

Researchers develop new technique for production of plasmonics devices

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Research laboratories are constantly developing new materials that are expected to exhibit novel properties bound to revolutionize this or that technology. But it's not enough to simply create these materials;

scientists also need to find efficient methods of processing and fine-tuning them. Moreover, composites are often made via the addition of nanoparticles into a base matrix, which is why it is necessary to find a way of manipulating the location, size, and concentration rate of these particles that would exclude even the smallest deviations that are invisible to the human eye.

Researchers from ITMO University have improved on the technique of local processing of composites based on nanoporous glass with addition of silver and copper. Now, it is possible to predict with high accuracy the optical properties of a plasmonic component during its treatment. This research was published in *Nanomaterials*.

For millennia, humanity had to adapt to the materials it had at its disposal: metals, wood, stone, minerals, etc. Today, humans have learned to adapt the materials they have to their own needs, creating [composite materials](#) out of several components. These materials have new properties and open up new opportunities. They have great potential for use in [optical devices](#) such as lasers, lidars, sensors, lenses, wave guides, and other devices that process light signals. In particular, researchers have great hopes for glass enhanced with metal nanoparticles.

"Such materials can be used as optical filters," explains Pavel Varlamov, a research engineer at the Faculty of Laser Photonics and Optoelectronics. "White light, as we know, consists of a large number of wavelengths and you might need to, for example, highlight or exclude a certain spectrum band, like blue or yellow. That's what optical filters are for, and they can be used in lasers, refractors, lenses, or wave guides."

Depending on which metal's ions are added into glass, the resulting composite can be used to manipulate various parts of the spectrum. For instance, if you were to add nanoparticles of silver and copper into glass, it would absorb radiation in the blue-green band. But adding silver and

copper nanoparticles into regular glass, such as the kind used to make windows or kitchenware, would be a complex and expensive process involving numerous chemical reactions. That's why scientists prefer to use special nanoporous glass for these purposes.

Once nanoparticles have been "fitted" into the pores, the material is altered with laser radiation in order to enhance it with new optical properties that make it possible, for instance, to accurately control the light spectrum by transmitting or absorbing light beams of a specific band.

But there is an issue: during the treatment intended to "glue together" the components of a new material, metal nanoparticles change their shape and even their chemical make-up. Throughout the process, material changes the way it interacts with laser radiation; essentially, it begins to better absorb radiation within a specific band of the spectrum. This presents several challenges for the treatment process. A laser cannot be simply tuned to specific values and then used to treat the material from start to end; it must be continuously adjusted to the changes that occur within the material.

"The method we've suggested makes it possible to create voluminous micro-scale elements with a plasmonic resonance peak that can be controlled in real time," says Roman Zakoldaev, a researcher at the Faculty of Laser Photonics and Optoelectronics. "The method aims to optimize the parameters of laser altering via feedback."

In order to adjust the laser's performance throughout the treatment, scientists need to instantly conduct complex calculations of changes that have already occurred and the changes that would need to be made to the laser's settings. For that, they need a flexible physico-mathematical model; such a model has become the basis of an algorithm designed to manage the processing of these materials.

The researchers from ITMO University have suggested a mathematical model that would take into account the strength of the radiation and the changes it causes in the material. This allows the researchers to produce materials with the exact optical properties that were initially factored into calculations.

"We were able to propose a calculation algorithm that presents the electronic structure, size, and concentration of nanoparticles with the optical properties of material as one effective environment (?)," says Maksim Sergeev. "Using the algorithm together with a model of diffusion-controlled growth of particles has made it possible for us to trace the optical changes in [laser](#) treatment in real time."

The suggested method would make the creation of unique optical plasmonic components cheap and easy to handle, opening up new opportunities for their integration into industrial production.

More information: Maksim M. Sergeev et al, Real-Time Analysis of Laser-Induced Plasmon Tuning in Nanoporous Glass Composite, *Nanomaterials* (2020). [DOI: 10.3390/nano10061131](https://doi.org/10.3390/nano10061131)

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