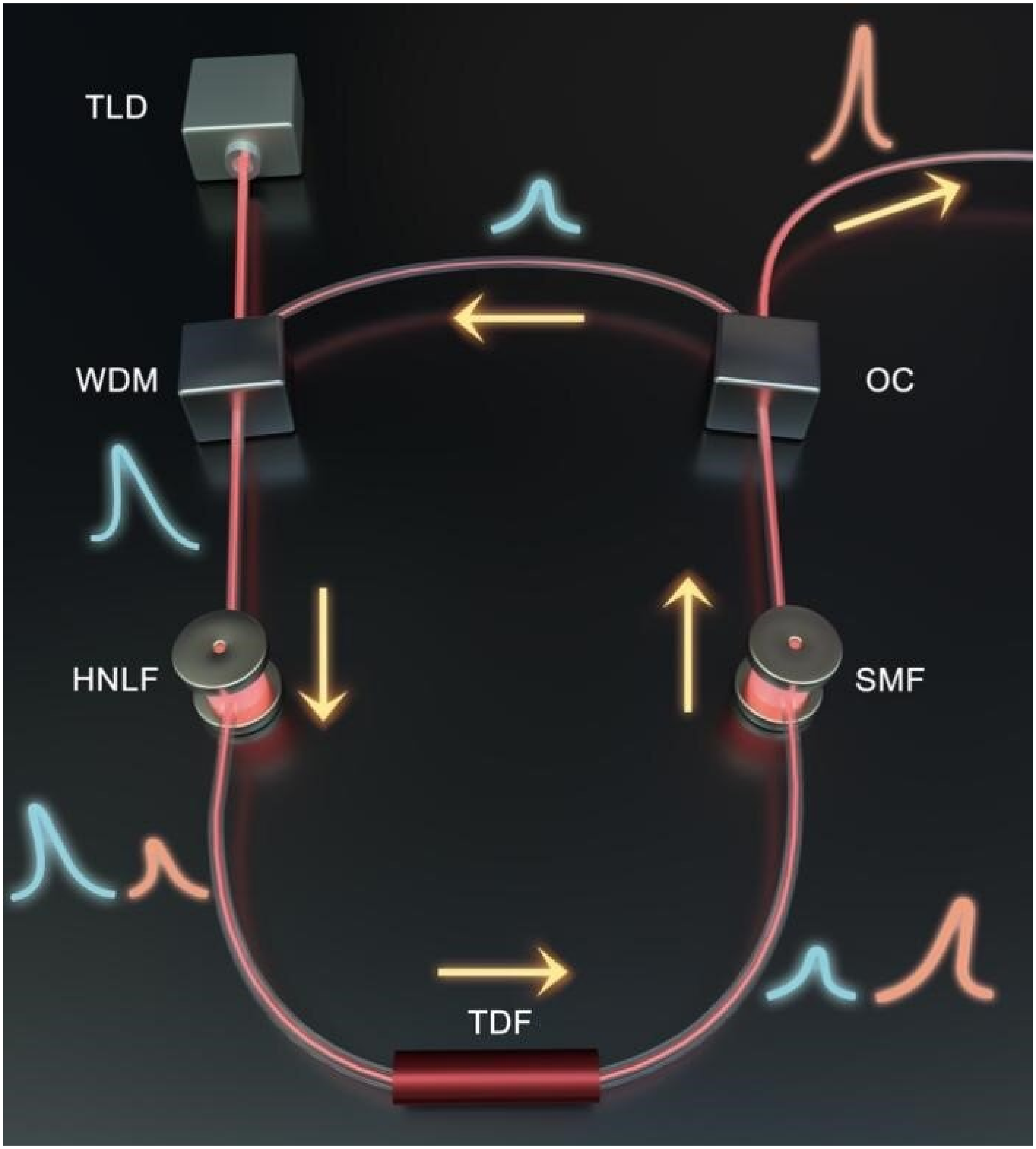
High-power hybrid laser emitter penetrates deeper into skin to enhance disease diagnosis

April 26 2022



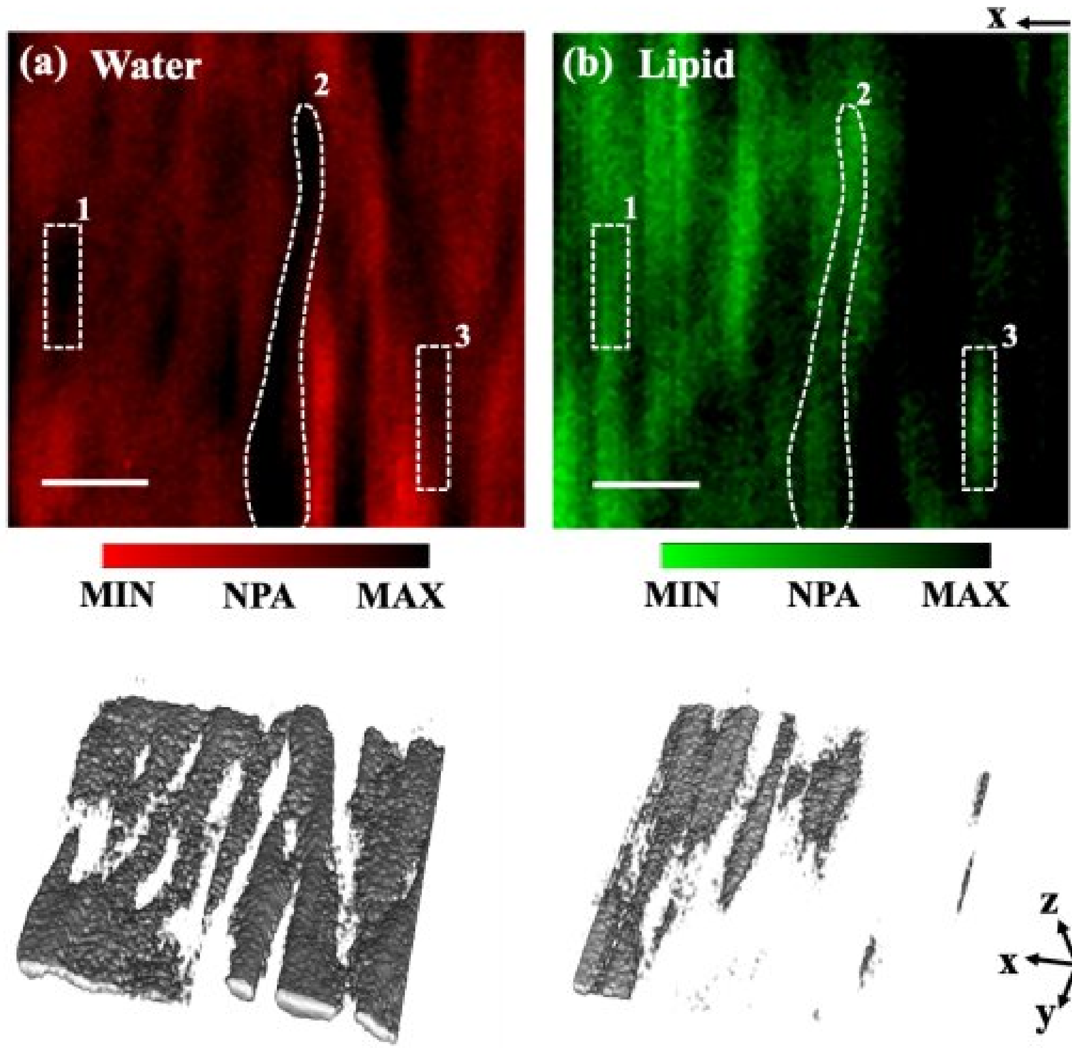
The energy of pump signal at 1.55μm band was converted to the idler signal at 1.9μm via four-wave mixing (FWM) and then it was amplified by a thulium-doped fiber (TDF) to output. Credit: Jiawei Shi, Mingsheng Li, Huajun Tang, Jiqiang Kang, Najia Sharmin, Amir Rosenthal, Kenneth K. Y. Wong

An advancement in ultrasound imaging is photoacoustic imaging (PAI), in which the skin or tissue absorbs pulses of laser light. The thermoelastic expansion of the skin or tissue emits sound, which is processed by the machinery to develop high-resolution images. Recent developments have theorized the existence of vibrational PAI, which could penetrate further into the skin.

In a new paper published in *eLight*, a team of scientists led by Professor Kenneth K. Y. Wong of the University of Hong Kong has developed a high-power hybrid laser emitter designed to penetrate deep into the skin. The paper, titled "Hybrid optical parametrically oscillating emitter at 1,930 nm for volumetric photoacoustic imaging of water content," sought to map out the water content in the body to analyze the biological properties of cells, tissues, and organs.

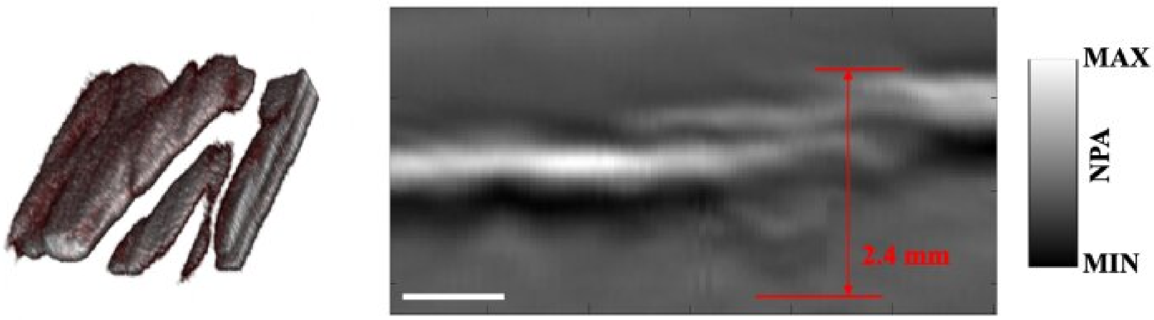
The PAI technique needs to generate high-resolution images with a low signal-to-noise ratio (SNR). The laser needs to have a high laser pulse energy, fast pulse repetition rate, and accurate wavelength tunability to achieve this goal. Water absorbs energy at a relatively low wavelength of about 1000 nm, which usually requires milli-joule level pulse energy. That sort of energy can burn the skin, while the lasers that operate at that level are expensive.

The research team developed a high-power all-fiber hybrid optical parametrically-oscillating emitter (HOPE) at 1930 nm. It is the best wavelength for determining the water content of tissue and fats. The HOPE emits laser pulses every 15 nanoseconds (ns), with a 1 nm bandwidth. The research team verified the performance of their system through a proof-of-concept optical-resolution PA microscope system.



A same piece of pork sample was scanned at both 1930 nm and 1750 nm for volumetric visualization of lipid-rich and watery components respectively. Credit: Jiawei Shi, Mingsheng Li, Huajun Tang, Jiqiang Kang, Najia Sharmin, Amir Rosenthal, Kenneth K. Y. Wong

The team found that the 1930 nm system improved penetration depth by 2.4 mm. The research team owed it to reducing photon scattering in the tissue within the shorter wavelength near-infrared lasers. The improved penetration ability could facilitate measurable imaging of water content in the deep tissue.



A piece of fresh salmon fish was imaged in a step of 30μm. The imaging depth is around 2.4 mm, which is a result from the compromise between low scattering coefficient and high absorption coefficient of the water at 1930 nm. Credit: Jiawei Shi, Mingsheng Li, Huajun Tang, Jiqiang Kang, Najia Sharmin, Amir Rosenthal, Kenneth K. Y. Wong

Better measuring of water content could improve the quality of medical diagnosis going forward. These excellent advantages could help open broad biological research and disease diagnosis avenues.

More information: Jiawei Shi et al, Hybrid optical parametrically-oscillating emitter at 1930 nm for volumetric photoacoustic imaging of water content, *eLight* (2022). DOI: 10.1186/s43593-022-00014-2

Provided by Chinese Academy of Sciences