

Gold bowties may shed light on molecules and other nano-sized objects

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One of the great challenges in the field of nanotechnology is optical imaging--specifically, how to design a microscope that produces high-resolution images of the nano-sized objects that researchers are trying to study. For example, a typical DNA molecule is only about three nanometers wide--so tiny that the contours of its surface are obscured by light waves, which are hundreds of nanometers long.

Now, researchers from Stanford University have greatly improved the optical mismatch between nanoscale objects and light by creating the "bowtie nanoantenna," a device 400 times smaller than the width of a human hair that can compress ordinary light waves into an intense optical spot only 20 nanometers wide. These miniature spotlights may one day allow researchers to produce the first detailed images of proteins, DNA molecules and synthetic nano-objects, such carbon nanotube bundles.

"One of our goals is to build a microscope with bowtie antennas that we can scan over a single molecule," says W.E. Moerner, the Harry S. Mosher Professor of Chemistry at Stanford. He and his Stanford colleagues introduced the bowtie nanoantenna earlier this year in a study published in the journal *Physical Review Letters* that was co-authored by postdoctoral fellow P. James Schuck and graduate student David Fromm in the Department of Chemistry, and Professor Emeritus Gordon Kino and graduate student Arvind Sundaramurthy in the Department of Electrical Engineering.

Golden bowties

The bowtie nanoantenna consists of two triangular pieces of gold, each about 75 nanometers long, whose tips face each other in the shape of a miniature bowtie. The device operates like an antenna for a radio receiver, but instead of amplifying radio waves, the bowtie takes energy from an 830-nanometer beam of near-infrared light and squeezes it into a 20-nanometer gap that separates the two gold triangles. The result is a concentrated speck of light that is a thousand times more intense than the incoming near-infrared beam.

"What you end up with is a very small optical spot that you could scan to make detailed images of molecules and other nano-particles," says Kino, the W.M. Keck Foundation Professor of Electrical Engineering, Emeritus. "Normally we use lenses to focus, but it's not possible to resolve detail in objects smaller than one-half the wavelength of light."

Because the shortest wavelength of visible light is 400 nanometers, a conventional microscope cannot resolve objects 200 nanometers or smaller. "But the bowtie antenna produces an optical spot that's 20-nanometers wide, so we're improving the resolution by a factor of 10," Kino says.

Polymers and sensors

In addition to nano-scale optical imaging, Moerner says that bowties may be useful in photopolymerization, a process that uses light to create synthetic compounds (polymers), which researchers can use to trap nano-particles and place them in specific locations. "It's difficult to put molecules and crystals exactly where you want them when you're working at a nano-scale," Schuck explains.

Bowties also may have applications in Raman spectroscopy, a technique that allows scientists to identify individual molecules by measuring the vibrational energy the molecule emits when exposed to light. "It's analogous to fingerprinting," Schuck explains. "Each molecule has a unique vibrational energy, and bowties have a potential use as biological or chemical sensors that can differentiate molecules."

The Stanford team plans to explore these and other practical applications of bowtie nanoantennas in future experiments. On Aug. 30, Moerner will discuss bowties and other developments in the field of nanophotonics at the annual meeting of the American Chemical Society in Washington, D.C.

Source: Stanford University

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