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Scientists develop a minimally traumatic and inexpensive ceramic laser scalpel

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Scientists from MIPT and their colleagues have developed a compact and powerful ceramic-based laser with applications in minimally traumatic and inexpensive laser surgical scalpels, and also for cutting and engraving composite materials. The results of the study have been published in *Optics Letters*.

Today, lasers are in consumer electronics devices, medicine, metallurgy, metrology, meteorology, and many other areas. Lasers are created by stimulated emission in an active medium, which could be a gas, liquid, crystal, or glass. The wavelength of a laser and the efficiency of converting energy into radiation are both dependent upon the parameters of the active medium.

Ivan Obronov, a researcher at MIPT, and his colleagues used a ceramic obtained from compounds of rare-earth elements – lutetium oxide with added thulium ions ($Tm^{3+}:Lu_2O_3$). It was the thulium ions that enabled the ceramic to generate laser radiation.

"Ceramics are a promising type of medium for lasers because they are produced by sintering powders into a polycrystalline mass. They are cheaper and easier to manufacture than single crystals, which is extremely important for mass adoption. In addition, it is easy to alter the chemical composition of ceramics, which in turn alters the laser properties," explains Obronov.

The laser they developed converts energy into radiation with an efficiency of more than 50 percent, while other types of solid state lasers have an average efficiency of approximately 20 percent; it generates infrared radiation with a wavelength of about two microns (1966 and 2064 nanometres). The wavelength is what makes this laser so useful for medical purposes.

"Radiation from the most common infrared lasers, with a wavelength of about one micron, has very little absorption and penetrates deep into biological tissue, which causes coagulation and large areas of 'dead' tissue. A surgical scalpel needs to 'operate' at a very specific depth, which is why two-micron lasers are used, as they do not damage underlying tissue," says Obronov.

According to him, doctors usually use two-micron flashlamp-pumped holmium lasers, but these devices are very expensive, relatively bulky, and are not very reliable.

"Ceramic lasers have a significant competitive advantage—they are cheaper to manufacture, simpler and more reliable, and approximately four times more compact than holmium lasers. They will be ideal for surgical use," says Obronov.

Another potential application of ceramic lasers is the composite industry. Widely used one-micron lasers are good at cutting metal, but polymers are practically transparent to them. A two-micron ceramic laser, on the other hand, can effectively cut and engrave plastics, such as composite materials.

Composites are increasingly being used to produce technological equipment such as aircraft components. The wing of the new Russian MS-21 airplane is almost entirely made of composites. A ceramic laser could also be a useful tool for production industries," concludes Obronov.

More information: Oleg Antipov et al. Highly efficient 2 μm CW and Q-switched Tm^3+:Lu_2O_3 ceramics lasers in-band pumped by a Raman-shifted erbium fiber laser at 1670 nm, *Optics Letters* (2016). DOI: 10.1364/OL.41.002298

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