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News

1 FEB 2016 RESEARCH & INNOVATION

Small Scales, Big Impact: Nanotech Researcher E.H. Yang Pursues Nanomaterials for Solar & Medical Innovations

Applications include solar power, medical tests, batteries

Professor E.H. Yang of the Stevens Department of Mechanical Engineering

When Eui-Hyeok "E.H." Yang peers into very small worlds, he sees very big things.

And his ability to envision and build new materials constructed on microscopic scales just might revolutionize the sustainable energy industry one day.

Yang, a Stevens professor of mechanical engineering, leads Stevens teams working in several distinct and exciting areas of micro- and nanotechnology, including developments that could one day produce innovations such as a window material that not only allows light to shine through but harvest some of the sunlight's energy and converts it to usable energy.

"Imagine every windshield or every piece of glass in a skyscraper becoming an invisible power source," he says.

But the potential for widespread use of new nanomaterials to help power buildings or vehicles could only be realized if those new materials are both properly designed and cost-effective to manufacture, cautions Yang.

"We would need to the fabricate new materials in large volumes," he continues, explaining one of the key technical challenges ahead for his research group. "The world of materials is fascinating, because once there is a new material — such as a particular smart polymer, or a form of graphene — to work with, you must determine the material's unique characteristics under various conditions and how that material might be used or applied.

"That process of discovery is where we are really making our mark."

Quicker blood tests, better batteries

Yang's work could also lead to potential applications in other areas such as space systems engineering, medicine, optics, energy storage and wastewater treatment.

"There's always something new to explore," he notes.

Yang received his undergraduate degree in control engineering and Ph.D. in electrical engineering from Ajou University in his native South Korea. After postdoctoral work at two of the world's top research institutions — the University of Tokyo and California Institute of Technology (Caltech) — Yang began a tenure as a senior member of the engineering staff at NASA's Jet Propulsion Laboratory, where he focused on innovations such as space-telescope mirrors that could deform to correct for aberrations and microscale actuators and valves that could be used to build experimental, basketball-sized spacecraft then being developed by the lab.

Yang joined Stevens in 2006, where he has established novel research programs investigating the surface properties of conjugated polymers and the growth of one- and two-dimensional nanostructures for sensing and energy applications. He currently directs Stevens' Micro Device Laboratory (MDL), a state-of-the-art multi-user fabrication facility that includes the university's 'clean room' and several sophisticated lithography and etching systems, among other tools.

"I received the first Ph.D. in Korea in MEMS (microelectromechanical systems), and for a time that was my chief research interest and specialty," Yang recalls. "But after I arrived at Stevens, I began branching out. I wanted to investigate new areas."

Indeed. Some of the other innovations his research group is studying include:

> **Carbon nanotubes grown on graphene with energy applications.** When Yang's graduate students attempted to create nanopatterns with armchair or zigzag edges on sheets of graphene (a strong, light, carbon-based material with excellent properties of heat and electrical conductivity) using nanoparticles, something unexpected happened: carbon nanotubes (CNTs) began forming and growing upward from the sheets. After further testing and perfecting of the optimal heat and chemical 'recipes' required to produce ideal CNTs on graphene, Yang's team realized the nanoarchitectures were structurally useful.
>
> One application he has studied is the use of CNTs and graphene to create supercapacitors that can store energy

efficiently. Arrays of tiny CNTs placed between sheets of graphene can hold large quantities of electrical charge and might prove useful in new battery- or cellphone-charging technologies in the future, Yang points out.

Graphene sensors for space exploration with defense applications. Applications for graphene have become a rapidly growing area of nanomaterials research. Yang has received grants from the National Science Foundation (NSF), the Air Force Office of Scientific Research (AFOSR) and the U.S. Army to develop new means of infrared detection, among other projects.

Working with Stevens physics professor Stefan Strauf, Yang is involved in a project to use very tiny bilayer ribbons of graphene to adjust the sensitivity of detectors to wavelengths within sensing devices that could represent a huge breakthrough in optics if it pans out. Current semiconductor technology only reacts to a narrow spectrum of infrared radiation, and the materials are consumed during detection, making the process expensive. Yang's technology holds the potential for a much quicker or more flexible response by the material, which could prove important in areas such as space exploration, observatory design or military reconnaissance.

Microfluidics for use in blood testing, wastewater treatment and other applications. More recently, Yang has pursued microfluidics — the study of the behavior of small droplets of liquid — in collaboration with fellow mechanical engineering professor Chang-Hwan Choi. The area is receiving increasing focus, spurred by the development of a host of new 'tunable' surfaces.

In one application, Yang’s team is working to manipulate droplets on 'smart' polymer surfaces and attempting to move the droplets along specific pathways to react with test reagent indicating the presence of specific diseases. The polymers change their attraction to the droplets as voltage is applied; the droplets change shape, flow and 'stick' in what turn out to be predictable ways depending on the specific quantities of voltage applied. "Our hope is that, one day, medical-test analyzers that currently require large, costly high-voltage devices in medical offices could be reduced to test kits roughly the size of a smartphone and powered by the equivalent of a AAA battery," Yang explains.

Variations of the technology could also be useful in such areas as wastewater treatment (where oils and liquids must be separated at early stages of processing) or the cleaning of petroleum-industry facilities and devices.

Teaching alongside research

In addition to his engineering and materials research, Yang is passionate about educating Stevens' undergraduates in the basics of nanotechnology. NSF supports Yang's Nanotechnology EXposure for Undergraduate Students (NUE-NEXUS) initiative, an offering of science elective courses in nanotechnology each semester to engineering undergraduates who would normally receive little to no exposure to this rapidly growing field.

"We hope some of them will develop and pursue an interest in micro- and nanotechnology," says Yang. "I truly enjoy giving these courses to undergraduates in what is traditionally a graduate-level topic, and the undergrads seem to enjoy it, too."

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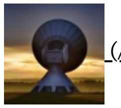
Stevens Researcher Named IEEE Fellow for Innovative Solutions in Exposing and Detecting Targets on Land or Sea (/news/stevens-researcher-named-ieee-fellow-innovative-solutions-exposing-and-detecting-targets-land-or-sea)  (/news/stevens-researcher-named-ieee-fellow-innovative-solutions-exposing-and-detecting-targets-land-or-sea)

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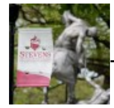
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1 Castle Point Terrace

Hoboken, NJ 07030

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201.216.5000 (tel:+12012165000)