Northwestern | McCORMICK SCHOOL OF ENGINEERING

NEWS & EVENTS

ENGINEERING NEWS

RESEARCH

Improving Internet with Mid-Wavelength Infrared

Novel phototransistor device could result in faster, cheaper Internet

JUL 26, 2016 // AMANDA MORRIS

With a growing number of people connecting to the Internet everyday, Internet cables are under the threat of a "bandwidth explosion."

Free-space optical (FSO) communication is a promising candidate to lighten the load. FSO uses visible or infrared light to wirelessly transmit data through open air as opposed to using cables, which have limited bandwidth. The new technology provides a low-cost and low-power alternative to traditional radio-frequency wireless data links.

Manijeh Razeghi

"The current state-of-the-art in FSO communications is based around near-infrared sources and photodetectors," said Northwestern Engineering's **Manijeh Razeghi** **(http://www.mccormick.northwestern.edu/research-faculty/directory/profiles/razeghi-manijeh.html)** . "Unfortunately, using these wavelengths come with major problems."

At high power, near-infrared wavelengths can damage the human eye, and they are hampered by atmospheric scattering and absorption. Razeghi, who leads Northwestern's **Center for Quantum Devices** **(http://cqd.eecs.northwestern.edu)** , has bypassed this issue by using mid-wavelength infrared radiation, which can benignly and flawlessly transmit through fog, smoke, and clouds.

Razeghi and her team have developed an extremely sensitive mid-wavelength infrared photodetector that has potential to replace near-infrared FSO communications links in many applications. Called a phototransistor, the novel device is a combination of an electronic transistor and optoelectronic photodiode.

On July 12, the research was published online in ***Applied Physics Letters*** **(http://scitation.aip.org/content/aip/journal/apl/109/2/10.1063/1.4958715)** . Abbas Haddadi, a postdoctoral fellow in Razeghi's laboratory, was first author of the paper.

"For the first time, we have demonstrated a phototransistor that is totally made of an artificial semiconductor," said Razeghi, Walter P. Murphy Professor of Electrical Engineering and Computer Science in Northwestern's McCormick School of Engineering. "This extremely sensitive device could be a game changer for FSO communication technology by providing low-cost, high-speed data links."

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RESEARCH

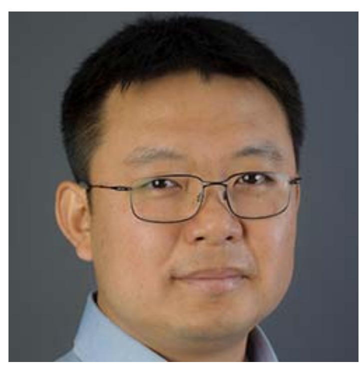
Enhancing Molecular Imaging with Light

New technology platform increases spectroscopic resolution by four fold

JUL 25, 2016 // AMANDA MORRIS

In 2014, an international trio won the Nobel Prize in Chemistry for developing super-resolution fluorescence microscopy, a technique that made it possible to study molecular processes in living cells.

Now a Northwestern Engineering team has improved this groundbreaking technology by making it faster, simpler, less expensive, and increasing its resolution by four fold.



Hao Zhang

"Despite the success of electron microscopy and scanning probe microscope techniques, there has remained a need for an optical imaging method that can uncover not only nanoscopic structures but also the physical and chemical phenomena occurring on the nanoscale level," said said **Hao Zhang** **(http://www.mccormick.northwestern.edu/research-faculty/directory/profiles/zhang-hao.html)** , associate professor of biomedical engineering in Northwestern's McCormick School of Engineering. "We envision that our technique can accomplish this."

Led by Zhang, the Northwestern team developed a new super-resolution optical imaging platform based on spectroscopy, a type of imaging that examines how matter responds to light. Called spectroscopic photon localization microscopy (SPLM), the platform can analyze individual molecules with sub-nanometer resolution.

Vadim Backman

The novel technology platform leverages photon localization microscopy (PLM), which captures inherent spectroscopic signatures of emitted photons, or light particles, to identify specific molecules. Current spectroscopic imaging and PLM technologies require multiple fluorescent dyes to enhance contrast in the resulting microscopic images. Unable to distinguish between dyes, these techniques record multiple images from different discrete wavelength bands.

The Northwestern team's SPLM, however, can characterize multiple dye molecules simultaneously, increasing the imaging speed in multi-stained samples. Removing the need for recording multiple images makes the imaging process simpler and less expensive. SPLM is also sensitive enough to distinguish minor differences from the same type of molecules.

"People need a series of filters and cameras to separate photons with different colors and acquire information," Zhang said. "It can be rather complicated and expensive if multiple cameras are employed. Using our technology, we can acquire multi-color images without filters because we know which color is associated with which photons simultaneously."

Cheng Sun

Supported by a Northwestern Engineering research catalyst award, the research was described online on July 25 in ***Nature Communications*** **(http://www.nature.com/ncomms/2016/160725/ncomms12290/full/ncomms12290.html)** . **Vadim Backman** **(http://www.mccormick.northwestern.edu/research-faculty/directory/profiles/backman-vadim.html)** , the Walter Dill Scott Professor of Biomedical Engineering, and **Cheng Sun** **(http://www.mccormick.northwestern.edu/research-faculty/directory/profiles/sun-cheng.html)** , associate professor of mechanical engineering, served as co-authors of the paper. Biqin Dong, a postdoctoral fellow in Zhang's laboratory, and Luay Almassalha, a graduate student in Backman's laboratory, are co-first authors of the study.

While Zhang plans to apply this new technology to his own research in optical imaging, he believes it will be useful for many fields, from materials science to the life sciences.

"Our approach not only enhances existing super-resolution imaging by capturing molecule-specific spectroscopic signatures," he said, "it will potentially provide a universal platform for unravelling nanoscale environments in complex systems at the single-molecule level."

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HONORS AND AWARDS

Synthetic Biologist Receives ACS Young Investigator Award

Julius Lucks received the award for his early contributions to the field

JUL 19, 2016 // AMANDA MORRIS

Northwestern Engineering's Julius Lucks has received the 2016 Synthetic Biology Young Investigator Award from the **American Chemical Society** **(https://www.acs.org/content/acs/en.html)** . Each year, the award recognizes the contributions of one scientist who has made a major impact on the field of synthetic biology early in his or her career.

Lucks will receive the award at the **Synthetic Biology: Engineering, Evolution, and Design** **(http://synbioconference.org)** (SEED) conference in Chicago and will present his work at SEED on Wednesday, July 20.

"It is an incredible honor to be recognized with this award," said Lucks, associate professor of chemical and biological engineering. "The field of synthetic biology is at an extremely exciting moment in its history, as can be seen clearly through all of the great work published in *ACS Synthetic Biology*."

Julius Lucks

Coming from Cornell University, Lucks will officially join the McCormick School of Engineering and Northwestern's **Center for Synthetic Biology** **(http://syntheticbiology.northwestern.edu)** in August. In earlier work, Lucks led the development of SHAPE-Seq, a technology that uses next-generation sequencing to characterize RNA structures in unprecedented throughput. SHAPE-Seq is now being used to uncover the role of the RNA structure in regulating fundamental cellular processes across the genome.

Lucks' research group focuses on dynamically programming cellular behavior with synthetic RNA circuitry, creating new classes of programmable RNA regulators with protein-like dynamic ranges and using SHAPE-Seq to understand RNA folding dynamics in the cell.

"For my group and I to be recognized with this prestigious award is an inspiration," Lucks said. "It has made us even more excited to unlock the potential of RNA and to keep building the synthetic biology community."

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HONORS AND AWARDS

Hani Mahmassani Named to 2016 Class of National Associates by National Research Council

Professor recognized for service to Transportation Research Board

JUL 18, 2016 // ALEX GERAGE

Hani Mahmassani **(../../../../research-faculty/directory/profiles/mahmassani-hani.html)** , professor of civil and environmental engineering and the William A. Patterson Chair in Transportation, has been named a National Associate by the National Academies of Sciences, Engineering, and Medicine's National Research Council.

Hani Mahmassani

One of nine individuals selected to the 2016 class, Mahmassani was recognized for his noteworthy service as a member of the organization's Transportation Research Board, which encourages scholarly research and correspondence that advances innovation in transportation.

Since joining the Transportation Research Board in 1977, Mahmassani has led dozens of policy studies, committees, and task forces that have addressed industry challenges and informed public policy decisions.

Mahmassani's research specializes in multimodal transportation systems analysis, planning and operations, and dynamic network modeling and optimization. As the director of Northwestern's Transportation Center, he leads an interdisciplinary approach to transportation and logistics education and research that serves industry, government, and the public.

View the full list of the 2016 Class of National Associates. **(http://www.trb.org/Main/Blurbs/174440.aspx)**

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RESEARCH

Reinventing the Wheel: Northwestern Researchers Develop Recyclable Rubber

The discovery could one day lead to recyclable car tires

JUL 13, 2016 // MONIKA WNUK

John M. Torkelson (../../../../research-faculty/directory/profiles/torkelson-john.html) , a Walter P. Murphy Professor in the Department of Chemical and Biological Engineering and the Department of Materials Science and Engineering at Northwestern University, has found a solution to a common problem with rubber: it can't be recycled.

Separating recyclables from the waste stream has become routine behavior. Paper, many plastics, glass, and metals are collected and converted into reusable (economically valuable) products, reducing landfill diversion and minimizing ecological footprint.

The ability of a non-paper material to be recycled – heated at high temperatures and recast for reuse – depends largely on the way in which its polymers are linked. Polymers, or chains of molecules arranged to give structure to larger molecules, are usually configured in either linear or cross-linked chains. Polymers that we typically recycle, namely thermoplastics, are made of linear chains, which can be heated to high temperatures, remolded in their melted state, and effectively reformed when cooled without losing their original properties.

When rubber - which is made of permanent cross-linked chains - is heated, it strengthens and can't be remolded or reheated into a usable product that retains its original durability and elasticity.

John M. Torkelson

Torkelson and two of his Ph.D. students, Kailong Jin (Chem. Eng. '17) and Lingqiao Li (Chem. Eng. '19) have developed a simple, one-step strategy to solve this problem by modifying the way in which the polymers in rubber are linked. The research, supported by the McCormick Research Catalyst Awards Fund at Northwestern University and by discretionary funds associated with Torkelson's Walter P. Murphy Professorship, will be detailed in an upcoming issue of *Advanced Materials,* and is currently available online as an **early view article (http://onlinelibrary.wiley.com/doi/10.1002/adma.201600871/abstract)** .

"Our approach can be used for any rubber applications that require elasticity and durability—from common products like shoes, to aerospace materials," said Torkelson.

Torkelson sees particular impact for the tire industry. The Rubber Manufacturers Association estimates that the US disposed of 244 million scrap tires in 2013. Only about 30 percent of those disposals were down-cycled for scrap tire markets like ground rubber applications or civil engineering, while more than 50 percent were simply burned for fuel. Nearly 10 percent - 20 million tires – were landfilled.

The team's approach would allow tires to be made using conventional polymers, maintaining the properties that make tires effective, but with modifications to the way the polymers are cross-linked. Currently, the resulting material has shown full retention of properties after two cycles of the process, with further trials to come.

The one-step synthesis approach, based largely on a process called nitroxide-mediated polymerization, separates the cross-links in rubber at high temperatures, making it possible for them to reform and retain their properties in a cooled state.

To successfully reform, the individual electrons that remain when a cross-link comes apart at high temperatures, called radicals, must find each other upon cooling. To be effective, the team needed to find a molecule that had both a stable (reforming) radical, as well as a carbon-carbon double bond, which they found in a molecule called TEMPO methacrylate.

The research builds on more than 15 years of work in the area by various researchers. Limitations of prior approaches included processes that were costly, chemically-intensive, and required many reaction steps under specific conditions. These processes were also characterized by low recovery of cross-links and material properties, according to Torkelson.

"Our approach requires only one round of chemical synthesis, uses all commercially-available components, which are also inexpensive and easy to synthesize, and is adaptable to a large fraction of cross-linked polymers out there," said Torkelson.

The research is patent pending and will be presented at the 2016 National American Institute of Chemical Engineers Meeting in August, as well as the National American Chemical Society Meeting in November. Lingqiao Li will build on this work as a **2016-2017 ISEN Cluster Fellow** **(http://isen.northwestern.edu/2016-2017-isen-cluster-fellows)** .

The team's next steps will include iterations to improve the methodology, and searching for industry partners to help bring the technology to market. They will also explore new applications.

"My group will dedicate the coming decade to this new line of research," said Torkelson. "It has that much potential."

Read the original article at the Institute for Sustainability and Energy at Northwestern (ISEN) website. (http://isen.northwestern.edu/reinventing-the-wheel-northwestern-researchers-develop-recyclable-rubber)