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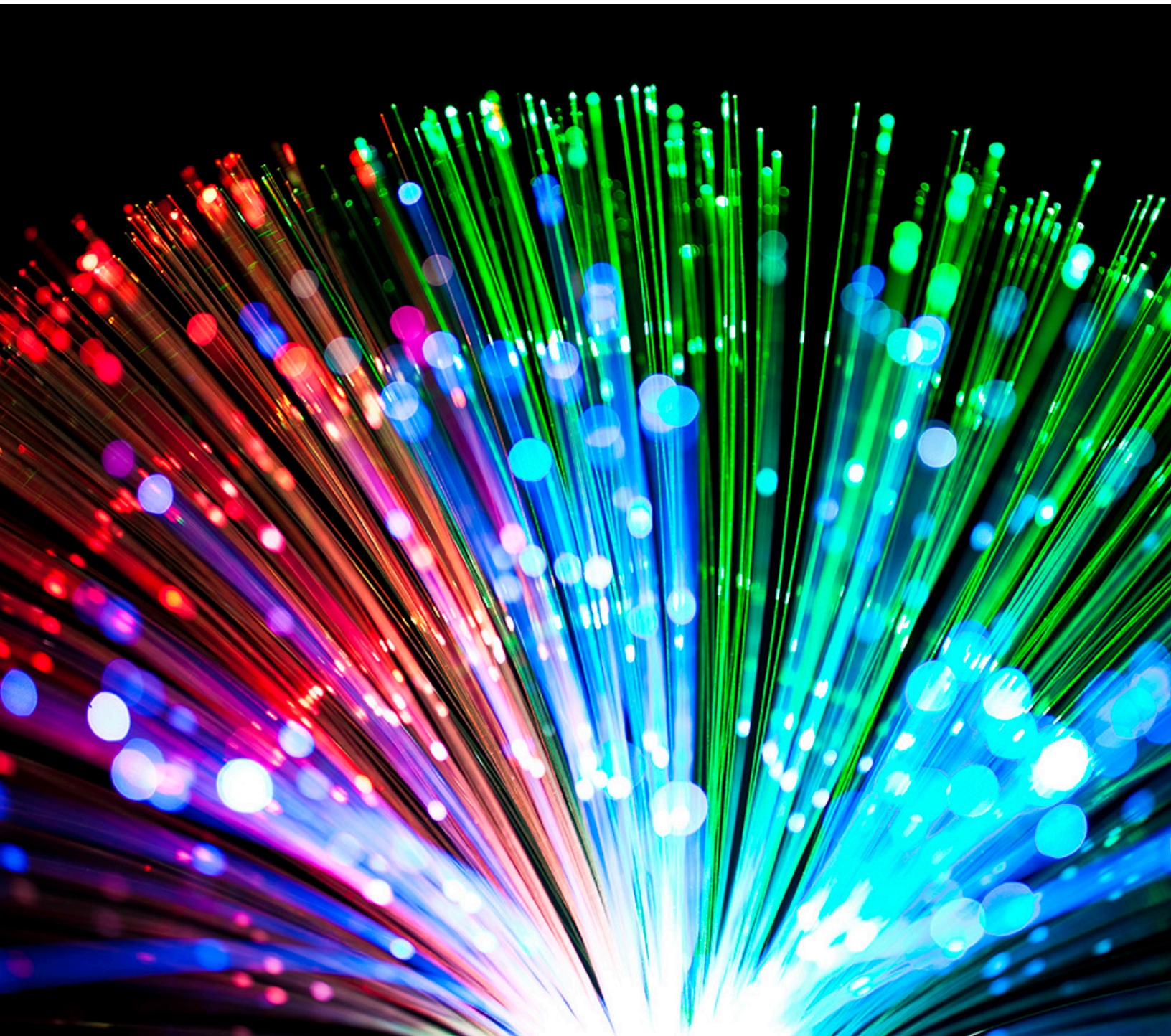
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# Materials Day

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## Photonic Materials



## **Materials Resources:**

Materials Processing Center provides an environment where students and professionals from industry, government and academia collaborate to identify and address pivotal multidisciplinary issues in materials processing and manufacturing at MIT.

<http://mpc-web.mit.edu>

Microphotonics Center @ MIT builds interdisciplinary teams, focused on collaborative research for the advancement of basic science and emerging technology pertaining to integrated photonic systems.

<http://mphotronics.mit.edu>

The Communications Technology Roadmap (CTR) is a project under the Microphotonics Industry Consortium, which in turn is part of the MIT Microphotonics Center. The purpose of this Roadmap is to understand the interaction between technology, industry, and policy dynamics and from there, formulate a vision for the future of the microphotonics industry.

<http://mph-roadmap.mit.edu/>

The Solid State Solar-Thermal Energy Conversion Center (S<sup>3</sup>TEC) objective is to create novel solid-state materials for the conversion of sunlight and heat into electricity.

<http://s3tec.mit.edu>

Center for Materials Science & Engineering is devoted to the design, creation, and fundamental understanding of materials that are capable of enhancing the human experience.

<http://mit.edu/cmse>

Department of Materials Science & Engineering is known as the world-wide leader in its field, pioneering advances in engineering sciences and technologies.

<http://dmse.mit.edu>

## **Dates for future Materials Day events:**

Tuesday, October 21, 2014

Tuesday, October 13, 2015

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
**MATERIALS PROCESSING CENTER**

*Materials Day at MIT*

# Photonic Materials

October 23, 2013

Photonic Materials will be the focus of this year's Materials Day event. In the past decade there have been great advances in the development of photonic materials for applications ranging from optical interconnections for microelectronic circuits to new biomedical systems enabled by innovations in materials processing. Speakers will address new applications of materials that are traditionally not thought of as photonic materials, such as silicon and germanium, as well as nanostructured materials such as quantum crystals and photonic crystals used in displays and energy harvesting devices, and new multifunctional fiber optic materials for use in biotechnology and communications. Materials Day activities will include a one-day conference featuring speakers from both inside and outside MIT. A student poster session will follow, featuring 50 to 100 posters with up-to-the-minute research results from the broad materials research communities in MIT's Schools of Engineering and Science.

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## Materials Day Agenda

8:00 am      **Registration** (Kresge Auditorium)

8:45 am      **Welcome and Overview**  
Professor Carl V. Thompson  
Director, Materials Processing Center  
Department of Materials Science & Engineering, MIT

### Session I:

9:00 am      **Optical Materials R&D at GE: From Science to Technology**  
Dr. Vanita Mani  
Technology Leader  
Energy Storage & Conversion Materials  
GE Global Research

9:40 am      **Nanophotonics for Energy-Conversion Applications**  
Professor Marin Soljacic  
Physics Department, MIT

10:20 am     **Break**

### Session II:

10:40 am     **From Smoke Signals to Clouds: Roadmaps, Roadblocks and Solutions**  
Professor Lionel C. Kimerling  
Director  
Microphotonics Center  
Department of Materials Science & Engineering, MIT

11:20 am     **Photonic Materials for Future Exabit Networks**  
Dr. Alice White  
Professor & Chair  
Mechanical Engineering Department, Boston University  
(Formerly Chief Scientist with Alcatel-Lucent Bell Labs)

12:00 - 1:00 pm      **Lunch**  
Student Center, 3rd floor, Twenty Chimneys/Mezzanine Lounge  
(Bldg. W20)

**Session III:**

1:10 pm **New Wave of Materials Challenges and Opportunities in the Growing Industry of Organic Light Emitting Devices**

Dr. Michael S. Weaver  
Director  
PHOLED Applications Engineering & Development  
Universal Display Corporation

1:50 pm **Colloidal Quantum Dots in Commercialized Lightbulbs and Displays**

Professor Vladimir Bulovic  
Director  
Microsystems Technology Lab, MIT

2:30 pm **How Can a Shirt See? The Birth of a Revolution in Fibers and Fabrics**

Professor Yoel Fink  
Director  
Research Laboratory of Electronics  
Department of Materials Science & Engineering, MIT

3:10 pm **Wrap-up and Discussion with Attendees**

**Materials Research Review Poster Session**

3:30 pm **Poster Session and Social**

La Sala De Puerto Rico  
2nd Floor Stratton Student Center  
(Bldg. W20)

5:45 pm **Poster Awards**

6:00 pm **Adjourn**



**Professor Carl V. Thompson**  
**Director**  
**Materials Processing Center**  
**Stavros Salapatas Professor of Materials Science and**  
**Engineering**  
**Massachusetts Institute of Technology**

**Biography**

Prof. Thompson received his S.B. in Materials Science and Engineering from MIT, and his S.M. and Ph.D. in Applied Physics from Harvard University, the latter in 1981. He was an IBM postdoctoral Fellow in the Research Laboratory of Electronics at MIT in 1982, and joined the faculty of MIT in 1983. Prof. Thompson spent the 1990-91 academic year in the Department of Metallurgy and Materials Science at Cambridge University and the 1997-98 academic year at the Max Planck Institut fur Metallforschung in Stuttgart Germany, and 2012 at the Karlsruhe Institute of Technology. He served as the President of the Materials Research Society in 1996, served on the MRS council from 1991 to 1997. He is currently The Director of MIT's Materials Processing Center, Co-Chair of the Program for Advanced Materials for Micro- and Nano-Materials of the Singapore-MIT Alliance and Co-Director of the Skoltech Center for Electrochemical Energy. Prof. Thompson has been a consultant with over thirty companies, including Intel, IBM, DEC, and a number of start-ups involved in development of microelectromechanical devices and systems. He has also collaborated in research with Intel, IBM, DEC, AMD, Motorola, TI, Chartered Semiconductor, and other companies.

Prof. Thompson's research interests include structure evolution during formation and processing of thin films and nanostructures, the mechanical and electrical properties of nanostructures, and the incorporation of thin films and nanostructures in electronic, electromechanical, and electrochemical devices and systems.



## **Dr. Vanita Mani**

**Technology Leader**

**Energy Storage & Conversion Materials**

**GE Global Research**

### **Optical Materials R&D at GE: From Science to Technology**

#### **Abstract**

We are in the midst of a lighting revolution. Within the last decade, there has been a shift from incandescent lighting to discharge lighting and solid state lighting. With this shift, the need for technology is great and speed is imperative. Materials for lighting applications must meet increasing performance demands like higher efficiency, better color, etc. To address future needs, in addition to these performance metrics, research & development needs to concurrently address product life and system cost. Examples of materials development for various lighting solutions will be discussed, providing due consideration to the three pillars of performance, life & cost.

#### **Biography**

Vanita Mani is the Technology Leader of the Energy Storage & Conversion Materials organization at GE Global Research. Working closely with various GE business units, her team delivers materials solutions for high temperature batteries, lighting phosphors, thin-film solar cells, and detectors for CT, X-Ray & Nuclear medicine. Vanita has a PhD from the University of Houston, MS from University of Kansas, and BTech from IIT Bombay, all in Chemical Engineering. Vanita has held various leadership roles in GE Global Research prior to her current role, including Global Technology Leader of Material Systems Technologies, Lab Manager of High Energy Physics, and Principal Investigator of Nanotube & Nanorod Research. She has contributed to various research programs in x-ray tubes, nanotechnology, circuit breakers, lighting and appliances. Prior to joining GE in 2000, Vanita was a Reservoir Engineer in the oil industry.



**Professor Marin Soljačić**  
Physics Department  
Massachusetts Institute of Technology

**Nanophotonics for Energy-Conversion Applications**

**Abstract**

By nano-structuring materials at length scales smaller than the wavelength of light, one can create effective materials, exhibiting optical properties unparalleled in any naturally occurring materials. The power of this approach is illustrated via a number of important examples. Firstly, it is shown that the control over the density of photonic states via such effective materials provides an optimal way to control the far field emission of radiation. Angularly selective absorbers, or transmitters could be enabled; these could enhance performance of solar absorbers. Moreover, this approach can be used to control black body emission, which can now be tailored almost at-will. And since over 90% of all primary energy sources are converted into electrical and mechanical energy via thermal processes, exciting energy-related applications could be enabled.

**Biography**

Marin Soljačić received a BsE degree in physics and a BsE degree in electrical engineering from MIT in 1996. He earned his PhD in physics at Princeton University in 2000. In September 2000, he was named an MIT Pappalardo Fellow in Physics, and in 2003 was appointed as a Principal Research Scientist in the Research Laboratory of Electronics at MIT. In September 2005, he became an Assistant Professor of Physics at MIT, in July 2010 an Associate Professor of Physics at MIT, and in July 2011 a Full Professor of Physics. His main research interests are in electromagnetic phenomena, focusing on nanophotonics, non-linear optics, and wireless power transfer. He is a co-author of 135 scientific articles and 31 issued US patents, and he has been invited to give more than 100 invited talks at conferences and universities around the world. He is the recipient of the Adolph Lomb medal from the Optical Society of America (2005), and the TR35 award of the Technology Review magazine (2006). In 2008, he was awarded a MacArthur fellowship grant. He is a correspondent member of the Croatian Academy of Engineering since 2009. In 2011 he became a Young Global Leader (YGL) of the World Economic Forum.



## **Professor Lionel C. Kimerling**

**Director**

**Microphotonics Center**

**Department of Materials Science & Engineering**

**Massachusetts Institute of Technology**

### **From Smoke Signals to Clouds: Roadmaps, Roadblocks and Solutions**

#### **Abstract**

Optical communication has been an essential technology, from the earliest millibit/s smoke signal transmission to the terabit/s fiber optic capacity of the Internet. New technology has led to revolutionary applications that have truly transformed society. This evolving communication technology engine has encountered classic social, political and economic roadblocks to commercial deployment. The current technology target is a path for scaling bandwidth density by 10,000x at constant cost, constant energy on a high volume manufacturing platform. Photonic integration in silicon offers the most promising scalable solution. The elements of silicon microphotonic technology will be discussed in the context of a progression of optical applications from indicator lamps to bar code readers to today's demand for zettabyte traffic and all-to-all connectivity. Lessons will be drawn to guide R&D investment and timely supply chain alignment.

#### **Biography**

Lionel C. Kimerling is the Thomas Lord Professor of Materials Science and Engineering at MIT. He is the founding Director of the MIT Microphotonics Center where he conducts an active research program in the design and processing of semiconductor materials and devices. He was head of the Materials Physics Research Department at AT&T Bell Laboratories, when he joined the faculty of MIT as Professor in 1990. He has authored more than 350 technical articles and more than 50 patents. He leads the MIT-Industry team of the Communication Technology Roadmap. Kimerling is the recipient of the 1995 Electronics Division Award of the Electrochemical Society, the 1996 MIT Perkins Award for Excellence in Graduate Advising, the 1997 Humboldt Senior Scientist Research Award and the 1999 John Bardeen Award of TMS. He is a Fellow of the American Physical Society, a Fellow of the AAAS, a Fellow of TMS, a Fellow of MRS and a Fellow of the School of Engineering of the University of Tokyo. His research has had fundamental impact on understanding of the chemical and electrical properties of defects in semiconductors and in the use of this knowledge for processing yield and component reliability. His research teams have enabled long-lived telecommunications lasers, developed semiconductor diagnostic methods such as DLTS, SEM-EBIC and RF-PCD, and pioneered silicon microphotonics.



## **Dr. Alice White**

**Professor and Chair**

**Mechanical Engineering Department**

**Boston University**

**(Formerly Chief Scientist with Alcatel-Lucent Bell Labs)**

**Photonic Materials for Future Exabit Networks**

### **Abstract**

Information networks have been one of the most important drivers of economic growth in the world over the last thirty years and will continue to be so for the foreseeable future. The Internet, powered by optical and wireless communications infrastructure, is on a trajectory to connect every person to every other and to much of mankind's knowledge; however, there are some fundamental limits to overcome. The orders-of-magnitude increases in capacity that are needed will require dramatic advances in systems and the underlying photonic components. With an eye to the future, I will survey some intriguing research results in photonic materials that have the possibility to change the trajectory of information systems. There are tough challenges facing the practical implementation of these materials technologies; however, the looming bandwidth crunch provides the incentive.

### **Biography**

Alice White recently joined the College of Engineering of Boston University from Bell Labs, where she had been Chief Scientist. She has a PhD in physics from Harvard University and a broad technical background in experimental solid state physics and fabrication of optical components. Since 1989, she held various leadership positions at Bell Labs including Director of Integrated Photonics Research, VP of the Physical Technologies Research Center, and President of the NJ Nanotechnology Center. Named a Bell Labs Fellow in 2001 for her work in "developing and applying novel integrated photonic device technologies in advanced optical networks", she is also a fellow of the American Physical Society, the IEEE Photonics Society, and the Optical Society of America.



## **Dr. Michael S. Weaver**

**Director**

**PHOLED Applications Engineering & Development  
Universal Display Corporation**

### **New Wave of Materials Challenges and Opportunities in the Growing Industry of Organic Light Emitting Devices**

#### **Abstract**

Organic lighting emitting devices (OLEDs) have caught the attention of the consumer. OLED smart phones are readily available in the global market with the popular Galaxy line by Samsung. OLED TV products which offer truly spectacular visual experiences have just been launched this year. While the early focus of OLED materials development was for display applications, the technology is now being considered as an energy efficient solid state lighting candidate. Lighting is now at a cross roads. Incandescent lamps are being banned because of their environmental impact, while compact fluorescent lamps have limited visual appeal, as well as safety concerns for residential lighting due to their mercury content. Both inorganic LEDs and OLEDs can provide energy efficient replacements for these older lighting technologies. Here we will discuss the history of materials development for OLED displays and luminaires and the future for a broad area of materials innovation that is desired to support this expanding industry.

#### **Biography**

Dr. Michael S. Weaver is the Director of PHOLED Applications Engineering and Development at UDC. He graduated in 1996 from Sheffield University with a Ph.D. in Physics. The field of study was electroluminescence in conjugated polymers. From 1996-2000 he worked for Sharp in Oxford, UK conducting research in small molecule OLED displays. He then joined UDC in 2000. Whilst at UDC Dr. Weaver has been involved in several major projects. He led the team that developed the world's first video rate displays on a flexible plastic substrates and has been working on improving the lifetime and efficiency of phosphorescent OLEDs since joining the company. Dr. Weaver to date has published over 100 papers and patents on the topic of organic electroluminescence.



## **Professor Vladimir Bulovic**

**Director**

**Microsystems Technology Laboratory**

**Massachusetts Institute of Technology**

### **Colloidal Quantum Dots in Commercialized Lightbulbs and Displays**

#### **Abstract**

The mainstream commercialization of semiconducting colloidal quantum dots (QDs) for light-emitting applications has begun: over one million Sony television units emitting QD-enhanced colors are now on sale. In addition to HD TVs, the high luminescence efficiency and uniquely size-tunable color of QDs also led to the recent use of optically-excited QD phosphors in energy-efficient lighting of high spectral quality. The next challenge is to develop electrically-excited QD films in the form of light-emitting devices (QD-LEDs) for use in energy-efficient, high-color-quality thin-film displays and solid-state lighting. Over the last decade several types of QD-LEDs have been developed with steadily improving performance, with the latest devices demonstrating external quantum efficiencies of >18%, corresponding to the internal quantum efficiencies of >90%. For these devices, brightness in excess of 50,000 cd/m<sup>2</sup> has been reached at operating voltages of only a few volts, and turn on voltages just below the QD bandgap energy/q. Not limited to the visible part of the spectrum, our recent QD-LEDs also show tunable emission into the near IR, exceeding the EQE of any other planar-emitting technology at wavelengths beyond 1 $\mu$ m. These latest demonstrations show that the promise of QD-LEDs is substantial, however for this young technology some key scientific and technical challenges still remain. The talk offer outlook on the ongoing strategies to overcome them, leading to an entirely new technology with high efficiency, high color quality, high color contrast and streamlined manufacturing process for exceptional displays and lighting.

#### **Biography**

Vladimir Bulović is the Professor of Electrical Engineering at MIT, holding the Fariborz Maseeh Chair in Emerging Technology, leading the Organic and Nanostructured Electronics laboratory, directing the MIT Microsystems Technology Laboratories and co-directing the MIT-ENI Solar Frontiers Center. Bulović's research interests include studies of physical properties of organic and organic/inorganic nanocrystal composite thin films and structures, and development of novel nanostructured optoelectronic devices. He is an author of over 150 research articles (cited over 10,000 times) and an inventor of 60 U.S. patents in areas of light emitting diodes, lasers, photovoltaics, photodetectors, chemical sensors, programmable memories, and micro-electro machines, majority of which have been licensed and utilized by both start-up and multinational companies. He is a founder of QD Vision, Inc. of Lexington MA, producing quantum dot optoelectronic components; of Kateeva, Inc. of Menlo Park CA, focused on development of printed organic electronics; and Ubiquitous Energy, Inc., developing nanostructured solar technologies. Prof. Bulović received his Ph.D. from Princeton University in 1998, where his academic work and patents contributed to the launch of the Universal Display Corp. and the Global Photonics Energy Corp. He is a recipient of the U.S. Presidential Early Career Award for Scientist and Engineers, the National Science Foundation Career Award, the Ruth and Joel Spira Award, Eta Kappa Nu Honor Society Award and the Bose Award for Distinguished Teaching. He was named to Technology Review TR100 List, and in 2012 he shared the SEMI Award for North America in recognition of his contribution to commercialization of the quantum dot technology. In 2008 he was named the Class of 1960 Faculty Fellow in recognition of his contribution to Energy Education, and in 2009 he was awarded the Margaret MacVicar Faculty Fellowship, MIT's highest teaching honor. In 2011 he was awarded the Faculty Research Innovation Fellowship for excellence in research and international recognition, while most recently Bulović was named the Fellow of the World Technology Network and the Xerox Distinguished Lecturer, in recognition for his continued contribution to innovation of practical applied nanotechnologies.



## Professor Yoel Fink

Director

Research Laboratory of Electronics

Department of Materials Science and Engineering

Massachusetts Institute of Technology

How Can a Shirt See? The Birth of a Revolution in Fibers and Fabrics

### Abstract

Fibers and fabrics are among the earliest forms of human expression; these materials shield us from the environment and play an important role in defining who we are. Surprisingly, in sharp contrast to other areas of our existence, fibers have remained practically unchanged for thousands of years.

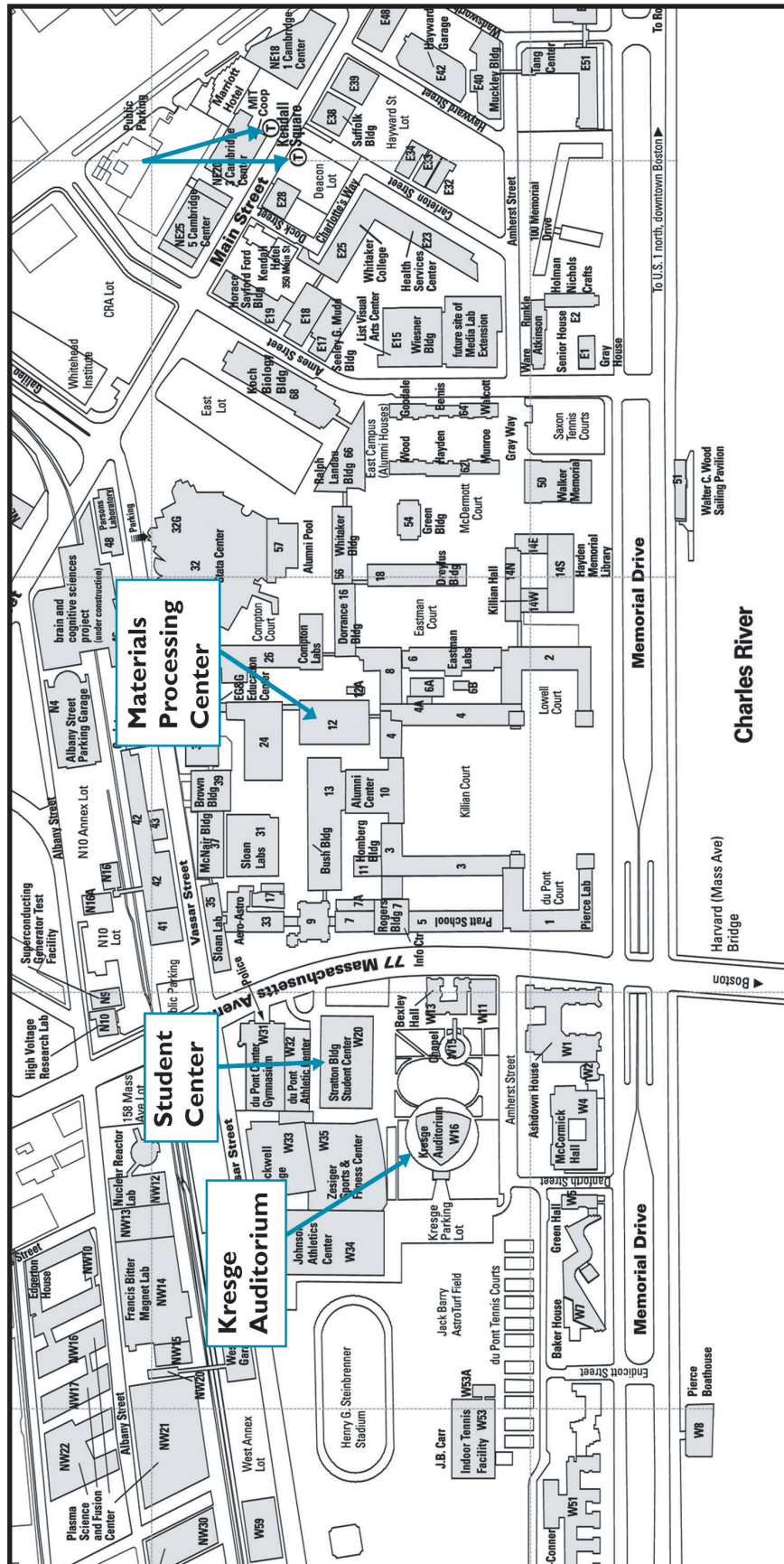
Can fibers become highly functional objects similar to computers and smartphones? Can they see, hear, sense, and communicate? Our research focuses on extending the frontiers of fiber materials from optical transmission to encompass electronic and even acoustic properties. Central to our approach is the combination of a multiplicity of disparate solid state materials, arranged in elaborate macroscopic architectures which are thermally drawn into kilometer long fibers with internal features down to 10 nanometers. Two complementary approaches towards realizing sophisticated functions are explored: on the single-fiber level, the integration of a multiplicity of functional components into one fiber, and on the multiple-fiber level, the assembly of large-scale fiber arrays and fabrics. We are in the midst of changing the way we think of fibers and fabrics forever.

The first steps in implementing this new vision for fibers has already occurred: The most important one involved the creation of the first multimaterial fiber for precision surgical applications. These fibers transmit a wavelength of light which could never be sent through a fiber. In doing so they enable surgeons to remove tumors while minimizing collateral damage to adjacent healthy tissue. Approximately 100,000 people have been treated thus far with this technology for removal of tumors from the brain, airways, hearing restoration and the treatment of endometriosis.

### Biography

Yoel Fink is a professor in the Materials Science and Engineering Department at MIT. Professor Fink received a B.A. degree in Physics (Cum Laude) and a B.Sc in Chemical Engineering (Summa Cum Laude) from the Technion, Haifa, in 1994. In 2000 he was awarded a Ph.D. degree from the Massachusetts Institute of Technology. That same year he joined the faculty of the MIT Materials Science and Engineering Department, and in 2011 he became a joint professor of Electrical Engineering and Computer Science. Professor Fink's research group has pioneered the field of multimaterial multifunctional fibers. He was a recipient of the Weizmann Institute Amos De-Shalit Foundation Scholarship in 1992, was awarded the Hershel Rich Technion Innovation Competition 1994, was a recipient of the Technology Review Award for the 100 Top Young Innovators in 1999, and was awarded the National Academy of Sciences Initiatives in Research Award for 2004. In 2006 he won the Joseph Lane Award for Excellence in Teaching, and in 2007 he was named one of the MacVicar Fellows awarded annually in recognition of outstanding teaching abilities. Professor Fink is a co-founder of OmniGuide Inc. (2000) and served as its chief executive officer from 2007-2010; he is currently Chairman of the Board. He is the coauthor of over seventy-five scientific journal articles, and holds over 40 issued U.S. patents on photonic fibers and devices. In September 2011, Professor Fink became Director of MIT's Research Laboratory of Electronics (RLE).

# Notes:





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