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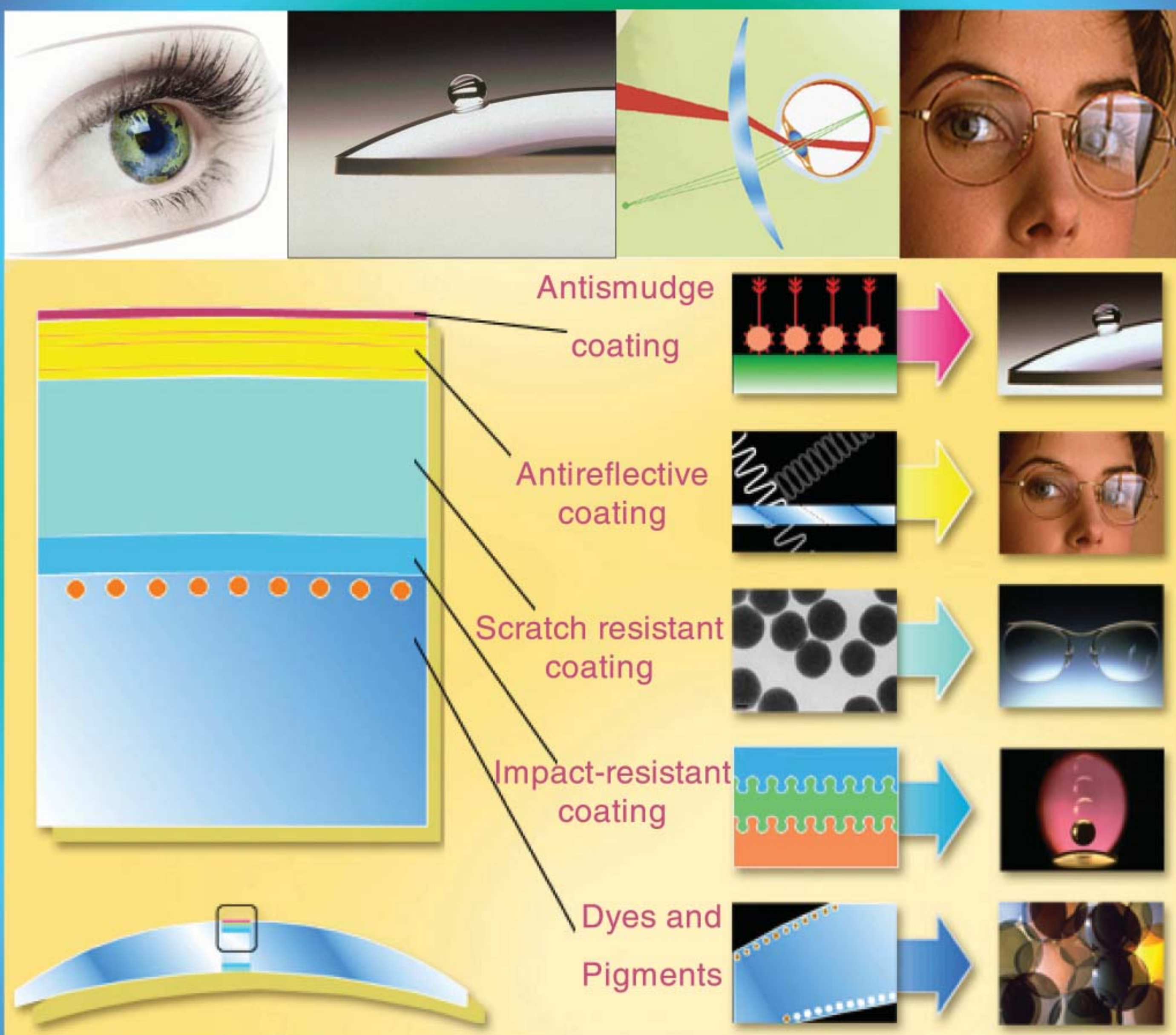
October 16, 2007

Materials Day '07

Thin Films and Coatings:
Designed and Processed to Enhance Function and Performance



Pictured on the Cover: Multifunctional coatings on an ophtalmic lens

The image was provided by Dr. Richard Bosmans, Scientific Director Materials, Essilor International R & D. For more information about this research, please attend Dr. Bosmans talk "Optical Thin Films for Eyewear Applications" at 9:40 am today.

The Materials Processing Center is proud of MIT's leadership role in working toward solutions to the global energy challenge. As part of MPC's commitment to that critical goal, this document has been printed by Hanson Printing on Mohawk options paper containing 30% post-consumer waste fiber and manufactured using renewable, non-polluting wind-generated electricity. Hanson uses exclusively soy inks.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MATERIALS PROCESSING CENTER

Materials Day at MIT

Thin Films and Coatings: Designed and Processed to Enhance Function and Performance

October 16, 2007

Materials scientists and engineers have migrated from the macro to the micro and on to the current nano arena in order to explore and access the potential for enhanced function and performance. Thin films and coatings are now being developed and used to tailor the properties of the underlying matrix with respect to hydrophobicity, absorption, reflectivity, reactivity in applications that range from consumer products and electronics to energy efficiency and biomedical applications. Materials Day 2007 will explore a number of these themes with presentations by MIT faculty as well as our annual graduate student poster session.

Materials Processing Center
Massachusetts Institute of Technology
77 Massachusetts Avenue
Room 12-007
Cambridge, MA 02139
http://mpc-web.mit.edu/

Materials Day Agenda
October 16, 2007

Kresge Auditorium (W16)

Thin Films and Coatings: Designed and Processed to Enhance Function and Performance

8:00 am Registration

8:50 am Welcome

Professor Lionel C. Kimerling
Director, Materials Processing Center
MIT, Department of Materials Science & Engineering

Session I: Consumer Products

9:00 am **Surface Engineering Using Layer-by-Layer Assembly of Polymers and Nanoparticles**

Professor Robert E. Cohen
St. Laurent Professor
MIT, Department of Chemical Engineering

Daeyeon Lee, Ph.D.
School of Engineering and Applied Sciences
Harvard University

9:40 am **Optical Thin Films for Eyewear Applications**

Richard Bosmans, Ph.D.
Scientific Director Materials
Essilor International R&D

10:20 am Break

Session II: Information Technology

10:40 am **Magnetic Multilayer Thin Film Rings for Magnetoelectronic Devices**

Professor Caroline A. Ross
MIT, Department of Materials Science & Engineering

11:20 am **Heat Assisted Magnetic Recording**

Xiaobin Zhu, Ph.D.
Seagate

12:00 pm Lunch
Student Center, 3rd floor, Twenty Chimneys (Bldg. W20)

Session III: Medical Materials

1:30 pm **Supra-molecular Nano-Materials and Lithography**

Professor Francesco Stellacci
MIT, Department of Materials Science & Engineering

2:10 pm **MAD (Multi-Agent Delivery) Nanolayers - New Approaches to Thin Film Drug Delivery**

Professor Paula T. Hammond
Bayer Chair Professor of Chemical Engineering
MIT, Department of Chemical Engineering

2:50 pm **Medical Applications of Thin Films in Devices and Drug Delivery**

George Papandreou, Ph.D.
Research Fellow,
Cordis Corporation

3:30 pm Wrap-up

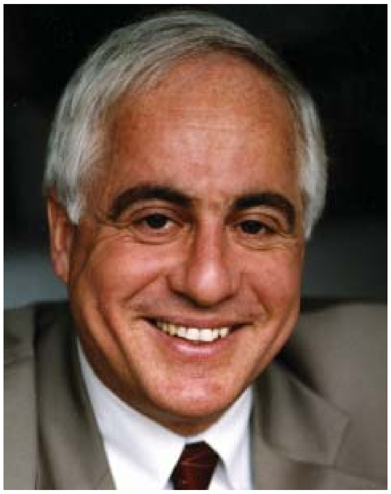
Materials Research Review Poster Session

3:45 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 Robert E. Cohen

St. Laurent Professor
MIT, Department of Chemical Engineering

Surface Engineering Using Layer-by-Layer Assembly of Polymers and Nanoparticles

Abstract

An electrostatic layer-by-layer deposition scheme has been used successfully to produce conformal ultra thin films on a variety of three-dimensional objects, including colloidal particles, membrane pores and nanofluidic channels as well as on conventional flat substrates. Various charged macromolecules and/or nanoparticles have been employed; in some cases suitable post-treatment of the films provides enhanced functionality. There is potential for applications of these films in areas such as structural color, antireflection, self-decontamination, antifogging, non-wetting and water gathering.

Biography

Bob Cohen was born and raised in Oil City, Pennsylvania, an environment that led to an early interest in the discipline of Chemical Engineering. He studied at Cornell University (BS), Caltech (MS and PhD) and Oxford University (Postdoc) prior to joining the MIT faculty in 1973. He has served as the founding Director of MIT's Program in Polymer Science and Technology (1984-1987) and as Associate Chair of the MIT Faculty (1989-1991) and Chair of the MIT Committee on Nominations. He is the architect of MIT's unique Doctoral Program in Chemical Engineering Practice, and he chaired that program's steering committee from its official launch in 1999 until 2004. He also chaired the Chemical Engineering department's committee on graduate studies from 1992 through 2001. Bob currently holds the endowed St. Laurent Professorship in the Chemical Engineering department, and he directs the DuPont/MIT Alliance.

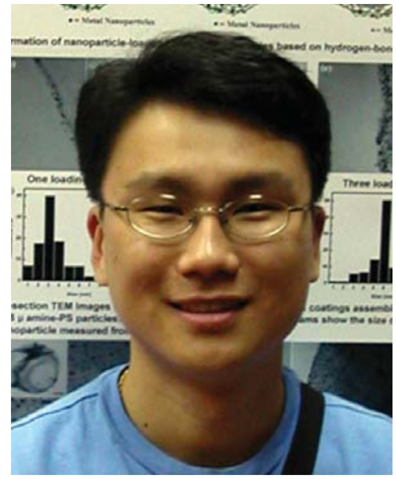
His 275 publications and 18 patents reflect interests in polymer structure/property relations. Students from his research group have developed successful careers in a variety of professional settings. Ten of the sixty-five doctoral students who have studied under his direction hold academic positions in major universities in the USA. Based on a set of patents produced in his laboratory, he co-founded MatTek Corporation (http://www.mattek.com) in 1985.

During leaves from MIT, Bob has enjoyed resident visitor status at the following institutions: Sandia National Laboratories, Istituto Guido Donegani in Novara, Italy, Harvard University Department of Chemistry, and at Balliol College, Oxford. Bob maintains strong ties to the worldwide polymer industry through long-standing consulting relationships and sponsored research in his laboratory, and he has collaborative relationships with academic researchers in England, Poland and Italy.

The Cohen Laboratory in the Chemical Engineering Department at MIT has key competencies in polymer synthesis, molecular characterization and physical property measurements. An unusual array of meso-scale (ca.5 gram batch) melt processing equipment enables his group to produce test specimens for mechanical and other macroscopic characterization experiments, complementary to the robotic dipping and spin coating devices that enable formation of a variety of ultra-thin film constructs.

Bob and his wife Jane (ESL educator) live in the Jamaica Plain neighborhood of the city of Boston. They have two children, Genevieve age 27 (Duke University, BS, and Tufts University, MS) and Eliot age 20 (An undergraduate at Northeastern University).

Daeyeon Lee, Ph.D.
School of Engineering and Applied Sciences, Harvard University

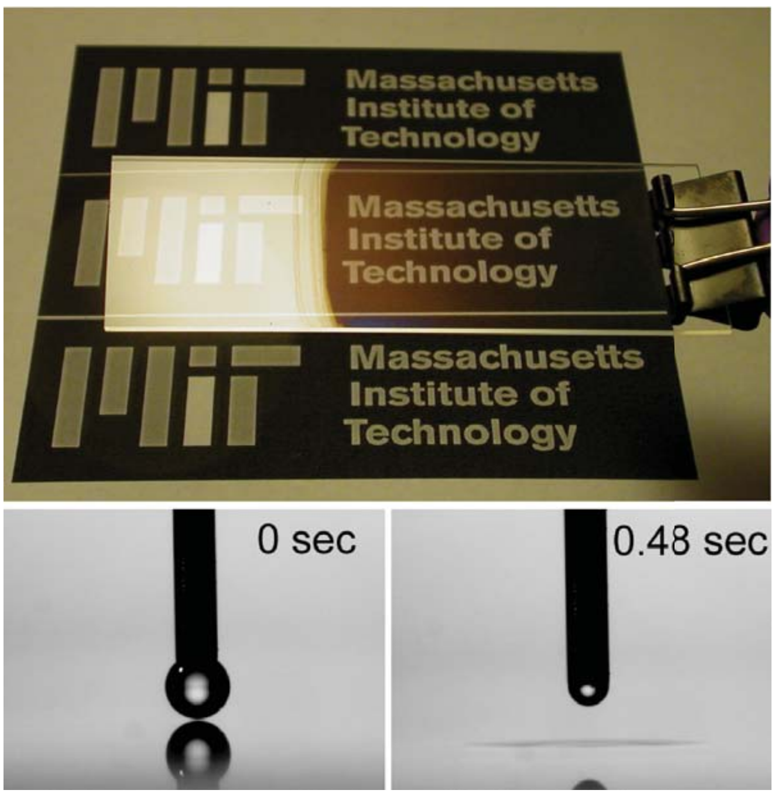


Biography

Daeyeon Lee received his B.S. in Chemical Engineering, from Seoul National University in 2001. In 2007 he received his Ph.D. in Chemical Engineering at MIT. Currently he is a postdoctoral fellow in the School of Engineering and Applied Sciences at Harvard University.

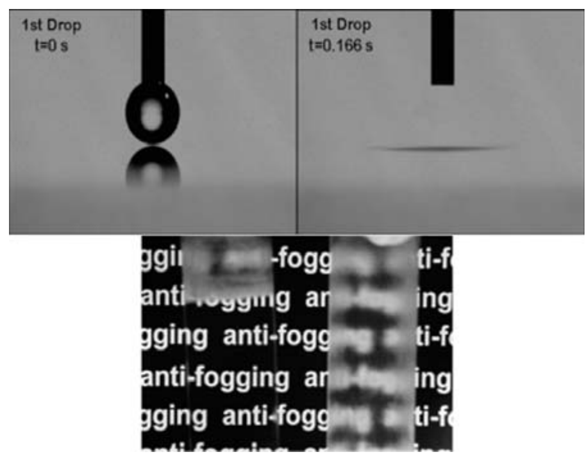
Dr. Lee will join the Department of Chemical and Biomolecular Engineering at the University of Pennsylvania in 2009.

Antireflection



Glass slide was half coated with anti-reflection coating. The coating also exhibits superhydrophilic properties as shown on the bottom images.
Lee, D.; Cohen, R. E.; Rubner, M.F.Nano Letters 2007, 7(5), 1444

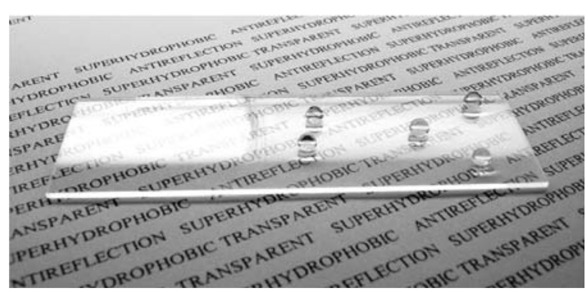
Anti-fogging



Cebeci, F. C.; Wu Z.; Zhai, L.; Cohen, R. E.; Rubner, M. F.Langmuir 2006, 22, 2856-2862

Superhydrophobic

Bravo, J.; Zhai, L.; Wu, Z.; Cohen, R. E.; Rubner, M. F. Langmuir 2007, 23, 7293-7298



Richard Bosmans, Ph.D.

Scientific Director Materials,
Essilor International R&D

Optical Thin Films for Eyewear Applications

Abstract

The central function of ophthalmic lenses is to provide a good quality of vision relying on high precision optical surfaces and sophisticated materials. Modern spectacle lenses are consumer products designed through fast growing complexity in the recent years. In order to serve a large variety of visual needs, a key challenge is to combine strong product customization along with mass production. The progressive replacement of mineral lenses by specialized optical polymers has paved the way to the addition of multifunctional coatings in order to improve wearers comfort as well as spectacle aesthetics.

We will explain what kind of complex coating system has been able to combine different features like light absorption, variable optical transmission, scratch resistance, impact resistance, antireflective and easy-to-clean lens surfaces, etc.. Optical thin films and vacuum surface processing play today a major role to achieve some of these functions along with nanotechnology.

The optimization of many different materials properties is necessary in regard to the composite and multilayer lens structure. In addition to the tight control of optical and cosmetic performance, more and more emphasis is being placed on mechanical and physicochemical properties of layers.

Finally, as a conclusion we will comment on current challenges and future opportunities of ophthalmic coatings.

Biography

Dr. Richard Bosmans is the Scientific Director Materials of Essilor International, Paris, a leading ophthalmic company. He has 20 years of R&D industrial experience, mainly in the field of surface coatings and thin films processes.

He started in 1986 with automotive equipment supplier Valeo, Paris, first in the Central Research Direction then in the R&D department of the Lighting Division, where he developed several surface treatments for plastic components like car headlamps.

In 1991, he joined Essilor International to set up a new research activity in optical thin films. He later held various management positions in the R&D Materials department which has been responsible for developing a large number of coated lens products and new surface technologies applicable to polymeric lenses. This led him to manage several teams of chemists, physicists and material scientists in France and USA, devoted to the design and development of multifunctional optical coatings.

He graduated from the Institut National des Sciences Appliquées in France and received a Ph.D. in Solid State Physics from Caen University.

Professor Caroline A. Ross

MIT, Department of Materials Science & Engineering,

Magnetic Multilayer Thin Film Rings for Magnetoelectronic Devices

Abstract

Patterned magnetic nanostructures are interesting, both as model structures for the study of the fundamentals of magnetic behavior, and for applications in data storage. Rings are particularly interesting because they can adopt a variety of stable and metastable magnetic states characterized by different numbers of domain walls. In this seminar we will describe the behavior of thin film magnetic rings with micron and submicron diameters made from single layer magnetic films, multilayer films and exchange biased stacks. We will show how the direction of circulation of the magnetization around the ring can be controlled, how the rings can be electrically contacted to show magnetoresistance values exceeding 100%; and we will describe how these structures may be used in multi-bit memory cells and logic devices.

Biography

Caroline Ross is Professor of Materials Science and Engineering at Massachusetts Institute of Technology. She joined MIT in 1997, after spending six years in research and development at Komag, a hard disk manufacturer in San Jose, California. Her background includes a BA and PhD (1988) in Materials Science from Cambridge University, UK, and a postdoctoral fellowship at Harvard University. Her areas of research are focussed on magnetic materials, especially for data storage applications in hard disks and patterned media; magnetic random access memories; materials for magnetooptical applications; magnetic and electronic devices; thin film technology and film growth, especially by sputtering, evaporation, electrodeposition and pulsed laser deposition, and templated self-assembly processes such as the formation of ordered structures in block copolymers.

Xiaobin Zhu, Ph.D.

Seagate

Heat Assisted Magnetic Recording

Abstract

The tremendous increase in magnetic areal density has been largely responsible for the proliferation of hard disk drive recording into new applications and markets. The superparamagnetic limit imposes a signal-to-noise ratio, thermal stability, and writability tradeoff that limits the ability to continue to scale traditional magnetic recording technology to higher storage densities. Heat Assisted Magnetic Recording (HAMR) offers a new degree of freedom with elevated writing temperature that holds the promise of extending the areal density of magnetic data storage. By temporarily heating the media during the recording process, the media coercivity can be lowered below the available applied magnetic write field, allowing higher media anisotropy and therefore smaller thermally stable grains. The heated region is then rapidly cooled in the presence of the applied head field where transition is recorded. In this talk, I will present recent updates of HAMR.

Biography

Dr. Xiaobin Zhu is a research staff member at Media group in Seagate Technology, Pittsburgh. He received his BS degree in Physics from Nanjing University, China in 1994, and the PhD degree in Physics from McGill University in 2002. Before joining Seagate Technology, he worked in the University of Alberta as a postdoctoral fellow. He has co-authored over 30 refereed papers in the area of magnetism, scanning probe microscopy and ultrafast microscopy. Dr. Zhu's research is focused on ultrafast magnetic imaging and high resolution magnetic imaging. In addition he studies heat-assisted magnetic recording and bit patterned media in Seagate.

Professor Francesco Stellacci

MIT, Department of Materials Science & Engineering,

Supramolecular Nano-Materials and Lithography

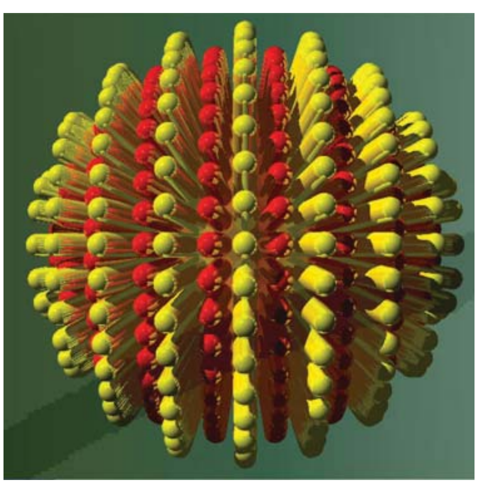
Abstract

It is known that specific molecules can spontaneously arrange on various surfaces forming two-dimensional poly-crystalline self-assembled monolayers (SAMs). SAMs composed of more than one type of molecule (mixed-SAMs) are used to simultaneously impart multiple properties. Scanning tunneling microscopy studies have shown that, in mixed SAMs, molecules phase-separate in domains of random shape and size.

It will be shown that mixed SAMs formed on nanoparticle surfaces spontaneously phase-separate into ribbon-like domains (called 'ripples') whose width is comparable to the size of a small molecule. The reasons that lead to this fine nano-structuring will be presented. Rippled nanoparticles show new properties solely due to their unique surface morphology. For example, the particles' solubility (defined as the saturation concentration) depends critically on the ratio between the dimensions of the phases and that of the solvent molecules. More in general we will show that the whole surface energy landscape depends on the size of the ripples. Unexpected consequences on cell/nanoparticles interactions will be presented.

Biography

Francesco Stellacci graduated from the Politecnico di Milano in 1998 with a thesis on Photochromic Materials. He then moved to the University of Arizona as a post-doctoral scholar and worked on two-photon microfabrication of three dimensional metallic structures. In September 2002 he became a faculty in the Department of Materials Science & Engineering at MIT, where he is now an Associate Professor.



Phase Separation in the Ligand Shell of Nanomaterials

Professor Paula T. Hammond

Bayer Chair Professor of Chemical Engineering
MIT, Department of Chemical Engineering

MAD (Multi-Agent Delivery) Nanolayers - New Approaches to Thin Film Drug Delivery

Abstract

The ability to develop multifunctional release coatings, and to tune the release profiles of drugs on a near continuous level provides a disruptive technology that can create numerous pathways to new medical applications, ranging from stents and medical sutures to hip and bone implants. We have recently demonstrated the construction of multilayers for which one of the polyions is a degradable polycation; in such systems, once the film is constructed, it undergoes hydrolytic degradation at biological conditions to release the corresponding polyanionic species originally bound in the LBL film. Depending on the nature of the anionic macromolecular drug system to be delivered, interdiffusion and its impact on the film composition can impact delivery behavior, yielding complex but tunable delivery behavior. The tuning of the release profile to obtain the simultaneous or timed sequential release of two separate model drugs at different times will be addressed, as well as the extended delivery of biologic drugs. New explorations include the use of unique redox active nanoscale systems as systematically deconstructible polymers in multilayers with potential uses as an electrochemical means of drug delivery. New methods of obtaining controlled release in response to electrochemical stimuli from thin films will also be addressed.

Biography

In 1994 Dr. Hammond was awarded the NSF Postdoctoral Fellowship in Chemistry while performing postdoctoral research in the Harvard University Chemistry Dept as a member of the Whitesides research group. In 2000, Professor Hammond was awarded the Junior Bose Faculty Award, and the GenCorp Signature University Award. She has also received the NSF Career Award, the EPA Early Career Award, the DuPont Young Faculty Award, and the 3M Innovation Fund Award. Dr. Hammond was one of a group of key faculty members involved in the planning and writing of the proposal for the Institute for Soldier Nanotechnologies (ISN) at MIT.

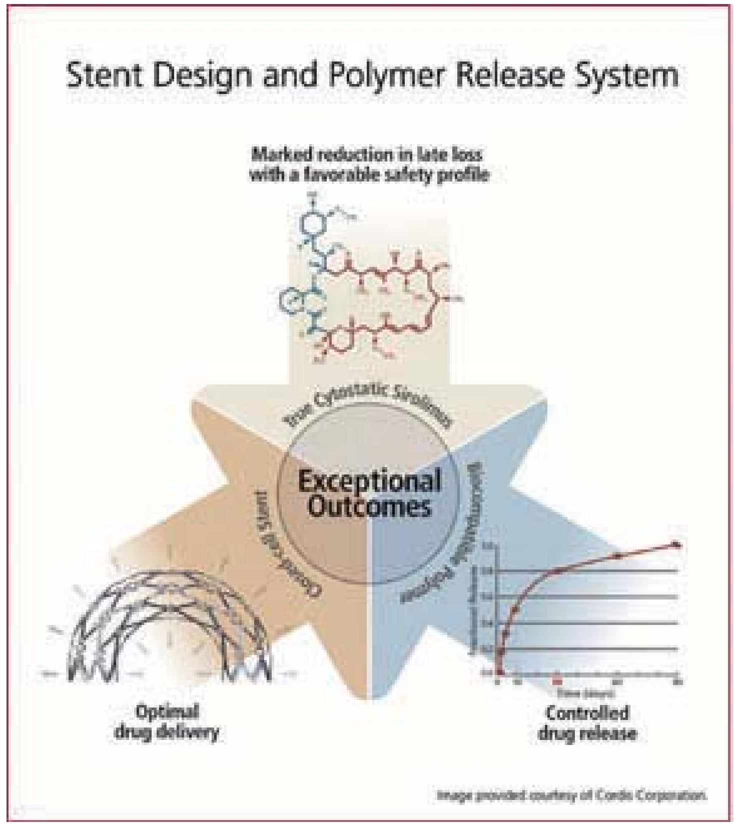
George Papandreou, Ph.D.

Research Fellow,
Cordis Corporation

Medical Applications of Thin Films in Devices and Drug Delivery

Abstract

To improve the biological performance of stents, thin films that contain polymers and drugs have been applied on the surface of these medical devices. Since its introduction in the market in 2002, the CYPHER® Sirolimus-eluting Coronary Stent has made the difference in the treatment of coronary artery disease for millions of patients worldwide. Highlights from the development of this medical device will be presented. The development of the next generation of drug-device combination products requires an in-depth understanding of the microscopic properties of such systems. Analytical methods adapted from the micro- and nano- worlds are currently used to characterize these devices, such as confocal Raman microscopy and atomic force microscopy. The information generated is used to guide the manufacture of the device. Examples of how these analytical methods can be used to enhance the function and performance of a drug-eluting stent will be discussed.



Biography

George Papandreou is a Research Fellow at Cordis, a Johnson and Johnson company. He has worked on various formulations for local drug delivery. Since the invention of drug-eluting stents, he worked on the development of the first successful commercial product of its kind, the CYPHER® Sirolimus-eluting Coronary Stent. He currently manages a formulation group engaged in the development and characterization of novel convergent technology products. He received a Ph.D. in organic chemistry from Cornell University in 1993, and previously worked as a medicinal chemist at Ciba, in Basel, Switzerland.

Materials Resources:

Materials@MIT is a portal website to all materials activities at MIT.
http://materials.mit.edu

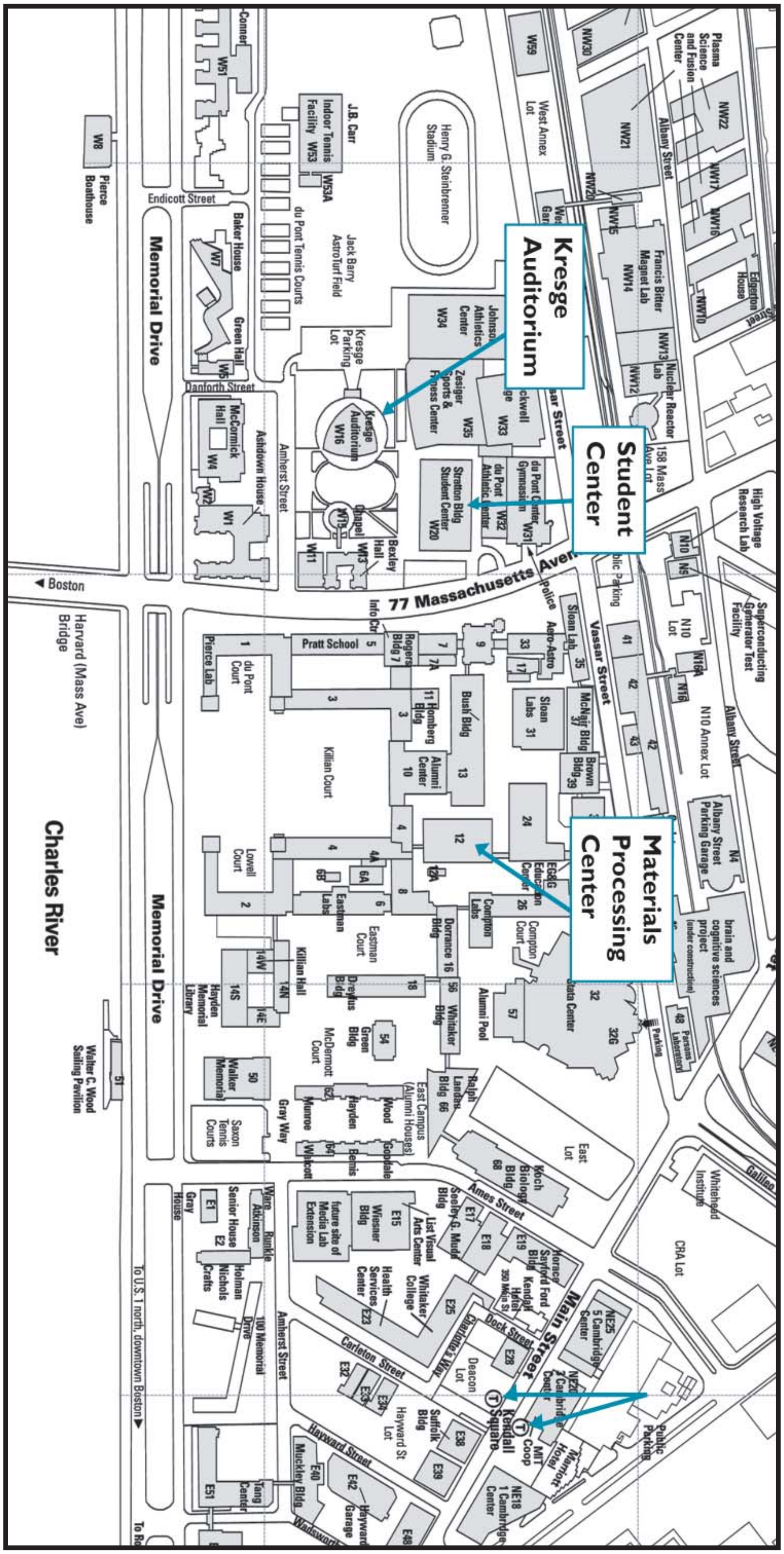
Materials Processing Center facilitates collaborative opportunities between Industry and Research Faculty.
http://mpc-web.mit.edu

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://mphotonics.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/

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://web.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/about/index.html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