Medical 'lightsabers': Laser scalpels get ultrafast, ultra-accurate, and ultra-compact makeover

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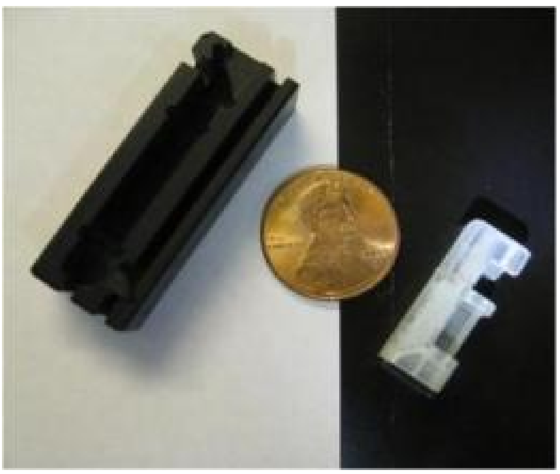
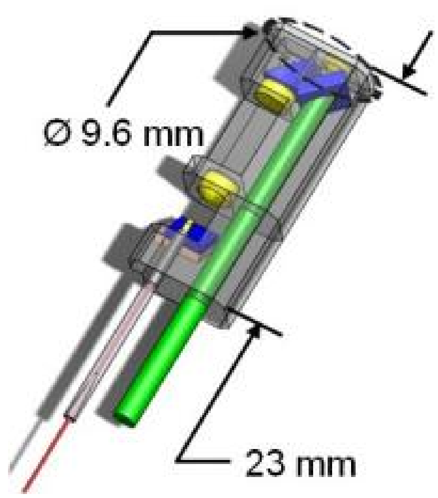


This is a photograph of the 9.6-millimeter probe housing (right) next to the housing of the earlier prototype 18-mm probe (left) showing the reduction in packaged probe size. A penny is shown for scale. The scale bar is five micrometers. Credit: Ben-Yakar Group, University of Texas at Austin

Whether surgeons slice with a traditional scalpel or cut away with a surgical laser, most medical operations end up removing some healthy tissue, along with the bad. This means that for delicate areas like the brain, throat, and digestive tract, physicians and patients have to balance the benefits of treatment against possible collateral damage.

To help shift this balance in the patient's favor, a team of researchers from the University of Texas at Austin has developed a small, flexible endoscopic medical device fitted with a femtosecond laser "scalpel" that can remove diseased or damaged tissue while leaving healthy cells untouched. The researchers will present their work at this year's Conference on Lasers and Electro Optics (CLEO: 2012) in San Jose, Calif., taking place May 6-11.

The device, which was engineered with off-the-shelf parts, includes a laser capable of generating pulses of light a mere 200 quadrillionths of a second in duration. These bursts are powerful, but are so fleeting that they spare surrounding tissue. The laser is coupled with a mini-microscope that provides the precise control necessary for highly delicate surgery. Using an imaging technique known as "two-photon fluorescence," this specialized microscope relies on infrared light that penetrates up to one millimeter into living tissue, which allows surgeons to target individual cells or even smaller parts such as cell nuclei.

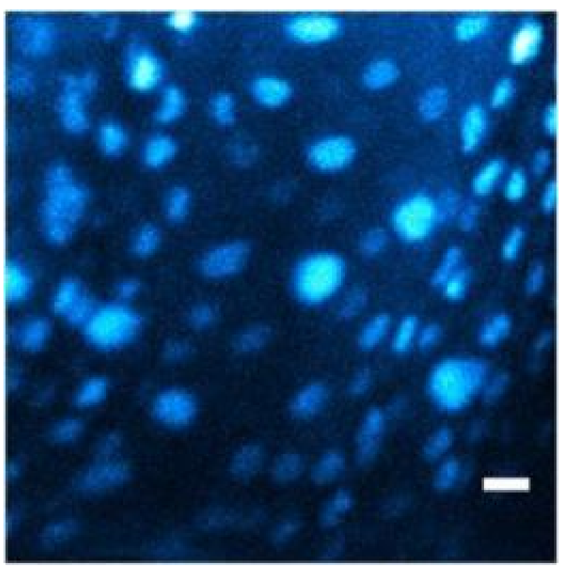


The packaged endoscope is overlaid with the optical system. The circumference is 9.6 millimeters and the length is 23 millimeters. Credit: Ben-Yakar Group, University of Texas at Austin

The entire endoscope probe package, which is thinner than a pencil and less than an inch long (9.6 millimeters in circumference and 23 millimeters long), can fit into large endoscopes, such as those used for colonoscopies.

"All the optics we tested can go into a real endoscope," says Adela Ben-Yakar of the University of Texas at Austin, the project's principal investigator. "The probe has proven that it's functional and feasible and can be [manufactured] commercially."

The new system is five times smaller than the team's first prototype and boosts the imaging resolution by 20 percent, says Ben-Yakar. The optics consist of three parts: commercial lenses; a specialized fiber to deliver the ultrashort laser pulses from the laser to the microscope; and a 750-micrometer MEMS (micro-electro-mechanical system) scanning mirror. To hold the optical components in alignment, the team designed a miniaturized case fabricated using 3-D printing, in which solid objects are created from a digital file by laying down successive layers of material.



An image taken with the probe's two-photon fluorescence microscope shows cells in a 70-micrometer thick piece of vocal cord from a pig. The scale bar is 10 micrometers. Credit: Ben-Yakar Group, University of Texas at Austin

Tabletop femtosecond lasers are already in use for eye surgery, but Ben-Yakar sees many more applications inside the body. These include repairing the vocal cords or removing small tumors in the spinal cord or other tissues. Ben-Yakar's group is currently collaborating on two projects: treating scarred vocal folds with a probe tailored for the larynx, and nanosurgery on brain neurons and synapses and cellular structures such as organelles.

"We are developing the next-generation clinical tools for microsurgery," says Ben-Yakar.

The new design has so far been laboratory-tested on pig vocal chords and the tendons of rat tails, and an earlier prototype was laboratory-tested on human breast cancer cells. The system is ready to move into commercialization, says Ben-Yakar. However, the first viable laser scalpel based on the team's device will still need at least five years of clinical testing before it receives FDA approval for human use, Ben-Yakar adds.

Provided by Optical Society of America

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