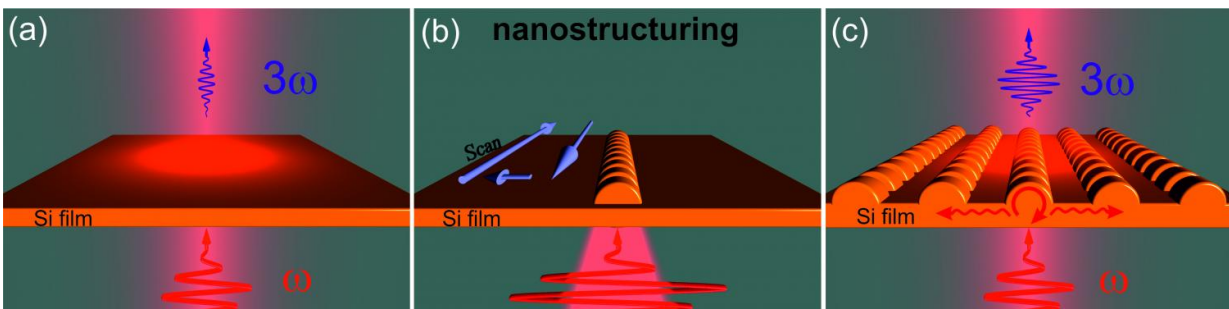


# Scientists develop new metasurfaces for deep UV-imaging

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Schematic sketches of UV generation from (a) smooth and (c) nanostructured Si film. (b) Principle of Si film laser-induced nanostructuring. Credit: ITMO University

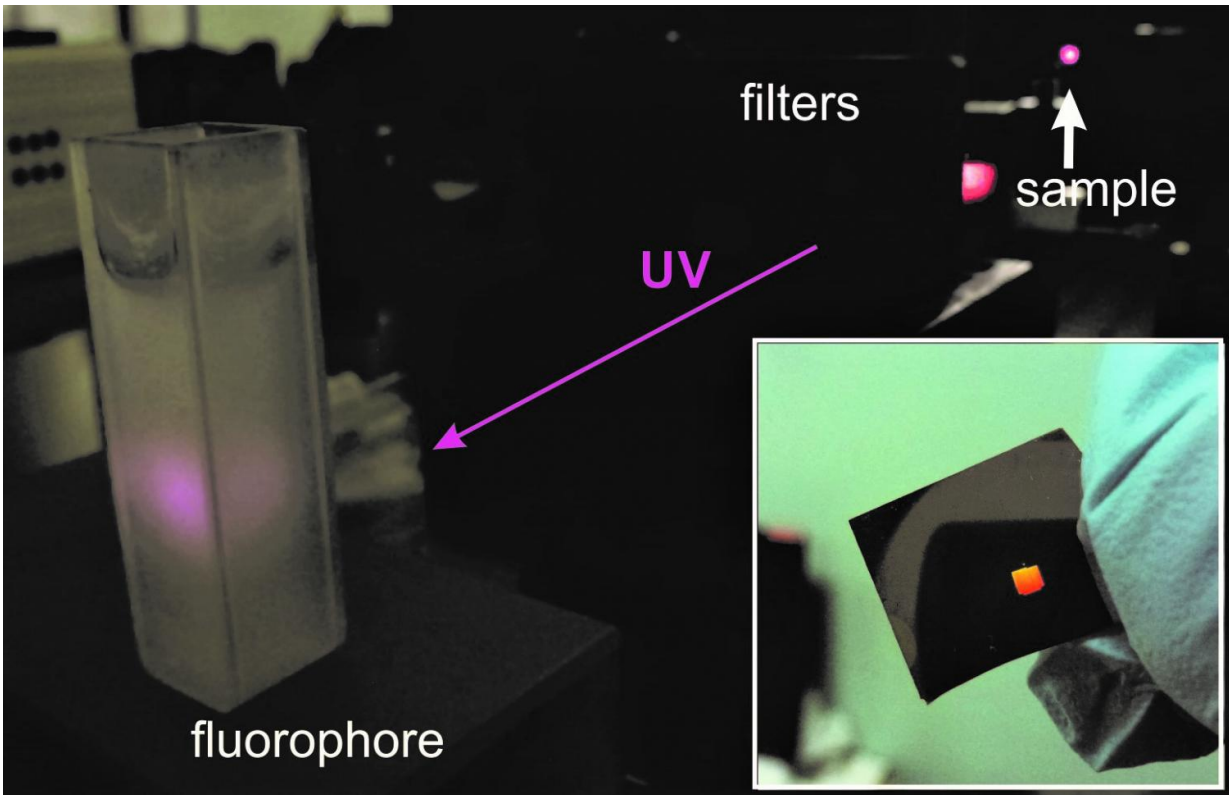
Russian researchers have developed a new material that converts infrared light to ultrashort pulses of ultraviolet. For this purpose, the scientists exposed silicon film to a laser so that its relief adjusted under the light wavelength and made properties of the material resonant. The result was a cheap and easy-to-make metasurface as effective as existing ones. The new technology is applicable in compact UV generators for biophotonics and medicine, and also devices for ultradense data processing in optical communications. The study was published in *Nanoscale*.

Biological media can reflect, absorb, scatter and re-emit light waves.

Each of these processes contains information about micro- and macrostructure of the media, as well as shape and motion of its components. In this regard, deep ultraviolet is a promising tool for biology and medicine. Its application includes laser diagnostics and control of fast processes in cells, laser therapy and surgery at the molecular level.

Researchers from ITMO University and Saint Petersburg Academic University have developed a new method for nanostructures fabricating, which is able to convert infrared light to deep ultraviolet. The structure is a film with a regular massive of nanolumps – metasurface. It is generated by radiating silicon film, whose thickness is 100 nanometers, with ultrashort or femtosecond laser pulses that form its relief. On the film surface, the laser smelts such nanolumps, which resonate only with its wavelength and thus allow more radiation to be turned into ultraviolet. In other words, the laser adjusts metasurface to itself. When the relief is formed, the scientists reduce the power so the film starts converting radiation without deformation.

The researchers have managed not only to convert [infrared light](#) into violet, but also to get deep ultraviolet. Such radiation is strongly localized, has very short wavelength and distributes as femtosecond pulses. "For the first time, we've created a metasurface that stably emits femtosecond pulses of high power in the ultraviolet range," notes Anton Tsyarkin, assistant of ITMO's Department of Photonics and Optical Information Technology. "Such light can be applied in biology and medicine, as femtosecond pulses affect biological objects more precisely."



Photography of fluorescence induced by generated UV light in fluorophore. Inset - view of the sample with a self-organized metasurface (orange area). Credit: ITMO University

For example, using deep UV, researchers can image a molecule during its chemical transformation and understand how to manage it. "A femtosecond compared to a second is almost like a second compared to the lifetime of the universe. It's even faster than the vibration of atoms in molecules. So such short pulses can tell us a lot about matter structure in motion," says first author Sergey Makarov, senior research associate of ITMO's Department of Nano-Photonics and Metamaterials.

The [new technology](#) may also find applications in [optical communications](#). "Using [ultrashort laser pulses](#) for data transmission, we

will make the flow denser and enhance its speed. It will increase the performance of systems for transferring and processing information. Additionally, we can integrate such metasurfaces into an optical chip to change beam frequency. This will help separate data flows and enable major computing at the same time," comments Anton Tsyppkin.

The metasurface obtained in this way is a monolithic structure, as opposed to being assembled of isolated particles, as it was before. It conducts heat better and thus lives longer without overheating.

In photonics, researchers always have to search for compromise. Standard nonlinear crystals used for ultraviolet generation are big, but can convert up to 20 percent of radiation. Such efficiency is higher than that of metasurfaces, but laser pulses lengthen inside crystals. "This happens because a laser beam contains many wavelengths that differ from each other only by several decades of nanometers. Such variance is enough to make some waves surpass others. In order to make pulses ultrashort again, additional expensive devices are required," explains Makarov.

Thin structures such as metasurfaces do not allow [laser pulses](#) to misalign, but still have a low efficiency. Furthermore, both metasurfaces and crystals are usually expensive and difficult to make. However, in the new study, the scientists have managed to make metasurface fabrication much easier and cheaper, and at the same time, these surfaces are as effective as their expensive counterparts.

**More information:** S. V. Makarov et al. Self-adjusted all-dielectric metasurfaces for deep ultraviolet femtosecond pulse generation, *Nanoscale* (2016). [DOI: 10.1039/C6NR04860A](https://doi.org/10.1039/C6NR04860A)

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