Interdisciplinary Literacy Assessment (ILA) Report:
Center for Materials and Devices for Information Technology Research

Introduction

"We have not done any systematic review of exactly what content that we consider essential for all our graduates. Without this framework we can't build new materials to fill gaps, we can't improve the efficiency of our materials to adapt to different audiences, and we can't measure the effectiveness of our materials or programs. We propose conducting an interdisciplinary literacy assessment that will give us the information and guidance we need to move forward."

Shaun Taylor, STC-MDITR Education Director
CMDITR Interdisciplinary Literacy Assessment Proposal

The STC-MDITR (Center) is designing an integrated and interactive photonics Wiki to help members learn more about the technical aspects of research in the Center. To help with this effort, we designed an online, interdisciplinary literacy assessment (ILA) to distribute to members to learn more about their current knowledge levels of 89 concepts and how relevant those concepts were to members' primary research projects. This report details the demographics, the methodology and the findings from the discovery phase of the ILA project. We expect to use these findings not only to build the Wiki, but also to effectively use our resources to increase interdisciplinarity within and among the Center campuses and to facilitate the design of the assessment phase for the ILA project.

Participants

During a four-week period between February 11 and March 15, the ILA survey was made available through Catalyst to members of CMDITR. During that time, 51 members completed the survey anonymously. Participants were from seven of the nine research campuses. While the majority of the surveys (58%) were completed by graduate students, post-doctoral researchers, research scientists and faculty also contributed to the results (Figure 1).

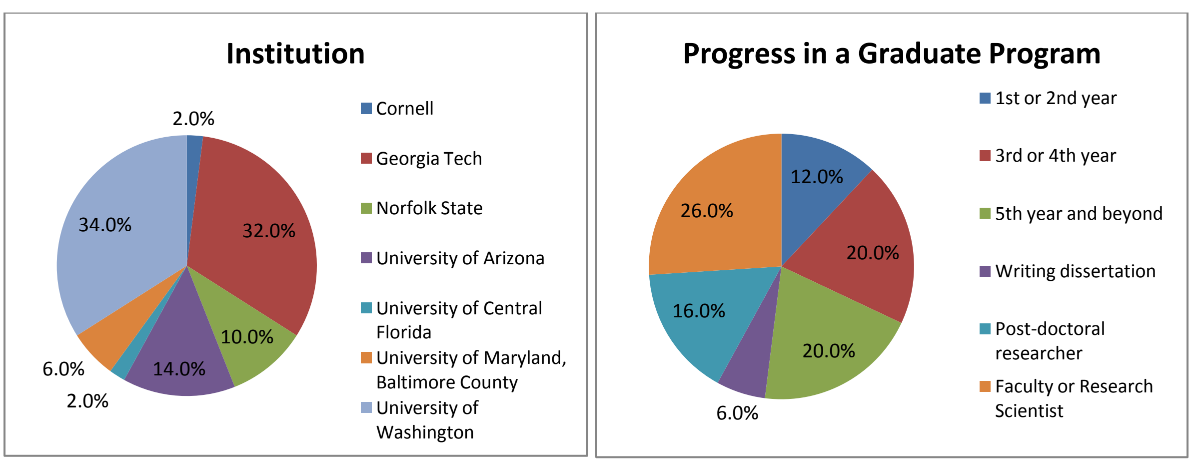

Figure 1. Percentage of participants based on home institution and progress in a graduate program.

Members from all five thrust areas completed the survey, and a small number of them identified multiple thrust areas to which their research contributes (Figure 2). Since we did not ask it as part of our survey, it is not clear if members who selected more than one primary thrust area work on more than one research project or if a single research project spans multiple thrusts. Lastly, we can see that the majority of the people who took the ILA survey consider themselves to have a chemistry background (Figure 2).

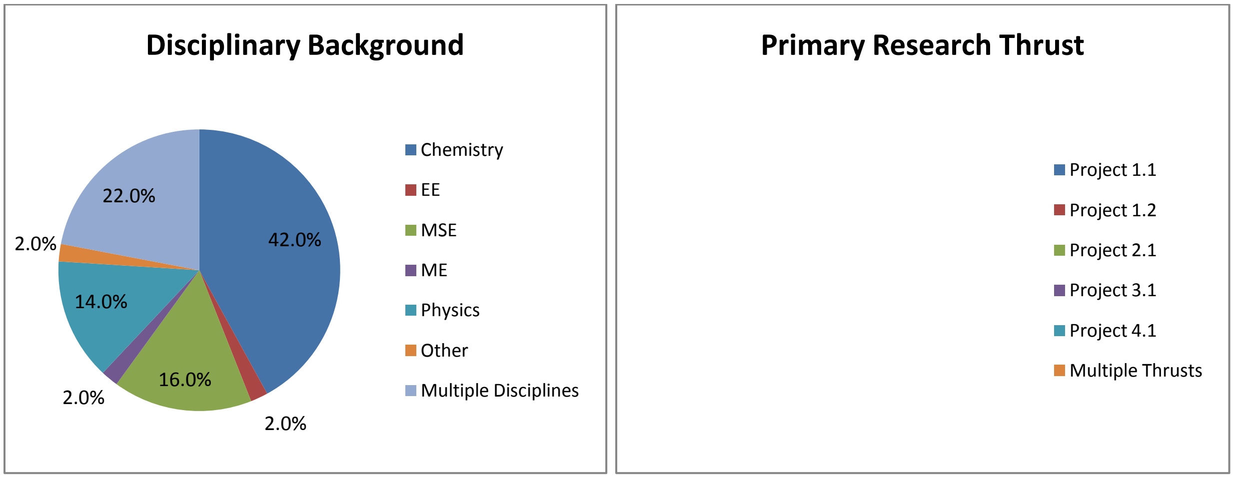

Figure 2. Percentage of participants based on disciplinary background and primary research thrust.

Methodology

The main purpose of developing and administering the ILA survey was to learn what CMDITR members believed were the core concepts that we should focus on as a Center. We defined core concept as a technical concept or a professional development concept that is central to understanding and communicating knowledge produced within CMDITR. Because core concepts are central to the Center, it is expected that all members, regardless of primary thrust area, should have a basic understanding of these concepts. These core concepts would allow us to assess the learning progress of our members and to develop or modify educational resources that are currently offered within the Center.

To design the ILA survey, we needed to compile a list of concepts. Twenty-five concepts were solicited from faculty and graduate students during interviews at the end of the Fall 2009 semester. Fifty-five concepts were chosen from peer-reviewed journal publications that reported on the STC-MDITR website for Year 7 (May 1, 2008 – April 30, 2009). As a former chemist who performed laboratory research for CMDITR, I was aware of the nature of research that was completed within the Center. To mitigate bias in selecting concepts, I reviewed journal articles until new terms failed to emerge. I categorized specific techniques (*e.g.*, nuclear magnetic resonance) into broader categories (*e.g.*, characterization of morphology). Approximately ten articles were reviewed before similar terms began to appear consistently. The list of 80 terms was emailed to two faculty members who were asked to review the concepts and edit as they saw fit. An additional nine concepts were added to the list. Therefore, the ILA survey that was administered to CMDITR members contained 89 concepts.

For each of the 89 concepts on the survey, participants were asked to rate their knowledge or comfort level of the concept (*i.e.*, not familiar, aware of the concept, somewhat informed, well informed, or expert) and the relevance of the concept to their own research (*i.e.*, low relevance, some relevance, core concept).

Results and Discussion

To determine which of the 89 concepts at least half of participants identified as core concepts, the percentages of respondents' selections for the relevance section of the survey were downloaded from Catalyst and arranged in an Excel® spreadsheet. The values were sorted from highest percentage to lowest percentage using "core concept" as the anchoring column. The same procedure was used to identify the concepts that were chosen as having little relevance to the member's own research (Table 1).

Only 15 of the concepts were chosen by at least half of the participants as being core concepts (16.9%), and 18 of the concepts were chosen by at least half of the participants as being low relevance (20.2%). Therefore, a majority of the concepts on the ILA survey held at least some relevance to participants. The fact that about 80% of the concepts on the list were of some relevance for participants' research suggests that the methodology for selecting the concepts has merit.

Core Concept (N = 15)	Percentage of Respondents (%)	Low Relevance (N = 18)	Percentage of Respondents (%)
Light absorption	78.00	Superconductivity	84.00
Electron donor material	67.35	Acid sensitive dyes	80.39
Chemical structure	66.67	Fracture	75.00
Electron acceptor material	65.31	Residual stress	74.00
Pi-conjugation	63.27	Fatigue	72.00
Electromagnetic spectrum	61.22	Surface modulator	72.00
Electric field	59.18	Strain and stress*	70.00
Your own research thrust within CMDITR	58.00	Time-resolved THz spectroscopy*	70.00
Charge mobility	54.90	Resists/resist materials	64.00
Light emission	54.00	Microring resonator	62.00
Exciton	52.00	Time-of-flight	61.22
Exciton dissociation	52.00	Cladding	58.82
Photoexcitation	52.00	Heavy atom effect*	58.00
Non-linear optics	50.00	Permeation	58.00
Organic semiconductors	50.00	Third-order NLO materials*	58.00
		Wavelength division multiplexing	58.00
		Hartree-Fock calculations	54.00
		Mach-Zehnder interferometers*	52.00

Table 1. Concepts that at least half of the participants chose as being core to their own research or as having low relevance to their own research. The asterisk indicates a concept in which at least one person in each thrust selected as having "some relevance" or being a "core concept".

To gain further insight into the relevance of the concepts provided on the ILA, we decided to identify which concepts were selected as either "some relevance" or "core concept" by at least one person in a given thrust. Recall that members of CMDITR should have a basic understanding of these core concepts regardless of their primary research thrust. Therefore, to use our resources most effectively, we should work to find a common ground that spans all five thrusts in our Center.

Independent of research thrust, 69 concepts (77.5%) had at least some relevance to members' primary research (Figure 3). Most of the concepts (93.3%) were selected as "some relevance" or "core concept" by at least one person in four of the five thrusts we currently support within the Center. There were, however, four concepts (4.5%) in which no participant selected it as a core concept, though it still held some relevance (Table 2). Similarly, independent of progress in a graduate program, 76 concepts (85.4%) had at least some relevance to members' primary research. We see the same four concepts having only some relevance to members' primary research when we consider the members' progress in a graduate program. Of note, faculty and research scientists (N = 13) reported superconductivity as having low relevance to their own research. This was the only concept on the entire ILA in which this group of participants did not have at least one member report "some relevance" or "core concept" for relevance of a given concept.

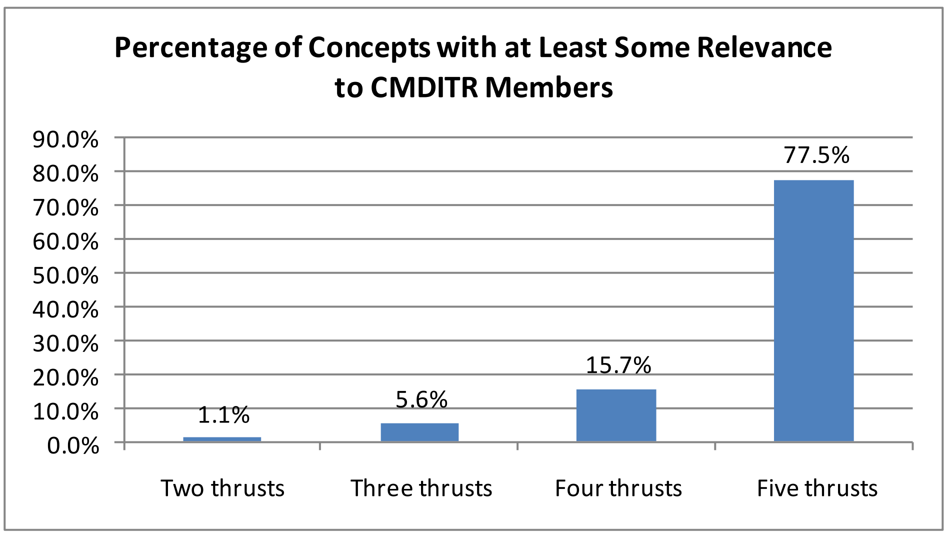

Figure 3. The percentage of 89 ILA concepts in which at least one person from a given thrust identified as either having "some relevance" or being a "core concept". The x-axis shows the number of thrusts in which at least one person selected "some relevance" or "core concept". The concepts represented by each of these bars are provided as supplemental material.

To guide our focus on educational resources provided to the Center, it is also important to understand how knowledgeable members feel they are with the concepts presented on the ILA survey. More importantly, did participants identify concepts as core concepts or low relevance based solely on how knowledgeable they were about the concepts? The percentages of respondents' selections for the knowledge section of the survey were downloaded into the same Excel® spreadsheet as the relevance data. For each concept, the percentages of participants who claimed to be well-informed or expert were summed. The sums of percentages were sorted from highest percentage to lowest percentage.

Concepts on which no participant reported having some relevance or being a core concept	
Based on primary research thrust	Based on progress in a graduate program
Acid sensitive dyes	Acid sensitive dyes
Photoacid	Photoacid
Photoacid generator	Photoacid generator
Surface modulator	Surface modulator

Table 2. Based on primary research thrust and progress in a graduate program, there were four concepts on which no participant reported having either some relevance or being a core concept. These concepts constitute four and one-half percent of the total concepts on the ILA survey.

For 39 of the concepts (43.8%), at least half the participants reported being well-informed or expert (Table 3). The 15 concepts that were identified as core concepts earlier (Table 1) did appear in Table 3. Moreover, the 39 concepts on which CMDITR members felt most knowledgeable were identified by at least one person in each primary thrust as having some relevance or being a core concept. Two interesting observation arise: (1) none of the concepts that most participants identified as low-relevance appear in Table 3 and (2) five of the 18 low-relevance concepts in Table 1 were identified as having at least some relevance to at least one person in each thrust (Figure 3). These observations suggest that members do not try to learn about concepts which they perceive as having low relevance for their own research. Because some of the concepts most participants believed to have low relevance for their own research were identified by other colleagues within their own thrust as having some relevance or being core concepts, more must be done to communicate explicitly how and why these concepts relate to the research being conducted in each thrust.

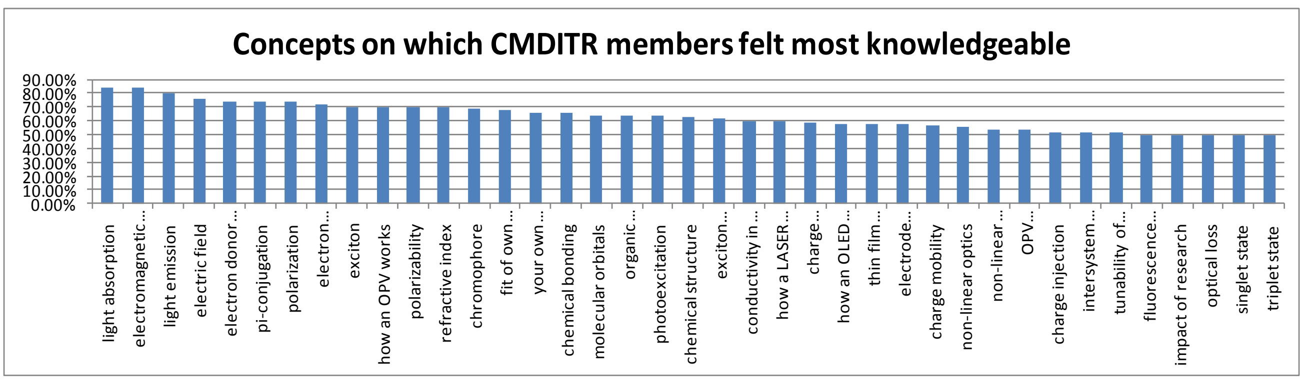

Table 3. Thirty-nine concepts on which fifty-percent or more CMDITR members reported being well-informed and expert.

To learn if there was common ground across thrusts based on how knowledgeable members reported being on the ILA concepts, we analyzed the data to see which concepts had at least one person per thrust who reported being well-informed or expert (Figure 4). In this case, there were 55 concepts (61.8%) on which at least one member in a given thrust reported being at least well-informed. According to the data, there were nine concepts (10.1%) in which none of the participants reported being an expert (Table 4). When the same analyses were done based on a member's progress in a graduate program, we found that at least one member in each category reported being well-informed or expert on 47 concepts (52.8%). As in the case of knowledge related to primary research thrust, there were eight concepts on which there were no experts in terms of progress in a graduate program (Table 3). Seven concepts appear on both lists, but only strain and stress and different research fields within CMDITR were chosen as having some relevance by at least one person in each primary research thrust.

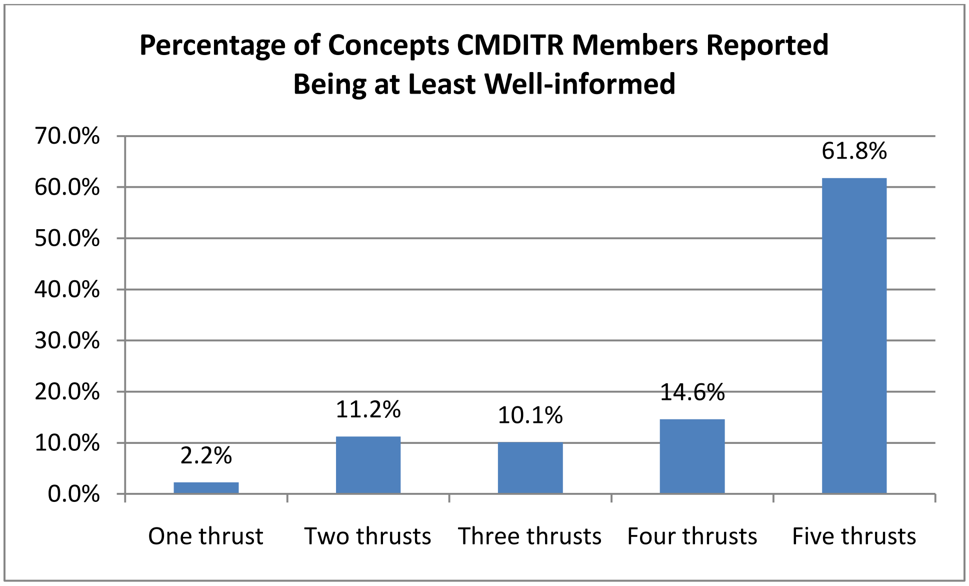

Figure 4. The percentage of 89 ILA concepts in which at least one person from a given thrust identified as either being "well-informed" or "expert". The x-axis shows the number of thrusts in which at least one person selected "well-informed" or "expert". The concepts represented by each of these bars are included as supplemental material.

Concepts on which no participant reported being an expert			
Based on primary research thrust		Based on progress in a graduate program	
Different research fields within CMDITR	Strain and stress	Acid-sensitive dyes	Strain and stress
Fatigue	Surface modulator	Fatigue	Surface modulator
Fracture	Superconductivity	Fracture	Time-of-flight
Photoacid	Time-of-flight	Photoacid	
Photoacid generator		Photoacid generator	

Table 4. Based on primary research thrust, there were nine concepts on which no participant reported being an expert. Based on progress in a graduate program, there were eight concepts on which no participant reported being an expert. These concepts constitute ten percent and nine percent of the total concepts on the ILA survey, respectively.

To understand if there were any significant differences of the individual scores of knowledge of concepts and a demographic category (*i.e.*, progress in a graduate program and primary thrust), a χ^2 cross-tabulation analysis was performed. Because we have only five categories of knowledge on our ILA instrument, we cannot use parametric statistical tests to analyze the data for statistical significance. The concepts that showed significant differences in the level of knowledge and/or the level of relevance based on progress in a graduate program (Table 5) and primary thrust (Table 6) are below.

Concepts in which there was a significant difference (p <0.05) based on a member's progress in a graduate program	
Knowledge (N = 5)	**Relevance (N = 5)**
Common causes of organic device degradation	Electro-optic modulators
Common and potential applications of organic electro-optic materials	Non-linear optics
Molecular orbitals	Polarizability
Non-linear polarization*	Superconductivity
Susceptibility	

Table 5. Knowledge of concepts on the ILA survey that were significantly different ($p < 0.05$) based on a member's progress in a graduate program. The asterisk indicates that there was also a significant difference in terms of relevance.

Concepts in which there was a significant difference (p < 0.05) based on a member's primary thrust within CMDITR	
Knowledge (N = 24)	**Relevance (N = 33)**
Charge mobility*	Charge injection
Charge traps*	Cladding
Electron acceptor materials*	Electrode workfunction
Electron donor materials*	Exciton
Electro-optic coefficient for a material*	How a LASER works
Electro-optic modulators*	How an OLED works
Encapsulation	Molecular orbitals
Encapsulation techniques	Morphology
Environmental degradation	Optical waveguides
How an OFET works*	OPV heterojunction
How an OPV works*	Organic device encapsulation methods
Mach-Zehnder interferometers*	Organic semiconductors
Microring resonator*	Polarizability
Non-linear optics*	Polarization
Non-linear polarization*	Wavelength division multiplexing
Optical loss*	
Organic device encapsulation*	
Organic device fabrication	
Polycrystalline films	
Second-order non-linear optic materials*	
Susceptibility*	
Third-order non-linear optic materials*	
Time-of-flight	
Time-resolved THz spectroscopy*	
Tunability of organic devices	

Table 6. Concepts on the ILA survey that were significantly different ($p < 0.05$) based on a member's primary thrust. The asterisk indicates that there was also a significant difference in terms of relevance.

We can see from the data that primary thrust area seems to make more of a difference on members' knowledge than progress in a graduate program. The ostensibly anomalous result can be explained to some extent by the fact that there are unequal numbers of participants in each thrust. The inequality is much more pronounced for primary thrust (Figure 2) compared to progress in a graduate program (Figure 1). While more research must be completed to learn if this finding is indeed anomalous, the finding may suggest that more efforts need to be made to increase the level of interdisciplinarity of research projects so that members are exposed to concepts outside their primary thrust areas. We know from the qualitative research findings from the Discovery Phase of the ILA project that members in CMDITR tend to stick with areas and methodologies in which they are more knowledgeable and comfortable.

Summary

The ILA survey was constructed using feedback from interviews with three CMDITR members and from peer-reviewed publications reported in Year 7 of the Center. The electronic ILA survey received 51 responses from members with diverse backgrounds. For many of the concepts on the ILA instrument, data analysis has shown that primary thrust area is more important than progress in a graduate program with respect both to self-reported knowledge or comfort level and to the perceived relevance on members' primary research project. However, this may be an anomalous finding considering the unequal numbers of participants within each thrust.

For most of the concepts that were included on the ILA, participants reported at least being well-informed and/or having some relevance to primary research projects. The ILA has been a useful tool to assess self-reported levels of knowledge and self-reported relevance to one's own research areas. While more surveys need to be completed to determine validity and reliability, our method of selecting concepts seems to have merit as indicated by the 93.3% of the concepts having some relevance to at least one person in each thrust. With further refinement of the 89 concepts, as well as placing additional concepts on the ILA survey (Appendix B), the instrument can be used successfully to periodically evaluate the educational needs of CMDITR members. One implication of this project is that new Centers being created will have the process to develop a (interdisciplinary) literacy assessment tool for their own needs. The data can enrich interdisciplinary efforts and can indicate areas where financial and human resources may be most effective.

Future efforts within the Center should focus on having all members complete the survey. By increasing the numbers of participants in various demographic categories, more powerful statistical analyses can be performed. The findings from the quantitative research can provide deeper insight into some of the results reported herein. Furthermore, knowing the baseline from which each member begins his/her time in the Center, the amount of interdisciplinarity one experiences may be measured. The baseline will also help us to evaluate, over time, the changes that occur in the levels of knowledge self-reported for each concept on the ILA. Coupled with data from the test bank questions that will be developed in the assessment phase of the ILA project, we will have at our disposable a valuable means to measure not only self-reported knowledge but also demonstrated knowledge on the ILA concepts.

In conclusion, the interdisciplinary literacy assessment survey will be a powerful tool to evaluate CMDITR members' self-reported level of knowledge and level of relevance for primary research for concepts included on the survey. Understanding the needs of our members can greatly facilitate the prioritization of limited financial and human resources allotted for educational initiatives.

Appendix A

The entire list of 89 concepts on the ILA instrument
acid sensitive dyes
amorphous films
being able to recognize other areas of science and/or engineering that impact your own STC research project(s)
bond-length alternation
carrier scattering times
characterization techniques of morphology
charge delocalization
charge injection
charge mobility
charge traps
chemical bonding
chemical structure
chromophore
cladding
common causes for organic device degradation
conductivity in organic devices
current and potential applications of organic EO materials
density-functional theory calculations
different research fields within CMDITR
diffusion
electric field
electrode workfunction
electromagnetic spectrum
electron acceptor materials
electron donor materials
encapsulation
encapsulation techniques
environmental degradation
EO coefficient for a material
EO modulators
exciton
exciton dissociation
fatigue
fit of own research withing CMDITR
fluorescence quantum yield
fracture
free carriers
frontier orbitals
Hartree-Fock calculations
heavy atom effect
how a LASER works
how an OFET works
how an OLED works
how an OPV works
intersystem crossing
light absorption
light emission
lithography
Mach-Zehnder interferometers
microring resonator
molecular orbitals
morphology
non-linear optics
non-linear polarization
optical loss
optical waveguides
OPV heterojunction
organic device encapsulation
organic device encapsulation methods
organic device fabrication
organic semiconductors
permeation
photoacid
photoacid generator
photoexcitation
pi-conjugation
polarizability
polarization
polycrystalline films
refractive index
residual stress
resists/resist materials
second-order non-linear optic materials
singlet state
strain and stress
superconductivity
surface modulator
susceptibility
thermal annealing of polymers
thermal stability
thin film deposition
third-order non-linear optics
time-of-flight
time-resolved terahertz spectroscopy
triplet state
tunability of materials used in organic devices
tunability of organic devices
wavelength division multiplexing
your own research thrust in CMDITR

Appendix B

Concepts written in by CMDITR members which did not appear on the ILA survey	
Written in on the Catalyst ILA survey	Written in on the STC Retreat Target Diagram
characterization techniques	density of states
characterization instrumentation	Fermi energy
dielectric effects	Fermi level
organic synthesis	highest occupied molecular orbital (HOMO)
photostability	interfaces
two-photon absorption	lowest unoccupied molecular orbital (LUMO)
	non-linear refraction
	non-linear spectroscopy
	OTFT testing
	polythiophene
	semiconducting polymers

Supplemental Material

The concepts listed based on the number of primary research thrusts that had at least one member report "some relevance" or "core concept"
5 thrusts (N = 69)
amorphous films
being able to recognize other areas of science and/or engineering that impact your own STC research project(s)
bond-length alternation
carrier scattering times
characterization techniques of morphology
charge delocalization
charge injection
charge mobility
charge traps
chemical bonding
chemical structure
chromophore
common causes for organic device degradation
conductivity in organic devices
current and potential applications of organic EO materials
density-functional theory calculations
different research fields within CMDITR
diffusion
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electrode workfunction
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electron acceptor materials
electron donor materials
encapsulation
encapsulation techniques
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how an OFET works
how an OLED works
how an OPV works
intersystem crossing
light absorption
light emission
lithography
Mach-Zehnder interferometers
molecular orbitals
morphology
non-linear optics
non-linear polarization
optical loss
optical waveguides
OPV heterojunction
organic device fabrication
organic semiconductors
photoexcitation
pi-conjugation
polarizability
polarization
polycrystalline films
refractive index
second-order non-linear optic materials
singlet state
strain and stress
susceptibility
thermal annealing of polymers
thermal stability
thin film deposition
third-order non-linear optics
time-resolved terahertz spectroscopy
triplet state
tunability of materials used in organic devices
tunability of organic devices
your own research thrust in CMDITR
4 thrusts (N = 14)
cladding
environmental degradation
EO coefficient for a material
fatigue
frontier orbitals
Hartree-Fock calculations
microring resonator
organic device encapsulation
organic device encapsulation methods
residual stress
resists/resist materials
surface modulator
time-of-flight
wavelength division multiplexing
3 thrusts (N = 5)
fracture
permeation
photoacid
photoacid generator
superconductivity

2 thrusts (N = 1)
acid sensitive dyes

The concepts listed based on the number of primary research thrusts that had at least one member report being "well-informed" or "expert"
5 thrusts (N = 55)
amorphous films
being able to recognize other areas of science and/or engineering that impact your own STC research project(s)
bond-length alternation
characterization techniques of morphology
charge delocalization
charge injection
charge mobility
chemical bonding
chemical structure
chromophore
common causes for organic device degradation
conductivity in organic devices
current and potential applications of organic EO materials
different research fields within CMDITR
electric field
electrode workfunction
electromagnetic spectrum
electron acceptor materials
electron donor materials
EO coefficient for a material
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how an OLED works
how an OPV works
intersystem crossing
light absorption
light emission
molecular orbitals
non-linear optics
non-linear polarization
optical loss
optical waveguides
OPV heterojunction
organic semiconductors
photoexcitation
pi-conjugation
polarizability
polarization
refractive index
second-order non-linear optic materials
singlet state
susceptibility
thermal stability
thin film deposition
third-order non-linear optics
triplet state
tunability of materials used in organic devices
tunability of organic devices
your own research thrust in CMDITR
4 thrusts (N = 13)
charge traps
cladding
density-functional theory calculations
diffusion
EO modulators
frontier orbitals
Hartree-Fock calculations
lithography
morphology
polycrystalline films
resists/resist materials
thermal annealing of polymers
time-of-flight
3 thrusts (N = 9)
acid sensitive dyes
carrier scattering times
environmental degradation
fatigue
Mach-Zehnder interferometers
microring resonator
organic device fabrication
photoacid
superconductivity
2 thrusts (N = 10)
encapsulation
encapsulation techniques
fracture
organic device encapsulation
organic device encapsulation methods
permeation
photoacid generator
residual stress
strain and stress
wavelength division multiplexing

1 thrust (N = 2)
surface modulator
time-resolved terahertz spectroscopy

The concepts listed based on the number of categories[†] for progress in a graduate program that had at least one member report "some relevance" or "core concept"
6 categories (N = 76)
acid-sensitive dyes
amorphous films
being able to recognize other areas of science and/or engineering that impact your own STC research project(s)
bond-length alternation
carrier scattering times
characterization techniques of morphology
charge delocalization
charge injection
charge mobility
charge traps
chemical bonding
chemical structure
chromophore
cladding
common causes for organic device degradation
conductivity in organic devices
current and potential applications of organic EO materials
density-functional theory calculations
different research fields within CMDITR
electric field
electrode workfunction
electromagnetic spectrum
electron acceptor materials
electron donor materials
EO coefficient for a material
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how an OLED works
how an OPV works
intersystem crossing
light absorption
light emission
Mach-Zehnder interferometers
microring resonator
molecular orbitals
morphology
non-linear optics
non-linear polarization
optical loss
optical waveguides
OPV heterojunction
organic device encapsulation
organic device encapsulation methods
organic device fabrication
organic semiconductors
photoexcitation
pi-conjugation
polarizability
polarization
polycrystalline films
refractive index
second-order non-linear optic materials
singlet state
strain and stress
susceptibility
thermal annealing of polymers
thermal stability
thin film deposition
third-order non-linear optics
time-of-flight
permeation
residual stress
resists/resist materials
triplet state
tunability of materials used in organic devices
tunability of organic devices
wavelength division multiplexing
your own research thrust in CMDITR
5 categories (N = 12)
diffusion
encapsulation
encapsulation techniques
environmental degradation
fatigue
fracture
Hartree-Fock calculations
lithography
photoacid
photoacid generator
surface modulator
time-resolved terahertz spectroscopy

4 categories (N = 1)
superconductivity

The concepts listed based on the number of categories† for progress in a graduate program that had at least one member report "well-informed" or "expert"
6 categories (N = 47)
amorphous films
being able to recognize other areas of science and/or engineering that impact your own STC research project(s)
charge delocalization
charge mobility
chemical bonding
chemical structure
chromophore
conductivity in organic devices
electric field
electrode workfunction
electromagnetic spectrum
electron acceptor materials
electron donor materials
EO coefficient for a material
exciton
exciton dissociation
fit of own research withing CMDITR
free carriers
how a LASER works
how an OFET works
how an OLED works
how an OPV works
light absorption
light emission
molecular orbitals
morphology
non-linear optics
non-linear polarization
optical loss
organic semiconductors
photoexcitation
pi-conjugation
polarizability
polarization
polycrystalline films
refractive index
second-order non-linear optic materials
singlet state
susceptibility
thermal stability
thin film deposition
third-order non-linear optics
permeation
resists/resist materials
triplet state
tunability of materials used in organic devices
your own research thrust in CMDITR
5 categories (N = 20)
bond-length alternation
carrier scattering times
characterization techniques of morphology
charge injection
charge traps
common causes for organic device degradation
density-functional theory calculations
diffusion
EO modulators
fluorescence quantum yield
frontier orbitals
intersystem crossing
lithography
Mach-Zehnder interferometers
microring resonator
OPV heterojunction
organic device fabrication
thermal annealing of polymers
time-of-flight
tunability of organic devices
4 categories (N = 9)
cladding
current and potential applications of organic EO materials
different research fields within CMDITR
fatigue
Hartree-Fock calculations
heavy atom effect
optical waveguides
residual stress
superconductivity
3 categories (N = 11)
acid-sensitive dyes
encapsulation
encapsulation techniques
environmental degradation
fracture
organic device encapsulation
organic device encapsulation methods
photoacid
strain and stress
time-resolved terahertz spectroscopy
wavelength division multiplexing

2 categories (N = 2)
photoacid generator
surface modulator

†The categories for progress in a graduate program are first or second year, third or fourth year, fifth year and beyond, writing dissertation, post-doctoral research, and faculty or research scientist.