LIQUID CRYSTAL INSTITUTE
ANNUAL REPORT
1997-1998

July 1, 1997-June 30, 1998
John L. West, Director
## Contents

LIQUID CRYSTAL INSTITUTE ANNUAL REPORT

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</tr>
</tbody>
</table>

Appendix I: ALCOM Outreach

- Symposium: Reflective Displays
- Short Course: Liquid Crystals: Materials and Display Devices
- Future of Print Media (on-line symposium)

Appendix II: Ph.D. Degrees Awarded
LIQUID CRYSTAL INSTITUTE
Director’s Report, 1997-1998

The Liquid Crystal Institute continued to expand and consolidate its well-established research, education and outreach programs. The faculty and staff of the LCI continue to attract major support for research from federal and state agencies, industry and private foundations. The LCI has strengthened collaborations with departments across campus, supporting new faculty, introducing joint appointments and submitting interdepartmental proposals. Our outreach programs continue to grow both in size and reputation. Regional and state development agencies increasingly look to the LCI as a catalyst for economic growth.

Following the recommendation of the on-site review team, the National Science Foundation approved full funding for the ALCOM Center through 2001. The NSF Science Board cited the ALCOM Education Outreach and Industrial Partnership Programs as models for other Science and Technology centers. The Ohio Department of Development formally included ALCOM in the Edison Centers program and the Ohio Board of Regents granted $1.5 million in capital equipment for the ALCOM center. The LCI is planning now for continuation of center funding beyond 2001. Working with our advisory board and industrial partners, we are investigating a range of strategies and funding sources to continue our highly successful center.

External funding of LCI programs remained essentially unchanged from the previous year. While at first disconcerting, a review of the funding levels for the last ten years reveals that funding this year continues the established trend of steady increases. However, the 96-97 year showed an unusually large increase of 52% from the previous year. This large increase resulted from the overlap of two large DARPA contracts that was not expected to repeat.

Our strong research programs and worldwide reputation are demonstrated by the substantial increase in publications and invited and submitted presentations. The Liquid Crystal Institute gave more papers than any other organization at the last Society for Information Display conference. Through ALCOM we held a symposium on Reflective Displays, December 11-12, that attracted researchers from around the world. This symposium highlighted LCI research and the leading role we have taken in this increasingly important field.

The Liquid Crystal Institute has also sponsored educational activities at all levels. With LCI support, the Chemical Physics Interdisciplinary Program has grown to include 30 graduate students, 20 in the research phase of their graduate program. Also, the LCI has helped attract and support new faculty in related departments. For example, Robert Twieg joined the Chemistry Department at Kent with strong support from the Liquid Crystal Institute, including principal investigator status in ALCOM, start-up funds for equipment, and buy out time to reduce his teaching load and allow more time for research. Overall, the Liquid Crystal Institute provided $88,200 in support from operational accounts to other departments. This is in addition to $577,362 in grants to faculty in related departments collaborating with the LCI.
The LCI also supports non-traditional education, such as the ALCOM Educational Outreach Program, which serves as a model for educational centers across the nation. Over the last year our education programs have moved aggressively in the development of web based experiments that can be accessed by students around the world. Working in conjunction with Keithley Instruments and supported by NSF, we are providing the training and support for high school science teachers to develop web-based experiments. Once trained this initial cadre will train others in what we hope will be exponential growth of the program.

The ALCOM Industrial Partnership Program has grown to include 31 North American companies. We are particularly proud of the growth of the liquid crystal industry in Northeast Ohio. In support of regional industries, we have completed the new clean room and liquid crystal display pilot line on the third floor of the LCI building. Local companies are using this new facility to develop manufacturing techniques and improve their products and competitive position. In the last year we established an advisory board composed of representatives of the local liquid crystal companies who provide advice on the operation and goals of this important new facility. We expect that local companies will increasingly use this facility and that it will attract other companies to locate in the region.

The LCI continues to act as a catalyst for economic development in the region and the state. As outlined above, we work with local companies to improve their competitive position. LCI graduates, support facilities and technology serve as magnets to attract new companies to the region. I joined the Ohio Department of Development on a trade mission to Korea and Japan, visiting semiconductor and liquid crystal companies and making a presentation at the Mid-West United States-Japan Trade Association meeting in Tokyo. The LCI has worked with local development agencies, such as the Greater Cleveland Growth Association, to evaluate and improve the economic position of Northeast Ohio.

LCI contacts with companies across the region, nation and the world show if the region is to capitalize on the high technology liquid crystal industry it must substantially improve the level of worker training. With its eight-campus system, Kent State University is uniquely positioned to meet this need. While worker training at the associate and baccalaureate level is not addressed directly by the LCI, we have begun and will continue to work with people across the university and the region to improve the level of worker training.

The Liquid Crystal Institute will continue to serve as a catalyst for collaboration and change. It will identify areas of new liquid crystal research, development and applications. It will work with departments across the university, development agencies across the region and state, and industry and other academic institutions around the world for research, education and economic development.

John L. West, Director
Summary of LCI Accomplishments, July 1997-June 1998

Ph.D. Degrees Awarded 2
Grants and Contracts 47
   Expenditures $4.5 million
   Renewals and New Awards 18
Students Supported
   Graduate 34
   Undergraduate (21 total) 11 Academic year
         11 Summer
Postdoctoral Researchers Supported 30
Visitors (Research Program) 17
Publications
   Journals and books 57
   Juried, technical reports, other 39
Presentations
   Professional societies 62
   Academic and other 57
Patent Activity
   Disclosures 5
   Applications 4
   US Patents Issued 5
Industrial Visitors 34
ALCOM IPP Members 31
Outreach Activities
   Symposium: Reflective Displays, December 11-12, 1997
   Short Course: Liquid Crystal: Materials and Display Devices, June 2-5, 1998
   K-12 Education tours, presentations, workshops
   Future of Print Media on-line symposium

Report compiled by
   Elaine M. Landry
   Operations Administrator
   LCI and ALCOM Center
FUNDING SOURCES: 1997-1998
LCI Expenditures (Thousands) by Source

Major Funding Sources
ALCOM Center (NSF, State of Ohio)
ALCOM Industrial Partnership Program
DARPA Low Power Displays and Reflective Displays
Funding Sources – 1988-1998

LCI Expenditures (Thousands) by Source

Technician at work in LCD research facility completed this year.
<table>
<thead>
<tr>
<th>Name</th>
<th>Year Appointed</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>John L. West</td>
<td>1984</td>
<td>Director (1997); Professor of Chemistry (1997)</td>
</tr>
<tr>
<td>Philip J. Bos</td>
<td>1994</td>
<td>Associate Director (1997); Associate Professor, Chemical Physics (1995)</td>
</tr>
<tr>
<td>Liang-Chy Chien</td>
<td>1989</td>
<td>Associate Professor, Chemical Physics (1995)</td>
</tr>
<tr>
<td>Valerie Ferrara</td>
<td>1995</td>
<td>Secretary</td>
</tr>
<tr>
<td>Valerie A. Henry</td>
<td>1991</td>
<td>Program Aide VI</td>
</tr>
<tr>
<td>Sandra S. Keast</td>
<td>1987</td>
<td>Senior Chemist (1993); resigned 3/98</td>
</tr>
<tr>
<td>Jack R. Kelly</td>
<td>1988</td>
<td>Associate Professor, Chemical Physics (1994)</td>
</tr>
<tr>
<td>Oleg D. Lavrentovich</td>
<td>1992</td>
<td>Associate Professor, Chemical Physics (1994)</td>
</tr>
<tr>
<td>Mary E. Neubert</td>
<td>1972</td>
<td>Senior Research Fellow (1976)</td>
</tr>
<tr>
<td>Peter Palffy-Muhoray</td>
<td>1983</td>
<td>Associate Director (1990); Professor of Chemical Physics (1994)</td>
</tr>
<tr>
<td>Davina Werner</td>
<td>1996</td>
<td>Secretary</td>
</tr>
<tr>
<td>Dengke Yang</td>
<td>1992</td>
<td>Assistant Professor, Chemical Physics (1995)</td>
</tr>
</tbody>
</table>

**EMERITI**

<table>
<thead>
<tr>
<th>Name</th>
<th>Years</th>
<th>Title</th>
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<tbody>
<tr>
<td>J. William Doane</td>
<td>1979-1996</td>
<td>Emeritus Director; Emeritus Professor of Physics (Retired, June 30, 1996)</td>
</tr>
<tr>
<td>Alfred Saupe</td>
<td>1968-1992</td>
<td>Emeritus Professor of Physics (Retired August 31, 1992)</td>
</tr>
<tr>
<td>Name</td>
<td>Period</td>
<td>Institution</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Dena Mae Agra</td>
<td>May-Aug. 1997</td>
<td>University of the Philippines</td>
</tr>
<tr>
<td>Jianmen Chen</td>
<td>Sept. 97-Dec. 97</td>
<td>Samsung Corp., Korea</td>
</tr>
<tr>
<td>Mario Cuppo</td>
<td>March-May 1998</td>
<td>University of Sao Paolo, Brazil</td>
</tr>
<tr>
<td>Sergio Gomez</td>
<td>March-April 1998</td>
<td>University of Sao Paolo, Brazil</td>
</tr>
<tr>
<td>KiRyong Ha</td>
<td>Aug. 96-July 97</td>
<td>Keimyung University, Korea</td>
</tr>
<tr>
<td>Michael Holmes</td>
<td>June 97-July 97</td>
<td>Univ. Central Lancashire, UK</td>
</tr>
<tr>
<td>Chong-Kwang Lee</td>
<td>Aug. 97-July 98</td>
<td>Gycongsang National Univ., Korea</td>
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<tr>
<td>Jae Jin Lyu</td>
<td>Aug. 97-Aug. 98</td>
<td>Samsung Corp., Korea</td>
</tr>
<tr>
<td>Larry Manuel</td>
<td>Feb. 98-Jan. 99</td>
<td>Univ. of the Philippines</td>
</tr>
<tr>
<td>James P. McClymer</td>
<td>Aug. 97-Dec. 97</td>
<td>University of Maine</td>
</tr>
<tr>
<td>Hiroyuki Mori</td>
<td>Sept. 96-present</td>
<td>Fuji Photo Film, Japan</td>
</tr>
<tr>
<td>Michinori Nishikawa</td>
<td>April 97-Oct. 98</td>
<td>Japan Synthetic Rubber Co.</td>
</tr>
<tr>
<td>J. Adrian Reyes</td>
<td>Feb. 97-Jan. 98</td>
<td>Mexican National University</td>
</tr>
<tr>
<td>Yuriy A. Reznikov</td>
<td>Feb. 98-July 98</td>
<td>Institute of Physics, Ukraine</td>
</tr>
<tr>
<td>Wataru Saito</td>
<td>April 97-April 98</td>
<td>Dai Nippon Printing Co., Japan</td>
</tr>
<tr>
<td>Tohru Sasaki</td>
<td>March 98-March 99</td>
<td>Hitachi Corp., Japan</td>
</tr>
<tr>
<td>Sergij Shiyakovskii</td>
<td>Feb. 97-Sept. 99</td>
<td>Institute for Nuclear Research, Ukraine</td>
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Table 2: Liquid Crystal Institute Research Staff

<table>
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<th>RESEARCH STAFF SUPPORT DEPARTMENT; GRANT*</th>
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<tr>
<td>Full Members</td>
</tr>
<tr>
<td>David W. Allender</td>
</tr>
<tr>
<td>Philip J. Bos</td>
</tr>
<tr>
<td>Liang-Chy Chien</td>
</tr>
<tr>
<td>J. William Doane</td>
</tr>
<tr>
<td>Daniele Finotello</td>
</tr>
<tr>
<td>Jack R. Kelly</td>
</tr>
<tr>
<td>Satyendra Kumar</td>
</tr>
<tr>
<td>Oleg D. Lavrentovich</td>
</tr>
<tr>
<td>Mary E. Neubert</td>
</tr>
<tr>
<td>Peter Palffy-Muhoray</td>
</tr>
<tr>
<td>Samuel N. Sprunt</td>
</tr>
<tr>
<td>Robert J. Twieg</td>
</tr>
<tr>
<td>John L. West</td>
</tr>
<tr>
<td>Philip W. Westerman</td>
</tr>
<tr>
<td>Dengke Yang</td>
</tr>
</tbody>
</table>

*Grant name indicates that a portion of the investigator’s salary was provided by grant(s), either as a cost share or direct charge (academic year or Summer)
Research Staff; Support Department; Grant

Alan Baldwin Physics Research Engineer
W. Ray Folks (to 1/98) LCI; S-VISION-Bos
William J. Fritz LCI; NRL-Doane
Jignesh Gandhi (to 6/98) LCI; DARPA-KDI-Yang
Maxwell Godfrey LCI; ALCOM Education-Palfy
Wongun Jang LCI; NASA, Yang
M. Amin Khan LCI; ALCOM, Neubert
Jae Hoon Kim Physics; ALCOM-Kumar
Yoan Kim LCI; DARPA Low Power-West
Tamas Kosa LCI; ALCOM & MURI-Palfy
Jong-Chan Lee LCI; 3M, Lavrentovich
Soon Nam Lee Physics & LCI, NRL-Sprunt & Chien; ALCOM
Yuhui Lin (to 12/97) LCI; OIS-Chien
Svetlana Lukishova LCI; ALCOM and MURI-Palfy
Bingidimi Mobele LCI; Beam Steering, Neubert
Yuri Nastiishyn LCI; ALCOM-Lavrentovich
Jonathan Ruth LCI; DARPA Low Power-Bos
Maria Sabeva LCI; AFOSR, Lavrentovich
Tatiana Sergan LCI; ALCOM and IMax-Kelly
Vassili Sergan LCI; DARPA-KDI-Bos
Rajesh Shenoy (to 2/98) LCI; ALCOM-Neubert
Yushan Shi (to 8/97) LCI; ALCOM-Kumar
Milind Sonpatki LCI; Research Chall/ALCOM, Chien and Kelly
Darius Subacius (to 1/98) LCI; ALCOM and AFOSR-Lavrentovich
Ruipeng Sun LCI; Vari-Lite, Yang
Bahman Taheri (to 6/98) LCI; ALCOM and IPP-West
Tat-Hung Tong (to 7/98) LCI; ALCOM-Chien
Valery Vorlusev Physics; Rockwell-Kumar
Shuangxi Wang LCI; ALCOM, Chien
Xiaodong Wang (8/97-3/98) NASA, Yang
Didier Wermieille LCI; ALCOM, Kumar (off-site ANL)
LCI Research Staff, 1997-1998

Research Staff, Continued

Fudong Xu LCI; Vari-lite-Yang; ALCOM, Bos
Yangming Zhu (to 12/97) LCI; DARPA Low Power-Yang

Technicians and Engineers

David Abdallah (to 10/97) Julie Kim (3/98 promoted to Senior Chemist)
Anima Bose Ralph Klouda (to 2/98)
Sandi Campbell (to 8/97) Kevin Liticker (to 4/98)
Jason Chonko Roy E. Miller, IV
Todd Ernst Gregg Podojil (to 9/97)
James Fracli Robert Polak
Seth Green (to 5/98) Liou Qiu
Richard Hewitt (to 1/98) Steven Smith (to 5/98)
Chad Jones (to 6/98) Margaret Walsh
Gregory Magyar Hugh Wonderly

Student Employees

Kate Allender, Wooster 97, 98 Benjamin Ingersoll
Emma Birath, Central Okla. 97 Chris Jaroniec, MIT 97
Brian Blake, Miami 98 Yelena Kurayeva
Randal Boettner, Otterbein, 97 Mark Lohman
Lauren Borkowski Colleen Marlow, Cal Poly 98
Shanti Cavanaugh, Cal Poly 98 Brian McCauley
Jason Chonko Carlos Miller
Aaron Cooley Forrest Nicholson
Jabari Farrar James Schershel, Ball State 98
Bart Heldreth Michael J. Smith
Erica Humeniuk
<table>
<thead>
<tr>
<th>Students</th>
<th>Department; Support Source; Advisor</th>
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<tbody>
<tr>
<td>James Anderson</td>
<td>Chemical Physics/LCI; DARPA Supplement; Bos</td>
</tr>
<tr>
<td>Letemeskel Asfaw</td>
<td>Physics; Sprunt (off-campus)</td>
</tr>
<tr>
<td>Volodymyr Bodnar</td>
<td>Chemical Physics; DARPA; West</td>
</tr>
<tr>
<td>Jennifer Colegrove</td>
<td>Chemical Physics; LCI</td>
</tr>
<tr>
<td>Mingji Cui</td>
<td>Physics; ALCOM; Kelly</td>
</tr>
<tr>
<td>Roland Ennis</td>
<td>Chemical Physics; LCI; ALCOM-Palffy</td>
</tr>
<tr>
<td>Hristina Galabova</td>
<td>Physics; ALCOM; Allender</td>
</tr>
<tr>
<td>Chad Hoke</td>
<td>Chemical Physics; ALCOM; Bos</td>
</tr>
<tr>
<td>Tomohiro Ishikawa</td>
<td>Chemical Physics; ALCOM; Lavrentovich</td>
</tr>
<tr>
<td>Shin-Woong Kang</td>
<td>Chemical Physics</td>
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<tr>
<td>Asad Khan</td>
<td>Chemical Physics (KDI Sponsored); Doane, Yang</td>
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<tr>
<td>Kevin Li</td>
<td>Chemical Physics</td>
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<tr>
<td>Shuxin Li</td>
<td>Chemical Physics</td>
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<tr>
<td>Hong Liu</td>
<td>Physics; ALCOM; Allender</td>
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<tr>
<td>Weinmin Liu</td>
<td>Chemical Physics; LCI; ALCOM-Kelly</td>
</tr>
<tr>
<td>Xuewu Liu</td>
<td>Physics; ALCOM; Finetello (Summer)</td>
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<tr>
<td>Ray Ma</td>
<td>Chemical Physics; ALCOM; Yang</td>
</tr>
<tr>
<td>Xiang-Dong Mi</td>
<td>Chemical Physics; DARPA; Yang</td>
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<tr>
<td>Sami Mkaddam</td>
<td>Math; ALCOM; Gartland</td>
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<tr>
<td>Hiroyuki Mori</td>
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<tr>
<td>Georgy Panasyuk</td>
<td>Physics; ALCOM; Allender</td>
</tr>
<tr>
<td>Eui Yeul Park</td>
<td>Chemical Physics</td>
</tr>
<tr>
<td>David Phan</td>
<td>Physics; Industry; Kumar</td>
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<tr>
<td>Andrew Primak</td>
<td>Physics; ALCOM; Kumar</td>
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<tr>
<td>Jiahua Que</td>
<td>Math; ALCOM; Gartland</td>
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<tr>
<td>Salman Saeed</td>
<td>Chemical Physics; LCI</td>
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<tr>
<td>Students, Cont.</td>
<td>Department; Support; Advisor</td>
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<tr>
<td>Tod Schneider</td>
<td>Chemical Physics; LCI</td>
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<tr>
<td>Anlun Tang</td>
<td>Physics; ALCOM; Sprunt</td>
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<tr>
<td>Charles Titus</td>
<td>Chemical Physics; 3M Fellowship</td>
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<tr>
<td>Dmitry Voloshsschenko</td>
<td>Chemical Physics; ALCOM</td>
</tr>
<tr>
<td>Charles Wang</td>
<td>Chemical Physics</td>
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<tr>
<td>Xiaodong Wang</td>
<td>Physics; ALCOM; West</td>
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<tr>
<td>Philip Watson</td>
<td>Chemical Physics, DARPA Supplement; Bos</td>
</tr>
<tr>
<td>Ming Xu</td>
<td>Chemical Physics, ALCOM, Yang</td>
</tr>
<tr>
<td>Haijun Yuan</td>
<td>Chemical Physics; LCI</td>
</tr>
<tr>
<td>Huairen Zeng</td>
<td>Physics; ALCOM; Finotello</td>
</tr>
<tr>
<td>Fang Zhang</td>
<td>Chemical Physics; LCI</td>
</tr>
<tr>
<td>Hailiang Zhang</td>
<td>Chemical Physics; LCI</td>
</tr>
<tr>
<td>Student</td>
<td>Dissertation/Thesis Title</td>
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<tr>
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</tr>
<tr>
<td>Hristina Galabova</td>
<td>A Theoretical Study of Surface Induced Phenomena in Nematic Liquid Crystals</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Xiaodong Wang</td>
<td>Polarized Ultraviolet Light Induced Alignment for Liquid Crystal Displays on Well-defined Polyimide Films</td>
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Table 4: Placement of Personnel

**Graduates**

<table>
<thead>
<tr>
<th>Name</th>
<th>Company/Location</th>
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<tbody>
<tr>
<td>Hristina Galabova</td>
<td>Reveo, Hawthorne NY</td>
</tr>
<tr>
<td>Xiaodong Wang</td>
<td>LCI NASA grant, Yang (8/97-3/98)</td>
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**Postdoctoral Fellows, Research Associates**

<table>
<thead>
<tr>
<th>Name</th>
<th>Company/Location</th>
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<tbody>
<tr>
<td>Jignesh Gandhi</td>
<td>S-VISION, Twinsburg</td>
</tr>
<tr>
<td>Yuhui Lin</td>
<td>Hong Kong</td>
</tr>
<tr>
<td>Rajesh Shenoy</td>
<td>Albany Molecular Research, NY</td>
</tr>
<tr>
<td>Yushan Shi</td>
<td>Washington University, St. Louis</td>
</tr>
<tr>
<td>Darius Subacius</td>
<td>Meadowlark Optics, Boulder CO</td>
</tr>
<tr>
<td>Bahman Taheri</td>
<td>Alpha Micron, Kent</td>
</tr>
<tr>
<td>Tat-Hung Tong</td>
<td>Univ. of Dayton Research Institute</td>
</tr>
<tr>
<td>Xiaodong Wang</td>
<td>Micro Display Corp., San Pablo CA</td>
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<tr>
<td>Yangming Zhu</td>
<td>KSU Computer Science</td>
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**Staff/Technicians**

<table>
<thead>
<tr>
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<th>Company/Location</th>
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<tbody>
<tr>
<td>David Abdallah</td>
<td>Bridgestone/Firestone, Akron</td>
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<tr>
<td>Sandi Campbell</td>
<td>CWRU Grad School</td>
</tr>
<tr>
<td>Seth Green</td>
<td>Alpha Micron, Kent</td>
</tr>
<tr>
<td>Richard Hewitt</td>
<td>Planar Systems, Beaverton OR</td>
</tr>
<tr>
<td>Chad Jones</td>
<td>Kent Displays Inc., Kent</td>
</tr>
<tr>
<td>Ralph Klouda</td>
<td>S-VISION, Twinsburg</td>
</tr>
<tr>
<td>Sandra Keast</td>
<td>Eli Lilly, Indianapolis IN</td>
</tr>
<tr>
<td>Kevin Liticker</td>
<td>S-VISION, Twinsburg</td>
</tr>
<tr>
<td>Gregg Podojil</td>
<td>Kent Displays Inc., Kent</td>
</tr>
<tr>
<td>Steven Smith</td>
<td>Motorola, Libertyville IL</td>
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Table 5: Grants and Contracts, 1997-1998

<table>
<thead>
<tr>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Agency</td>
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<tr>
<td>b. Grant/Contract Number</td>
</tr>
<tr>
<td>c. Period</td>
</tr>
<tr>
<td>d. Initial/Renewal/Continuation</td>
</tr>
<tr>
<td>e. Amount</td>
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</table>

1. Center for Advanced Liquid Crystalline Optical Materials (ALCOM), Consortium of Kent, Case Western Reserve and Akron universities

- a. National Science Foundation
- b. NSF DMR89-20147
- d. Continuation (Years 7 and 8)
- e. $2.5 million per year
  - 54% Kent, 34% CWRU, 12% UA
- f. J.L. West, PD; D.W. Allender,
  - D. Finotello, S. Kumar, S. Sprunt, Physics;
  - P. Bos, L.-C. Chieu, J.R. Kelly,
  - O.D. Lavrentovich, M.E. Neubert,
  - P. Palffy-Muhoray, D.K. Yang, LCI;
  - J.E. Fulghum, R.J. Twieg, Chemistry;
  - P. Farrell, E.C. Gartland, Jr., A. Ruttan,
  - Math/CS; L. Bartolo, Lib/Media Services.

- J.L. Koenig, Associate Director;
  - W.E. Gordon, S. Hudson, A.M. Jamieson,
  - J.B. Lando, J.A. Mann, R.G. Petschek,
  - C. Rosenblatt, D.E. Schuele, K.D. Singer,
  - P.L. Taylor, S.Q. Wang, CWRU; M.R.
  - Fisch, John Carroll; F.W. Harris, S.Z.D.
  - Cheng, T. Kyu, Akron
- g. S. Shiyanioukii

- h. R. Klouda, G. Magyar, D. Abdallah,
  - S. Campbell, R. Liticker, R. Miller, J. Kim,
  - M. Walsh, L. Qiu; B.Taheri, T. Kosa,

- A. Khan, R. Shenoy, F. Xu, T. Tong
- i. H. Galabova, H. Liu, R. Ma, R. Ennis,
  - S. Mkaddem, X. Liu, M.Cui, C. Hoke,
  - T. Ishikawa, D. Voloshchenko, A. Primak,
  - A. Tang, M. Xu, H. Zeng, E. Thomas,
  - H. Yuan, F. You, D. Hines, Y. Zhu
  - 442231

2. ALCOM Support

- a. Ohio Board of Regents

- d. Continuation; equipment
- e. $333,333 (Year 3 of 3)
- f. Same as 1f

3. ALCOM Support

- a. Ohio Board of Regents

- d. Initial, equipment
- e. $500,000 (Year 31of3)
- f. Same as 1f

4. ALCOM Support

- a. Ohio Department of Development
- c. Feb. 96-Jan. 98; Feb. 98-Jan. 00

- d. Continuing award
- e. $360,000 per year
- f. Same as 1f
  - 445224
5. Real Physics On-line
   a. NSF ALCOM Supplement
   c. 2/97-1/98
   d. Continuing
   e. $18,867
   f. Palffy-Muhoray
        442231

6. Reflective Polymer Stabilized LCD
   a. DARPA
   b. N61331-94-K-0042
   c. 6/94-6/98
   d. Continuation and No-cost Extension
   e. $470,000 (Year 3)
   f. J.L. West, J.W. Doane, D.K. Yang,
       P. Bos
   h. R. Hewitt, C. Jones, H. Wonderly,
       J. Hamric, W. Fritz
   i. J. Anderson 440131

7. Reflective Cholesteric Displays:
   Dynamic Drive and Surface Topography
   Issues
   a. DARPA
   b. DAAH04-96-10245
   c. 6/96-5/99
   d. Supplement to #7 (GRA support)
   e. $137,700
   f. P.J. Bos and D.K. Yang
   i. J.E. Anderson and P. Watson 444321

8. Reflective Cholesteric Displays
   a. DARPA, KDI Subcontract
   b. N61331-96-C-0042
   c. 7/96-6/99
   d. Year 2 of 3
   e. $615,074
       Yang
   g. A. Seed, Chemistry
   h. R. Hewitt, C. Jones, G. Podojil, Y. Kim,
       J. Francl, O. Falana, S. Smith, T. Ernst,
       V. Sergan, J. Ruth, Y. Zhu, J. Gandhi
   i. X. Mi, V. Bodnar 444327

9. Alignment and Defects of 3M
   Lyototropic Liquid Crystals
   a. 3M (Phase I)
   c. 2/98-8/98
   d. Initial
   e. $88,545
   f. O.D. Lavrentovich, J.R. Kelly, S. Kumar
   h. J.C. Lee
   i. T. Schneider
       444673

10. Broadband Beam Steering
    a. US DOD (STTR)
    c. 6/98-5/00
    d. Initial
    e. $150,000 (Boulder Nonlinear Systems)
    f. M.E. Neubert
    f. Bing Moche
       444332

11. Liquid Crystals on Silicon
    a. S-VISION
    c. 10/96-9/97
    d. Initial
    e. $60,000
    f. P. Bos
    h. W.R. Folks 444641
12. WPAFB IPA Visiting Scientist  
a. Wright Patterson AFB  
c. 9/96-9/97  
d. Continuation  
e. $125,000  
f. J.L. West  
h. D.R. Wiff 444325

13. Liquid Crystal Display Research Center  
a. Ohio Board of Regents  
c. Equipment  
d. Initial  
e. $2,578,000  
f. J.L. West, P.J. Bos

14. Conductive Polymer Displays  
a. Office of Naval Research  
c. 6/97-11/97  
d. Initial  
e. $20,900  
f. J.L. West  
h. W.J. Fritz, H. Wonderly 444331

15. Polymer Dispersed FE LCD Tech.  
a. Industry  
c. 6/96-5/97  
d. No-cost extension  
e. $250,000  
f. S. Kumar  
g. V. Vorflusev  
h. D. Phan 444448

16. Evaluation of NASA Polymers  
a. NASA  
c. 5/97-5/98  
d. Initial  
e. $20,000  
f. O.D. Lavrentovich

17. Wide Grid Polarizers for LCD  
a. Moxtex (NSF Subcontract)  
c. 10/97-9/98  
d. Initial  
e. $34,804  
f. J.R. Kelly  
h. T. Sergan 442102

18. Liquid Crystal Glasses Improvements  
a. IMAX Corp.  
c. 9/96-12/99  
d. Initial  
e. $30,000  
f. J. Kelly  
h. T. Sergan 444615

19. PDLC for Holographic Recording Applications  
a. Ministry of Education, Taiwan  
c. 8/96-7/98  
d. Initial  
e. $13,751  
f. L.C. Chien 444621
20. Alignment and Packing Behavior of LC and LCP ...
   a. AFOSR MURI
   b. F49620-97-1-0014
   c. 11/96-12/98

d. Continuation

e. $88,736; 35,551
f. P. Palffy-Muhoray
h. T. Kosa, S. Lukishova
   444328

21. Liquid Crystal Blazed Gratings for Laser Beam Steering
   a. AFOSR F49620-96-1-0449

d. Continuation

e. $282,976
f. O.D. Lavrentovich, P.J. Bos
h. D. Subacius, S. Shyanyovskii; M. Sabeva
   444324

22. Studies on Dynamics and Optics of 0-360 Twist Bistable LCD
   a. NASA
   c. 1/97-12/97

d. Initial

e. $1,500
f. P.J. Bos
i. C. Hoke
   444114

23. Polyimide Alignment Films
   a. Gov. of Korea
   c. 8/96-7/97

d. Initial

e. $10,000
f. J.L. West
h. K. Ha
   444608

24. PSCT Materials for Projection Displays
   a. Vari-Lite
   c. 9/97-9/98

d. Renewal

e. $71,416
f. D.K. Yang
h. F. Xu; R. Sun
   444618

25. Surface Alignment of Nematic LC
   a. George Mason University
   c. 1/97-1/98

d. Initial

e. $10,000
f. O.D. Lavrentovich
   444635

26. Optimization of Smectic A PDLC Films
   a. Dai Nippon Printing
   c. 4/97-3/98 (cont. to 8/98)

d. Initial

e. $110,176
f. J.L. West, J.R. Kelly, O.D. Lavrentovich
h. A. Bose
   444636
27. Photo-curable LC Monomers
   c. 7/97-12/97
   d. Initial

28. Development of LC Devices for Astronomy
   a. NASA Goddard Space Center
   c. 3/97-2/98; NC extension 2/99

29. Optical Study of Structure and Dynamics in Advanced Polymer Stabilized LC
   a. ONR N00014-97-1-0163
   c. 12/96-5/98

30. Construction of MCAT Undulator Beamline
   a. DOE Advanced Photon Source, ANL
   c. 10/96-12/99

31. Synchrotron X-Ray Scattering Facility at the APS
   a. Ohio Board of Regents
   c. 7/97-6/99

32. Viewing Angle Improving Films for Liquid Crystal Displays
   a. Ohio Board of Regents
   c. 7/97-6/99

33. Biological Lyotropic Liquid Crystals
   a. Ohio Board of Regents
   c. 7/97-6/99

34. Color Sequential Imaging
   a. Colorlink
   c. 5/97-4/00
   d. Initial
   e. $200,000
   f. P.J. Bos
   h. W. R. Folks
   j. S. Saeed
   444664
35. Studies of the Dynamic Characteristics of TN-LCDs
   a. Hitachi Visiting Scientist
   c. 3/98-3/99
   d. Initial
   e. $20,000
   f. J.R. Kelly
   j. Tohru Sasaki
      444672

36. High Performance Liquid Crystals for Laser Communications
   a. Hughes Research Labs
   c. 3/98-3/99
   d. Initial
   e. $20,000 (P.O.)
   f. M.E. Neubert

37. Computational, Experimental and Theoretical Studies of One-dimensional Confined Liquid Crystals
   a. NATO
   c. 12/96-12/98
   d. Initial
   e. $9,495
   f. O.D. Lavrentovich
      444629

38. Visiting Scientist, Japan Synthetic Rubber
   a. JSR
   c. 4/97-10/98
   d. Initial
   e. $20,000
   f. J.L. West
   j. Michinori Nishikawa
      220232

39. Surface Properties and Effects in Liquid Crystals
   a. CRDF
   c. 7/97-6/99
   d. Initial
   e. $11,000
   f. O.D. Lavrentovich
      444647

40. Photo-alignment of Nematic Liquid Crystals on Polyimide Polymer Layers
   a. CRDF
   c. 7/97-6/99
   d. Initial
   e. $15,212
   f. J.L. West
      444648

41. Investigation of Physical and Optical Properties of Ferroelectric PDLC
   a. CRDF
   c. 11/96-10/98
   d. Initial
   e. $37,000
   f. S. Kumar

42. Structure and Defects in Lamellar Thermotropic and Lyotropic Soft Matter Systems
   a. NSF/CNRS (France)
   c. 5/98-4/01
   d. Initial
   e. $19,500
   f. O.D. Lavrentovich
      442106

43. NMR Characterization of Bile Micellar Structures
   a. Ohio Board of Regents
   c. 1997-1998
   d. Initial
   e. $18,760
   f. P.W. Westerman

44. Lyotropic Liquid Crystal Research: Advances in Membrane Protein Research
    a. Ohio Board of Regents
    c. 1997-1998
    d. Continuation
    e. $10,000
    f. P.W. Westerman

45. Liquid Crystal Polymer Dispersions and Related Microconfined Systems
    a. US-Slovene Science and Tech. Program
    c. 1995-1997
    d. Continuation
    e. $33,000 + 4,422,000 Slovene tolers
    f. P.J. Bos

46. Investigation of the Influence of Structure Factors on the Stability of Smectic C* & C_α Phases in Compounds and Mixtures
    a. NSF & Maria Shlodowska Foundation
    c. 1996-1999
    d. Initial
    e. $23,000
    f. M.E. Neubert; R. Dabrowski, Warsaw, Poland

Awards through KENT STATE UNIVERSITY FOUNDATION

Clean Room Construction
   e. $500,000
   f. John L. West

Teaching Laboratory Equipment
   e. $250,000
   f. John L. West

LCI/Materials Science Building
   e. $50,000 ($250,000 total gift)
   f. John L. West
Table 6: Proposals for Extramural Support

<table>
<thead>
<tr>
<th>Title</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>a. Agency</td>
<td>e. Project Director; Principal Investigators</td>
</tr>
<tr>
<td>b. Period</td>
<td>f. Faculty Associates or Visiting Scientists</td>
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<tr>
<td>c. Initial/Renewal/Continuation</td>
<td>g. Status</td>
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<tr>
<td>d. Amount Requested</td>
<td></td>
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</table>

1. Optimization and Modeling of Full Color Displays
   a. Motorola
   b. 1998-2001 (three years)
   c. Initial
   d. $51,225
   e. P.J. Bos
   g. Awarded, pending IPP agreement

2. LCD Optical Shutter for Eye Protection Devices
   a. NATO Science for Peace Program
   b. Three years
   c. Initial
   d. $270,000 (8 million Belgian Francs)
   e. P.J. Bos with J. Pirs, Univ. Ljubljana
   g. Pending (defended July 1998)

3. Center for Electro-Active Polymers (CEAP)
   a. DARPA
   b. 8/98-7/02
   c. Initial
   d. $7.5 million
   e. K.D. Singer, PD; L.-C. Chien, P. Palffy-Muhoray, R.J. Twieg (et al.)
   g. Pending

4. Liquid Crystalline Elastomeric Systems for Mesoscale Functional Design as Actuators for Robotic Devices
   a. DARPA
   b. 7/98-6/03
   c. Initial
   d. $1,846,514
   e. J.L. Koenig and L.-C. Chien
   g. Pending

5. One and Two Dimensional Diffraction Gratings in Polymer Stabilized Liquid Crystal Composites...
   a. Army Research Office
   b. 6/98-5/01
   c. Initial
   d. $454,186
   e. L.-C. Chien and S.N. Sprunt
   g. Not awarded

6. Alignment and Defects of 3M Lyotropic Liquid Crystals
   a. 3M Corp.
   b. 2/98-8/98
   c. Initial and continuation
   d. $88,545 and $88,400
   e. O.D. Lavrentovich, J. Kelly, S. Kumar, Phase I; ODL, JRK, L.-C. Chien, Phase II
   g. Awarded
7. Computational, Experimental and Theoretical Studies of One-Dimensionally Confined Liquid Crystals
   a. NATO Intl Scientific Exchange
   b. 9/98-9/00
   c. Renewal
   d. $6,000
   e. O.D. Lavrentovich and C. Zannoni
   g. Awarded

8. Structures and Defects in Lamellar Thermotropic and Lyotropic Soft Matter Systems
   a. NSF/CNRS France
   b. 5/98-4/01
   c. Initial
   d. $19,500
   e. O.D. Lavrentovich
   g. Awarded

9. Broadband Beamsteering
   a. DOD (STTR) Boulder Nonlinear Systems
   b. 6/98-5/00
   c. Initial
   d. $150,000
   e. M.E. Neubert
   g. Awarded

10. High Performance Liquid Crystals for Laser Communications
    a. AFOSR, Hughes and Cal Tech JPL
    b. 6/98-5/00
    c. Initial
    d. $40,000
    e. M.E. Neubert
    g. Awarded

11. School-based Remote Experiments on the Web
    a. NSF EHR
    b. 7/98-7/99
    c. Continuation
    d. $160,000
    e. P. Palffy-Muhoray and L. Bartolo
    g. Awarded

12. Nonlinear Optics of Liquid Crystals
    a. NSF International Programs/Brazil
    b. 10/98-9/00
    c. Initial
    d. $28,600
    e. P. Palffy-Muhoray
    g. Pending

13. Bistable Reflective Cholesteric Layers
    a. DARPA/Sarnoff Labs
    b. 10/97-9/98
    c. Initial
    d. $104,011
    e. J.L. West
    g. Not awarded
14. Fabrication of PDLC Test Displays
   a. DARPA/Sarnoff Labs
   b. 7/98-6/01
   c. Initial

d. $273,772
e. J.L. West
g. Awarded

15. Cholesteric-LCD Document Reader
   a. NIST ATP Program (KDI)
   b. 7/98-6/01
   c. Initial
   d. $450,000
   e. P.J. Bos and J.L. West
   g. Not awarded

16. Optimization of Advanced Smectic A PDLC Films
    a. Dai Nippon Printing
    b. 4/98-3/99
    c. Continuation
    d. $123,728
    e. J.L. West, J. R. Kelly, O.D. Lavrentovich
    g. Award postponed

17. Conducting Polymer Substrates
    a. ONR SBIR (KDI Subcontract)
    b. 6/97-10/97
    c. Initial
    d. $20,000
    e. J.L. West
    g. Awarded; Phase 2 pending

18. Liquid Crystal Light Shutter for Astronomical Applications
    a. NASA
    b. 10/98-4/99
    c. Continuation
    d. $26,000
    e. D.K. Yang
    g. Awarded

19. PSCT for Projection Displays
    a. Vari-Lite
    b. 4/98-3/99
    c. Continuation
    d. $71,416
    e. D.K. Yang
    g. Awarded

20. Orientational Phenomena in Homeotropic Liquid Crystal Films: Experiment, Theory and Applications
    a. NSF-Slovenia
    b. 11/98-1/01
    c. Initial
    d. $48,828
    e. D. Finotello
    g. Pending

21. Bending Magnet Beamline at APS
    a. NSF
    b. 7/98-6/01
    c. Initial
    d. $2.8 million
    e. S. Kumar
    g. Not awarded
Proposals for Extramural Support, 1997-1998

22. Novel Morphologies and Dynamical Properties of Polymer-Stabilized Liquid Crystals
   a. Research Corporation
   b. 6/98-6/99

23. Novel Electro-Optic Chromophores with Enhanced Photostability for Integrated Optics Applications at 830 nm
   a. Air Force SBIR
   b. 6/98-12/98

24. Optical Polymers and Manufacturing Processes for Low-Cost WDM Devices and Systems
   a. NIST/ATP Focused Programs
   b. 9/98-8/01

25. Frequency Shifting Devices with Poled Polymers
   a. Molecular Optoelectronics Corp.
   b. 9/98-2/99
   c. Initial

   d. $50,000
   e. S. Sprunt
   g. Not awarded

   c. Initial
   d. $33,000
   e. R.J. Twieg
   g. Not awarded

   c. Initial
   d. $90,000 (Subcontract to Lightwave Microsystems and BFGoodrich)
   e. R.J. Twieg
   g. Pending

   d. $30,000
   e. R.J. Twieg
   g. Pending
### Table 7: Publications

**David W. Allender**


**Philip J. Bos**


Liang-Chy Chien


Daniele Finotello


**Jack R. Kelly**


**Satyendra Kumar**


Oleg D. Lavrentovich


Mary E. Neubert


Peter Palffy-Muhoray


**Samuel N. Sprunt**


**John L. West**


"ALCOM, the National Science Foundation Science and Technology Center for Advanced Liquid Crystalline Optical Materials," *EKISHO* **2/1**, 57-61 (1997).


**Philip W. Westerman**


**Deng-Ke Yang**


<table>
<thead>
<tr>
<th>KSU Discl. #</th>
<th>Patent/ Appl. No.</th>
<th>Title</th>
<th>Date</th>
<th>Inventors</th>
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<tbody>
<tr>
<td>123</td>
<td>5,668,614</td>
<td>Pixelized LCD Materials Including Chiral Material Adopted to Change Its Chirality upon Photo-Irradiation</td>
<td>9/16/97</td>
<td>Chien, Doane</td>
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<tr>
<td>105</td>
<td>5,691,795</td>
<td>Polymer Stabilized Liquid Crystalline Light Modulating Device and Material</td>
<td>11/25/97</td>
<td>Doane, Yang, Chien</td>
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<tr>
<td>103</td>
<td>5,695,682</td>
<td>Liquid Crystalline Light Modulating Device and Material</td>
<td>12/9/97</td>
<td>Doane, Yang, Chien</td>
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<tr>
<td>145a,b</td>
<td>5,748,277</td>
<td>Dynamic Drive Method and Apparatus for a Bistable Liquid Crystal Display</td>
<td>5/5/98</td>
<td>Huang, Bos, Yang</td>
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<tr>
<td>152.1</td>
<td>5,766,694</td>
<td>Method for Forming Uniformly-Spaced Plastic Substrate Liquid Crystal Displays</td>
<td>6/16/98</td>
<td>West, Bos</td>
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<td>152.2</td>
<td>08/953,596</td>
<td>Method for Forming LCD Cell Walls Using a Patterned Electric Field</td>
<td>10/17/97</td>
<td>Rouberol, Ji, Francl, West</td>
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<td>181</td>
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<td>Diffractive Grating with Electrically-Controlled Periodicity</td>
<td>4/15/97</td>
<td>Lavrentovich, Subacius</td>
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<td>182</td>
<td>09/076,564</td>
<td>Cumulative Two Phase Drive Scheme for Bistable Cholesteric Reflective Displays</td>
<td>5/12/98</td>
<td>Zhu, Yang</td>
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<td>183</td>
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<td>Dual Frequency Cholesteric Display and Drive Scheme</td>
<td>5/2/97</td>
<td>M. Xu, Yang</td>
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<td>184</td>
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<td>A Low Cost Dynamic Drive Scheme for Multiplexing Bistable Reflective Cholesteric LCDs Utilizing Commercial STN Driver Chip</td>
<td>2/21/97</td>
<td>Ruth, Hewitt, Bos</td>
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<td>185</td>
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<td>Uniform Alignment of Lyotropic Dye Films for Optical Elements (Polarizers)</td>
<td>7/11/97</td>
<td>Schneider, Nastishyn, Lavrentovich</td>
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</table>
187 09/076,577 Drive Schemes for Gray Scale Bistable Cholesteric Reflective Displays 5/12/98 Yang, Huang, Miller
Table 9: Presentations at Professional Meetings

David W. Allender


Philip J. Bos


"Cholesteric diffractive devices with a field-controlled grating vector," D. Subacios, S. Li, S.V. Shishakovskii, P.J. Bos and O.D. Lavrentovich, ALCOM Symposium on Reflective Displays.


L.-C. Chien


**Daniele Finotello**


**Jack R. Kelly**


"Improvement of the optical characteristics of a twisted-nematic display using negative in-plane and splayed discotic films," T.A. Sergan and J.R. Kelly, SID 98.


**Satyendra Kumar**


**Oleg D. Lavrentovich**


"Cholesteric diffractive devices with a field-controlled grating vector," D. Subacius, S.Li, S.V. Shivanovskii, P.J. Bos and O.D. Lavrentovich, ALCOM Symposium on Reflective Displays.

**Mary E. Neubert**


**Peter Palffy-Muhoray**


Samuel N. Sprunt


John L. West


"LC alignment mechanism for polarized UV-exposed polyimide films," K. Ha, W. Ahn and J.L. West, SID 98.


**Philip W. Westerman**


**Deng-Ke Yang**


"Cell designs for fast reflective cholesteric LCDs," X.D. Mi and D.-K. Yang, SID 98.


Presentations at Professional Meetings, 1997-1998


Table 10: Academic Presentations and Other Activities

David W. Allender


Philip J. Bos


L.-C. Chien


Jack Kelly


Satyendra Kumar

"What is 'really' responsible for liquid crystal alignment?" Liquid Crystal Institute Seminar, Oct. 1, 1997.
"Liquid crystal alignment on solid substrates," University of the Philippines at Diliman, Jan. 7, 1998.

Oleg D. Lavrentovich

"Networks of oily streaks in cholesteric display cells," IBM Japan Research Center, Kanagawa, Nov. 18, 1997.

**Peter Palffy-Muhoray**


"Ratchets, molecular motors and the photoalignment of liquid crystals," National University of Mexico, Mexico City, June 1, 1998.

**John L. West**

"Infrastructure in Northeast Ohio," Cleveland Tomorrow panel, March 27, 1998.


**Deng-Ke Yang**


"Scattering liquid crystals," Department of Physics, University of California, Berkeley, August 1997.
<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Topic</th>
</tr>
</thead>
</table>
| July 3    | Professor Slobodan Zumer  
University of Ljubljana, Slovenia | "Ordering, fluctuations and forces in paranematic surface layers" |
| August 26 | Dr. Holly Fu  
AT&T Bell Labs  
Murray Hill NJ | "Plastic liquid crystal displays: Plastic substrate selection and cell spacing considerations" |
| August 28 | Dr. Boris Veytsman  
Pennsylvania State Univ. | "Hydrogen bonded liquid crystals: Self-organization and molecular recognition" |
| Sept. 5   | Dr. Hidefumi Yoshida  
Fujitsu Laboratories  
Kawasaki, Japan | "Wide viewing angle TFT-LCD with vertical alignment and photo-alignment technology" |
| Sept. 17  | Professor Satyendra Kumar  
Dept. of Physics  
Kent State University | "What is 'really' responsible for liquid crystal alignment?" |
| Sept. 19  | Professor Noel Clark  
Department of Physics  
University of Colorado, Boulder | "Bownews! Spontaneous chiral layers and domains in a novel antiferro-electric phase of bent core (bow shaped) molecules" |
| Sept. 24  | Professor Victor Belyaev  
Central R&D Cometa  
Moscow, Russia | "Effect of molecular structure on microscopic and physical properties of nematic liquid crystals" |
| Oct. 8    | Professor Bernard Kippelen  
Optical Sciences Center  
University of Arizona, Tucson | "Recent advances in photorefractive polymers and liquid crystals" |
| Oct. 15   | Dr. Sergij Shiyanovskii  
Institute for Nuclear Research  
Kiev, Ukraine, and LCI | "Computer simulations of 3D nematic and cholesteric structures" |
| Oct. 22   | Dr. Jianmin Chen  
Samsung Electronics AMLLCD Div.  
Seoul, Korea, and LCI | "A novel liquid crystal display mode for wide viewing angle applications" |
| Oct. 29   | Professor Fouad Aliev  
Dept. of Physics  
University of Puerto Rico | "Dynamic properties of confined LCs: Photon correlation and broad-band dielectric spectroscopy investigations" |
| Nov. 5    | Professor Joe B. Whitehead, Jr.  
Depts. of Physics & Chemistry  
University of Southern Mississippi | "Characterization of liquid crystal/polymer dispersions" |
<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Institution</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 7</td>
<td>Professor James P. McClymer</td>
<td>Dept of Physics &amp; Astronomy</td>
<td>&quot;Breakdown of dynamic scaling . . . and other fun things from EHD&quot;</td>
</tr>
<tr>
<td></td>
<td>Dept of Physics</td>
<td>University of Maine</td>
<td></td>
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<tr>
<td>Nov. 19</td>
<td>Dr. J. Adrian Reyes</td>
<td>Dept of Physics</td>
<td>&quot;Ray propagation in liquid crystal for nonplanar geometries&quot;</td>
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<tr>
<td></td>
<td>National University of Mexico</td>
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<tr>
<td>Dec. 3</td>
<td>Professor Yang Yang</td>
<td>Dept. of Materials Science and Engineering</td>
<td>&quot;Polymer electroluminescent devices and their recent progress&quot;</td>
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<td></td>
<td>UCLA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
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<tr>
<td>Jan. 28</td>
<td>Dr. Pavel I. Lazarev</td>
<td>Optiva, Inc.</td>
<td>&quot;Lyotropic liquid crystal polarizers&quot;</td>
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<tr>
<td></td>
<td>San Mateo CA</td>
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<tr>
<td>Feb. 11</td>
<td>Professor Eugene C. Gartland, Jr.</td>
<td>Dept. of Math &amp; Computer Science</td>
<td>&quot;Numerical modeling of structures and structural phase transition in confined liquid crystal systems&quot;</td>
</tr>
<tr>
<td></td>
<td>Kent State University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb. 18</td>
<td>Dr. Yves Lansac</td>
<td>Department of Physics</td>
<td>&quot;Atomistic simulation of photo-induced instabilities in smectic A liquid crystals&quot;</td>
</tr>
<tr>
<td></td>
<td>Univ. of Colorado, Boulder</td>
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<td></td>
</tr>
<tr>
<td>April 15</td>
<td>Professor Jack L. Koenig</td>
<td>Dept. of Macromolecular Sciences</td>
<td>&quot;Spectroscopic imaging of phase separating liquid crystal systems&quot;</td>
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<tr>
<td></td>
<td>Case Western Reserve University</td>
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<td></td>
</tr>
<tr>
<td>April 23</td>
<td>Dr. Bruce K. Winker</td>
<td>Rockwell Science Center</td>
<td>&quot;Gray scale and contrast compensator for LCDs using obliquely oriented anisotropic network&quot;</td>
</tr>
<tr>
<td></td>
<td>Thousand Oaks CA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 24</td>
<td>Professor Robert B. Meyer</td>
<td>Martin Fisher School of Physics</td>
<td>&quot;Symmetry and textures in thin smectic C liquid crystal films&quot;</td>
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<tr>
<td></td>
<td>Brandeis University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 29</td>
<td>Professor David M. Walba</td>
<td>Department of Chemistry</td>
<td>&quot;Chiral liquid crystal phases from achiral molecules&quot;</td>
</tr>
<tr>
<td></td>
<td>University of Colorado, Boulder</td>
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</tr>
<tr>
<td>May 1</td>
<td>Dr. Alan Lien</td>
<td>IBM T.J. Watson Research Center</td>
<td>&quot;Non-rubbing liquid crystal alignment technology&quot;</td>
</tr>
<tr>
<td></td>
<td>Yorktown Heights NY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 15</td>
<td>Professor Sin Doo Lee</td>
<td>Liquid Crystal Laboratory</td>
<td>&quot;Ferri-like liquid crystalline ordering during the antiferroelectric-ferroelectric phase transition under external field&quot;</td>
</tr>
<tr>
<td></td>
<td>Seoul National Univ., Korea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 10</td>
<td>Dr. Joseph W. Perry</td>
<td>Jet Propulsion Lab, Cal Tech</td>
<td>&quot;Structure/property relationships and applications of two-photon absorbing molecules&quot;</td>
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Table 12: ALCOM Industrial Partnership Program

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Aerospace Display Systems</td>
<td>Hatfield PA</td>
</tr>
<tr>
<td>Lucent Technologies</td>
<td>Murray Hill NJ</td>
</tr>
<tr>
<td>AlphaMicron, Inc.</td>
<td>Kent OH</td>
</tr>
<tr>
<td>Lumex Inc.</td>
<td>Palatine IL</td>
</tr>
<tr>
<td>Ametek</td>
<td>Sellersville PA</td>
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<tr>
<td>LXD</td>
<td>Cleveland OH</td>
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<tr>
<td>Brewer Science</td>
<td>Rolla MO</td>
</tr>
<tr>
<td>3M Corporation</td>
<td>Minneapolis MN</td>
</tr>
<tr>
<td>Corning, Inc.</td>
<td>Corning NY</td>
</tr>
<tr>
<td>Meadowlark Optic</td>
<td>Longmont CO</td>
</tr>
<tr>
<td>Crystalloid Electronics</td>
<td>Hudson OH</td>
</tr>
<tr>
<td>Motorola</td>
<td>Tempe AZ</td>
</tr>
<tr>
<td>Dow Chemical Co.</td>
<td>St. Louis MO</td>
</tr>
<tr>
<td>National Semiconductor</td>
<td>Santa Clara CA</td>
</tr>
<tr>
<td>dpiX - A Xerox Company</td>
<td>Palo Alto CA</td>
</tr>
<tr>
<td>Optical Imaging Systems</td>
<td>Northville MI</td>
</tr>
<tr>
<td>Eastman Kodak Co.</td>
<td>Rochester NY</td>
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<tr>
<td>Planar Advance Inc.</td>
<td>Beaverton OR</td>
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<tr>
<td>Honeywell</td>
<td>Phoenix AZ</td>
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<tr>
<td>Polaroid</td>
<td>Cambridge MA</td>
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<tr>
<td>Hughes Research Labs</td>
<td>Malibu CA</td>
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<tr>
<td>Raychem Corp.</td>
<td>Menlo Park CA</td>
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<tr>
<td>IBM TJ Watson Research Center</td>
<td>Yorktown Heights NY</td>
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<tr>
<td>Reveo Inc.</td>
<td>Hawthorne NY</td>
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<tr>
<td>In Focus Systems</td>
<td>Wilsonville OR</td>
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<tr>
<td>Rockwell International Science Corp.</td>
<td>Thousand Oaks CA</td>
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<tr>
<td>Kent Displays, Inc.</td>
<td>Kent OH</td>
</tr>
<tr>
<td>Rohm and Haas Co.</td>
<td>Bristol PA</td>
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S-VISION
Twinsburg OH

Three Five Systems
Tempe AZ

Vari-Lite
Dallas TX
Table 13: Visits by/to Industry and Commercialization

<table>
<thead>
<tr>
<th>1997</th>
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<tr>
<td>July 17</td>
<td>SpectraSwitch</td>
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<td>July 25</td>
<td>Tutco</td>
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<tr>
<td>August 8</td>
<td>Reveo</td>
</tr>
<tr>
<td>August 12</td>
<td>Siemens Optical Group</td>
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<tr>
<td>Aug. 11</td>
<td>3M Corp.</td>
</tr>
<tr>
<td>Aug. 20</td>
<td>Sign Strut</td>
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<td>Sept. 8</td>
<td>Toshiba</td>
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<td>Sept. 11</td>
<td>Philips Research</td>
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<td>Sept. 19</td>
<td>Hitachi</td>
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<td>Sept. 22</td>
<td>Xerox</td>
</tr>
<tr>
<td>Sept. 22</td>
<td>Nanox Corp., NSG America</td>
</tr>
<tr>
<td>Sept. 26</td>
<td>Hornell Speed Glass</td>
</tr>
<tr>
<td>Sept. 26</td>
<td>Peacock Software</td>
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<tr>
<td>Sept. 29</td>
<td>ALSA Instruments</td>
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<tr>
<td>Oct. 20</td>
<td>Nitto Denko</td>
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<tr>
<td>Oct. 20</td>
<td>Vari-Lite</td>
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<tr>
<td>Dec. 18</td>
<td>Rohm and Haas</td>
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<td>Jan. 7</td>
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<td>Brewer Science</td>
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<td>Nitto Denko</td>
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<td>Jan. 27</td>
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<td></td>
<td>ASET, IBM Japan, Merck</td>
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<td>Japan, Sumito Chemical Co.</td>
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<td>Steris Corp.</td>
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<td>Dow Chemical</td>
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<td>Feb. 17</td>
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<td>Web Design</td>
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<td>Feb. 18</td>
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<td>Samsung</td>
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<td>SanTech</td>
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<td>March 9</td>
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<td>Polaroid</td>
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<td>3M Corp.</td>
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<td>Rockwell International</td>
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<td>May 14</td>
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<td>Nitto Denko</td>
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<td>May 26</td>
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<td>Toray Industries</td>
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<td>3M Corp.</td>
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<td>June 16</td>
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<td>National Semiconductor</td>
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</table>
Table 14: Education and Public Service

ALCOM Education Program Personnel
Professor Peter Palfy-Muhoray, ALCOM Education Coordinator
Professor Laura M. Bartolo, Library and Media Services, ALCOM PI
Dr. Maxwell Godfrey, ALCOM Education Project Coordinator

Other Participants
Dr. John West, Professor Phil Bos, Dr. Tamas Kosa, Dr. Bahman Taheri, Dr. Jon Ruth,
Doug Bryant, Rich Hewitt, Kevin Liticker, Ralph Klouda, Chad Hoke, Tod Schneider,
Brenda Buck

Activities and Presentations
Consulting for Great Lakes Science Center, Dr. Maxwell Godfrey
Science Educators Council of Ohio
ALCOM Education Outreach Kits
The Electronic Classroom (joint project with Library and Media Services)
Ask-a-Scientist, World Wide Web, 805 threads
Experiment at a Distance, http://olbers.kent.edu/alcomed/Experiment/ea.html
Communities Day at Kent, Sept. 13, 1997
Alumni Homecoming, Oct. 3, 1997
Family Day at Kent, Nov. 1, 1997
Portage County Science Fair, Dr. Maxwell Godfrey, March 7, 1998
Greater Cleveland Growth Association, Panel on Infrastructure in Northeast Ohio,
March 27, 1998 Dr. John West
Ohio Department of Development Trade Mission and US Midwest-Japan Trade
Association Meeting, Tokyo, March 31-April 2, 1998, Dr. John West
Leadership Portage County 1998 Education Day, April 2, 1998, Dr. John West
InterUniversity Sampler, April 28, 1998, Dr. John West

Other Activities (see Appendices)
- ALCOM Symposium: Reflective Displays, December 11-12, 1997
- Short Course: Liquid Crystals: Materials and Display Devices, June 2-5, 1998
- On-line symposium: "Future of Print Media," with School of Journalism/Mass
  Communications

58
### Presentations and Tours
#### July 1997-June 1998

<table>
<thead>
<tr>
<th>Date</th>
<th>Organization Name</th>
<th># of Participants</th>
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<tbody>
<tr>
<td>July 13-16</td>
<td>Creative Connections, Labs and Demos</td>
<td>13</td>
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<tr>
<td>July 16-17</td>
<td>Physics Modelling Program (Adult)</td>
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<td>July 24</td>
<td>Math &amp; Science on the Move (Adult)</td>
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<td>July 31</td>
<td>Lab instruction</td>
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<td>Aug. 22</td>
<td>Middle and Secondary School students</td>
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<td>Aug. 26</td>
<td>KSU Admissions Officers, Tour</td>
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<td>Sept. 12</td>
<td>Inventure Place Demonstration</td>
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<td>Sept. 13</td>
<td>Kent Staff Appreciation Day</td>
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<td>Sept. 23</td>
<td>Ohio Employees Ownership Center, Tour</td>
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<td>Sept. 24</td>
<td>St. Joseph's School (Middle)</td>
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<td>Oct. 4</td>
<td>Arts &amp; Sciences Alumni</td>
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<td>Oct. 18</td>
<td>CRSTC (Adult)</td>
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<td>Oct. 24</td>
<td>Harmon Middle School, Demo</td>
<td>75</td>
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<td>Oct. 25</td>
<td>Physics in Action (grades 1-8)</td>
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<td>Oct. 31</td>
<td>Harmon Middle School, Demo</td>
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<tr>
<td>Nov. 1</td>
<td>Kent Family Day, Tours</td>
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<td>Nov. 3</td>
<td>School of Technology Grad Students, Tour</td>
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<td>Nov. 10</td>
<td>Girl Scouts, Demo</td>
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<td>Nov. 12</td>
<td>Brown Middle School, Demo</td>
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<td>Nov. 13</td>
<td>Cleveland Health Center School, Secondary</td>
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<td>Nov. 17</td>
<td>Central Elementary, Kent, Tour</td>
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<td>Roosevelt High School</td>
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<td>Dec. 2</td>
<td>IEEE, Akron Chapter (Adult), Tour</td>
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<td>Dec. 6</td>
<td>Continental Middle School, Cleveland</td>
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<td>Dec. 10</td>
<td>Lea Eaton Elementary, Nordonia</td>
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<tr>
<td>Jan. 13</td>
<td>Nordonia High School</td>
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<td>Nordonia High School</td>
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<td>Jan. 20</td>
<td>Stark Campus Advisory Board (Adult)</td>
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<td>Feb. 2</td>
<td>Lakewood High School</td>
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<tr>
<td>Feb. 25</td>
<td>Echo Hills Elementary School</td>
<td>150</td>
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<tr>
<td>March 6</td>
<td>Field High School</td>
<td>100</td>
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<td>March 7</td>
<td>Portage County Science Fair</td>
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<tr>
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<td># of Participants</td>
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<tr>
<td>March 9</td>
<td>Independence High School</td>
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<tr>
<td>April 2</td>
<td>Leadership Portage County</td>
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<tr>
<td>April 6</td>
<td>Our Lady of the Elms High School</td>
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<tr>
<td>April 23</td>
<td>&quot;Take Our Daughters to Work,&quot; Demo</td>
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<tr>
<td>April 25</td>
<td>Hudson Science Club</td>
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</tr>
<tr>
<td>April 30</td>
<td>Brimfield Elementary School</td>
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<tr>
<td>May 19</td>
<td>PACE, Portage County</td>
<td>11</td>
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<tr>
<td>May 21</td>
<td>Stow High School</td>
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<tr>
<td>June 20</td>
<td>Great Lakes Science Center (Adult)</td>
<td>30</td>
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<tr>
<td>June 26</td>
<td>Univ. of Akron Upward Bound</td>
<td>42</td>
</tr>
</tbody>
</table>

Total 2,061
APPENDIX I

ALCOM OUTREACH ACTIVITIES

SYMPOSIUM ON REFLECTIVE DISPLAYS

WORKSHOP: LIQUID CRYSTAL MATERIALS AND DISPLAY DEVICES

ON-LINE SYMPOSIUM: FUTURE OF PRINT MEDIA
ALCOM Symposium

Reflective Displays

December 11-12, 1997

Sheraton Suites
Cuyahoga Falls, Ohio

Sponsored by the
National Science Foundation
Science and Technology Center for
Advanced Liquid Crystalline Optical Materials
Lunch, Casual Overlook
12:30

Symposium Conclusion
12:45

H. Yuan, WPX, Va Xerox Company
3:30

Photographic PQC Reflective Displays

2:00

S. Kan, Air Force University/ACTION

2:30

Phase Separated Polymer Electrode Smectic-C* Liquid Crystal

T. Sonomura, SciQ Display

3:00

Planar Reflective Displays

R. B. Akins, Motorola, Inc.

11:25

Consumer Requirements for Reflective Displays

Panel: R. Akins, I.W. Dong, Y. Liman

Moderator: J. West

10:40

Session Chair: John I. West

10:20

Break

10:00

ACOM Winter Conference

10:00

Coffee and Pastries, Cuypersoom

8:00

Friday, December 12

I.W. Dong, Kent State University, Inc.
Cholesteric Reflective Displays: Present and Future
8:30

Breakfast, Ballroom West
7:00

Coffee, Ballroom West
6:00

Poster Session, Balloon Room
5:00-7:00

Poster Session Chair: Samuel Sprent

0:00

Welcome

8:20

Session Chair: David W. Allender

8:30

Welcome and Opening Remarks

8:00

ACOM Symposium on Reflective Displays

10:30

J. West, Osram University of Applied Science and Technology
Condensation of Some Reflective Display Technologies

12:00

P. Bo, Boss, Kent State University/ACTION
Condensation of Some Reflective Display Technologies

12:00

A. Kan, Air Force University/ACTION

12:00

M. Woodman, VM Company
Condensation of Some Reflective Display Technologies

11:15

X. Liman, Tokyo University of Agriculture and Technology

10:30

锹

8:20

Session Chair: Jack K. Koening

10:00

Break

0:00

K. H. Yang, ISM
Projection Display

2:15

Micro LC Models and LC Phase Gratings for Reflective

1:15

S. I. Yuan, Hughes Aircraft Labs
Refractive ITL Displays

8:30

V. V. Allender, Alizadeh

8:00

Panel: K. H. Yang, ISM

9:15

Session Chair: David W. Allender

8:30

Welcome

8:00

ACOM Symposium on Reflective Displays

10:30

J. West, Osram University of Applied Science and Technology
Condensation of Some Reflective Display Technologies

12:00

P. Bo, Boss, Kent State University/ACTION
Condensation of Some Reflective Display Technologies

12:00

A. Kan, Air Force University/ACTION

12:00

M. Woodman, VM Company
Condensation of Some Reflective Display Technologies

11:15

X. Liman, Tokyo University of Agriculture and Technology

10:30

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8:20

Session Chair: Jack K. Koening

10:00

Break

0:00

K. H. Yang, ISM
Projection Display

2:15

Micro LC Models and LC Phase Gratings for Reflective

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Facility

Established in 1965, the Liquid Crystal Institute (LCI) is the oldest, largest, and most comprehensive liquid crystal research program in the country. It also maintains the largest university-based liquid crystal flat panel display research and development program in the world.

Institute achievements include the discovery and characterization of new liquid crystalline phases and invention of new types of liquid crystal devices such as polymer dispersed and polymer stabilized liquid crystals.

The Liquid Crystal Institute is also headquarters for the National Science Foundation Science and Technology Center for Advanced Liquid Crystalline Optical Materials (ALCOM), a consortium of three Northeast Ohio universities: Kent State University, Case Western Reserve University, and The University of Akron.

The new 65,000-square-foot Liquid Crystal/Material Science building also houses associated research centers and the graduate Chemical Physics program. The facility consists of 22,000 square feet of research laboratories, a 2,500-square-foot classroom, three teaching labs, two classrooms, and a 150-seat auditorium.

Web Sites
LCI: http://www.lci.kent.edu
ALCOM: http://alcom.kent.edu/ALCOM/ALCOM.html
Short Course: http://alcom.kent.edu/ALCOM/shortcourse.html
Liquid Crystals: Materials and Display Devices

A hands-on lecture/laboratory course that provides a working understanding of liquid crystal materials and display applications. Laboratories provide participants with the basic skills required to use these materials effectively and fabricate TN, STN, ECB, and PDLC devices. Lectures and laboratory sessions will be held at the Liquid Crystal Institute, Kent State University, Kent, Ohio. Bus transportation will be provided between the Sheraton Suites and the institute each day.

Lectures

Fundamentals
- Introduction to liquid crystal phases
- Basic theory of liquid crystals
- Physical properties
- Relationship of chemical structure and physical properties

Liquid Crystal Device Physics
- Alignment layers and electric field effects
- Device configuration of TN, PDLC, ECB, STN, SmC*, and bistable devices
- Electro-optical properties
- Viewing angle limitations
- Modeling methods

Display Applications
- RMS addressed passive matrix displays
- PDLC devices
- Bistable matrix displays
- Ferroelectric displays
- Active matrix displays

Laboratories

Tour of ALCOM Laboratories
- Characterization facility
- PDLC development lab
- Polymer stabilizer device development lab
- Prototyping facility
- Basic research labs

Principles of Device Fabrication
Hands-on construction of small liquid crystal cells demonstrating principles of:
- Polymer dispersed liquid crystal (PDLC)
- Twisted nematic (TN)
- Supertwisted nematic (STN)
- Electrically controllable birefringent (ECB)

Device Analysis
- Principles of operation
- Device characterization

Previous Participants
Past participants from the United States and Canada include 156 from a wide variety of industries, 12 from universities, the U.S. Army, Navy, Air Force, National Bureau of Standards, and Patent Office.

At the conclusion of the short course, participants evaluate all aspects of the course. Their comments and suggestions are incorporated in the planning of future courses. Comments from past participants include the following:

"Great balance between lecture and lab. Pure research and industry application."
"I thought the course was well-prepared, well-presented, and very informative."
"Great course. I will definitely recommend it."
"Keeping up on current research is important. PDLC’s were all new to me. The course was very informative and well run. Accommodations and personnel were great."

Faculty

The course is taught by University faculty with active research and a minimum of ten years experience in the areas covered by their lectures. Previous faculty include:

David W. Allender
Chair, Department of Physics. Dr. Allender has given numerous invited lectures on fundamental properties of liquid crystals. His interests include modulation and instabilities, surfaces, and linear and nonlinear optical properties.

Philip J. Bos
Associate Professor, Chemical Physics Interdisciplinary Program. Dr. Bos is the inventor of the pi cell and an alignment method for SmC* devices. His research interests include novel liquid crystal devices and applications.

J. William Doane
Director Emeritus of the Liquid Crystal Institute. Dr. Doane is the co-inventor of the polymer dispersed liquid crystal (PDLC) and bistable reflective cholesteric texture technologies. He is a co-founder of Kent Displays, Inc.

Jack R. Kelly
Associate Professor, Chemical Physics Interdisciplinary Program. Dr. Kelly is the creator of the software package, "Twist Cell Optics." His research interests focus on modeling of display devices and physical properties of liquid crystals.

John L. West
Director, Liquid Crystal Institute. Dr. West is the co-inventor of PDLC devices. He concentrates research on the development of PDLC and cholesteric materials for use in electro-optic devices.

Deng-Ke Yang
Assistant Professor, Chemical Physics Interdisciplinary Program. Dr. Yang is co-inventor of bistable cholesteric display (BCD) technology, currently the world’s most promising technology for electronic paper.
Electronic publishing requires a sophisticated portable display for success. This display must be lightweight and rugged, operate for many hours using lightweight batteries and exhibit high resolution and contrast.

The ideal display does not exist. However, driven by the huge potential market, researchers are working for its development. Because of their light weight and low power consumption, this research effort focuses on liquid crystals.

Liquid crystals are used in most of today’s portable displays. They were originally introduced in the early to mid-1970’s for digital wristwatches and handheld calculators. In the late 1980’s liquid crystal displays were incorporated in the first laptop computers. Today the typical laptop computer includes a relatively large (12” and larger diagonal), full color, liquid crystal display with good resolution. However, the low light efficiency of the current LCDs require power hungry back-lights to produce bright images. A one to two pound battery is required to operate the display for a couple of hours. Clearly the current LCD technology must be improved if the promise of electronic publishing is to be realized.

Researchers at the Liquid Crystal Institute are working on the development of a new type of reflective liquid crystal display that promises to become the digital ink for the electronic publishing in-
dustry. Based on cholesteric liquid crystals, these displays can be switched between a colored and black state by application of a small electric field (Figure 1).

Figure 1. LCI has created a prototype tablet-sized, lightweight cholesteric liquid crystal display with 200 dpi that could be used by soldiers in the field to display maps.

No Power is Required To Maintain Images On Cholesteric Displays

The two optical states of the cholesteric liquid crystals are stable in the absence of a field, so no power is required to maintain an image. This is in contrast to conventional liquid crystal displays, such as those used in laptop computers, which require power to maintain an image.

Because the page-based images produced for electronic documents — such as newspapers, magazines, books, maps and reports — are likely to be changed less frequently than television-based video images, the cholesteric displays will consume significantly less power.

The cholesteric displays are also brighter than the typical twisted-nematic (TN) liquid crystal displays used in laptops because they do not use polarizers. Up to 50% of the incident light can be reflected using a single cholesteric display, as opposed to less than 10% for the current liquid crystal displays. An even brighter, full color display can be made using multiple layers of the cholesteric materials.

Flexible Plastic Displays

Since electronic publishing also requires rugged lightweight displays, we have been developing cholesteric displays using plastic substrates. Because these displays do not require polarized light, commercially available flexible plastic substrates can be used. This is opposed to the conventional liquid crystal technologies that require non-birefringent substrates, which make it difficult for them to use plastic.

Researchers at the LCI have prototyped a 4" by 4" display with 80 dots-per-inch (dpi) resolution using flexible polyester substrates (Figure 2). The polyester substrates have a transparent coating of indium tin oxide that is etched to produce the row and column electrodes using conventional photolithography techniques.

The cholesteric material includes a polymer network that adheres to the top and bottom substrates, providing mechanical integrity to the display. These displays weigh a fraction of a comparable glass display and will not shatter.

LCI researchers also have developed new techniques to form polymer walls
around the individual pixels of the cholesteric displays. These polymer walls provide mechanical integrity without degrading the optical performance of the display.

The new cholesteric displays meet the requirements of electronic publishing. They consume little power and can operate for many hours using lightweight batteries. They can be made using light-weight plastic substrates. They produce bright, high contrast images that are easy to read in a variety of lighting conditions. Finally, they are relatively simple to produce, lowering their cost.

The technologies required to make electronic publishing a reality are being rapidly developed. Communications technologies are approaching the required speed and cost. Developments in electronics and battery technology will provide the lightweight package consumers will demand.

Finally, the new cholesteric materials will provide the digital ink that will substitute for the traditional pigmented inks on the printed page. The convergence of these technologies should make tablet-sized portable electronic media for publishing a reality in the not too distant future.

Figure 2. This 4" by 4", 80 dpi bistable reflective cholesteric display utilizes flexible polyester substrates.
Dr. John L. West

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Liquid Crystal Institute
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Kent, OH 44242
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Fax: 330.672.2796
E-Mail: <johnwest@scorpio.kent.edu
LCI: <www.lci.kent.edu>
ALCOM: <alcom.kent.edu/ALCOM/ALCOM.html>

John L. West has been director of the Liquid Crystal Institute at Kent State University since January 1997. Dr. West played a major role in the growth of the Institute under the directorship of Dr. J. William Doane. He was appointed a Senior Research Fellow in 1984 and concentrated on the development of polymer dispersed liquid crystals. He became Associate Director for Applied Programs in 1988. He participated in the preparation of the proposal for the National Science Foundation Science and Technology Center for Advanced Liquid Crystalline Optical Materials (ALCOM). He initiated its Industrial Partnership program, which has attracted over 30 North American companies.

In parallel with his administrative duties, Dr. West maintains an active and productive research program. He has published over 75 articles and holds ten U.S. patents related to liquid crystal materials. He concentrates research on the development of PDLC and cholesteric materials for use in electro-optic devices and on photoalignment of liquid crystals.

Dr. West has a Ph.D. and M.S. degree from Carnegie Mellon University and a B.S. degree from the College of William and Mary.
## APPENDIX II

**DOCTORAL DISSERTATIONS ON LIQUID CRYSTALS**

<table>
<thead>
<tr>
<th>Date</th>
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<th>Advisor/Department</th>
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<tr>
<td>1972</td>
<td>LESSER, DAVID Crystal Structure Analysis by X-ray of 2,2'-Dibromo-4,4'-bis-(p-methoxybenzylideneamino) Biphenyl.</td>
<td>Brown Chemistry</td>
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<td>1972</td>
<td>LEE, Y. S. An Ultrasonic Shear Wave Study of the Mechanical Properties of a Nematic Liquid Crystal</td>
<td>Brown Chemistry</td>
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<tr>
<td>12/72</td>
<td>WILSON, JACK Mössbauer Effect in a Smectic Liquid Crystal</td>
<td>Uhrich Physics</td>
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*Executive Officer, AAPT, University of Maryland

*Employment, where known as of July
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<th>Date</th>
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<th>Department</th>
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| 3/73  | VISINTAINER JAMES  
Spin-Lattice Relaxation in the Nematic Liquid Crystalline Phase  
*Research Scientist, Goodyear Tire and Rubber Co., Akron, Ohio | Doane              | Physics    |
| 3/73  | WISE, RAYMOND  
A Nuclear Magnetic Resonance Study of Smectic C Liquid Crystals  
*Professor, Physics, and Dean, Heidelberg College, OH | Doane              | Physics    |
| 6/73  | FELLNER, HANS G.  
Light Scattering from Liquid Crystals.  
*Professor, Slippery Rock University, Pennsylvania | Franklin/Christensen | Physics    |
| 8/73  | KESS, SHARON  
The Photostatistics of Brillouin Scattering by a Liquid Crystal.  
*IBM Corporation, R&D, Vermont | Franklin           | Physics    |
| 8/73  | DETJEN, ROBERT E.  
A Mössbauer Investigation of the Lattice Dynamics of the Smectic Liquid Crystalline State. | Uhrich             | Physics    |
| 8/73  | MURPHY, JOHN A.  
NMR Pulsed Gradient Studies of Diffusion in Liquid Crystals.  
*Keithley Instruments, Solon, Ohio  
**RETIRED** | Doane              | Physics    |
| 12/73 | NANDY, PAPIYA SENGUPTA,  
Theoretical Studies of the Electrohydrodynamic Instabilities in Nematic Liquid Crystals.  
*Instructor, Physics, Jadavpur University | Saupe              | Physics    |
| 3/74  | SCHENZ, ANNE FILER  
Optical and Faraday Studies of Liquid Crystals  
*General Foods, White Plains, NY | Neff               | Chemistry  |
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<td>6/74</td>
<td>CHU, KWO-SUN: Theories of Intermolecular Potential and Molecular Diffusion in the Mesophases of Liquid Crystaline Systems. *Professor and Chair, Dept. of Physics, Fort Hays State Univ., Hays KS</td>
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<td>6/75</td>
<td>PHOTINOS, PANAGIOTIS J.: Mean Field Study of the Formation of Uniaxial Smectic Liquid Crystals with Polarized Layers.  *Associate Professor and Chair, Dept. of Physics, Southern Oregon State University, Ashland OR</td>
<td>Saupe  Physics</td>
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<td>6/76</td>
<td>AIMIUWU, VICTOR Q.: Fe-57 Mössbauer Study of Four Ferrocene Derivatives in a Smectic B Liquid Crystalline Glass.  *Lecturer, Ahmadu Bello University, Nigeria</td>
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<td>FLICK, CATHERINE M. (C-P) An Electron Paramagnetic Resonance Study of the Action of Selected Polyene Antibiotics on Lipid Planar Multilayers (Model Membranes)</td>
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<td>UKLEJA, PAUL Spin-Lattice Relaxation and Director Fluctuations in Nematic Liquid Crystals</td>
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<td>*Associate Professor, SE Massachusetts University, Bedford</td>
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<td>BOS, PHILIP J. NMR Studies of Orientational Order in the Smectic C Liquid Crystalline Phase.</td>
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<td>*Associate Professor, Chemical Physics, Kent State Univ.</td>
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<td>BRISBIN, DOUGLAS J. Divergence of the Bend Curvature Coefficient above the Nematic-Smectic A Phase Transition: Freedericksz Transition.</td>
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<td>MAJOROS, STEPHEN J. A Test of Curvature Elasticity above the Nematic-Smectic A Phase Transition.</td>
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<td>*Assistant Professor, Cuyahoga Community College</td>
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<td>GRADDICK, WILLIAM The Effect of Calcium on the Thermotropic Phase Behavior of Dipalmitol Phosphatidylcholine (DPPC) Multilayers.</td>
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<td>NAIKSATAM, PRAKASH Structure-Property Relationships of Thermotropic Liquid Crystals.</td>
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<td>EKACHAI, ARUN X-ray and Optical Studies of Several Smectic Phases.</td>
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<td>*Industrial Scientist, Kaiser Electronics, San Jose, California</td>
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<td>VAZ, NUNO A. Nuclear Magnetic Resonance Studies of Orientational Order in Lyotropic Liquid Crystals.</td>
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<td>DeHOFF, RICHARD J. Specific Heat in the Vicinity of a Nematic-Smectic A-Smectic C Multicritical Point.</td>
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<td>*Research Scientist, Tektronix, Inc., Beaverton, Oregon</td>
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<td>Orientational Order in Phospholipid, Cholesterol-Phospholipid, and Protein-Phospholipid Bilayer Membranes: A DMR Study.</td>
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<td>KUZMA, MICHAEL R.</td>
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<td>Molecular and Segmental Orientational Order in Thermotropic Liquid Crystals: An NMR Study.</td>
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<td>*Scientist, Imaging Center, William Beaumont Hospital, Royal Oak MI</td>
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<td>SHIH, LIH-BIN Laser Light Scattering of Surface Fluctuations of Liquid Crystals.</td>
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<td>YANIV, ZVI A Deuterium Magnetic Resonance Study of Biaxial Ordering and Self-diffusion in Chiral Nematic and Smectic Phases.</td>
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<td>TODOROFF, DOUGLAS G. Sn-119 Mössbauer Investigation of Different Sn-bearing Molecules in Nematic and Smectic Glasses.</td>
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<td>BENIGNI, SAMUEL P. An X-ray Study on the Thermal Behavior of Potassium-Palmitate-Water Mixtures.</td>
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<td>GOODEN, CLARENCE E. Light Scattering and Magnetic Deformation Study of the Nematic-Smectic A Transition.</td>
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<td>BIGGERS, RAND R. Thermal Properties near the Nematic-Smectic A Tricritical Point.</td>
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<td>BOONBRAHM, POONPONG Optical Studies on Micellar Nematics and on Phase Transitions between Nematic States.</td>
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*Research Scientist, S. C. Johnson, Racine, Wisconsin

*Research Scientist, U. S. Naval Coastal Systems, Panama City, Florida

*Staff Scientist, RCA, Inc., Lancaster, Pennsylvania

*Research Scientist, Eglin Air Force Base, Fort Walton Beach, Florida

*Research Scientist, Wright-Patterson Air Force Base, Ohio

*Lecturer, Prince of Songkla University, Thailand.
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<td>5/84</td>
<td>STRENK, LAWRENCE M. A Deuterium NMR Study of Orientational Order and Spatial Modulation in Phosphatidyl Choline Bilayers Including Those Containing Cholesterol and Protein.</td>
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<td>12/84</td>
<td>HAFIZ, NAJMA Nematic Phases in Liquid Crystals: Theory of Uniaxiality and Biaxiality and an NMR Study of Reentrants.</td>
<td>Allender/Doane Physics</td>
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<td>RAHMAN, JOLLY A. The Development of Some Molecular Models for Smectic A Phases.</td>
<td>deVries/Spielberg  Physics</td>
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* *Assistant Professor, Slippery Rock University, Pennsylvania
* Research Scientist, U.S. Air Force, Dayton, Ohio
* Vice President of Technology, S-VISION, Twinsburg, Ohio
* President and CEO, Stenk Scientific Consultants, Inc., Middleburg Heights, Ohio
* Assistant Professor, Behrend College, Erie, Pennsylvania
* Assistant Professor, Department of Physics, Indiana University at South Bend
* Research Scientist, Tektronix Inc., Beaverton, OR
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<td>deVries/Spielberg</td>
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* | Sape | Physics |
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*Research Specialist, Mei Technologies, Boston MA | Allender | Physics |
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*Postdoctoral Fellow, Los Alamos National Lab, NM | Kumar | Physics |
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*Research Specialist, Alltristar Corp., Mogadore OH | Spielberg | Physics |
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* Research Fellow, Liquid Crystal Institute | Doane | Physics |
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*Computer Specialist, Cray Computer, NJ | Johnson | Physics |
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* Senior LCD Engineer, S-VISION, Twinsburg, Ohio | Kelly | Physics |
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* Research Scientist, Polaroid Corp., Waltham MA | Johnson | Physics |
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*Research Associate, Liquid Crystal Inst. (to 1/98) | Lavrentovich | Physics    |
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*Research Scientist, Honeywell, Inc., Phoenix AZ | Doane      | Physics    |
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*Senior Scientist, Kent Displays, Inc. | Doane      | Physics    |
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*Senior Project Engineer, Honeywell, Phoenix AZ | Kelly      | Physics    |
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*Staff Scientist, Meadowlark Optics, Longmont CO | Kelly      | Physics    |
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*Staff Scientist, Physical Optics Corp., Torrance CA | Fintotello | Physics    |
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*Staff Scientist, dpiX A Xerox Co., Palo Alto CA | Palffy-Muhoray | Physics    |
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*Staff Scientist, Reveco Corp., Hawthorne NY | Allender    | Physics    |
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