New super-resolution microscope to be built at UH

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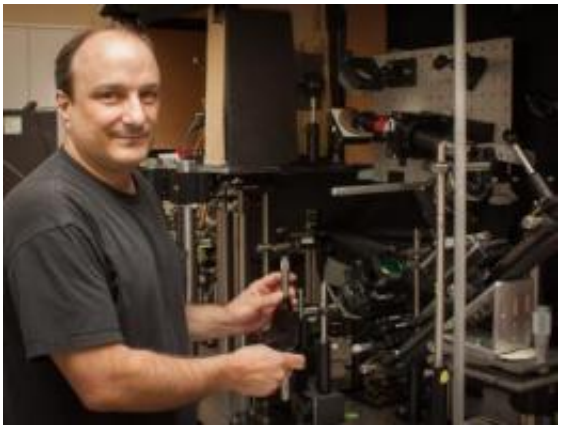

Before receiving a $1 million Keck Foundation grant to build a new super-resolution microscope, Steven Baldelli and his colleagues built a prototype to prove that the concept would work. Credit: Chris Watts

A new microscope to be built at the University of Houston (UH) will give scientists a better way to study the chemical properties of an array of surfaces, running the gamut from plastics and metals to cells and water. Researchers say this will help in both environmental studies and materials science.

A three-year, $1 million grant from the W. M. Keck Foundation was awarded to Steven Baldelli, an associate professor of chemistry at UH, to build the device. Baldelli is collaborating on this project with Kevin Kelly, an associate professor of electrical and computer engineering at

Rice University.

"Surfaces are everywhere; however, studying their chemistry is a bit tricky since surfaces are often only one or two atoms thick," Baldelli said. "Surfaces typically have different properties than the bulk of the material."

The microscope that Baldelli's group is building will allow scientists to get more information about surfaces. The current technique of sum frequency generation, or SFG, uses a laser and provides the overall surface's chemical nature, but not the detailed chemistry of different regions across a surface and how they are reacting.

"If you look at a piece of metal, some parts will be shiny, some dull, some rusty," Baldelli said. "The chemistry is not uniform across the surface. This new microscope will capture and provide data for all the areas. Current techniques blur the details of specific regions."

Baldelli says that knowing more about the various regions of a surface will be useful to many areas of science, including environmental science for studies of minerals and natural water surfaces, as well as materials science for making different materials such as metals, alloys and polymers. For the new microscope, Baldelli is combining SFG with a technique called compressive sensing imaging, which will allow scientists to break apart the data into localized regions to see the reactions of the specific area.

According to Baldelli, the laser allows them to learn how surface molecules are behaving by looking at how the molecules interact with the laser's light. When the laser beam hits the sample, the researchers recover the signal and analyze what happens after it hits, giving them data on whether the sample absorbs light, emits new signals of light or changes the polarization of the light.

Before receiving the Keck Foundation grant, the Baldelli and Kelly groups built a prototype to prove that the concept would work. Baldelli and UH graduate student Xiaojun Cai worked on the chemistry and laser optics, while Kelly and his student Ting Sun manipulated the imaging data for analysis of the surface signals. Their results were published in the *Journal of Chemical Physics*, along with another team member and UH alumnus, Bian Hu, who worked with the Rice group. The article is available online at http://jcp.aip.org/resource/1/jcpsa6/v135/i19/p194202_s1.

"It took a couple of years and was built with spare parts, but we have been able to prove that the principle works," Baldelli said. "We've shown that we can recover the images and surface signals."

The grant will allow the team to purchase a faster laser, giving them the ability to construct a device with improved image resolution and speed of data acquisition. With more than 50 groups worldwide using the current SFG technique for surface chemistry measurements, Baldelli says that once this new microscope is completed and fully tested, it will be easy for scientists worldwide to adopt the added feature of compressive sensing.

"About two-thirds of the groups using SFG already have a laser with fast acquisition," Baldelli said. "Once we build and test this combined SFG and compressive-sensing microscope, other groups should be able to implement the technique without too much additional expense."

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