2013 Research and Development Conference

Day 1  Wednesday, November 13 | MIT Campus

8:00  Registration & Continental Breakfast

8:55  Welcome & Introduction  Karl F. Koster

9:00  Is Corporate R&D the Victim or Master of Doubletalk?  Howard Anderson

The corporate gospel has been that sustained high investment in research will lead to a boatload of insanely great products that will carry a company to a new level, driving growth in profits and staking out vibrant emerging markets. But it’s time to ask: does it really work? And if it does, why are so many prestigious and supposedly well-run companies continually blindsided? Is the answer that it’s not working well and perhaps just doesn’t work at all any more. Corporations need to take a closer look at their devotion to internal research.

9:45  The Process of Innovation  Eugene A. Fitzgerald

Despite all the data to the contrary, many still cling to a linear model of innovation, starting with inspiration and marching inexorably towards profit. Experience reveals a very different model of innovation, an iterative process that challenges individuals and organizations alike and capitalizes equally on success and failure. Examining cases from AT&T Bell Labs, MIT, and the start up community provides lessons for would-be innovators across industries seeking to move beyond models and have impact in the real world.

10:30  Break

11:00  Gordon-MIT Engineering Leadership Program  Joel Schindall

The Bernard M. Gordon-MIT Engineering Leadership Program fosters new approaches that prepare the nation’s young engineering leaders for productive and effective careers in engineering companies. To develop the potential leaders of engineering innovation, invention, and implementation, the program works both with students enrolled at MIT and beyond the Institute with industry. The program is committed to ensuring that MIT continues to lead the nation in graduating effective engineering leaders.

11:15  From Research to Economic Impact: A perspective on accelerating the commercial impact of research based innovations  Yoel Fink

MIT’s RLE investigators have pioneered disruptive technologies derived from basic research: Acoustic noise cancellation, Optical Coherence Tomography, HDTV, precision surgical scalpels and more. The question I will attempt to answer is whether one can accelerate the pace of transfer of innovative research ideas into products. I will share my perspective as a materials scientist, laboratory director and entrepreneur, and apply case studies in the commercialization of research innovation. RLE’s approach and initiatives aimed at addressing this opportunity will be presented.

12:00  Lunch and Startup Exhibition - MIT Media Lab, E14, 6th Floor
Sustainable Materials Chemistry and Processing  
Antoine Allanore

The demand for materials, particularly minerals and metals, has experienced an exceptional growth in the last decades. In parallel, the capital and environmental costs of the corresponding technologies have reached levels that are increasing the financial risks of such metals and mining projects. In this context, our research aims at understanding the limitations of existing processes, for example in metal extraction or fertilizer processing, in order to provide innovations such as the use of unconventional resources or a new water-free metal production process with low capital footprint. Our approach proves to lead to renewed scientific insight into fundamental materials questions such as the oxidation of metals and alloys, the physical properties of liquid compounds or the mechano-activation of minerals.

Laboratory for Material Chemomechanics  
Krystyn J. Van Vliet

Data-driven Diagnosis and Management of Criticality Risk within the Firm  
Randall Kirchain & Elsa Olivetti

Uncertain availability and large price fluctuations of critical materials can inhibit the large-scale deployment of technologies that are capable of transforming materials use. Typically criticality analysis is ad hoc in nature, does not examine the role of market dynamics or analyze the efficacy of technological or market-based mitigation strategies particularly relative to the risk of dynamic, short-term criticality events. This talk will describe research to screen for criticality and model how technological and market changes affect criticality, including context-dependent evaluation of risk-mitigation strategies around materials substitution.

Alexie M Kolpak

Computational materials design approaches have the potential to play a key role in the discovery, design, and development of novel materials with few or no critical elemental components. For many applications in the energy space (i.e., solar cells, fuel cells, water splitting catalysts, etc.), successful design of such materials requires the development of (a) a fundamental understanding of the strengths and weaknesses of current critical materials-based systems and (b) processes-structure-function relationships that can be used to guide ration design of critical materials-free systems with equivalent or enhanced behavior. In turn, achieving these goals requires the ability to predict the atomic and electronic structure and properties of realistic surfaces and interfaces under operation conditions -- a prospect that often exceeds current capabilities for all but the most simple systems, or those that have already been very well-characterized experimentally. In this talk, I will discuss recent work in my group aimed at developing new methods to enable highly accurate modeling of complex surfaces and interfaces, and I will present results illustrating efforts to design a variety of critical element-free materials for CO2 capture and conversion, photocatalytic fuel generation, and photovoltaics.
AGENDA

TRACK 2: SOLAR POWER
Room 407

2:00  **Beyond Conventional Solar Cells - Technology that Enables High-Value Energy Applications**  
*Vladimir Bulovic*

A set of new solar cell technologies, all recently demonstrated at M.I.T., are particularly amenable to ubiquitous solar deployment that goes beyond the reach of conventional silicon and thin film technologies: transparent solar cells for integration with glass surfaces, paper-thin solar cells for rapid, large-area deployment of rugged, lightweight cells, and three-dimensional solar cells for modular deployment over minimal installation areas. These new technologies are playing an important emerging role in capturing our most abundant energy source.

2:45  **Status of PV Technologies**  
*Tonio Buonassisi*

3:30  Break

4:00  **New Materials for Solar Photovoltaics**  
*Jeffrey Grossman*

4:45  **Nanostructured Flexible Solar Cells**  
*Silvija Gradecak*

Emerging photovoltaic (PV) devices based on solution-processable nanostructured materials offer opportunities for the production of low-cost solar cells. However, current limitation of the nanostructured PV devices is inefficient hopping charge transport through discontinuous percolation pathways, and therefore modest power conversion efficiencies. We have developed nanowire solar cells that are based on organic/inorganic hybrid device structures with enhanced efficiencies. Furthermore, we have developed a simple method to grow high-quality ZnO nanowires on graphene via a solution-based method that enables development of flexible solar cells. Several critical parameters to further boost the device efficiency and enable scalable, cost-efficient production will be discussed.

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TRACK 3: BRAIN, MINDS AND MACHINES
Mezzanine

2:00  **Optimization-Based Control Design and Verification for Nonlinear Systems: Enbline Humanoid Robots to Compete in DARPA's Biggest Robot Competition Ever**  
*Russ Tedrake*

The robots are coming. Major recent investments by the U.S. government in advanced robotics research have enabled new hardware and new algorithms that could have a dramatic impact in industry. Just last year DARPA announced the largest robotics program in its history, the DARPA Robotics Challenge, which challenges teams to enable a humanoid robot to walk over rough terrain, manipulate debris and tools, and even climb into a utility vehicle and drive around obstacles; this is the sequel to the 2007 DARPA Urban challenge which paved the way for autonomous vehicle programs at Google and all of the major automakers. In this talk, I’ll give some highlights of the technical advances in planning and feedback control design that are enabling our humanoid and many other advanced robots including robots that can run like an ostrich (at > 30 mph), fly like a bird, and even land on a perch.

2:45  **Commonsense Reasoning for Interactive Applications**  
*Henry Lieberman*

Things fall down, not up. You eat breakfast in the morning. If people yell at you, they're probably angry. One of the reasons that computers seem dumber than humans is that they don't have common sense - a myriad of simple facts about everyday life and the ability to make use of that knowledge easily when appropriate. Cell phones should know enough not to ring during the
concert. Cameras should realize that if you took a group of pictures within a span of two hours, they are probably all of the same event.

A long-standing dream of artificial intelligence has been to put that kind of knowledge into computers. It is a hard problem, but considerable progress has been made. We have collected a large commonsense knowledge base and have special techniques for reasoning with this kind of knowledge. Crucial is to understand the design problems in human interaction that AI can help with. Commonsense can provide intelligent defaults in interfaces, sanity checks, fail-soft designs that don’t cause catastrophic errors, and debugging help when things go wrong. We may have gotten too used to putting common sense in that category of “impossible” problems and overlooked opportunities to actually put this kind of knowledge to work. We need to explore new interface designs that don’t require complete solutions to the common sense problem, but can make good use of partial knowledge and human-computer collaboration.

3:30 Break

3:45 The Center for Brains, Minds and Machines  Tomaso Poggio

The dream of understanding the mind and the brain was at the core of several new fields created at MIT during the ‘50s and ‘60s. Information theory and cybernetics arose from the research of Shannon, Wiener, McCulloch, Pitts, Lettvin. Generative linguistics was launched by Noam Chomsky. Artificial Intelligence by Marvin Minsky, Seymour Papert and John McCarthy. David Marr was a pioneer in building the foundations of computational neuroscience and cognitive sciences. The same dream is now the main motivation for a new Center for Brains, Minds and Machines. I will describe our vision of interdisciplinary research bridging disciplines such as computer science, neuroscience and cognitive science on the topic of intelligence – the greatest problems in science and engineering and a key to our future as a society.

4:00 How Blind Children in India are Helping Us Understand How We Learn to See  Pawan Shina

The hope inherent in pursuing basic research is that sometime in the future the work will prove beneficial to society. This fruition can often take many years. However, in some instances, even the conduct of basic research can yield tangible societal benefits. I shall describe an effort that perhaps fits in this category. Named ‘Project Prakash’, this initiative provides sight to blind children on the one hand and helps address questions regarding brain plasticity and learning on the other. Through a combination of behavioral and brain-imaging studies, the effort has provided evidence of visual learning late in childhood and has illuminated some of the processes that might underlie such learning.

4:45 What Makes Human Intelligence Different  Patrick Winston

There are many kinds of intelligence and some kinds are impressively exhibited by systems such as Siri and Watson. But there are many other kinds of intelligence that separate human intelligence not only from the intelligence Siri and Watson but also from the intelligence of all other species, past and present. What are those other kinds of intelligence? Perhaps our most important ability is our ability to understand, compose, and tell stories. If we can model that ability, we will be able to take all sorts of applications to another level.
2:00  Clean Water Technology Research at MIT  John Lienhard

Water supply is a growing challenge worldwide. Water scarcity affects both the developed and the developing world, and it affects regions that are considered dry as well as regions that are not. Research on water at MIT touches all aspects of water supply. This talk will discuss basic concepts of water supply and methods of purification, with a focus on desalination technology. Novel research at MIT in desalination and water supply will be described. This will include research related to membrane technologies, thermal and solar technologies, water distribution, wetlands, and challenges specific to the developing world. Issues related to the water-energy nexus will also be considered.

2:45  Water and Food Security  Dennis McLaughlin

Water and food security are closely related, especially in developing countries where subsistence agriculture plays an important role. There is considerable controversy in the scientific and policy literature about the nature of current and future water shortages and their possible impacts on food production. This talk identifies critical issues to be resolved and discusses some promising analytical methods, using a recent study of Chinese water and agricultural production as an example.

3:30  Break

4:00  The Water-Energy-Food Nexus  Dara Entekhabi

The production of food today is intensive in both water use and energy consumption. The dramatic increase in food production efficiency that followed the Green Revolution is now beginning to reach limits imposed by regional water availability, energy prices, degradation of soils and air quality among other factors. In this presentation the prospectus for continued food production efficiency and production at scales to meet growing demand in volume and in type will be outlined.

4:45  Real Time Monitoring and the Development of a Smart Water Grid  Andrew Whittle

The development of a wireless sensor network that provides real-time monitoring of water distribution systems enables reliable predictions of water demand and provides automated detection and localization for a range of hydraulic anomalies, from bursts to leaks. On-going research aims to develop similar alerts for anomalies in water quality using the same platform and is focused increasingly on energy efficiency for pumping and storage within the system. Recent commercialization of the technology is enabling deployment at city-scale.

5:30  Networking Reception in the Kresge Lobby
AGENDA

2013 Research and Development Conference

Day 2 Thursday, November 14 | MIT Campus

7:30 Registration and Continental Breakfast

8:00 Welcome & Introduction Karl F. Koster

8:05 MIT’s Production in the Innovation Economy Martin Schmidt

MIT has just concluded a two year study that seeks to understand how production capabilities link to the innovation process. Through extensive interviews, surveys, and analysis, the Production in the innovation Economy (PIE) work provides clear and compelling evidence for the critical importance of a production ecosystem in the effective movement of ideas to real impact. This talk will summarize the findings of PIE, and place them in the broader context of regional and federal efforts to strengthen domestic production.

8:45 How to Learn from Biology: a New Generation of Legged Robots for Disaster Response Sangbae Kim

In designing a new generation of legged robots capable of navigating hazardous environments, it is critical to understand the design principles employed by animals. The talk will introduce several examples that successfully implement bio-inspired design principles learned from animals. Our highlighting example is the development of the MIT Cheetah, currently running at 13.5mph with a locomotion efficiency rivaling animals. We seek to derive design principles from biomechanics in order to develop most efficient, robust robots, which will be a vital part of disaster response in the future.

9:15 Lessons from MEDRC Brian Anthony

The vision of MEDRC (Medical Electronic Device Realization Center) is to transform the medical electronic device industries: to revolutionize medical diagnostics and treatments, bringing health care directly to the individual; and to create enabling technology for the future information-driven healthcare system. Specific areas that show promise are wearable or minimally invasive monitoring devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers. MEDRC establishes partnerships among the microelectronics industry, the medical devices industry, medical professionals, and MIT to collaboratively achieve improvements in the cost and performance of medical electronic devices similar to those that have occurred in personal computers, communication devices and consumer electronics. The successful realization of such a vision also demands innovations in the usability and productivity of medical devices, and new technologies and approaches to manufacture devices. We will explore examples in ultrasound imaging and ambulatory physiological monitoring.

9:45 Break
Concurrent Technology Tracks

TRACK 5: MANUFACTURING
Twenty Chimneys

10:00  **Self-Assembly & Programmable Materials**  *Skyler Tibbits*
The making of our human-scale world is outdated, energy intensive, error-prone and inefficient. From the laborious mass-customization of the maker-movement to consumer product assembly lines, the construction industry and outdated infrastructural systems, an opportunity has emerged to revolutionize the assembly of our physical world. As demonstrated across recent developments in nanotechnology, synthetic biology and the biomedical industry, the phenomena of self-assembly and programmable matter similarly offer a radical solution at much larger scales. Self-assembly is a scale-independent technology that allows components to come together on their own and transform shape or property for highly efficient and programmably adaptive systems. The combination of additive manufacturing and programmable materials, or 4D Printing, offers one technological solution for the smart assembly of our future world.

10:45  **3D Printing of “Artificial Bone” Composite Material**  *Markus Buehler*

11:30  **Break**

11:45  **TBA**  *Neil Gershenfeld*

12:30  **Principles and Processes for Scalable Nanomanufacturing**  *A. John Hart*
Nanostructured materials offer incredible potential to enhance and enable critical technologies, including energy storage systems, composite structures, medical devices, and next-generation electronics. Realization of these and further unimagined possibilities will hinge on the design of innovative manufacturing processes, along with novel machines and metrology tools to populate the factory floor. I will share my perspective on the research and technology principles needed to enable truly scalable nanomanufacturing. As case studies from recent work by my group, I will describe a novel roll-to-roll CVD reactor for high-speed growth of 2D materials such as graphene, and self-assembly of carbon nanotubes into 3D microstructures.

TRACK 6: SAFETY AND RISK
Room 407

10:00  **Flexibility in Engineering Design**  *Richard de Neufville*
Recent work demonstrates that we can frequently achieve up to 30% improvement in the expected value of investments in engineering projects, especially for the more risky, innovative, or long-term endeavors. We can achieve this by incorporating appropriate flexibility in the original design. Essentially, suitable systems engineering can create valuable “real options.” MIT work has developed practical analytic tools to quantify these benefits for multiple simultaneous options. Examples from major projects will illustrate the presentation.

10:45  **Port Resilience: Why, What and How**  *James Rice, Jr*
The US seaports play a central role enabling the US economy, yet these critical nodes in the supply chain are not yet resilient. Some of the vulnerabilities in maritime transportation have been revealed in recent disruptions including natural disasters (e.g. Hurricane Sandy), and industrial accidents (Gulf Deepwater Horizon oilspill). This presentation will identify some of the vulnerabilities in the Maritime Transportation System and an online application that may be useful for cargo reallocation in the event of a disruption.
11:45  **Using New Data to Evaluate Risk and Flexibility in Large-Scale Real Estate Development Projects**  *David Geltner*

The digital revolution has enabled quantification of pricing and risk characteristics for real estate assets comparable to publicly-traded securities such as stocks, bonds, and commodities. Combined with advances in econometrics and computing, this has allowed the development of price indices and asset price analytics, some pioneered by the MIT Center for Real Estate working together with industry partners. Such quantification of risk and the characteristics of real estate returns enables a practical application of sophisticated option valuation theory and simulation modeling to the type of large-scale (typically multi-phase) real estate development projects that characterize much of the world’s urbanization this century.

12:30  **Overcoming Big Data Quality Challenges and the Emergence of the CDO**  *Stuart Madnick*

There are tremendous new opportunities arising from the use of “Big Data,” but merely having lots of data does not have much value if it is not of high quality. In this talk we will start with a brief definition of “Big Data” and some interesting examples of Big Data applications, such as ways to anticipate risks. Then we introduce the MIT Information Quality (MITIQ) research program, and finally discuss our development of the “CDO Cube” to help explain the rise of the Chief Data Officer (CDO) in many organizations.
stories about place we need to be conscious of the dualities that exist in data representation and strive for a practice that develops strategies for using “Big Data for a Public Good” or what I call Critical Data Visualization. I define, Critical Data Visualization as a set of alternative practices which explore how we can make the work we do with data and images richer, smarter, more relevant, and more responsive to the needs and interests of citizens traditionally on the margins of policy development. I will illustrate the possibilities of Critical Data Visualization by showing several projects in my research lab (Civic Data Design Lab). I will specifically discuss the collection and visualization of infrastructure data using cell phone in countries where these systems are part of the informal economy, how we can use social media data to contextualize planning processes, and using new data sources to visualize and expose governmental policies.

12:30 Universal Villages—What, Why, and How—and Sample Project: Improving Traffic Throughput  
Berthold Horn & Yajun Fang

Fast urbanization in world-wide brings serious challenges. To improve quality of life, new vision of future society, "Universal Village," is proposed at MIT as multi-functional multi-format sustainable communities and new life style incorporating the ideal mixture of city and suburban areas, and use need-based human-nature-oriented systematic top-down design approach. As an example, a novel method based on information flow both downstream and upstream in traffic is disclosed for suppressing the instabilities in traffic flow.

TRACK 8: MIT NANO-INNOVATION
Mezzanine

10:00 MIT’s NanoFab for Advancing the 21st Century Nano-Innovations  
Vladimir Bulovic

MIT’s newly envisioned integrated nanoscience and nanotechnology facility (NanoFab) is advanced with a mission to redefine the frontiers of research, exploration, education, and innovation. Dedicated exclusively to experimentation and instruction, the MIT NanoFab is designed as a central resource for creating disruptive technologies that could reimagine areas of personal medicine, energy systems, ubiquitous computing, multi-scale manufacturing, sustainable infrastructure, and quantum science and technology. The talk will offer sample views into recent MIT nanotechnology advances.

10:45 Electronic, Optical and Magnetic Materials Platforms for Neural Recording and Interrogation  
Polina Anikeeva

The mammalian nervous system is often compared to an electrical circuit, and its dynamics and function are governed by ionic currents across the membranes of neurons. Many neurological disorders are characterized by inhibited/amplified neural activity in a particular region of the nervous system (e.g. depression) or lack of communication between the two regions (e.g. paraplegia following spinal cord injury). Current approaches to treatment of these disorders are often based on drugs with undesirable side effects and limited terms of effectiveness or on bulky, mechanically invasive electronic devices. Consequently, there is a pressing need for biocompatible materials and devices allowing for precise minimally invasive manipulation and monitoring of neural activity.

The Bioelectronics Group is forging two complimentary materials approaches to neural stimulation and recording: (1) flexible polymer and hybrid optoelectronic devices for intimate neural interfaces; (2) magnetic nanomaterials for minimally invasive manipulation of neural activity. A fabrication process inspired by optical fiber production creates flexible multifunctional probes capable of optical, electronic and pharmacological interfaces with neural tissues in vivo. These fiber-inspired neural probes (FINPs) can be tailored to applications within a specific part of nervous system such as the brain or spinal cord.

11:30 Break
Nanoengineered Surfaces & Coatings for Efficiency Enhancements
Kripa Varanasi

Thermal-fluid-surface interactions are ubiquitous in multiple industries including Energy, Water, Agriculture, Transportation, Electronics Cooling, Buildings, etc. Over the years, these systems have been designed for increasingly higher efficiency using incremental engineering approaches that utilize system-level design trade-offs. These system-level approaches are, however, bound by the fundamental constraint of the nature of the thermal-fluid-surface interactions, where the largest inefficiencies occur. In this talk, we show how surface/interface morphology and chemistry can be engineered to fundamentally alter these interactions in a wide range of processes including condensation, boiling, drop dynamics, ice and clathrate hydrate mitigation, separation, catalysis, durable materials and nanomanufacturing. Applications of these nanoengineered surfaces for dramatic efficiency enhancements in various energy, water, and transportation systems including oil & gas (flow assurance and energy efficiency), aircraft, turbines, engines, power and desalination plants, and electronics cooling will be highlighted. Finally, novel lubricant surfaces that can efficiently dispense complex fluids like ketchup, mayonnaise, jelly, hairgels, etc will be presented. Commercialization efforts of this product under LiquiGlide coating will be discussed.

Atom-Thick Materials for the Next Electronics Revolution
Tomás Palacios

Electronics is at a crossroads. The materials and technologies that have enabled the information revolution of the last 60 years are quickly reaching their ultimate physical limit. Fortunately, a new generation of atom-thick materials has recently been discovered. This talk will review these new materials, all of them less than one nanometer thick, and the novel devices and applications enabled by their amazing properties.

Adjournment and Bagged Lunch