SPRING 2015

VEU
VILLANOVA ENGINEERING UPDATE

VILLANOVA UNIVERSITY COLLEGE OF ENGINEERING

SMALL BUT MIGHTY: NANOTECHNOLOGY RESEARCH GAINS STRENGTH AT VILLANOVA

Since its birth in the early 1980s, modern nanotechnology has seen rapid research growth worldwide, including here at Villanova University. Defined as the study and application of matter on an atomic, molecular and supramolecular scale, this burgeoning technology already has begun to have an impact on our lives. Its potential use across nearly all disciplines of science, engineering and technology is evidenced by recent breakthroughs reported in academic journals around the world:

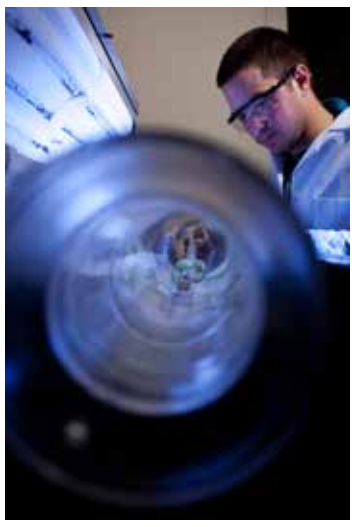
- Nanosensors that detect heart attacks before they happen
- Nanomaterials to improve protection of soldiers
- Carbon nanotube membranes for purifying sea water
- Gold nanoshells and lasers to destroy cancer tumors with heat
- Silver nanoparticles to kill bacteria

In the College of Engineering, Mechanical, Chemical, Electrical and Computer Engineering faculty are pursuing a variety of related applications, and have received a number of national research grants to support their work:

- $324,709 from the National Science Foundation (NSF) for "Thermal Transport in Nanoenhanced Phase Change Materials" (2009–2013)
- A $60,000 one-year grant from the Nanotechnology Institute for the study of low-temperature mechanical reinforcement of nanoparticle thin films (2011)
- $325,483 from the NSF for Development of Enhanced Performance Energy Storage Materials Using Tailorable Percolation Networks of Nanofibers (2012–2015)

NSF Grant Supports Cutting Edge Technology

In fall 2014, a team of Villanova Mechanical Engineering faculty earned the College's most significant nanotechnology award to date: A $412,106 Major Research Instrumentation grant from the NSF for "The Acquisition of Atomic Layer Deposition Device for Nanoscale Materials Development Research."



A chemical vapor deposition method is being used to grow nanomaterials.

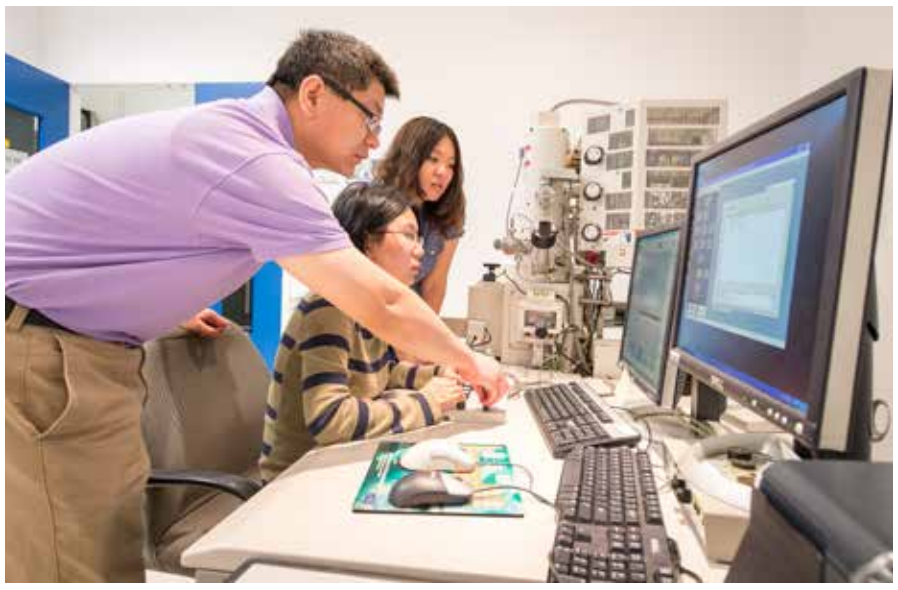
Put in simplest terms, the atomic layer deposition device creates a thermal or plasma thin film material with atomic precision, enabling critical new research areas. Under the direction of Professor Amy Fleischer, PhD, '91 ME, '96 MSME, the Villanova Atomic Layer Deposition facility will be established in the Center for Engineering Education and Research (CEER). The new device will join the College's existing nanotechnology instrumentation in the Nano-Bio-Mechanical Characterization Laboratory directed by Associate Professor of Mechanical Engineering Gang Feng, PhD, and the Nanomaterials and Surface Science Laboratory led by Randy Weinstein, PhD, Associate Dean of Academic Affairs and professor of Chemical Engineering.

Working with Dr. Fleischer on this project are Mechanical Engineering colleagues Dr. Feng and Calvin Li, PhD, assistant professor. The project also involves Daeyeon Lee, PhD, a Chemical Engineering professor from the University of Pennsylvania; and Xuemei Cheng, PhD, a Bryn Mawr College Physics professor. "This facility will serve as a regional center, enabling collaborative research and development between faculty and student researchers in three different areas of expertise, and at three distinct types of institutions," says Dr. Fleischer. Gary A. Gabriele, PhD, Drosdick Endowed Dean of the College of Engineering, adds, "This latest award places Villanova in the ranks of research institutions nationwide that are on the cutting edge of this emerging technology."

> "Having the latest instrumentation for nanotechnology research is practically a requirement for bringing the best faculty on board, which is what we must do to stay competitive as we transition into a doctoral/research university classification."
>
> —Gary A. Gabriele, PhD, Drosdick Endowed Dean, College of Engineering

Current Nanotechnology Research

Examples of nanotechnology research currently being conducted at the University include Drs. Feng's and Daeyeon's layer-by-layer assembly process to fabricate multifunctional nanostructured thin films for optical use. Their goal is to make ultrathin films more robust and scratch resistant for use as anti-fogging and anti-reflection coatings commonly applied to eyeglasses. Dr. Feng also is working



Using a state-of-the-art scanning electron microscope, Associate Professor Gang Feng, PhD, Mechanical Engineering, and his doctoral students, Di Zhang and Yue Xu, investigate synthesized nanomaterials.

on characterizing individual nanomaterials (nanowires, nanotubes, nanoshells and nanoparticles) so they can be accurately and quickly evaluated for designing high performance nano-systems. In addition, he is pursuing nanomechanical characterization and modeling of hard tissues to develop target-specific therapeutic treatments that may alter bone microstructure to prevent fracture. Associate Professor of Mechanical Engineering Ani Ural, PhD, also is looking at fracture behavior as related to the structure, distribution and material properties of micro- and nanostructural-components of bone.

Drs. Fleischer's and Li's research is focused on nano-enhanced phase change materials for advanced energy systems. A few of Dr. Fleischer's specific projects include the effect of graphene folding on thermal conduction in nanocomposites, viscosity of nano-enhanced energy storage materials and heat flow at nanoparticle interfaces. Dr. Li is working on nano to centimeter multiscale hierarchical structures for two-phase change heat transfer and nano-enabled thermomagnetic energy conversion.

Also in the Department of Mechanical Engineering, Professor Sridhar Santhanam, PhD; Associate Professor Kei-Pen Jen, PhD; and Professor and Department Chair C. Nataraj, PhD, are researching nanostructured ceramics to enhance manufacturing technologies. Nanostructured ceramics offer the possibility of enhanced strength and toughness which make them excellent candidates for a variety of applications.

The following Villanova Engineering faculty also are conducting nanotechnology research:

Michael A. Smith, PhD, '99 MSChE, associate professor, Chemical Engineering

- Effects of self-assembled nanostructured silica surface roughness on the behavior of vanadium oxide

Randy Weinstein, PhD, Associate Dean of Academic Affairs and professor, Chemical Engineering

- Use of graphite nanofibers as catalysts for chemical reactions
- Creation of self-assembled monolayers (layers that are one molecule thick) for the lubrication of small devices and use as corrosion inhibitors

Aaron Wemhoff, PhD, associate professor, Mechanical Engineering

- Development and application of molecular dynamics modeling toward analysis of nanosystems

Noelle Comolli, PhD, associate professor, Chemical Engineering

- Development of customizable tumor-targeting nanoparticles

Considering the relative infancy of the field and the progress already being made, the possibilities presented by nanotechnology are limitless. Dr. Feng says, "Our fundamental understanding of the relationship between the nanostructure and the functional behavior of nanomaterials will ultimately enable us to design and fabricate multifunctional nanomaterials for a variety of advanced applications, from energy conversion and storage to water purification and biomedical applications—uses that impact our everyday lives." ■