Industrial Femtosecond Lasers for High Precision Micro-Machining

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High average power femtosecond lasers are becoming more widely used as a tool for industry to machine materials with high precision whilst imparting minimal thermal damage to the surrounding area. The high peak power produced by such systems allow almost any material to be processed, including those that are transparent at the laser wavelength.

A 1 µm laser system that utilises a dual-function pre/power amplifier based on thin-slab architecture [1] will be presented. The novel amplifier design combined with a unique pumping technique [2] allows the system to output > 120 W from 1 MHz to 40 MHz with a pulse duration of 900 fs. The beam profile is Gaussian with an M^2 value of < 1.3 in both axes. An integrated pulse-picker may be used to control individual pulses up to 10 MHz. This allows burst-mode operation to be implemented; a very important function for applications such as glass separation [3]. Not only can the bursts be controlled in the temporal domain, but the pulse energy of each individual pulse may be controlled in order to shape the bursts.

Insertion of an LBO nonlinear crystal at the output of the system allows for wavelength conversion from 1030 nm to 515 nm with a conversion efficiency of up to 74 % and a pulse duration of 750 fs. 515 nm is preferred for machining materials such as copper where the absorption at this wavelength is higher than at 1030 nm. A UV version of the laser operating at 343 nm will also be discussed.

[1] J. R. Lee, B. S. Fulford, "Optical amplifier arrangement", UK patent GB2505315B (2014)
[2] H. J. Baker, J. R. Lee, B. S. Fulford, D. J. L. Birkin "Laser beam amplification by homogenous pumping of an amplification medium", UK patent GB2518794 (2016)
[3] S. Abbas Hosseini, Peter R. Herman, "Method of material processing by laser filamentation", US patent US20130126573A1 (2013)