Can silver nanoparticles be the key to a more compact laser?

9 June 2008, By Miranda Marquit

“In random media, multiple scattering and interference reduce the diffusion of light, and in case of extremely strong scattering, photon localization, or Anderson localization of light, is predicted like electrons in glasses,” Katsuhisa Tanaka, a scientist in Kyoto University, tells *PhysOrg.com*. He and his colleagues are interested in using so-called disordered material to create lasers that could increase our understanding of physics – as well as make the laser creation process simpler.

With Xiangeng Meng, Koji Fujita (also doing work at PRESTO in Saitama, Japan), Yanhua Zong and Shunsuke Murai at Kyoto University, Tanaka has been working on using transparent films embedded with nanoparticles of silver to study the feedback coherence from certain random lasers. Their work can be seen in *Applied Physics Letters*: “Random lasers with coherent feedback from highly transparent polymer films embedded with silver nanoparticles.”

“Random lasers are laser sources that arise from multiple scattering events in random systems so that the strength of light scattering is of large importance in determining the feedback type of laser oscillation, Tanaka explains. “We are interested in such lasers because their fabrication process is technically simple while high gain is involved. At present, researchers are focusing on random lasers based on dielectrics with high refractive index, while little attention has been paid to metal nanostructures-based amplifying random media.”

He continues: “Actually, metal nanostructures are rather potential materials in laser devices. The use of surface plasmon resonance of metal nanostructures is extremely attractive because they bring about surface enhanced Raman scattering, enhancement of spontaneous emission, and amplified spontaneous emission, and so on. What we have consisdered for a long time is whether laser actions with high gain could be achieved by combining metal nanostructures and laser working medium.”

Indeed, this led Tanaka and his peers to wonder if surface plasmon resonance can help random lasing. The answer, in their minds, is yes: “We found that the presence of silver nanoparticles results in the coherent output even though the scattering strength of the system is very weak. We believe that surface plasmon plays an important role in the laser operation.”

In order to make the demonstration work, the Kyoto team embedded silver nanoparticles on highly transparent polymer films. The process was made possible through the in situ method, in which heat is used to create the hybrid material, combining polymer with metal in a way that is useful in terms of lasing. “We have calculated the transport mean free path of our sample and found that it is far larger than the sample size. The light propagates in such systems nearly freely without resistance,” Tanaks says. “Then, the issue that puzzles us is this: What on earth induces laser oscillation?”

Tanaka points out that silver nanoparticles make a difference: “First, localized optical modes near silver nanoparticle surface provide high optical gain for lasing. Second, scattering properties can be flexibly controlled by the size and shape of nanoparticles, and significantly contribute to light transport in random systems compared to that in dielectric nanoparticles.”

In terms of application, Tanaka sees possibilities for fundamental physics knowledge, as well as practical uses for this set-up. “Since the phenomena of random laser are reported for systems having very different scattering strength from nearly transparent to highly-scattering media, it is possible that the laser mechanism -- or dominating laser mode -- is different depending on the scattering strength. Thus the primal importance is to clarify the mechanism, which is beneficial to the progress of the physics."

As far as practical applications, he says that there is a strong possibility of a compact laser. Plus, Tanaka continues, "Since this type of lasers does not require rigorous alignment of reflectors to form cavity in contrast to the conventional Fabry-Perot type ones, the making process is much simpler."

The team at Kyoto continues to work on this project. Tanaka and his coworkers say that more needs to be known with regard to how the distribution of the silver nanoparticles within the polymer affects the laser. Additionally, they feel that this work could lead to advances in lasers that are based on organic semiconductors.

APA citation: Can silver nanoparticles be the key to a more compact laser? (2008, June 9) retrieved 25 October 2020 from https://phys.org/news/2008-06-silver-nanoparticles-key-compact-laser.html