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Subsurface temperature imaging techniques during infrared laser-tissue interactions

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Thermal cameras can be used to study the thermal effects during IR laser tissue interaction, however, it is limited to the surface of a tissue and the typical video rates are 25 to 50 frames/s. A new strategy has been developed to enable visualization of the absolute temperature distribution below the surface by sandwiching biological tissue between ZincSelenide windows. A thermo camera, enhanced with close-up optics, looks through the window from aside during laser exposure at the surface. In addition, high speed imaging up to 10.000 frames is used to visualize the temperature gradients below the surface in a transparent tissue model based on color Schlieren techniques.

The basic temperature distribution and dynamics underneath the surface of biological tissues were studied with various IR laser systems: 810 nm continuous wave Diode, 2.0 µm continuous wave Thulium, 2.78 µm pulsed Er:YSGG, continuous wave and pulsed 10.6 µm CO2. Depending on the wavelength, designated optical fibers were used to deliver the IR light to the tissue: silica fibers, hollow waveguides, silver halide fibers and photonic bandgap fibers. The laser beam was either in a static position or scanned over the surface. The thermal imaging was simultaneously recorded with normal video for comparison.

The thermal, high speed and normal imaging techniques showed to be both compatible and complementary. The subsurface thermal imaging enable comparison and better understanding of the tissue effects between various continuous wave and pulsed IR laser systems and delivery systems.