Today, Wei-Chuan Shih, an associate professor of electrical and computer engineering, is continuing to explore the science and potential applications of his discovery of porous gold nanoparticles. These nanoparticles offer a larger surface area due to their porous nature. Shih’s work involves generating hot electrons by shining light on these nanoparticles, with the goal of harnessing their energy for various applications.

The NanoBioPhotonics Group at UH, under Shih’s direction, has been exploring how these porous gold nanoparticles react to light for several years. Last spring, Shih reported that the light-converted heat can be used to kill bacteria. Last month, he described in Nano Letters the first time surface-enhanced near-infrared absorption had been demonstrated for chemical detection and identification.

Light at specific wavelengths can excite the electrons in these nanoparticles, spurring them into movement. Taking advantage of the energy generated by this motion involves measuring what occurs over tiny fractions of time. Once the nanoparticle is struck by light, the electrons are set in motion within a few femtoseconds, or one quadrillionth of a second. The electron oscillation begins to convert to heat after a few picoseconds, or one trillionth of a second.

“We can generate hot electrons by shining light on these nanoparticles, so we are trying to take advantage of that, trying to find a way to make them work,” Shih said.

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It is the hot electrons within the first few femtoseconds that we would like to harvest, Shih said.
Under the NSF grant, Shih said researchers in his lab will study whether the hot electrons can be used to enhance a catalyst that drives chemical reactions and boosts signaling. He will work to enhance that signaling and determine ways to use it.

“There is some evidence to suggest plasmonic resonance can promote catalytic reactions,” he said of the interaction of light and the nanoparticles. “The light excites these electrons to oscillate within the nanoparticle.” Plasmonic resonance describes the way electrons in a piece of metallic nanomaterial react to light, and Shih said it happens only at certain wavelengths.

Research to speed chemical reactions can have huge payoffs in the oil or petrochemical industry, as small improvements can yield large impacts. But Shih is focused on biosensing, using the chemical reactions to produce a stronger signal from tiny targets, more quickly.

“We are interested in ultrasensitive detection of disease, including cancer biomarkers such as nucleic acids and proteins,” he said.

Learning to better amplify the signal could have a number of applications. Shih noted that enzyme-linked immunosorbent assay, or ELISA — an analysis commonly used to measure proteins in research labs — depends on a catalysis reaction to boost the signal. Discovering a way to improve the efficiency of the method would have broad consequences, just one example of how the work could be useful, he said.

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