

Imaging technique pulls plasmon data together

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Rice University graduate student Kyle Smith checks a sample while testing the lab's snapshot hyperspectral imaging system. Rice scientists developed the system to take instantaneous spectra of multiple plasmonic nanoparticles. Credit: Jeff Fitlow

Rice University scientists have developed a novel technique to view a

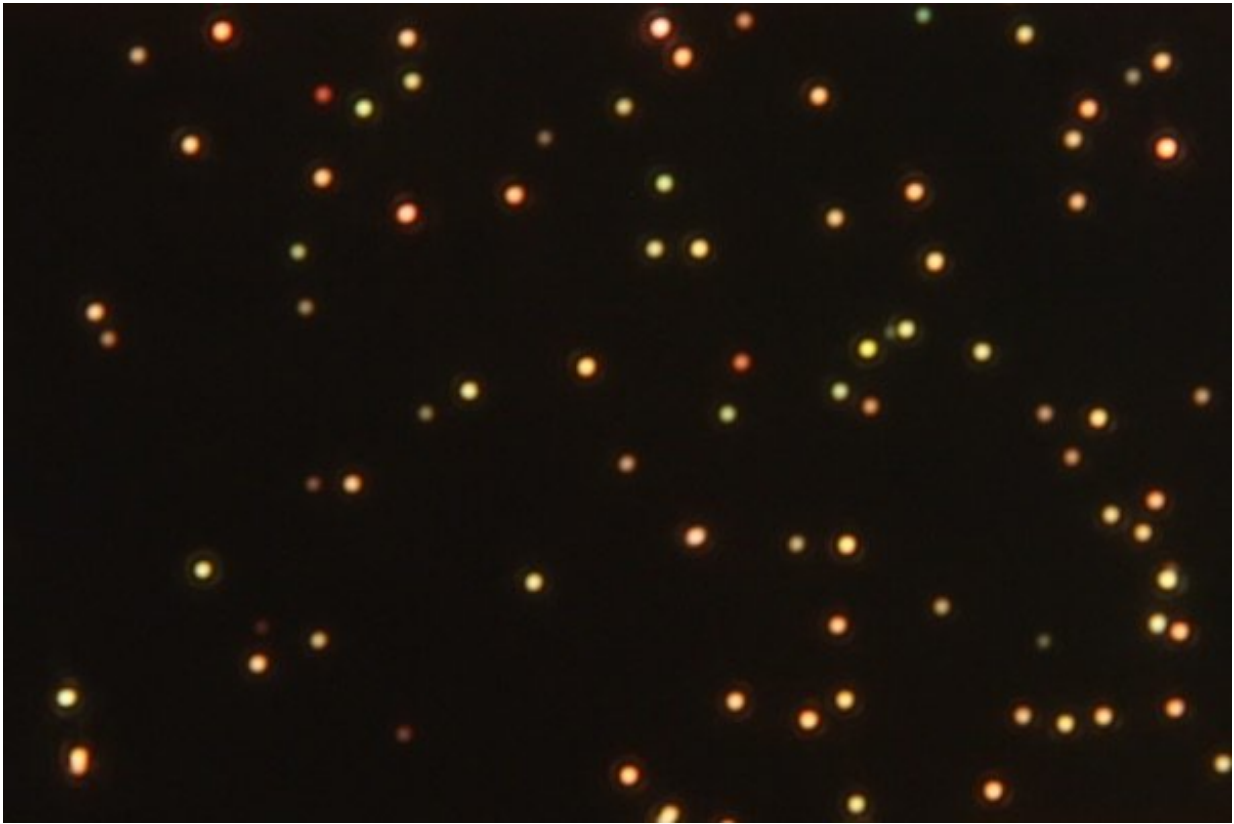
field of plasmonic nanoparticles simultaneously to learn how their differences change their reactivity.

Their new method is called snapshot hyperspectral imaging (SHI), which up to now has been used primarily in astronomy. SHI allows researchers to view minute differences between otherwise identical nanoparticles and see how they react in response to light and environmental changes.

The technique could help industries fine-tune products such as plasmonic catalysts for petrochemical processing, light-triggered nanoparticles for cancer treatment, solar cells and microelectronics.

SHI is detailed in the American Chemical Society's *Journal of Physical Chemistry*. It was developed by the Rice labs of Stephan Link and Christy Landes, both professors of chemistry and computer and electrical engineering.

Plasmons are the coordinated oscillation of electrons in metals that is triggered by light. Plasmonic nanoparticles are nanometer-sized crystals that absorb and react with light with extraordinary sensitivity. Because their size, shape, composition and local environment all influence their properties, [plasmonic nanoparticles](#) can be tuned for a wide range of applications.



Under a standard microscope, these plasmonic nanoparticles may seem identical, but an image captured by a snapshot hyperspectral imaging system developed at Rice University shows just how different they are. The system images multiple nanoparticles and their plasmonic responses – the light they emit when excited – to show how they differ due to defects or differences in their size or shape.

Credit: Rice University

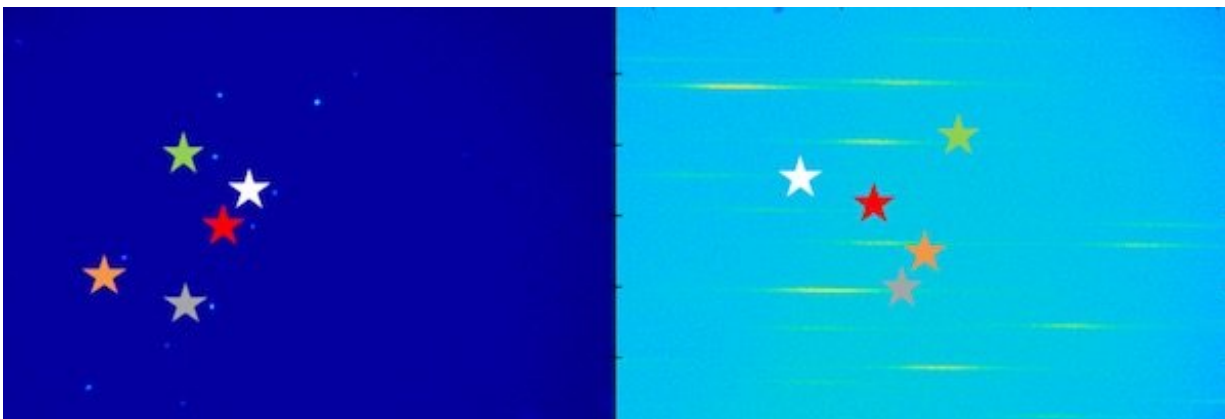
Researchers who make and study plasmonic [particles](#) generally want to know and control their reactivity, so it is crucial to be able to study many individual particles simultaneously with the best resolution of time, space and energy possible.

Until now, getting all that data has been a challenging process for single particles and impossible to do in real time.

The new method simplifies this challenge by incorporating novel hardware and performing two analyses at once: particle localization and spectroscopy. "Measuring reactions on heterogeneous samples is hard," Landes said. "You want intimate details about how a particle's surface, shape and size influence its reactivity, but once you go to look at a different particle in the sample with that level of detail, it's too late! It has already reacted."

"The trick here is to take snapshots of many particles while we're also collecting spectral information," Link said. "When combined, they provide details with millisecond time resolution about many particles while they're reacting. We don't have to start the reaction over again to get meaningful statistics."

SHI aligns a microscope, a pair of camera systems, a broad-spectrum supercontinuum laser and a diffraction grating to synchronize multiple streams of data about the target particles in an instant. It matches spatial information with spectral emissions and resolves wavelengths of light to about a fifth of a nanometer. The spectral images have a signal-to-noise ratio above 100-to-1 for ordered arrays. For random arrays with overlapping spectra, the ratio is about 20-to-1.



The dual camera snapshot hyperspectral imaging system developed at Rice University captures several types of data about plasmonic nanoparticles in an instant. The image at left shows the positions of nanoparticles in an array, while a spectral analysis of the same nanoparticles at right shows the differing range of spectra for each. Knowing the range of plasmonic responses in nanoparticles will help industry fine-tune their manufacture for specific applications. Credit: Rice University

"When you make a sample of nanoparticles, you don't get particles with exactly the same size and shape," co-author and graduate student Benjamin Hoener said. "You wind up with particles that have defect sites, slightly different shapes and crystal structures that make them absorb light and molecules on their surfaces a little differently."

A snapshot that shows each particle's color and intensity can make those differences obvious. "From that we can get important information about their electrochemical and optical properties," said postdoctoral researcher and co-author Sean Collins.

Co-lead author and graduate student Kyle Smith said SHI captures data in a thousandth of a second. "Processes in these particles occur very quickly, and they're difficult to monitor," he said. "We were able to observe kinetic processes that hadn't been observed at this time scale."

The system allows researchers to get a sense of what's happening around individual particles as well, Hoener said. "Because they're also sensitive to the local environment, we can track when electrochemical reactions occur on a single particle, at what (electrical) potential those reactions occur and compare them to see what makes this process happen faster on one particle than another," he said.

To test the system, the researchers measured randomly deposited gold

nanoparticles and gathered up to 20 simultaneous spectra with excellent resolution. In future tests, they anticipate that versions of SHI with more advanced camera sensors will capture spectra of up to 500 individual gold particles simultaneously. They hope to enhance SHI to enable spectroscopic imaging of [nanoparticles](#) as they grow from nondetectable seeds.

More information: Silke R. Kirchner et al. Snapshot Hyperspectral Imaging (SHI) for Revealing Irreversible and Heterogeneous Plasmonic Processes, *The Journal of Physical Chemistry C* (2018). [DOI: 10.1021/acs.jpcc.8b01398](#)

Provided by Rice University

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