phys. Rev. E* **57**, 5644-5650 (1998).

"Correlation Between Rub-Induced Grooves in a Polyimide-Treated Substrate and Microstructure of Rubbing Fiber: An Atomic Force Microscopy Study," M.P. Mahajan, C. Rosenblatt, *J. Appl. Phys.* **83**, 7649-7652 (1998).

"Capillary Filling of Nematic Liquid Crystals," X.-D. Mi, D.-K. Yang, *Phys. Rev. E* **58**, 1992-2000 (1998).

"Cholesteric Diffraction Devices with a Field-Controlled Grating Vector," S.V. Shiyankovskii, D. Subacius, D. Voloshchenko, P.J. Bos, O.D. Lavrentovich, *SPIE* **3475** (1998).

"High-Resolution X-Ray Photoelectron Spectroscopy of Aliphatic Hydrocarbons," E.A. Thomas, A.R. Carrick, J.E. Fulghum, *Surface and Interface Analysis* **26**, 278-289 (1998).

"FT-IR Imaging of the Interface in Multicomponent Systems Using Optical Effects Induced by Differences in Refractive Index," R. Bhargava, S.-Q. Wang, J.L. Koenig, *Appl. Spectrosc.* **52**, 323 (1998).

Publications, continued on page 5

# ALCOM workshops provide fun and challenge for teachers and students

As part of the ALCOM Education Outreach program, ALCOM principal investigators are instructing students and teachers in North-east Ohio in a National Science Foundation workshop program, *School Based Remote Experiments on the Web*. Twenty-two teachers from six North-east Ohio high schools are participating in the academic year workshops.

The workshops promote learning through the use of experiments which can be accessed via the internet. Teachers work in teams consisting of science and math teachers and librarians/media specialists to design their own experiments. During the workshops they learn how to build the experiments and put them up on the web.

At the end of the academic year, six new web-based experiments will be available for use. More important, 22 teachers will take away the knowledge of how to create additional experiments on their own.

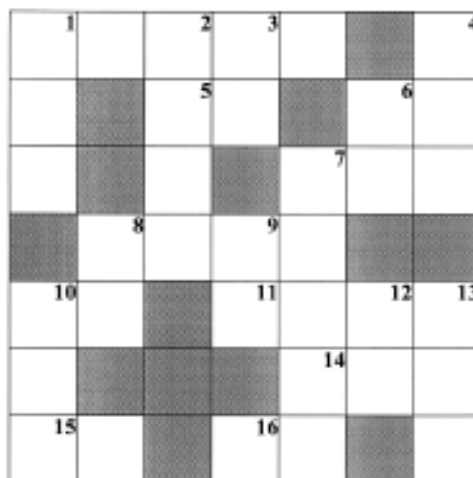
Creating experiments for the internet is a

long, detailed project for students. "We wanted to give the students something to show them that physics and math could be fun, challenging, and educational at the same time," according to Dr. Max Godfrey, ALCOM Education Outreach Project Coordinator. The result is the puzzle below.

Teachers took the puzzle back to their classrooms and challenged the students to solve it. The first postmarked correct solution to the puzzle would receive a 1st place certificate; however, two correct solutions were received the same day.

Cleveland area students, Rayshawn Swanson from Collinwood High School and Daria Homenk from Magnificat High School solved the puzzle correctly and received certificates.

For answers to the puzzle, send email to [brenda@scorpio.kent.edu](mailto:brenda@scorpio.kent.edu).



- Year of the puzzle . . . 1939  
 4,840 square yards = 1 acre  
 4 roods = 1 acre  
 20 shillings = 1 pound

A farm, Little Pigsby, has been owned by the Dunk family for several centuries. Dog's Mead is a rectangular field on the farm. How old is Mrs. Gooby?

**Down**

1. Value in shillings per rood of Dog's Mead
2. Square of the age of Mrs. Gooby (Farmer Dunk's mother-in-law)
3. Age of Mary
4. Value of Dog's Mead in pounds
6. Age of Ted, first born, who was twice as old as Mary in 1935
7. Square of number of yards in breadth of Dog's Mead
8. Number of minutes it takes Dunk to walk 1 1/3 times around Dog's Mead
9. See 10 Down
10. 10 Across times 9 Down
12. One more than the sum of the digits in 10 Down
13. Number of years the Dunks have owned Little Pigsby

**Across**

1. Area of Dog's Mead in square yards
5. Age of daughter Martha
6. Difference in yards between the length and breadth of Dog's Mead
7. Number of roods in Dog's Mead times 8 down
8. Year farm came into possession of Dunk family
10. Dunk's age
11. Year of birth of Mary, the youngest child
14. Perimeter of Dog's Mead in yards
15. Cube of Dunk's walking speed (miles per hour)
16. 15 Across minus 9 Down

FTIR used to examine formation of PDLCs using UV-curable matrices

At Case Western Reserve University, S.Q. Wang's research group is using FTIR spectroscopy and imaging to examine the formation of polymer dispersed liquid crystals using UV-curable matrices. Kinetics of the curing reaction of the matrix can be monitored by FTIR as has conventionally been the role of FTIR in curing systems.

They have shown that rapid scan FTIR spectroscopy can also be used to detect the onset of phase separation by using the difference spectrum of the curing composite relative to the uncured homogeneous mixture. Moreover, in the same experiment using unpolarized IR radiation, the onset and extent of nematic order is observed. Thus, classical FTIR spectroscopy has been shown to be an important tool to monitor the formation process of PDLCs. Thermoplastic and thermocuring matrices are used for comparative studies.

Once the PDLCs are formed, their spatial chemical composition is characterized using FTIR imaging which determines the relative concentration of the liquid crystal in the matrix and the matrix material in liquid crystal droplets. This capability has been used to examine samples made from a two-step process. The two-step process has resulted in significantly lower inter-solubility of the liquid crystal and the matrix.

The group has also applied FTIR imaging to study the question of differential component segregation in LC mixtures cured with a pre-polymer mixture. They have developed the capability to understand the formation process and obtain spatially-resolved chemical composition in PDLCs which allows them to optimize the liquid crystal usage and potentially improve properties.

**Macroprocessing of Conducting Polymers as Alignment Layers**

C.-J. Tseng, Padetha Tin\*, William Myers, Ramona Myers, Y.Z. Wang, AJ.Epstein, J.A. Mann, Jr. and J.B. Lando, Case Western Reserve University and \* NASA Lewis Research Center

**I) Polarized Light Emitting Diodes using Polyparaphenylene (PPP) Langmuir Blodgett (LB) Films**

The research group has shown that PPP LB films emit blue light under electron injection with a maximum of 550 nm. Polarized luminescence from oriented PPPLB films shows a dichroic ratio of 1.3 to 1.5. Electroluminescence experiments show a red shift from 500 to 530 nm when the applied forward bias is increased.

Research Notes, continued on page 5

## AlphaMicron is newest liquid crystal startup company to locate in NE Ohio

AlphaMicron, Inc., is the latest startup company to locate near the Liquid Crystal Institute (LCI) in Kent, Ohio. The company conducts research on ambient light control for helmet-mounted displays through an Air Force SBIR grant. AlphaMicron recently initiated a SBIR Phase II to implement devices on plastic substrates for testing purposes. An initial prototype has already been produced.

The company is the brainchild of three LCI scientists, Professor Peter Palffy-Muhoray, Dr. Bahman Taheri, and Dr. Tamas Kosa. They created the company to bridge the gap between university-based basic research and product-oriented industry.

Less than two years old, the company has a 2500 sq. ft. facility which includes a Class 100 cleanroom and characterization facility with equipment capable of fabricating liquid crystal devices. Recently the company obtained direct internet connection through the installation of its own T1 line.

Currently, AlphaMicron has eight employees which include engineering technicians, research assistants and administrative staff.

Like other Northeast Ohio companies, AlphaMicron set up its operation near the LCI to take advantage of its Resource Facility which provides synthesis, prototyping, and characterization services.

"The LCI and ALCOM Industrial Partnership Program have played a key role in the smooth operation during the startup of AlphaMicron," according to Bahman Taheri. "We were able to use the ALCOM facilities until our cleanroom was operational and will continue to interact with the LCI as our business expands."

AlphaMicron started at ground zero with no outside financial investors. The company hopes to serve as a model for other Northeast Ohio startup companies that are created by university faculty and staff.

AlphaMicron joined the ALCOM Industrial Partnership Program in 1997 and is represented on the ALCOM Resource Facility Advisory Board.



*Technicians fabricate liquid crystal devices in the prototyping room at AlphaMicron's facility in Kent.*

If you would like more information on AlphaMicron, please contact Dr. Bahman Taheri at (330) 676-0648; fax: (330) 676-0649.

## Jon Ruth named as new IPP liaison

Dr. Jon Ruth was recently named the new industrial partner liaison, replacing Dr. Bahman Taheri. Dr. Ruth is a research fellow at the Liquid Crystal Institute.

Ruth earned a B.S. in physics from the University of Santa Clara, and his M.S. and Ph.D. in experimental physics at the University of Colorado, Boulder. He worked at the Naval Research Laboratory prior to joining the LCI.

His research efforts at the LCI have concentrated on the development of low cost drive schemes for reflective Bistable Cholesteric Texture (BCT) displays. A recent project successfully demonstrated the use of STN drivers and commodity electronics to drive page-size (8.5"x11", 896x1152) BCT displays.

Dr. Ruth can be reached by telephone: (330) 672-3999 ext. 303; fax: (330) 672-2796; or email: [ipp@lci.kent.edu](mailto:ipp@lci.kent.edu).

### II) Deposition of Lithium Salt of Poly-10,12-Nonacosadiynoic Acid (PDA) Langmuir-Blodgett Films onto Atomic Force Microscopy $\text{Si}_3\text{N}_4$ Tips

Single-layer Li/16-8 PDA LB films were successfully deposited onto AFM tips via horizontal deposition. The results of the scanning electron microscopy pictures of the used tips shows that a single-layer Li/16-8 PDA LB deposition protects the Au  $\text{Si}_3\text{N}_4$  tips from eroding during imaging. This fact implies that Li/16-8 PDA LB films are strong enough to withstand tip scratching.

### III) Surface Molecular Structure of Lithium Salt of 10,12-Nonacosadiynoic Acid Monomer and Polymer Langmuir-Blodgett Films via Atomic Force Microscopy and their Comparisons to the Electron Diffraction Pattern

The two-dimensional unit meshes of the Li/16-8 DA and Li/16-8 PDA LB films were determined by contact mode atomic force microscopy. The PDA image showed the same surface structure as the results from electron microscopy.

### IV) Surface Light Scattering Spectroscopy Combined with Brewster Angle Microscopy: nCB Langmuir-Blodgett Films

For the first time surface light scattering spectra were measured on a footprint coherent with the Brewster Angle Microscope. The LB films were 8CB ( $\text{C}_8\text{H}_{17}-(\text{C}_6\text{H}_4)_2\text{CN}$ ) which undergo phase transitions at known surface densities.

"Pretilt Angle Generation on Photoreactive Polymer Films," H.G. Galabova, D.W. Allender, J. Chen, *Phys. Rev. E* **58**, 3295-3301 (1998).

"Orientational Susceptibility and Elastic Constants Near the Nematic-Isotropic Phase Transition for Trimers with Terminal-Lateral-Lateral-Terminal Connections," D. Kang, M.P. Mahajan, R.G. Petschek, C. Rosenblatt, C. He, P. Liu, A.C. Griffin, *Phys. Rev. E* **58**, 2041-2046 (1998).

"Electrorheological Creep Response of Tumbling Nematics," N. Yao, A.M. Jamieson, *J. Rheol.* **42**, 603-619 (1998).

## DEGREES, APPOINTMENTS & RECOGNITION

### Polymer Tutorial Receives BBC Education Web Guide Listing

The *Polymers and Liquid Crystals* tutorial web site developed with ALCOM support by the Departments of Physics and Macromolecular Science at Case Western Reserve University has been selected by the BBC for inclusion in its Education Web Guide.

The site provides a one-stop shop for the best educational resources on the internet and is the focal point for all of the BBC's educational resources.

The sites included in the Web Guide are hand-picked by a team of subject specialists and scrutinized for educational rigor by experts at BBC Education.

The Education Web Guide team "was particularly impressed by the quality and education content of the site" and have placed a short review of it in their searchable database.

The BBC Education Web Guide can be found at: [www.bbc.co.uk/education/webguide](http://www.bbc.co.uk/education/webguide).

## CALENDAR

**ALCOM Retreat**, January 6-8, 1999  
Glenmoor Country Club, Canton, OH

**ALCOM Symposium**  
February 18-19, 1999  
Sheraton Suites, Cuyahoga Falls, OH  
[alcom.kent.edu/ALCOM/symposia.html](http://alcom.kent.edu/ALCOM/symposia.html)

**Materials Research Society Spring 1999 Meeting on LC Materials and Devices**, April 5-9, 1999, San Francisco, CA, [www.mrs.org/](http://www.mrs.org/)

**European Conference on LCs 99**  
April 25-30, 1999 Crete, Greece  
[www.physics.upatras.gr/ecle99/](http://www.physics.upatras.gr/ecle99/)

## 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.cwrw.edu/cse/emacs/>

### Department of Physics, CWRU

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

### Polymer Science, University of Akron

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

### On-Line Polymer Liquid Crystal Tutorial

<http://plc.cwrw.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>

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