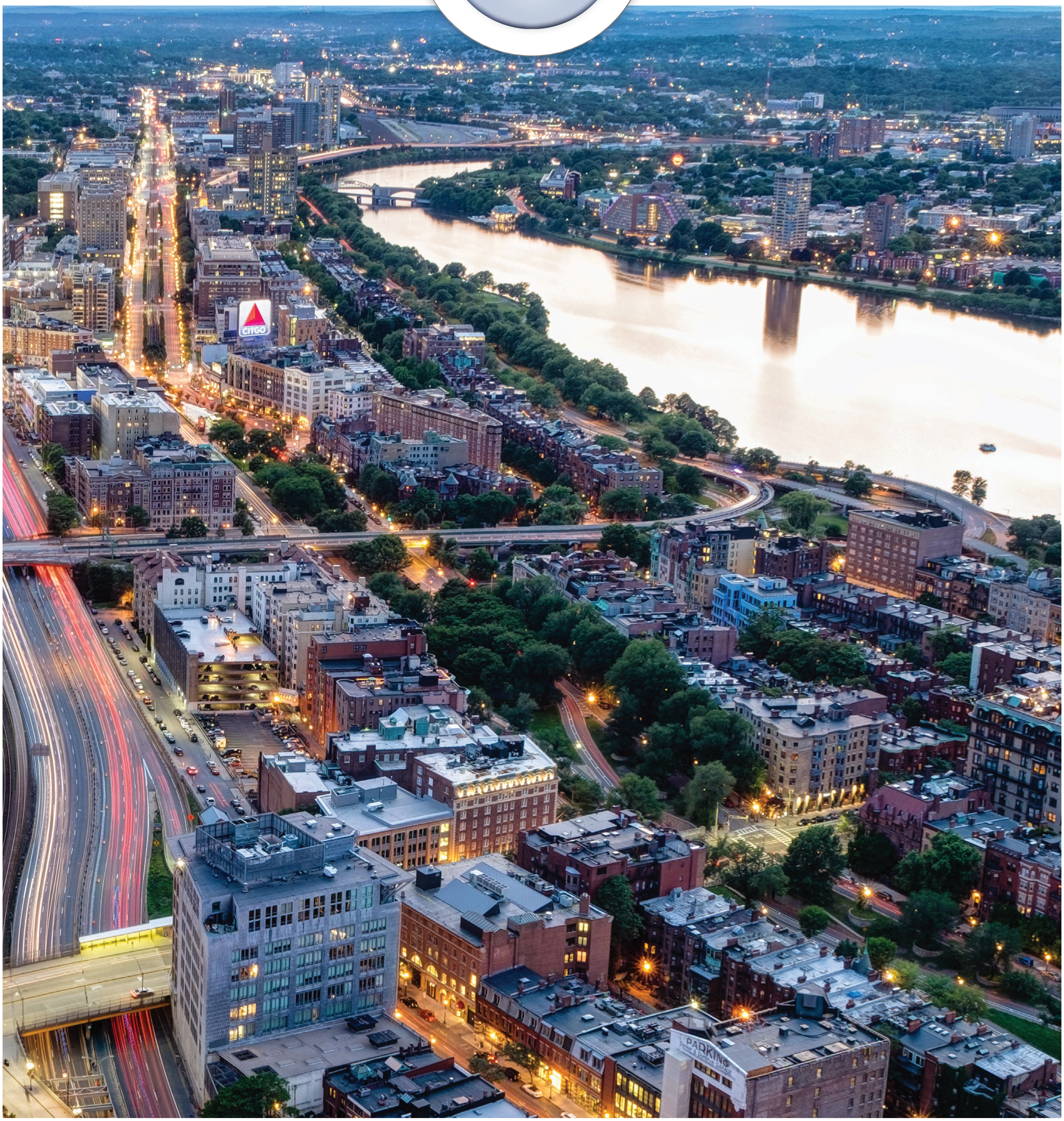
BU BOSTON UNIVERSITY DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE NEWS

2015/2016



SYNBIO P. 3

HACK-PROOF P. 5

A GREAT YEAR

Welcome to this year's overview of the Boston University Department of Electrical and Computer Engineering. It was an exhilarating year! The strong support and commitment of our administration allowed us to conduct five successful searches for important new faculty whose areas of expertise range from computational imaging to cyber-physical systems. Building on our campus-wide Data Science Initiative, we continued our expansion in data science with the addition of Brian Kulis last year and we plan to add even more faculty next year. ECE faculty continued to develop their impressive research portfolios, such as Prof. Doug Densmore's new $10 Million NSF award to apply computer engineering methods to synthetic biology. This work will be coupled to our new $170.5 Million, nine-story Center for Integrated Life Sciences and Engineering, on which construction started this year. Our academic program also continued to expand,with steady enrollment growth accompanied by the largest number of graduate degrees in our history. Overall, the BU ECE Department's sustained commitment to growth and excellence continues unabated, building on our strong foundation to create an even brighter future. Have a more detailed look at our programs, at our faculty, and at your opportunities in Electrical and Computer Engineering at BU. I hope we see you on campus!

W. Clem Karl
ECE Chairman & Professor

NEW FACES

BRIAN KULIS
Asst. Professor
Data Science
New faculty,'15

MICHEL KINSY
Asst. Professor
U. of Oregon
Hardware Security

WENCHAO LI
Asst. Professor
SRI International
Cyber Physical Systems

ALEX OLSHEVSKY
Asst. Professor
UIUC
Network Science

MILOŠ POPOVIĆ
Asst. Professor
UC at Boulder
Intergrated Photonics

LEI TIAN
Asst. Professor
UC Berkeley
Computational Imaging

CROSS-DISCIPLINARY RESEARCH AREAS

Use this key to see applications of cross-disciplinary research in ECE (pg. 4, 5 & 6).

- Electrical and Computer Bioengineering
- Mobile/Cloud Computing with Security
- Intelligent Computation and Data Science
- Imaging and Optical Science
- Photonics, Electronics, and Nanotechnology

SUCCESS

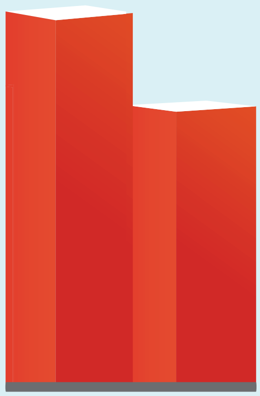
PROGRAM GROWTH

18% PROGRAM GROWTH RATE*

2016 Degrees Awarded:

- 149 Graduate degrees
- 104 Undergraduate degrees

22%
Growth in undergrad degrees awarded



14%
Growth in graduate degrees awarded

*Compound average growth rate over 5 years.

FUNDING GROWTH

10% FUNDING GROWTH RATE*

*Compound average growth rate over 10 years.

FACULTY FACTS

27 Average h-index
3.8K Average number of citations
9 Average number of publications per year

10% Female
7% Underrepresented Minority

3 National Academy Members
24 Society Fellows
15 NSF CAREER Award Winners
2 Former IEEE Society Presidents

COLLEGE QUICK FACTS

35

COE rank has risen **19** spots in **10** years to **35** according to USNWR.

TOP 10

USNWR ranks BU COE **#10** in research expenditures per faculty member.

$171 M

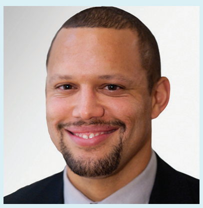
$170.5 million spent on new facilities.

Source: US News and World Reports (USNWR) & University Records.

SHAPING SYNBIO

RESEARCH AREA

RESEARCHERS:



Prof. Densmore

ADVANCING AN EMERGING DISCIPLINE AND ESTABLISHING AN INDUSTRY

ECE researchers would like to take the guesswork out of biological design and speed the development of synthetic biology in the process. Working under a new $10 million National Science Foundation "Expeditions in Computing" grant, Professors Densmore, Khalil, Wong and Bhatia will lead the Living Computing Project. This venture is a comprehensive effort to quantify synthetic biology, using a computing engineering approach to create a toolbox of carefully measured and catalogued biological parts that can be used to engineer organisms with predictable results. These parts will allow the entire field to understand better what computing principles can be applied repeatedly and reliably to synthetic biology. "This puts a stake in the ground to make synthetic biology more rigorous," Densmore said. "We want to build a foundation that's well understood, built to use software tools, and that can serve as an open-source starting place for many advanced applications."

Synthetic biologists take snippets of DNA and combine them in novel ways to produce defined behavioral characteristics in organisms. For instance, Densmore envisions a day when it is possible to engineer a cell that changes state when it detects cancer. The cell could be introduced into a patient, retrieved after a time, and read like the memory of a computer, allowing much earlier and less invasive detection of disease than is now possible. Engineering that cell will be far easier and faster if researchers have a detailed inventory of parts and the corresponding software tools they use to create it.

"What is power consumption in biology?" Densmore cites as an example. "What are the metrics in biology that make sense, can be repeated, and are reliable? You can't make decisions in engineering without metrics and quantifiable information." "Programming a flower to change color, a cell to repair damaged tissue, or a mosquito to defeat malaria is likely to require a different computational model than programming an app for your laptop," said Bhatia. "Discovering this new type of computational thinking in partnership with synthetic biologists is what I am most excited about."

By Michael G. Seele

NEW $170.5 M CENTER FOR INTERGRATED LIFE SCIENCES AND ENGINEERING

Boston University is launching the center to bring together forward-thinking researchers from the hottest fields in computer engineering and bioengineering. Scientists will combine genomic technologies like DNA sequencing and synthesis, 3-D printers and robots. They will tinker in pursuit of cutting-edge questions like these: How do you guide cells to regenerate and build new tissue– or reengineer the body's immune system to attack tumors so they disappear? *By Sara Rimer,* BU Research

FROM WIFI TO LIFI

RESEARCH AREA

RESEARCHERS


Prof. Little


Prof. Bishop


Prof. Ishwar


Prof. Konrad

LIGHTNING-FAST INDOOR DATA

When you use your smartphone or tablet for a Skype call or to search the internet at home or at a coffee shop, you usually rely on WiFi. When too many people want to watch their favorite shows at the same time, none of them, can get a steady streaming signal (the dreaded hourglass) since the bandwidth of each WiFi access point is quite narrow. Soon, however, all members of a family may be able to watch different shows on their mobile devices at the same time, each in 4K definition, without any difficulties.

ECE researchers are working to make this vision a reality. With the ongoing LED lighting revolution, not only do they want to deliver energy-efficient and visually-pleasing illumination, but they also want to send data to mobile devices at high rates by means of visible light communication (VLC), often referred to as LiFi (Light Fidelity). Since LED light can be modulated at hundreds of MHz, future light fixtures can serve as data transmitters without bothering our eyes, since humans cannot see light fluctuations above 60 Hz. To achieve this goal, however, several issues need to be resolved. How to reliably send data at high rates using visible-light spectrum? How to steer and focus the light beam on a small area of a mobile receiver? And, finally, how to find where the mobile receivers are? Several of our faculty are working to answer these questions within the Lighting Enabled Systems and Applications (LESA) Engineering Research Center funded by the National Science Foundation.

Professor Thomas Little and his research team work on optical wireless communication and networking using the visible spectrum produced by overhead lighting. These optical networks will bring much needed additional capacity, reduce download delays, and have low installation and maintenance costs. Properties of light allow for short-distance and low-interference communication links yet add significant new capacity between mobile devices and the Internet.

Professor David Bishop's team is working on steering the light to assure quality illumination and to focus data light beams. Their current research focuses on microelectromechanical systems (MEMS) that allow spatial division multiplexing within solid state lighting. In addition to steering the light, the optical MEMS are capable of focal length variation so the light reflected from the mirror can be shaped (either focused or diffused) dynamically.

Professors Janusz Konrad and Prakash Ishwar, and their students are leveraging light sensors to identify where people are in a room, what they are doing and which way they are facing in order to optimize illumination and to steer data light beams towards mobile devices. They use ultra-low resolution sensors, as low as a single pixel, in order to assure user privacy; that is, to learn what a person is doing without identifying the person.

By Professor Janusz Konrad

Image courtesy of Shutterstock

HACK-PROOF CHIPS

RESEARCH AREA

RESEARCHERS

Prof. Joshi

Prof. Ünlü

SAFEGUARDING MICROCHIPS

Most of the attention paid to hacking currently is on software-based "cyberattacks". But what if a rogue engineer secretly inserts a malicious circuit into an IC chip? Attacks on hardware are as serious a security issue as software cyberattacks, especially in military applications where the danger is that computerized equipment essential to national security can be compromised.

Lately, the US Military has become increasingly worried about the security of Integrated Circuit (IC) chips used in military systems. The major concern so far has been about tampering of chips during the design phase. However, University of Michigan researchers have recently shown that a small malicious circuit can be easily inserted while a processor chip is being manufactured. This malicious circuit can in turn compromise the chip's operation in the field.

Many companies that sell VLSI chips rely on third-party manufacturers since that gives them access to advanced CMOS technology at low cost. To protect against tampering, during manufacturing, the company engineers use side-channel information (power, temperature, etc.) collected from a variety of on-chip and off-chip sensors to determine if a chip received from a third-party manufacturer is functioning normally. This approach can easily detect large malicious circuits inserted during manufacturing, but it cannot detect small malicious circuits.

Professors Ajay Joshi, Selim Ünlü, and their students have been working on addressing this hardware security vulnerability over the past year. The team has identified a method to optically watermark an IC chip to secure it against any tampering during its manufacture. On this highly interdisciplinary project, Professor Joshi serves as the VLSI expert, while Professor Ünlü provides imaging and nanoantenna technology expertise.

Their method leverages optical structures that are designed as copper metal nanoantennas built into the IC chip. These metal nanoantennas are engineered to collect unique scattering responses that are highly sensitive to their geometry and the optical properties of the structures present in their surroundings. The layout of the entire IC chip design can determine an overall optical watermark for the chip, which serves as the golden reference. The IC chip design is then sent for manufacturing. The manufactured chip is imaged on delivery to compare the chip image to the golden reference using sophisticated signal processing techniques. Any mismatch between the golden reference and its image is considered to be a sign of a compromised chip.

By Professor Ajay Joshi and David Rollow

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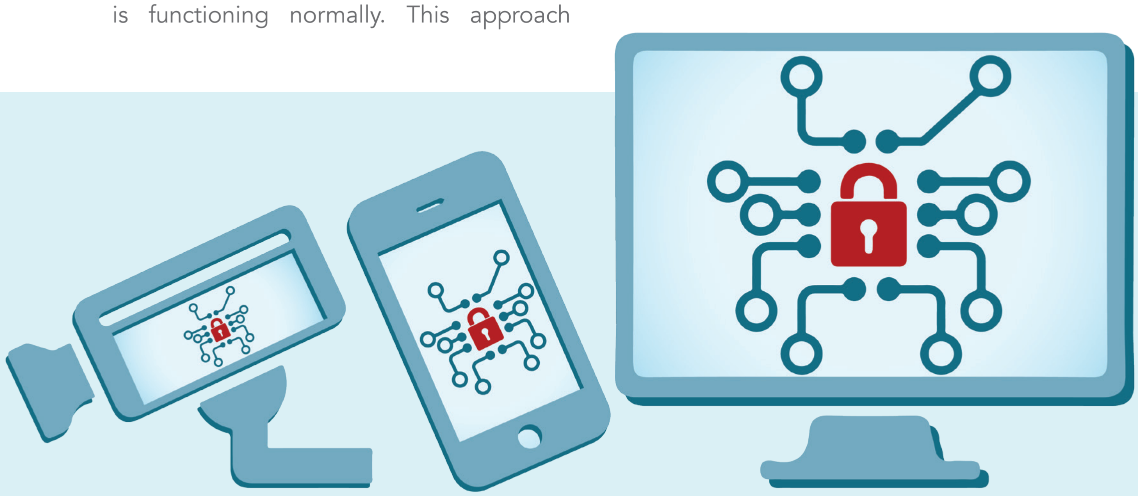

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Sr. Associate Chair

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Associate Chair for Graduate Studies

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Senior Lecturer
Associate Chair for Undergraduate Studies

OSAMA ALSHAYKH
Lecturer

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DAVID BISHOP
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RICHARD BROWER
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LUCA DAL NEGRO
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MARK KARPOVSKY
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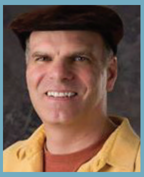
MALAY MAZUMDER
Research Professor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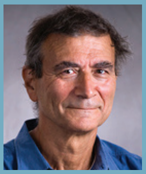
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BIG DATA RISES IN ECE

On joining ECE as a junior faculty member, **Brian Kulis** was quickly recognized as a rising star in the machine learning field. In September 2015, the University awarded the inaugural Peter J. Levine Career Development Professorship to Kulis in recognition of his career achievements.

Kulis received a National Science Foundation Faculty Early Career Development (CAREER) Award for research on machine learning systems, and he will be a critical member of the College of Engineering's new Master's Degree specialization in data analytics.

To Brian Kulis, advances in machine learning and artificial intelligence bring with them the opportunity to mesh theory with such real-world applications as driverless cars and computers able to describe aloud objects in front of them.

"You want computers to be able to recognize what they are seeing in images and video," says Kulis. "For instance, can it recognize all the objects in a picture? Or a more difficult problem would be, can it look at a video and describe in English what is happening in the video? That is a major application area for machine learning these days."

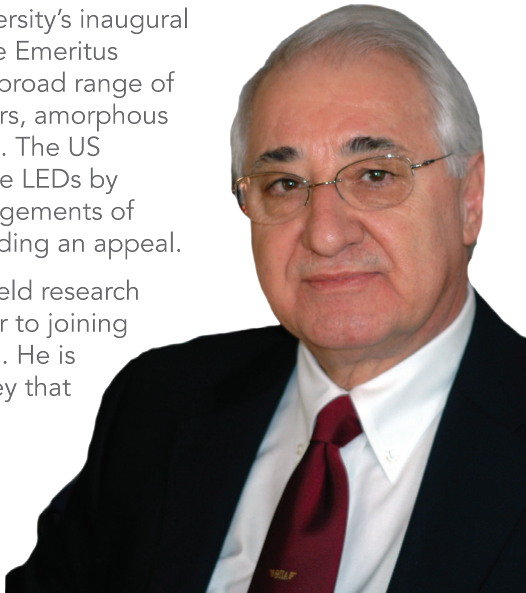
By Michael S. Goldberg, BU Today

A BRIGHT LEGACY

Professor **Theodore Moustakas**, who joined BU in 1987, was named the University's inaugural Distinguished Professor of Photonics and Optoelectronics in 2014 and became Emeritus Professor in late 2015. He is widely recognized for research contributions to a broad range of topics in optoelectronic materials and devices, including nitride semiconductors, amorphous semiconductors, III-V compounds, diamond thin films and metallic multi-layers. The US District court recently recognized Professor Moustakas' role in developing Blue LEDs by awarding Boston University more than $13 million in patent damages for infringements of Moustakas's patent for blue LEDs (light emitting diodes). The judgment is pending an appeal.

Professor Moustakas received his PhD from Columbia University in 1974. He held research positions at Harvard University and Exxon Corporate Research Laboratory prior to joining Boston University in 1987 as Professor of Electrical and Computer Engineering. He is also the cofounder of RayVio Corp., a venture-backed company in Silicon Valley that makes UV LEDs.

By David Rollow



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Annual Report 2014-2015
Producer: GABRIELLA MCNEVIN

COMPUTING EFFICIENTLY

ASSOCIATE PROFESSOR AYSE COSKUN

The theme of my research is to improve efficiency of computing, meaning we want our computers to do more work using less energy. The benefit of improving computing efficiency has both widespread and individual impact. Looking at small-scale systems such as mobile phones, we aim to improve properties like battery life, which will improve everyday user experience. On a larger scale, improving the efficiency of data centers will impact the carbon footprint of our overall energy consumption.

Since I joined the computer engineering program at BU, we have recruited accomplished faculty; we have a much larger body of graduate and undergraduate students; and we have rapidly growing research centers such as the Center for Information & Systems Engineering and the Cloud Computing Initiative. It's a completely different landscape from when I arrived and being a part of that growth initiative has been truly exciting for me. One of my favorite aspects of BU is the collaborative environment. There is a lot of encouragement to go beyond your immediate circle and perform interdisciplinary research in emerging areas. My research group has benefited tremendously from this environment.