Energy dissipation from vibrating gold nanoparticle strongly influenced by surrounding environment

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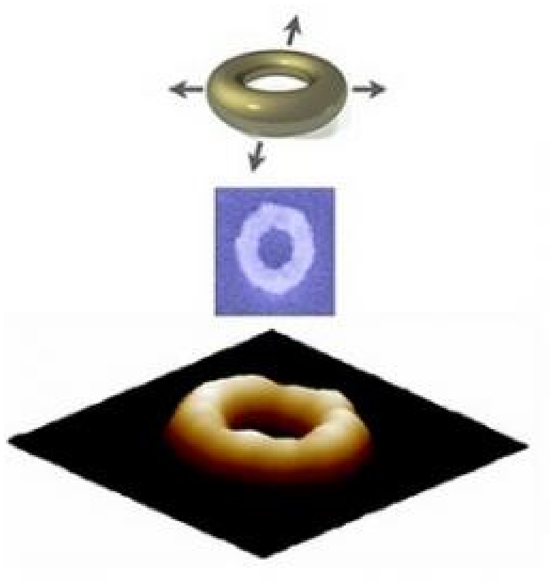

Illustration representing topography of a gold nanoring where a new method of sensing has been shown based on the damping of acoustic vibrations probed by transient absorption spectroscopy Copyright : A*STAR

Metal nanoparticles could play a key role in next-generation light detectors, optical circuits, and cancer therapies. For these future technologies to be realized, it is important to understand what happens when nanoparticles are caused to undergo vibrations, and the consequent scattering of light that can occur due to oscillations, or surface plasmons, in their free electron cloud. However, little is known about exactly how these vibrations are affected by the nanoparticle's immediate surroundings — in particular, how the environment affects the dissipation of energy from a nanoparticle when it vibrates.

Sudhiranjan Tripathy at the A*STAR Institute of Materials Research and Engineering and co-workers, collaborating with Arnaud Arbouet and colleagues from the National Center of Scientific Research (CNRS) in France, have now analyzed the effect of different environments on individual gold nanoparticles, their acoustic vibrations and associated energy dissipation.

The researchers examined individual nanorings made of gold using transient absorption spectroscopy, which involves exciting the sample with a pulse of laser light before measuring the absorbance of light at various wavelengths. They measured both the vibration period and damping time — the rate at which the nanoring loses its energy to its surroundings.

"When a metallic system is downsized to nanometric dimensions, its vibration modes can become very different in comparison to its bulk form," explains Tripathy. "For example, the damping of the acoustic vibrations is strongly affected by the elastic properties of the environment and the interface between the nanoparticle and its environment."

Previous spectroscopy studies have experimented with large groups of nanoparticles, but the collective approach has its limits because nanoparticles of different sizes may have different vibration periods. The researchers overcame the problem by working with individual nanorings, but the workaround did have its own difficulties.

The first challenge was the nanofabrication of perfectly controlled and characterized nano-objects. Secondly, there was the issue of detecting and monitoring the acoustic vibrations of one single metal nano-object. This meant that the researchers had to measure relative changes on the order of one in 10 million.

The researchers studied individual nanorings that were surrounded by either air or glycerol, and focused on how the different environments affected the damping time of the vibrations. This provided valuable insight into how energy dissipated from the nanorings to their environment. Most tellingly, the damping times were significantly shorter in the highly viscose glycerol.

“Our work opens up exciting perspectives including the use of metal nanoparticles as mass sensors, or as nanosized probes of the elastic properties of their local environments,” says Tripathy.

More information: Marty, R. et al. Damping of the acoustic vibrations of individual gold nanoparticles. *Nano Letters* 11, 3301–3306 (2011). pubs.acs.org/doi/abs/10.1021/nl201668t

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