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Advanced medical applications as a challenge for development of new and compact lasers, Assoc. Prof. Ivan Buchvarov, Sofia University

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Abstract:
Since the discovery of lasers, they have been viewed as promising instruments for producing specific material states by selective manipulations that could not be realized by conventional incoherent addition of thermal or electronic energy to the material. Although the selective laser chemistry is still a dream, the selective control of material processing done by optimization of laser wavelength, pulse duration, pulse energy per unit area and laser average power is frequently used to move some contemporary technology beyond of its limits. The utilization of the unique mid-infrared (IR) laser radiation in hard and soft tissue and in materials research has produced and identified a wealth of high-impact applications and potential technology breakthroughs in these areas. Until now, mid-IR free-electron lasers are major laser sources which have been successfully used to demonstrate a number of new emerging technologies e.g. surgery with minimal collateral damage- brain surgery, optic nerve sheath fenestration, mid-IR laser enhanced trans-dermal drug delivery , mid-IR laser induced green fluorescence protein gene transfer and laser induced syntheses of new materials. Free-electron lasers are multimillion-dollar facilities with unique pulse characteristics and they are not accessible to the general public. Many of the above applications require optical pulses shorter than the characteristic thermalization time of the material, and pulse energies sufficiently high enough for material ablation. In addition, the average power of the laser has to be large enough to enable "high-throughput" and acceptable product yields. A portable and cost-efficient alternative to the FEL providing high energy/average power tunable mid-IR radiation can be obtained based on all-solid state laser technology. Using a optical parametric conversion in combination with novel near-IR laser pump source near 1 μm and new non-linear materials we have obtained high-power (>3 W) tunable laser radiation across the peak of the water absorption ~ 3 μm with an unprecedented energy level (>6 mJ) at a repetition rate of 500-1000 Hz. This laser system promises new capabilities for optimization of surgical treatments because the incision parameters (i.e. ablation profile, collateral cell damage etc.) depend on the structural properties and water content of the tissue. Thus the laser can be used to develop a minimally invasive surgery in a tissue-specific manner. Biocompatibility improvement of biomaterials by texturing with ultra-short laser pulses will be also considered. In addition prospective of development of new methods for laser induced syntheses of super hard materials will be presented.

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