

IV. KNOWLEDGE TRANSFER

1. KNOWLEDGE TRANSFER OBJECTIVES AND ACCOMPLISHMENTS

a. Mission, Objectives, and Accomplishments

The Center's knowledge transfer mission is to create an effective mechanism for transferring the results of the Center's research, technology, education, and ethics teaching to the scientific community, industrial partners, government agencies, and the general public. By engaging a number of different audiences, we will develop a broad awareness of and appreciation for the Center's unique interdisciplinary research and resulting discoveries. As CMDITR-developed technology matures further emphasis will be placed on developing strategic partnerships with companies to enhance our technology transfer and licensing activities to enable commercial development that would benefit the general public.

Knowledge Transfer objectives include:

1. An increased awareness of the impact of CMDITR research on the economy, quality of life, and national security among Center participants, the scientific community, policy makers, and the general public;
2. An improved understanding among Center participants of the benefits and methods of protecting and disseminating IP;
3. The effective transfer of Center-developed technology to government and industry;
4. An alignment of the Center's goals with the needs of industry and potential funding sources and investors;
5. The development of strong international collaborative research efforts;
6. The tracking of knowledge transfer activities within the Center.

In this past year, we have begun to see significant rewards for our efforts to extend the impact of CMDITR research into the commercial sector. We have grown our Industrial Affiliate Program (IAP) membership to 10, and expect 4 more by the end of 2006. These industrial partners leveraged CMDITR resources by providing over \$1M in funds. In addition, CMDITR research has led to one start-up company in the last year. Partnerships have been formed with several groups within the DoD and DoE. Several companies are incorporating CMDITR research into their strategic plans and some are making significant investments to increase the pace of development of CMDITR technologies (as described in more detail below). The Center has been asked by other STCs and organizations to make our ethics course more widely available. This course is now being used by external organizations and groups. These include two STCs (CReSIS and CERSP), as well as research groups at Case Western, UA (Biochemistry) and GT (Chemistry). In addition, CMDITR's K-12 modules, which allow 6-12 grade students to interactively explore scientific principles, are now being disseminated in the Tucson area.

We continue to direct a significant proportion of our Knowledge Transfer efforts towards educating and informing policy-makers and funding partners, nationally and internationally, to ensure that government officials and agencies will have accurate and up-to-date information on the state-of-the-art in the areas of Center research and technology development.

In year-4, Center research has led to the creation of 1 start-up company; 21 patent applications reported; 8 invention disclosures filed; 189 publications in refereed journals; and more than 200 conference presentations and special lectures.

b. Performance and Management Indicators

- Publications in refereed journals* 189
- Contributions to textbooks and encyclopedias* 10
- Press releases and other Center publicity in general media outlets* 8
- Other publications (including proceedings abstracts) 88
- Government briefings and advisory activities 12
- Patent applications reported by CMDITR members since last annual report 21
- Invention disclosures* 8
- CMDITR participation levels at meetings, workshops and professional conferences
Center members gave 183 presentations at professional conferences and an additional 76 lectures and seminars at various academic, industrial and governmental institutions
- Start-up company activity
In the past year one new company has been founded as a result of CMDITR research: Advanced Electroluminescence Sciences (AES).
- Number of Industrial Affiliate Members
10 companies with 4 more expected by end of 2006
- Number of participants certified for RCR
80% (172/216) of Center participants are currently certified through our on-line modules. Historically, 325 CMDITR members have been certified.
- CMDITR public website access and usage
The CMDITR's public website has had 72,000 visitors since its launch in year-2.
- Use of CMDITR internal website database as an information conduit to members and industry affiliates
In year-4, 294 members have used the CMDITR internal website during 4,800 login sessions.
- Sharing of CMDITR products
The RCR modules have been made available to any organization with an educational mission via <http://responsibleresearch.org>. 2 other STCs and 2 educational groups have registered to use the tutorials. The tutorials will continue to be promoted in upcoming years, and we anticipate higher usage in year-5 and beyond.

c. Knowledge Transfer Program Challenges

CMDITR research is at the cutting edge of new materials and devices for information-technology applications. Accordingly, one of the CMDITR's main challenges is that organic photonic and electronic materials are at a relatively early state of materials development compared to inorganic materials where billions of dollars are already invested in manufacturing infrastructure. Many potential industrial partners are only cautiously taking their first steps towards exploring the potential of organic materials and devices. Although specific opportunities and challenges vary between projects, general skepticism about the long-term stability of organic materials and cynicism engendered by inflated claims made by some start-up companies, are issues that CMDITR must and does address. The Center, while being optimistic about the potential impact of its technology, has attempted to communicate both its breakthroughs and challenges realistically. While the short-term consequence of this caution may be to slow down the rate of investment in our work, we believe that it is crucial to maintaining our credibility, both as a reliable source of information and as an organization that delivers on our commitments. This credibility will translate into increased long-term impact.

Recent advances by CMDITR research groups continue to reinforce the enormous potential of our end-to-end approach to the design and synthesis of new organic materials and of novel devices incorporating these materials for a new generation of information-technology products. CMDITR faculty continue to actively engage influential figures from industry and government, providing them with up-to-date information on the progress of CMDITR organically-based materials and devices and on the potential to create the next generation of information-technology products.

We expect to see an increased exploration of our materials and devices by leading companies in the information technology industry as a result of: new breakthrough results; the efforts of CMDITR members in briefing government, industry, and the general public; and the success of start-up companies successfully developing first-generation products using CMDITR technology.

2. KNOWLEDGE TRANSFER ACTIVITIES

a. List of Activities

The Knowledge Transfer activities from year-4 can be measured against the 6 objectives listed in Section 1a above. In this section, activities will be highlighted to represent the ongoing effort and related progress that is being made in our efforts to extend the impact of CMDITR research to as broad a group as possible. Details of the Knowledge Transfer activities from the past year can be found in the following sections: Presentations, VIII.1b.; Editorial, Advisory, and Other, VIII.1c.; Inventions, VIII.4b.; Patents, Licenses, and Start-ups, VIII.4a.; Media Publicity, VIII.8. & X.E.

Objective 1: An increased awareness of the impact of CMDITR research on the economy, quality of life, and national security, among Center participants, the scientific community, policy makers, and the general public

The types of materials and devices being developed have tremendous potential to have broad impact in:(1) end-to-end design and synthesis of organic molecules being used to develop new materials; (2) new manufacturing methodologies required for these materials; and (3) new applications that these lightweight and flexible materials and devices will enable. One of the critical Knowledge Transfer activities of this Center has been, and will continue to be, informing industrial, government, and academics about the new materials and devices being developed within CMDITR and about their potential in information technology applications.

CMDITR members maintain an active schedule of briefings, seminars, and regular informal contact with key corporate, academic, and general-interest audiences. Seventy-six such seminars and briefings were carried out over the past year by CMDITR members. These include briefings of various upper level committees at: NSF; DARPA; Army Research Lab; Aberdeen, MD; Science Advisor to the Chief of Naval Operations Strategic Studies Group; and the American Chemical Society. CMDITR faculty also serve on a variety of advisory boards that focus on promoting science and setting academic standards for students throughout the nation, for example, the advisory board of the Orlando Science Center and the National Assessment Governing Board Discussion Forum. Many have given seminars promoting public knowledge of CMDITR's work; for example, to the Seattle Technology Alliance, the Seattle Community Development Roundtable, and Washington and California Rotary Clubs. Additionally, Center members actively promote their knowledge of CMDITR-related research through general-

interest media outlets. To help present the mission and goals of the center to a generalist audience, a professionally produced CMDITR video clip is now available online (<http://services.ltc.arizona.edu/mediaservices/stc/stcpromo.mov>) and by DVD. The work of Center faculty has been highlighted in professional journals, the popular press (both print and television), and through faculty giving presentations to the general public. Some key activities of CMDITR faculty related to dissemination of knowledge and shaping of policy are listed below.

Leadership Roles in Professional Societies

- International Standing Committee for Polymer Optical Fiber
- OSA Board of Directors
- Chair, CLEO Long Range Planning

Conferences Organized/Co-organized

- Pacifichem
- American Chemical Society, Spring Meeting Atlanta, GA, 2006
- 4th International Symposium on Nanomanufacturing
- ASME Summer Heat Transfer Conference 2005
- ASME IMECE 2006 Meeting.
- Laser and Electro-optics Society (LEOS)
- SPIE Annual Meeting
- Photonics West
- IEEE National Meeting
- Conference on Lasers and Electro-optics (CLEO)
- Gordon Research Conference on Electronic Processes in Organic Materials
- International Conference on Organic Nonlinear Optics / International Conference on Organic Photonics and Electronics
- International Conference on Synthetic Metals
- Sixth International Topical Conference on Optical Probes of Conjugated Polymers and Biosystems
- 8th European Conference on Molecular Electronics (ECME)
- 4th Worldwide Chinese Theoretical and Computational Chemistry Conference (WCTCC) & 2nd International Conference on Theoretical Chemistry, Molecular Modelling and Life Sciences (ICTCLS)
- Optics Valley of China International Symposium on Optoelectronics
- International Symposium on Optical Power Limiting and Intensity Dependent Optical Processes
- Simulation of Semiconductor Processes and Devices Conference

Journal Editorship:

- Chemical Communications
- Synthetic Metals
- Advanced Functional Materials
- European Journal of Inorganic Chemistry
- Nonlinear Optics and Quantum Optics
- Materials Science and Engineering Reports
- Journal of Experimental Nanosciences

Selected Generalist Review Articles, Press Releases and Media Coverages:

- New Scientist Magazine

- Environmental Health Perspectives
- Georgia Tech News
- Northwest Science & Technology
- Photonics Spectra
- MRS Bulletin
- ACS Atlanta Show Daily

In addition CMDITR faculty routinely provide background briefing for magazines writing about science and technology including Fortune Magazine and Chemical & Engineering News.

Highlights:

- Peter Delfyett serves as General Chair of IEEE and as CLEO General Chair, as well as on the Board of Directors of OSA, and Chairperson CLEO Long Range Planning Committee, and, thus, has tremendous influence on policy within key organizations critical to photonics.
- Larry Dalton is a member of: Advisory Committee, Mathematical and Physical Science Directorate, National Science Foundation (2005-2008); Committee of Visitors, Division of Materials Research, National Science Foundation (2005); Advisory Group on Electron Devices (AGED), Defense Science Board, Office of the Secretary of Defense, Pacific Northwest National laboratory; and Peer Review Panel for the Energy Science and Technology Directorate.

Objective 2: An improved understanding among Center participants of the benefits of, and processes for, the creation, protection, and dissemination and intellectual property

The Responsible Conduct of Research (RCR) online training modules continue to serve as our primary vehicle to develop a baseline understanding among our members of intellectual property issues. To date, 330 Center participants have completed the three-module online RCR certification. In 2004, a seminar series was launched to supplement these online modules with case-study discussions on RCR topics. These seminars were provided to CMDITR participants as well as other graduate students, faculty and staff at UW, UA, and GT. The foci of these seminars were conflict of interest, intellectual property, and authorship as well as Center-specific issues such as the societal implications of THz Imaging Spectroscopy and RFID-Tagging. Our efforts in RCR have served as a role model both within our institutions and within the wider STC community. There are currently four external groups utilizing the online modules. Materials developed for the the seminar series have also been requested by groups external to the Center. The aggressive approach that CMDITR has taken to train its participants in these issues has helped to spark broader institutional initiatives, as a result of which, CMDITR faculty have been asked to help with new initiatives to institutionalize RCR training at a campus-wide level.

Highlight:

- CMDITR online RCR modules are being disseminated to a broader audience outside our Center. The initial external use (and validation) of the design and content of our RCR program came from the Georgia Tech chemistry department where the RCR modules are now in their second year of use in a the second-year graduate student class. The Georgia Tech Office of Sponsored Programs is looking into supporting the further development and expansion of the CMDITR online RCR modules in order to deploy them more broadly across the Georgia Tech campus. The Vice President's office has granted a group of faculty on campus, through a competitive proposal process, a focused research grant to seed the formation of an ethics center whose goal is initially to serve a resource for Georgia Tech, Georgia State, and Clark Atlanta University.

Objective 3: The effective transfer of Center-developed technology to government and industry.

Ties between CMDITR and industry have been substantially strengthened in the past year. Building on a portfolio of CMDITR technologies that were previously licensed and that form the foundation for new device product development efforts, Lumera Corp continues to interact with Center faculty, four of whom sit on Lumera's Scientific Advisory Board. CMDITR continues to create new technologies and to aggressively protect its IP; thus, CMDITR faculty have reported 8 invention disclosures and 21 patent applications to protect Center technologies in the past year. Samples of CMDITR-developed materials have been provided to Lumera, Lockheed Martin, Boeing, Intel, Fujitsu, Photonics Systems, AFRL (Rome, Wright-Patterson), Redstone Army Research Lab, and China Lake NAVY Weapons Research Lab for testing. As part of the CMDITR's commitment to the effective transfer of materials to potential end-users, the Director has committed to personally oversee the Center scale-up facility to ensure it can meet the continually growing requests for materials.

The Industrial Affiliates Program (IAP) has increased its membership to 10 companies, and we are in the final stages of negotiations to sign up four additional members. CMDITR has received more than \$1M from IAP members in the form of grants, contracts, and gifts. This level of support provides strong evidence of the impact of our research on industry. Twenty-two representatives from 19 companies attended our Feb 2006 IAP Expo along with 63 CMDITR researchers. This was the largest IAP meeting since the inception of the program, and resulted in a very interactive and informative exchange of ideas.

CMDITR members continue to take an active role in the formation and ongoing operations of start-up ventures created to develop and commercialize Center discoveries. Focal Point Microsystems, co-founded by CMDITR faculty, continues to derive scientific guidance from Center members. Focal Point's addition of full-time dedicated technical staff, including a CTO, is evidence of continued successful growth in the past year. Focal Point Microsystems has obtained SBIR funding and renewal and new contracts from Lockheed-Martin (one of our Industrial Affiliates). A newer start-up venture involving Center members from GT and UW is LumoFlex LLC. This venture seeks to develop organic electronic materials and devices. Last year, LumoFlex received funding from Georgia Tech Venture Lab and the Georgia Research Alliance to assist it in effectively moving CMDITR technology towards commercialization. Limoflex has also been developing a strategic partnership with a global chemical company. Larry Dalton, a co-founder of the Center for Technology Entrepreneurship at UW, has promoted CMDITR students in business plan competitions, one of which led to the founding of LiveMeter Technologies, Inc. by a UW chemistry student.

A brief summary of some key interactions with industry is given below:

- Lumera Corporation: extensive interactions at all levels of the company. Dalton, Jen, Robinson, Chen, Marder, Perry, Peyghambarian and Norwood have assisted in the design and characterization of EO materials, design and fabrication of modulators using these materials and on strategic planning. Primary contact: Tom Mino, CEO.
- Lockheed Martin; close interaction between Dalton, Jen, and Susan Ermer (Lockheed rep.) on EO materials for space applications.
- Lintec Corporation; Kippelen and Marder have been working closely with Yasukazu Nakata, Deputy Mgr of Technology Research Section R&D Planning Dept. on organic transistors.

- Boeing; Dalton, Jen, and Scherer have been working with Bill Krug (Boeing) on an electro-optically tuned, 1 x 4 x 1 wavelength division multiplexer device that was successfully fabricated, packaged, and recently delivered to NAVAIR.
- Solvay Corporation; Brédas, Kippelen and Marder have been working with Guy Laurent, Francine Delplanque and Leopold Demiddeleer (Director, New Business Development) on the creation of a new organic electronics effort funded by Solvay Advanced Polymer, Alpharetta, GA.
- Focal Point Microsystems (founded by CMDITR faculty); Perry and Marder have been working closely with Ian White (CTO) on development of proprietary structures fabricated by two-photon 3D lithography for Lockheed Martin.
- Nitto Denko Technical; Peyghambarian and Norwood have helped developed EO polymers and their applications as memory devices, modulators and signal processing components.
- Intel Corporation; collaborations involving Dalton, Jen, Lipson, Scherer and Intel facilities in Oregon, California, and Arizona. Intel provides direct R&D funding and student internships and has hired a number of CMDITR students in the past two years. Several Intel managers including Kenneth Cadien (Intel Fellow and Director of Innovative Technology) are working to broaden participation and implement new concepts such as permanently embedding Intel researchers in CMDITR laboratories.

Highlights:

- CMDITR's IAP members (10 companies) now contribute more than \$1M a year to the Center.
- Building on a portfolio of CMDITR technologies previously licensed from UW and Arizona Microsystems (a spin-off company created by CMDITR faculty) and following a successful IPO, Lumera Corporation (NASDAQ) continues to license recent record-setting EO materials developed within CMDITR. Four CMDITR faculty sit on Lumera's Science Advisory Board to provide technical guidance. This year Lumera reported the delivery of a customer-ready device that incorporates Center technology. This device is currently in the advanced stages of evaluation by potential customers, and Lumera has established the capacity to scale-up production to meet customer demand. To support future advances in EO materials, Lumera provides unrestricted gift funding to several CMDITR faculty at UW and GT.

Objective 4: An alignment of the Center's goals with the needs of industry and potential funding sources and investors.

Center members are able to maintain an up-to-date awareness of the opportunities and issues facing the information technology industry, and how Center research results can potentially address those opportunities and issues through a variety of mechanisms.

CMDITR faculty serve on corporate Scientific Advisory Boards and/or are founders of companies including Lumera Corporation, NP Photonics, Focal Point Microsystems, LumoFlex, Neah Powers, Luxtera, and AES.

CMDITR faculty have briefed management from Boeing Corporation, Intel, Lockheed-Martin, HP Corporation, BASF Corporation, GE Corporation, Ciba Corporation, 3M, BP Solar, Chevron, Motorola Labs, Samsung Corporation, Solvay Corporation, Lumera Corporation, Lintec Corporation, JSR, Corporation, Nitto Denko Corporation, Samsung Corporation, Brewer Sciences, Freespace Semiconductor, SSCI Inc., WJ, Luna Innovations Inc., Schneider Electronics, Industrial Technology Research Institute (Taiwan) about CMDITR activities.

The annual IAP Expo was held at UA on February 22, 2006 and was a great success: 22 industrial representatives were in attendance and 6 member companies made presentations. Eleven CMDITR members presented updates on research achievements during the past year, and >20 CMDITR students participated in a poster session. This successful gathering resulted in discussions about collaborations and internships. Plans were also made to assign industry advisors for students, and for company members to spend extended visits in Center labs. In addition, the CMDITR Strategic Advisory Board will be held on May 5th, 2006, allowing the CMDITR management team to get some additional feedback on the potential applications of Center research discoveries.

Highlight

- CMDITR faculty formed a research relationship with International Technology Exchange, Inc. (Intex) where researchers and students have been able to learn directly about the operation of a plasma-enhanced chemical-vapor deposition system and about aspects of the coating process for Intex's amorphous-carbon technology for OLEDs. An Intex employee was assigned to UA, working on-site with our students. Other collaborations include the fabrication of OLEDs using Intex coatings as electrodes and characterization of these OLEDs.

Objective 5: The development of strong international collaborative research efforts.

CMDITR faculty continue to be very active internationally, traveling extensively to speak about Center research and the potential of our new discoveries. In-depth relationships continue to be developed; in some cases, these are leading to formalized exchange and collaboration opportunities.

CMDITR members play an active role in advising both governments and foreign institutions on organic materials research. For example, CMDITR members serve to promote Center-related research in Europe through involvement with organizations such as the European Union Research Advisory Board. Bernard Kippelen has briefed a delegation from the government of the French Province of Lorraine. Larry Dalton is a member of the Engineering and Physical Sciences Research Council (EPSRC), UK (from 2005).

The recently-signed Memorandum of Understanding between GT and the Chinese Academy of Science (CAS) will lead to the establishment of a cooperative international research program involving CMDITR students and faculty; a joint workshop is planned in academic year 2006-2007. A CAS faculty member recently spent two weeks working at GT and a CMDITR student is scheduled to spend 10 weeks at the CAS in Spring 2007.

CMDITR faculty hold various visiting, joint and honorary professorships and advisory positions at a variety of foreign institutions including: University of Mons-Hainaut (Belgium); Institute of Chemistry, Academia Sinica (Taiwan); Department of Chemistry, National Tsing Hua University (Taiwan); Institute of Chemistry, Chinese Academy of Science; Shanghai Jiaotong University (China); Huazhang University of Science and Technology (China); Wuhan University (China); and the Russian Academy of Sciences.

CMDITR competed successfully for an NSF-sponsored International Travel Grant Program for students, which is being augmented at some institutions with other funds. For example, at GT, CMDITR obtained funding for a focused research group to support exchanges with Imperial College, London (UK).

Highlight:

- Jean-Luc Brédas has a dual European-US academic experience, which gives him a unique opportunity to stress mobility and underrepresented minority issues, and to promote the incorporation of education and outreach activities in the next generation of European-Commission sponsored research projects. He was a European Union Research Advisory Board (EURAB) delegate to the Workshop on “Barriers to International Collaboration in Science” organized by the President’s Council of Advisors on Science and Technology (PCAST) in October 2004, and to the joint AAAS-EC Symposium on “Public Attitudes and Engagement with Science: American and European Perspectives” in February 2005. He is also currently a member of the EURAB working group on International Cooperation

Objective 6: *The tracking of knowledge transfer activities within the Center.*

Section VIII.4 lists the Knowledge Transfer activities that took place in year-4 as recorded in our database. The database and its easy-to-use web interface allow us to track activities throughout the Center, and also serve as a primary tool for the sharing and dissemination of information, both within the Center and with our key external partners.

Highlight:

- Our internal website has been improved to include a secure archive of CMDITR journal publications in the form of pdf files. This will be developed in year-5 to become a searchable database of papers based upon key words. In addition, selected lectures, signature course materials, and retreat presentations have been captured and are being made available to CMDITR participants via online streaming video.

b. Knowledge Transfer Outcomes and Impacts

CMDITR technology has impacted both government and industry. Evidence of this impact is the creation of the DARPA MORPH program (Dev Shenoy, Program Manager). Faculty have been invited to participate on DARPA workshops on photonic crystals, negative-index materials, photovoltaics, and conformal imaging systems. Faculty have also participated in a NSF workshop that preceded its organic electronics program and in DOE workshops on lighting.

Lumera Corporation was an early believer in the potential to develop revolutionary products using Center technology and has completed a successful IPO on NASDAQ.

Three CMDITR faculty members have been awarded a substantial grant from Solvay Corporation to develop OLED technology in a university-industry partnership. CMDITR students will have the opportunity to work hand-in-hand with Solvay scientists, both at Solvay and at GT. This helps to validate Center efforts to move research results into product applications. The combined efforts of CMDITR members and its industrial partners helps educate and inform the non-technical community, including potential investors, about CMDITR-based materials and device technologies. In addition, CMDITR faculty have received research contracts or gifts from Boeing Corporation, Intel, Lockheed-Martin, Lumera, Lintec Corporation, JSR Corporation, Nitto Denko Corporation, and Samsung Corporation.

As noted above, CMDITR’s research is routinely highlighted in trade journals and the popular press, ensuring that Center accomplishments are known to a diverse audience of stakeholders.

Our RCR modules have been incorporated into curricula at our various institutions and efforts are underway to expand the scope of this RCR training program.

c. Knowledge-Transfer Future Plans and Directions

CMDITR continues to build on its successes in knowledge transfer, and in the next year we expect to place particular emphasis on:

- Promoting our work by organizing of new meetings, press releases, and through greater distribution of our promotional video.
- Implementing an Industrial Internship Program.
- Strengthening our ties with Solvay and Intel Corporation.
- Supporting student travel to obtain international training and disseminating information about Center research.

3. KNOWLEDGE-TRANSFER EXTERNAL PARTNERSHIPS

The interactions fostered by CMDITR faculty with Lumera, Lockheed-Martin, Boeing, Solvay, and Nitto Denko transcend sponsored research; rather, they represent true partnerships between industry and the Center, as evidenced by joint papers and patents, and by exchange of materials and scientists.

In a similar manner the close interaction between CMDITR faculty and research at AFRL, NRL, China Lake Naval Weapons Laboratory, and NREL involve co-development of materials and devices.

Finally the CMDITR has forged strong partnerships abroad, particularly with the Chinese Academy of Sciences, the University of Mons-Hainaut, Imperial College London (specifically on the development of photovoltaic materials, where faculty members on both sides have visited), and Oxford University (where Susan Odom, an CMDITR participant and NSF predoctoral fellow, has spent 4 months working in the laboratories of Prof. Harry Anderson).