NYU WIRELESS

10th ANNIVERSARY

NYU WIRELESS

Pulse

2023 · VOL. 10, NO. 1
NYUWIRELESS.COM

Pat Donohue, Editor
Rebecca Brooke, Senior Copy Editor
Printed by GHP Media

NYU WIRELESS is a vibrant academic research center pushing the boundaries of wireless communications, sensing, networking, and devices.

Centered at NYU Tandon School of Engineering and involving leaders from industry, faculty, and students throughout the entire NYU community, NYU WIRELESS offers its Industrial Affiliates, students, and faculty members a world-class research environment that is creating fundamental knowledge, theories, and techniques for future mass-deployable wireless devices in a wide range of applications and markets.

NYU WIRELESS hosts an annual Open House for all of its students and Industrial Affiliate Members, followed by the prestigious invitation-only Brooklyn 6G Summit, in cooperation with Nokia Bell Laboratories, for the Center's Industrial Affiliates and thought leaders throughout the global telecommunications industry. Please visit B6GS.com for current Summit dates. We also hold a Workshop every eighteen months designed to bring together the foremost wireless researchers for a free exchange of ideas.

NYU WIRELESS, info@nyuwireless.com

Leadership Founding Director Ted Rappaport, Director Thomas L. Marzetta, and Associate Directors Sundeep Rangan, John-Ross Rizzo, and Dennis Shasha manage NYU WIRELESS across Brooklyn and Manhattan campuses of NYU. Rappaport has powered the 5G millimeter wave era and is a leading educator in the wireless arena, having authored many books and started two companies and three major academic wireless research centers. Rangan is an Electrical Engineering Professor at NYU Tandon and was a co-founder of Flarion Technologies, which developed Flash-OFDM, one of the first cellular OFDM data systems. Marzetta originated the concept of Massive MIMO and seeks ten-fold improvements over Massive MIMO through a closer union of wave propagation physics and communication theory. Rizzo is an Assistant Professor in the Departments of Rehabilitation Medicine and Neurology at NYU Langone Health. His research is focused on wearable technology and blindness and visual impairment. Shasha of Courant's Computer Science Department is widely known for his expertise in data-intensive algorithms and streaming data and is a highly acclaimed inventor of mathematical puzzles.

The Industrial Affiliates Program NYU WIRELESS invites global companies to join our Industrial Affiliates program. The program offers instant access to cutting-edge research results and talented students in a mutually beneficial relationship among NYU WIRELESS researchers, students, facilities, and leading industry partners. NYU WIRELESS would like to thank our Industrial Affiliate Partners as well as NSF, NIH, and DOD for their continued support. Learn more about our Industrial Affiliates program by visiting our website at nyuwireless.com/industrial-affiliates.

CELEBRATING A DECADE OF CONNECTION

NYU WIRELESS is the world's first academic research center to combine engineering, computer science, and medicine. The center was launched in 2012 by Founding Director and Professor Theodore "Ted" Rappaport, who pioneered the use of the millimeter-wave (mmWave) spectrum, and more recently, sub-terahertz frequencies, paving the way for the powerful cell phones and other wireless devices most of us will rely on in the coming decades.

Since 2019, NYU WIRELESS has been under the direction of Distinguished Industry Professor Thomas Marzetta, who led the development of massive MIMO (multiple-input multiple-output), another core component of modern wireless networks.

Establishing a robust, innovative wireless center in New York City has taken vision, collaboration, and the support of countless dedicated individuals who have embraced that vision to carry it forward. Throughout the past ten years, the center has been fortunate to have the backing of NYU's leadership, which, together with dedicated faculty members, talented students, and the ongoing investment of our innovative Industrial Affiliate partners, has helped propel us in exciting and previously unimagined directions.

Thank you to everyone who has supported and guided our vision. The success and many achievements of NYU WIRELESS would not have been possible without you!

FROM THE FOUNDER

In 2013, we launched *Pulse*, a newsletter created to update our constituents about the advances made at NYU WIRELESS, then a fledgling academic research center.

At the time of NYU WIRELESS's founding in the fall of 2012, most of its faculty and students were officially associated with Brooklyn Polytechnic University, an engineering school with a celebrated past. Efforts were then underway to merge Brooklyn Poly with New York University, the prestigious liberal arts school just across the river in Manhattan. It was a bold move on our part to adopt a Center name that included "NYU," since the merger of the two universities was far from certain.

During those early days, NYU was beginning to make major investments in satellite campuses in Abu Dhabi and Shanghai, and Brooklyn Poly was ranked only 67th in *U.S. News & World Report*'s graduate engineering school ranking. The wireless world had not yet thought much about 5G, as it was then just building out 4G LTE across the planet.

Reflecting over the past ten years, from that first issue of *Pulse* and our uncertain beginnings, I am in awe of the ingenuity and tenacity of our students, faculty, and administration who have worked together to position our students and their research at the forefront of the 5G revolution and beyond. We have seen tremendous growth in the quality and number of graduate students applying to the wireless program, and the number of major Industrial Affiliates that champion our work and recruit our graduates has skyrocketed as well. The trust and continual investments given by these Industrial Affiliate companies and the National Science Foundation have been transformative, allowing great things to happen on our campus and propelling our recent *U.S. News & World Report* graduate engineering ranking to as high as 33, a truly meteoric rise in just a decade. To date, more than $50 million in external funding has enabled NYU WIRELESS and its multi-disciplinary cadre of researchers in the Tandon School of Engineering, the Courant Institute of Mathematical Sciences, and the NYU Grossman School of Medicine to conduct pioneering research that benefits the global wireless industry. Best of all, our strong industrial support has enabled us to invest in hundreds of scholarships for the brightest graduate students from around the world. The talented individuals who have passed through our laboratories are now building the global 5G and 6G ecosystems in industry and academia. Our growth has allowed NYU to recruit excellent young faculty members in many application areas of wireless communications, RF chip design, robotics, and computing, and their discoveries will enable revolutionary use cases in the decades ahead.

As a career-long academic with an entrepreneurial bent, I have always loved the fact that it is possible to change the world from a university campus. I'm enormously grateful and feel so blessed to have been part of the revolutionary activities of NYU WIRELESS during the past decade. With your continued commitment and spirit of collaboration, we shall continue to bend the world!

Thank you for your support on this wonderful odyssey, and best wishes in wireless!

—Ted

Theodore S. Rappaport is the David Lee/Ernst Weber Professor in the Department of Electrical and Computer Engineering, NYU Tandon School of Engineering; Professor of Computer Science at the Courant Institute of Mathematical Sciences; and Professor of Radiology Medicine at NYU Langone Health. He is the Founding Director of NYU WIRELESS.

Five Reasons to Celebrate Ten Years of NYU WIRELESS

1 Notable research developments and stellar students

2 Visionary faculty

3 Millions in grant funding

4 Collaboration and community with the world's leading innovators

5 Academic and industrial leadership

FROM THE DIRECTOR

I joined the faculty of NYU in 2017 after twenty-two years at Bell Labs, having worked both as an individual contributor and as the head of the department once directed by legendary communications engineer S. O. Rice. Two years later, I was asked to serve as Director of NYU WIRELESS—a great honor and a huge responsibility. After four years interacting with my dedicated and visionary colleagues, many of the world's top students, and our innovative Industrial Affiliates, I am more confident than ever that NYU WIRELESS will continue to shape the future generations of wireless.

There is endless speculation regarding the form and function that 6G will assume. Of one thing I am sure: spectral efficiency will be the dominant consideration, just as it drove all previous generations of wireless. The demand for wireless throughput will continue to grow, but the quantity of available electromagnetic spectrum will never increase.

We tend to view the quest for spectral efficiency and its (apparently) chief enabling technology, multiple-antenna wireless (MIMO), as phenomena of the last forty years. In fact, both were discussed in 1919 by the Swedish-American engineer E. F. W. Alexanderson in his paper "Transoceanic Radio Communication." At that time, it was believed that wireless communication across oceans required long-wavelength radiation with carrier frequency less than 15 KHz. Within this limited spectrum there was capacity, worldwide, for only a few dozen first-class transmitting stations. Alexanderson noted that what today would be called a phased-array of antennas could impart directionality to the transmitted power, and that by judicious choice of transmission direction, many more stations could be accommodated in the available spectrum. The concept of MIMO was born!

Since its launch in 2013, *Pulse* has documented the many groundbreaking contributions of NYU WIRELESS to the art of wireless. As NYU WIRELESS enters its second decade, I am excited to see what the future holds. I know that the creativity and persistence of our students and faculty—supported by our Industrial Affiliate Members—will yield the discoveries that will enable the next generations of wireless. And *Pulse* will be there to share the news!

Thomas L. Marzetta is a Distinguished Industry Professor and Director of NYU WIRELESS.

Notable Research Developments and Stellar Students

2013 NYU WIRELESS researchers propose a novel delivery service called streamloading, which could ultimately make spotty streaming and data-hogging downloads a thing of the past.

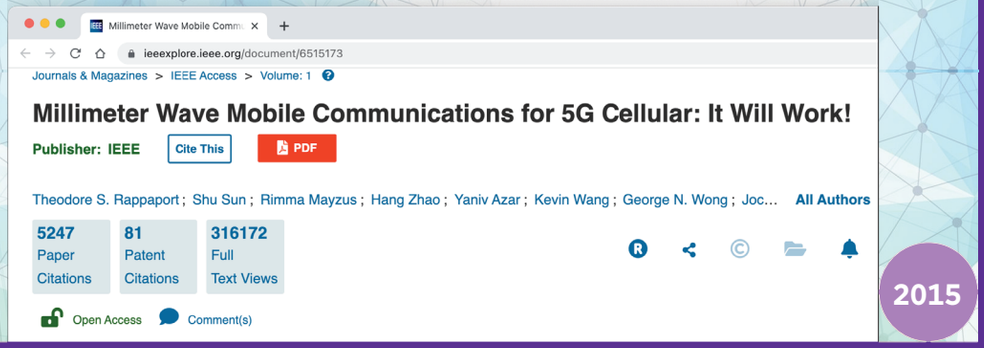
2015 NYU WIRELESS researchers receive the IEEE Donald G. Fink Award for their seminal paper "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!"

2016 NYU WIRELESS releases a groundbreaking NYUSIM Channel Simulator that provides a complete statistical channel model and simulation code with an easy-to-use interface for generating realistic spatial and temporal wideband channel impulse responses.

2019 On March 15, Founding Director Theodore Rappaport was invited to address the commissioners of the Federal Communications Commission before its vote on the Spectrum Horizons Act authorizing consumer radio spectrum above 95 GHz for the first time in the history of the United States.

2021 NYU WIRELESS researchers unveil new ways of enhancing the performance of electrochemical micro-sensors—a discovery that could lead to the detection of biomolecules, such as dopamine, at lower concentrations than is possible today.

2023 NYU WIRELESS Ph.D. alum Shu Sun, one of the first Ph.D. students at the center, was recognized with a double honor from the IEEE Vehicular Technology Society (VTS). She received the 2023 Neil Shepherd Memorial Best Propagation Paper Award and the 2023 IEEE VTS Early Career Award, for "fundamental contributions to the development of 5G millimeter-wave communications."

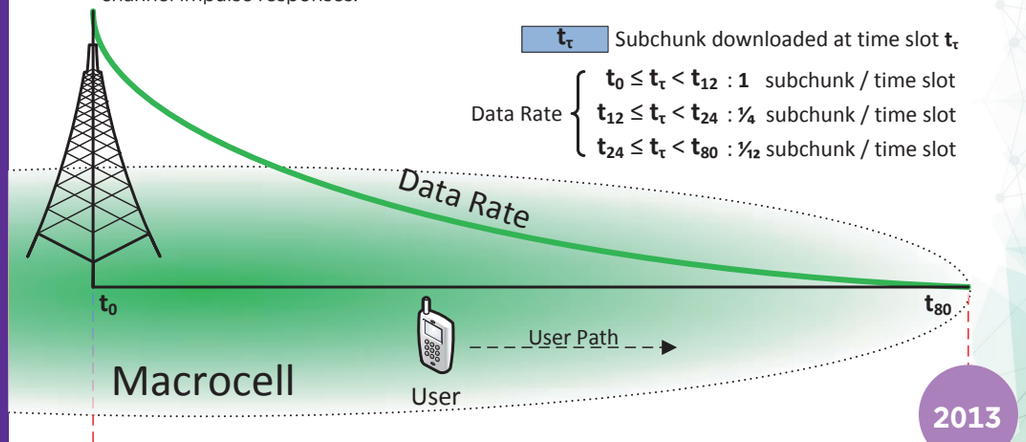


2015

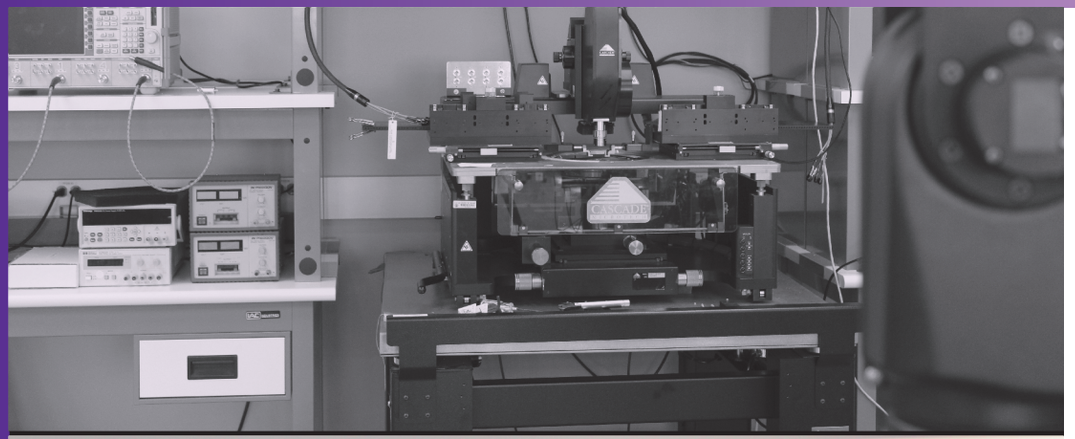

2016

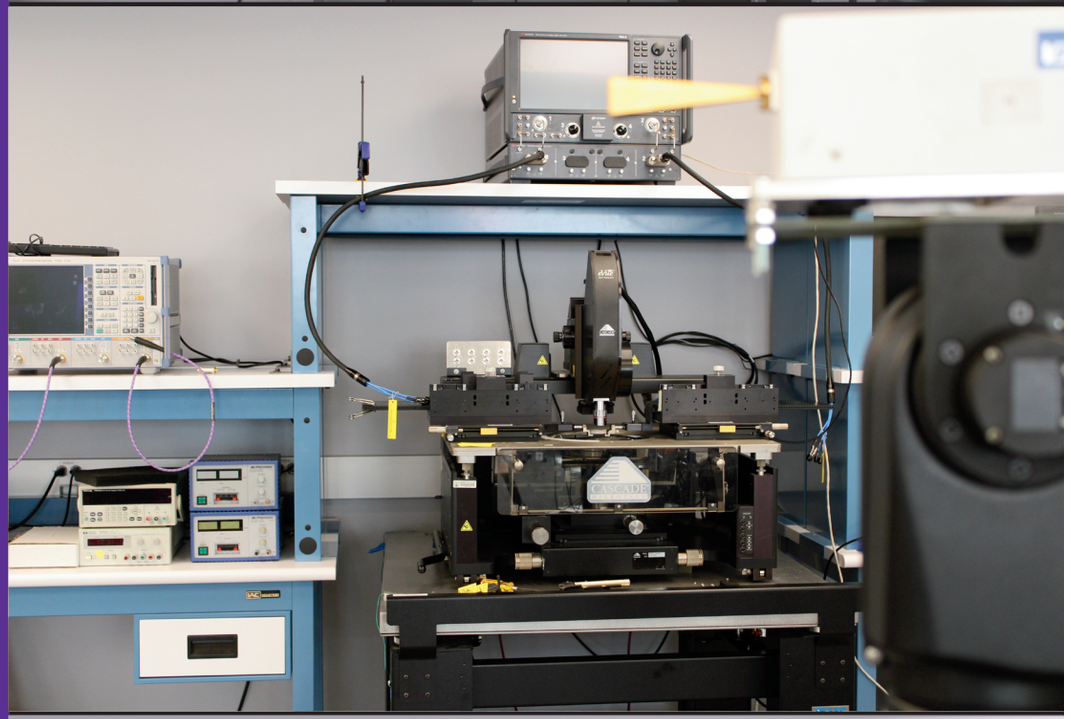

2021

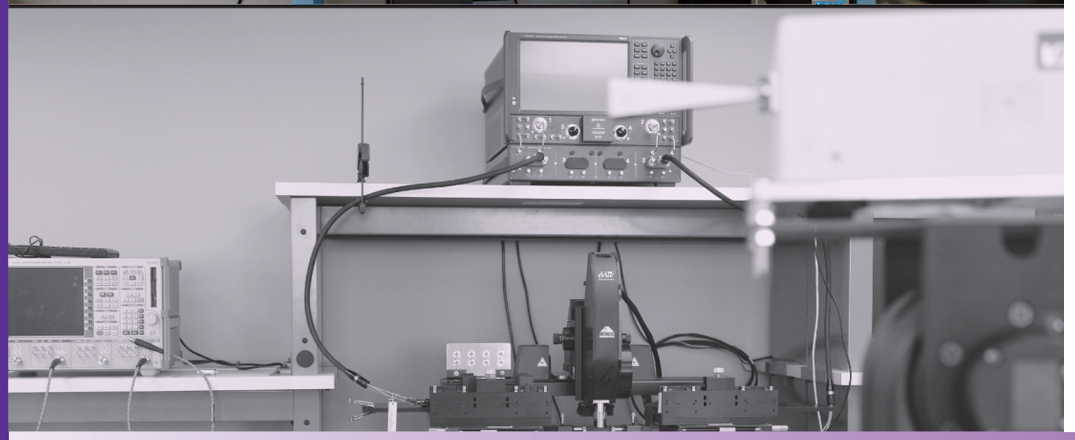

2023



2013







Visionary Faculty and Millions in Grant Funding

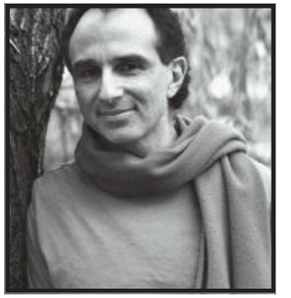
In addition to her many accolades, Institute Professor **Elza Erkip** has received the National Science Foundation CAREER award, the IEEE Communications Society Women in Communications Engineering (WICE) Outstanding Achievement Award, and the IEEE Communications Society Edwin Howard Armstrong Achievement Award.

Professor **Shiv Panwar** was named a Fellow of the National Academy of Inventors in 2022, joining NYU WIRELESS Founding Director Ted Rappaport, who became an NAI Fellow in 2018. Panwar was also honored by the Indian Institute of Technology, Kanpur, with its Distinguished Services Award in 2020.

Under the National Science Foundation's Platforms for Advanced Wireless (PAWR) initiative, $22.5 million was awarded in 2018 to establish COSMOS (Cloud enhanced Open Software defined MObile wireless testbed for city-Scale deployment). The New York–based project, with Associate Director **Sundeep Rangan** as the NYU lead, has focused on design, development, and deployment of an advanced wireless city-scale testbed to support real-world experimentation on next-generation wireless technologies and applications.

NYU WIRELESS Founding Director **Ted Rappaport** was awarded $3 million from the National Science Foundation in 2022 for a new Terahertz Measurement Facility. Together with collaborators from the University of

Colorado at Boulder, the University of Nebraska-Lincoln, and Florida International University, the NYU team will pioneer basic measurements of devices, circuits, materials, and radio propagation channels at the highest reaches of the radio spectrum.



For his technical and literary contributions to the field of data management, Associate Director **Dennis Shasha** was named a Fellow of the Association for Computing Machinery (ACM) in 2014, an INRIA international chair in 2015, and a senior member of the National Academy of Inventors in 2023.

Collaboration and Community with the World's Leading Innovators

In 2014, Nokia and NYU WIRELESS hosted the first-ever Brooklyn 5G Summit, now one of the premiere annual events in the wireless world.

NYU WIRELESS researchers are collaborating with colleagues at NYU Tandon, top corporations, and government partners to increase the competitiveness of the U.S. in networking and computing technologies to ensure the security and resilience of NextG technologies and infrastructure. This NSF-supported project is called Resilient and Intelligent Next Generation Systems (RINGS).

NYU WIRELESS is a key participant in the Next G Alliance, designed to advance North American global leadership over the 5G evolutionary path and 6G early development.

The 2022 NYU WIRELESS Workshop: Re-Inventing the Physical Layer brought together the foremost wireless researchers for a free exchange of ideas. The workshop, which going forward will be held every eighteen months, was organized by NYU WIRELESS Director Tom Marzetta together with NYU Tandon Institute Professor Elza Erkip, Professor Petar Popovski of Aalborg University, and Professor Liesbet Van der Perre from KU Leuven.

NEXT G ALLIANCE
An ATIS Initiative

NYU WIRELESS NYU TANDON

NYU WIRELESS Workshop

Leadership

NYU WIRELESS is led by some of the top innovators in the field. This diverse group of pioneering researchers is developing advances to maximize the potential of current and future generations of wireless.

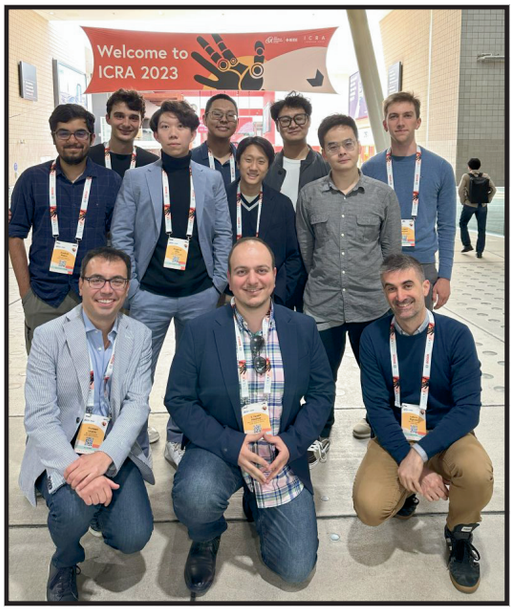
Physician-scientist **John-Ross Rizzo** is an Associate Director of NYU WIRELESS, the Ilse Melamid Associate Professor of Rehabilitation Medicine, and an Associate Professor in the Department of Neurology at NYU Langone Health. Dr. Rizzo was recently named to New York City's Metropolitan Transportation Authority's Board of Directors, where he will explore the potential of new technologies to improve subway station accessibility for those with disabilities.

Assistant Professor **Farokh Atashzar** leads the Medical Robotics and Interactive Intelligent Technologies (MERIIT) Lab. The lab's goal is to develop and implement artificial intelligence, advanced control systems, surgical robotic systems, and more.

Professor **Yao Wang** is an expert in medical imaging, machine learning, computer vision, 360-degree video, and virtual reality. She and her students in the NYU Video Lab are developing ground-breaking new ways to analyze, manipulate, and wirelessly transmit images.

Assistant Professor **Giuseppe Loianno** is Director of the Agile Robotics and Perception Lab, where he and his students perform fundamental and applied research in robotics autonomy. He is a recipient of the Defense Advanced Research Projects Agency (DARPA) Young Faculty Award to develop the next generation of agile and collaborative robots.

Associate Professor **Davood Shahrjerdi** leads the Nanofab Cleanroom at NYU Tandon. His research focuses on the study of new electronic materials and devices for making nano-engineered hybrid integrated systems.



Professors Giuseppe Loianno, **Farokh Atashzar**, and **Ludovic Righetti** (kneeling) with some of their students.

NYU WIRELESS Faculty, Post-Docs & Research Scientists

Theodore Rappaport, Founding Director

Thomas L. Marzetta, Director

Sundeep Rangan, Associate Director

John-Ross Rizzo, Associate Director

Dennis Shasha, Associate Director

Farokh Atashzar, Assistant Professor

Henry Bertoni, Professor Emeritus

Marwa Chafii, Associate Professor

Aditya Dhananjay, Post-Doctoral Associate

Elza Erkip, Institute Professor

Fraida Fund, Post-Doctoral Associate

Siddharth Garg, Associate Professor

David Goodman, Professor Emeritus

Ramesh Karri, Professor

Michael Knox, Industry Professor

Pei Liu, Research Scientist

Yong Liu, Associate Professor

Giuseppe Loianno, Assistant Professor

Marco Mezzavilla, Research Scientist

Shivendra Panwar, Professor

Hamed Rahmani, Professor

Davood Shahrjerdi, Associate Professor

Lakshmi Subramanian, Associate Professor

Yao Wang, Professor

NYU WIRELESS Industrial Affiliate Members

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™
CROWN CASTLE
DELL Technologies
ERICSSON
interdigital
MEDIATEK
NOKIA
NSF
QUALCOMM
SHARP
SONY
UMC

NYU WIRELESS
NYU Tandon School of Engineering
370 Jay Street, 9th Floor
Brooklyn, NY 11201
646-997-3403
nyuwireless.com

Address Service Requested

NYU WIRELESS Newsletter
Download and read copies of our previous newsletters online
by visiting **nyuwireless.com/nyu-wireless-newsletter-the-pulse**

@NYUWIRELESS NYU WIRELESS NYU WIRELESS