MID-INFRARED SOLID-STATE LASER SYSTEMS FOR MINIMALLY INVASIVE SURGERY

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Abstract: In 1995 it was demonstrated that targeting biological tissues with a mid-infrared Mark-III Free-Electron Laser (FEL) at wavelengths near 6.45 µm results in tissue ablation with minimal collateral damage and a substantial ablation rate, which is especially useful for e.g. neural & ophthalmologic surgery [1,2]. Based on these findings the European Union has granted a 3 year FP7 project to a consortium to develop advanced table-top solid-state photonic sources for this specific wavelength in the mid-IR spectral range, as a practical, reliable and cost-effective alternative to large-scale free-electron lasers (FELs). The ultimate goal of this project is to make this laser source a viable supplement to the existing medial laser assortment on the market. 4 work packages have been defined in this project. Material research [WP1]; Pump laser development [WP2], OPO development [WP3] and Verification [WP4] Each project partner is working one of more work packages to ultimately develop 4 OPO systems that will be compared to the existing FEL results. The visualisation and quantification experiments are being performed by the UMC Utrecht in collaboration with the VU medical center to analyze the ablation parameters of these systems. Unique visualization techniques have been developed to study the interaction of various infrared laser wavelengths. Model and biological tissues are used to obtain a better understanding of the ablation mechanism and the contribution of physical processes such as shockwaves, cavitation, explosive vapor, tissue heating, thermal conduction and diffusion. Using a unique sub surface thermal imaging set up, Schlieren imaging and high speed imaging techniques a comparison among parameters such as energy, pulse duration and diameter of focus can be obtained [3]. At this point one of the four OPO systems in development is running stable at 6.45 µm with energy levels around the ablation threshold of tissue (1.2 mJ at 25 Hz).. We have obtained some preliminary ablation results with our imaging setups on this system, however the energy levels are still to low to verify these findings to the FEL literature results. Milestones of the coming project year indicate that the energy levels of the OPO systems will be around 5 to 10 mJ per pulse at repetition rates around 25 Hz. This will enable a decent comparison with existing laser sources and the FELs and explore its earlier mentioned future clinical applications.