Do you believe in research miracles? YES!

• ENGINEERING

“This is an impressive feat for any university, says Alan Snyder, Vice President and Associate Provost for Research and Graduate Studies at Lehigh, and a testament to the interdisciplinary research teams that developed the three winning proposals. According to Wachs, use of the E-XPS for surface analysis will overcome shortcomings of traditional XPS instrumentation that can only operate under ultra-high vacuum pressures. With this new “near ambient pressure” capability offered by the new generation of E-XPS spectrometer, Wachs envisions research activities with the potential to advance the fundamental science and design of advanced functional materials. Many materials’ properties and functions are determined by the arrangement of their atoms—the composition, structure, and electronic properties at the material’s surface,” Wachs explains. “With the E-XPS, Lehigh researchers have a more powerful tool than ever before in the study of molecules. It is used to identify unknown substances, to characterize specific arrangements of atoms within molecules, and to study the changing interactions between molecules in solution.

Kerney Glover’s lab has recently improved the signal-to-noise ratio of its existing 500 MHz NMR with the addition of a so-called “cold probe” that uses liquid helium to cool the system’s electronics. With support from the NSF grant, the team is adding a new user console to make the device even more powerful. “The NMR allows you to get information on every single atom,” Glover says. “For protein work, this added sensitivity is very, very important and represents the latest platform.”

This system will be enable new capabilities in material synthesis that can only operate under ultra-high vacuum pressures. With this new “near ambient pressure” capability offered by the new generation of E-XPS spectrometer, Wachs envisions research activities with the potential to advance the fundamental science and design of advanced functional materials.

PROPOSAL #2
High Pressure Spatial Chemical Vapor Deposition (HPS-CVD) Reactor Development

THE TEAM
Nelson Tanou, Siddtika Pimparkar, Jonathan J. Winer, Volkan Dinoff, Nicholas C. Strandwitz, Renbo Song

“Advanced functional materials possess unique surfaces and interfaces that find widespread use, such as generation of clean H₂ fuel via photocatalytic splitting of water, solar energy storage, semiconductors, wear of materials' surfaces, biological processes, water treatment, biomolecules in their native wet environments, and medicine,” says Wachs. “Successful applications require detailed information about the surfaces and interfaces of these materials in different environmental conditions.”

“The E-XPS will give Lehigh researchers unparalleled access to surface elemental composition and chemical state information about such interactions in different environments—gas-solid, solid-liquid, and liquid-gas—over a wide range of temperatures. This is incredibly sophisticated equipment, and it is difficult for most universities to obtain such equipment without support like this from the NSF.”

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“Many materials’ properties and functions are determined by the arrangement of their atoms—the composition, structure, and electronic properties at the material’s surface,” Wachs explains. “With the E-XPS, Lehigh researchers have a more powerful tool than ever before in examining and understanding the molecular structure at the top layer of a material.”

An interdisciplinary faculty team associated with Lehigh’s Center for Photonics and Nanoelectronics (CPN) is using its MRI support to create a High Pressure Spatial Chemical Vapor Deposition (HPS-CVD) reactor, intended to be ready to grow new materials beginning in January 2018. The instrument will be managed by CPN’s technical staff, and it will be housed in the Smith Family Laboratory, a 12,000 ft² facility that enables semiconductor epitaxy, nanofabrication, and advanced device characterization.

This system will be enable new capabilities in material synthesis that includes growth under extremely high-pressure conditions, growth under extremely high-temperatures, the ability to integrate new elements, and the ability to integrate highly dissimilar materials. According to Tanou, core Lehigh faculty working in III-nitrides and new oxide/oxynitride wide bandgap semiconductors are highly productive, with more than 90 journal papers published at Lehigh over the past 5 years.

“We are truly excited to have the opportunity to build a next generation reactor with the capability of growing new materials under extreme conditions,” says Tanou, who also serves as director of CPN. “A reactor that can grow unconventional III-nitride semiconductors, oxynitride materials, and potentially integrate them with other 2-dimensional layered materials, will allow us to make novel and promising materials, to answer fundamental questions about them, and to use them to build groundbreaking devices.”

Nuclear Magnetic Resonance (NMR) spectroscopy is one of the most powerful tools available for the structural study of molecules. It is used to identify unknown substances, to characterize specific arrangements of atoms within molecules, and to study the changing interactions between molecules in solution.

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Glover specializes in the structures of membrane proteins, specifically caveolin, found on the surface of cells and involved in making special pits, called caveolae, in the cellular membrane. “This protein is implicated in heart disease, cancers, muscular dystrophy and Alzheimer’s disease,” he says, “so developing our understanding of caveolin is very important.”

Glover adds that the instrument will be available to students and researchers who need to examine materials on such a small scale. “This ensures that the impact of the NSF’s investment is as significant as possible,” he says.