I. GENERAL INFORMATION

1. MDITR INSTITUTIONS AND CONTACTS

Date submitted	April 30, 2004
Reporting period	August 1, 2003 – July 31, 2004
Name of the Center	Center on Materials and Devices for Information Technology Research
Name of the Center Director	Larry R. Dalton
Lead University	University of Washington
Contact Information	
Address	Department of Chemistry, Box 351700
Phone Number	206-543-7464
Fax Number	206-616-8602
Email Address of Center Director	dalton@chem.washington.edu
Center URL	http://stc-mditr.org/

Names of participating institutions, role, and (for each institution) name of contact person and other contact information

Institution 2 Name	University of Arizona
Institution Contact Person	Neal Armstrong
Address	Department of Chemistry, PO Box 210041, Tucson, AZ 85721
Phone Number	520-621-8242
Fax Number	520-621-8407
Email Address of Institution	nra@email.arizona.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.
Institution 3 Name	Georgia Institute of Technology
Institution Contact Person	Seth Marder
Address	School of Chemistry and Biochemistry, 770 State Street, Atlanta, GA 30332-0400
Phone Number	404-385-6048
Fax Number	404-385-6057
Email Address of Institution	seth.marder@chemistry.gatech.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.
Institution 4 Name	University of California, Santa Barbara
Institution Contact Person	Alan Heeger
Address	Physics Department, Santa Barbara, CA 93106-9530
Phone Number	805-893-3184
Fax Number	805-893-4755
Email Address of Institution	ajhe@physics.ucsb.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.

Institution 5 Name	University of California, Berkeley
Institution Contact Person	Jean Fréchet
Address	Department of Chemistry, 718 Latimer Hall, Berkeley, CA 94720-1460
Phone Number	510-643-3077
Fax Number	510-643-3079
Email Address of Institution	frechet@cchem.berkeley.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.
Institution 6 Name	University of Southern California
Institution Contact Person	William Steier
Address	Department of Electrical Engineering-Electrophysics, Mail code 0483 Los Angeles, CA 90089-0271
Phone Number	213-740-4415
Fax Number	213-740-8684
Email Address of Institution	steier@usc.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.
Institution 7 Name	California Institute of Technology
Institution Contact Person	Axel Scherer
Address	1200 E. California Boulevard, MC 200-36, Pasadena, CA 91125
Phone Number	626-395-4691
Fax Number	626-577-8442
Email Address of Institution	etcher@caltech.edu
Role of Institution at Center	Collaborate and enhance all Center programs including research, education, knowledge transfer, and partnerships.

2. BIOGRAPHICAL INFORMATION FOR NEW FACULTY

Brief biographies for the following new STC faculty participants are included in Appendix A:

Professor Michael Hayden – University of Maryland, Baltimore County
Professor Sue Ann Bidstrup Allen – Georgia Tech
Professor Rigoberto Hernandez – Georgia Tech
Professor David Ginger – University of Washington
Dr. Antao Chen – University of Washington
Professor Ernest Davidson -- University of Washington

3. EXECUTIVE SUMMARY

The STC on Materials and Devices for Information Technology (MDITR) came into existence on August 1, 2002. MDITR is headquartered at the University of Washington and includes participants from the Georgia Institute of Technology, U. of Arizona, California Institute of Technology, U. of California at Santa Barbara, U. of California at Berkeley, and the U. of Southern California. Also affiliated with the Center are a number of designated minority institutions including universities that constitute the Alliance for Nonlinear Optics.

Vision -- The MDITR Center's vision is to advance the scientific understanding of engineered non-traditional (organic, hybrid, and nanostructured) materials for next generation information technology (IT) in order to make these materials practical for widespread usage in relevant photonic, electronic and opto-electronic devices, just as silicon is currently utilized for electronic signal processing. Our vision also includes training a workforce, with improved diversity that is capable of effectively implementing next generation IT technology.

Mission -- Our mission is to predict the signal processing properties of bulk non-traditional IT materials from basic molecular and structural information; to design and fabricate useful devices with novel electronic, photonic, and opto-electronic performance that can benefit virtually every sector of society; and to integrate the research and education missions so that the impact on society in terms of economic activity, workforce training, and development of human potential will be palpable and long-lasting.

Impacts through Research Leadership -- In its second year, the Center moved to national and international leadership in development of new organic and hybrid materials and devices for information technology. This is evidenced by recent corporate and governmental decisions including the launching of the $25M DARPA program on Supramolecular Photonics and decisions by Intel, Boeing, Lockheed Martin, Battelle, and others to consider organic and hybrid materials developed by MDITR in their future technology portfolios. During 2003-2004, Center PIs were recipients of 13 awards (including national awards of professional societies) for their research accomplishments. Center students and postdocs were recognized by ten awards. Center representatives are playing prominent roles on government advisory panels addressing critical national technology needs (e.g. the National Nanotechnology Initiative, the smart electric grid ("Gridwise"), chipscale wavelength division multiplexing (CS-WDM), satellite and airborne surveillance and telecommunications; embedded network sensing). Internationally, the Center is developing strong interactions with the European scientific community through representation on the European Research Advisory Board and Georgia Tech's campus in Metz, France. Our aim is to foster increased exchange of students between Europe and the US, thus preparing our students to work in global markets. Longer term, MDITR's role in knowledge transfer and education continues to grow as we develop working relationships with professional societies (AAAS, ACS, SPIE), government agencies (NASA, DoE, DoD), and minority universities (NMHU, Norfolk State, Spelman College, Alabama A&M).

Research Program – The MDITR Center's research plan follows four thrusts:

Theory - The theory group works in collaboration with the experimentalists to facilitate the design of novel materials and to provide an understanding of the mechanisms underlying the behavior of those materials. This requires improved theory at all levels ranging from first-principles molecular quantum mechanics, to statistical mechanics for intermediate length scales, to the simulation of devices at the micrometer scale.

Electro-optic and All-optical Switching Materials and Devices - This program investigates the poling efficiency of non-linear optical chromophores in novel supramolecular frameworks to develop "disruptive" electro-optic (EO) and all-optical (AO) materials. Optimization of such materials with respect to alignment and photochemical stability, tunability (conductivity, refractive index), and mechanical properties is crucial to the development of devices for light-weight, low drive voltage, and ultrahigh-speed information processing.

Light Emission and Organic Electronics - The goal of this program is to develop an organic materials platform that will enable the fabrication of low cost, large area, printable electronic circuits on plastic substrates. The approach is to exploit new chemistries to control and improve charge transport, charge injection, light harvesting, and light-emission for the processing, storage, and display of information.

Microfabrication and Nanoengineered Materials - This group develops nanoengineered materials and micro- and nanofabrication processes in order to create a new generation of high-performance, low-cost, active photonic and electronic devices. New methodologies for 3D mesoscale patterning and hierarchical assembly of materials on multiple length scales are being investigated to enable on-chip integration and control of properties via nanoscale structure.

Research Highlights -- In year-2 these integrated research activities have demonstrated:

- The importance of quantum mechanical calculations in guiding and explaining improvements of molecular hyperpolarizability
- The use of statistical mechanical calculations to guide the improvement of macroscopic electro-optic activity to record level, and to suggest structures that would lead to perfect or nearly perfect ferroelectric order
- Electro-optic activity of 160 pm/V at telecommunication wavelengths
- That electro-optic circuits and devices can be fabricated by soft lithography
- Integration of "silicon photonics" with organic electro-optics
- Important new mechanisms of lattice hardening to improve the thermal stability of electro-optic materials
- 5 orders-of-magnitude improvement of the photostability of OEO materials in materials with EO activity > 80 pm/V
- New microresonator device structures relevant to a range of applications
- Terahertz signal generation and detection with record sensitivity
- New third order (AO) materials and application to development of frequency-resolved optical grating (FROG) devices and image correction
- A low-cost, compact, portable device for ultra-short pulse characterization by FROG using efficient third harmonic generation (THG) in organic molecules
- A doped organic semiconductor with hole mobilities > 1 cm^2/Vs at rt and thermally stable organic liquid-crystal phases at rt that exhibit electron mobilities of 0.2 cm^2/Vs in air (potential for processing by ink-jet printing)
- Organic solar cells based on high mobility materials with power conversion efficiencies of 3% under white light illumination
- Ultra-bright red organic electrophosphorescent devices with 8% external quantum efficiency, and CIE coordinates (0.65, 0.34) very close to the NTSC red standard
- The ability to create controlled defect sites in two-photon microfabricated photonic band gap structures
- High quality opal and inverse opal photonic bandgap structures made by self-assembly
- The ability to read *single strands* of molecularly coded memory based on specific sequences of DNA

Education Highlights

- Developed comprehensive Education Program Plan based upon education retreat held at outset of year-2
- Developed two web module prototypes on Optical Fibers (for grades 6-8 and 9-12). Reviews by national experts in K-12 education were very positive and will provide the basis to formulate next steps for this program.
- Established a Center-sponsored undergraduate summer (2004) research program at UW, UA and GT. 19 students will participate in gateway and capstone research projects. Over half are female and several are from under-represented minority groups.
- Implemented in April-2004 our online "Responsible Conduct of Research" ethics short-course (3 modules, 18 topics, 21 case studies + questions with auto-certification)
- Graduate degrees completed: 19 PhD; 2 MS; 4 BS; and 1 faculty placement

Knowledge Transfer Highlights

- In 2004, 44 STC-related papers in prep., submitted, or published, 29 conference presentations, 19 seminars/lectures. In 2003, 125 publications (some updated from 2003 AR), 43 conference presentations, 22 seminars/lectures delivered since Aug 2003.
- Two patents issued with STC participants named as coinventors; seven provisional/utility patent applications and 14 invention disclosures filed in year-2
- Assumed a defining role in policy and programs at NSF, DARPA, the European Science Commission, and with respect to the National Nanotechnology Initiative.
- Organized a special symposium at the 2004 AAAS national meeting entitled "21st Century Photonics". Three associated MDITR press releases have received coverage in at least 15 other web and print locations.
- Enrolled two undergrads who attended our 2003 ACS-PRF Chemistry of Information Technology Workshop in MDITR graduate programs
- Edited special issue of the *Journal of Physical Chemistry* highlighting Center research.

External Partnership Highlights

- Industrial Affiliates Program – achieved target membership of six companies, held the first Research Expo for Affiliate members, and launched a secure Affiliates website
- Created center-wide initiative to work with Norfolk State U. to help them create Ph.D. program in Materials Science with an emphasis on photonics and assist Alabama A&M in a Ph.D. Physics specialization in Optics and Materials Science
- Early stage networking with minority institutions via student and faculty exchange, collaborative research, and educational seminars at New Mexico Highlands U., Yavapai College, Northern Arizona U., Clark Atlanta U., Florida International U.

Diversity Highlights

- Recruited two African American women into MDITR graduate programs
- Visited several minority institutions to present the work of MDITR and suggest opportunities for interaction. Hosted T. Timofeeva and B. Cardelino from ANLO.
- Initiated collaborative research program with James Bu of Clark Atlanta University
- Obtained results for at least 4 joints papers with ANLO research partners
- Initiated the indefinite loan of Beowolf cluster computer to Spelman College
- Initiated a plan for raising profile of *all* STCs at minority societies and institutions

Management Highlights

- Quickly adapted to the addition of the Georgia Institute of Technology as a full partner institution in response to relocation of four MDITR PIs and 26 associated students and staff from the University of Arizona
- Recruited three key administrative personnel including Managing Director, Diversity Program Manager, and IP/Tech Transfer/Industrial Relations Manager
- Refined our internal website/database as a Center resource for information archival, interpretation, and dissemination (member profiles, administrative templates, center outputs, ethics shortcourse). Database is now merged with our revamped public website to provide "live" updates on center activities.
- First Scientific Retreat and first IAP Expo (held in conjunction) in Seattle, WA – Feb '04
- Developed indicators for measuring Center performance

Integration

On the research front, a number of outstanding accomplishments are derivative from integrative efforts. For example, the Theory Thrust has provided quantum and statistical guidance to the EO-AO Thrust for the synthesis and processing of new electro-optic materials that exhibit record electro-optic activity of 200 pm/V (a value that exceeds our 5 year benchmark). The MNM and EO-AO Thrusts have partnered to develop devices that integrate electro-optic materials into silicon photonic bandgap structures and microfabricated or self-assembled structures with the goal of making tunable bandgap-based devices. To augment this effort, Michal Lipson of Cornell University has been awarded a seed grant to integrate "silicon photonics" more effectively into the Center.

Integration of our technical expertise with education is expressed in several formats. At the University of Arizona, MDITR PIs are leading the way with web modules designed to supplement K-12 curricula in the physical sciences. Our upcoming summer REU program will pair 19 entry-level and advanced undergrads with MDITR scientists and engineers to engage them in research. Fundamental research concepts have been mapped by our PIs and linked to educational resources in what we call our Interdisciplinary Resource Repository (currently in pilot testing). In the hands of university-level students, we envision this type of resource as a powerful self-learning tool. Our collaboration with ACS to put on our 2003 Chemistry of Information Technology Workshop resulted in a model integrative activity with long-lasting consequences. This event brought MDITR faculty together in an educational setting, directly impacted 50 students and faculty from non-STC colleges and universities, and yielded educational tools (presentation slides and professional video) for our online Resource Repository.

Overview and Outlook

The second year has provided us with our first real opportunity to perform critical internal evaluations of our progress and goals in all aspects of the Center's research, education, administration, and knowledge transfer functions, taking into account input of the NSF site visit committee and our advisory boards. This process has led to a refinement of our plans and a refocusing of resources. We have created critical infrastructure in terms of personnel, policy, and web-based resources that have increased the efficiency of our management of the STC. Some of these resources have been carefully designed to be exportable to our peer STCs should they so desire. In summary, as measured against our management indicators our progress to date has exceeded our expectations and the steps we have taken this year serve to ensure even greater progress in future years.