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RAPID: High-power, High-repetition-rate picosecond (ps) Laser for Industrial High-end Micromachining

Micromachining in electronics- semiconductor- and medical-industry creates more and more applications that require a level of precision, which can not be reached with conventional laser technology. However, a unique machining quality can be achieved using ultra-short laser pulses with a duration < 15 ps. Such extremely short pulses generate a non-thermal interaction in the ablation process, allowing micromachining with virtually no heat-affected-zone, no micro-cracks, and no recast. The multi-photon process also provides strong absorption in all materials, even in transparent media.

Making such ultrafast lasers ready for industrial applications was a challenge for many years. The lasers had to be developed from scientific instruments to robust, turn-key devices. Also power and repetition rate had to be scaled by orders of magnitude, to become cost effective.

Dr. Achim Nebel and his team pioneered this field from the beginning. In June 2003 LUMERA LASER introduced the STACCATO, the pre-runner of the RAPID laser. It was the first industrial ps-laser, based on a 10 W, 50 kHz Nd:Vanadate-regenerative amplifier. This laser improved the micro-machining throughput by a factor of > 20, compared to the 1 kHz, 1 W Ti:Sapphire lasers, that were state-of-the-art at this time. Based on extensive application experience with the STACCATO the project team subsequently developed the RAPID laser for highest performance and micromachining speed: The RAPID laser series was launched first in June 2005 with a 2 W version, and includes now laser models with 10 W, 25 W, and 50 W of output power, generating 10-ps-pulses with repetition rates as high as 1 MHz.

The quality of the micromachining results are outstanding. Typical ablation rates now can exceed 10 mm^3/min and compete with ns-laser ablation rates. The lasers are based on mature Nd:Vanadate technology and have proven their reliability with many units in the field, collecting many 100.000 hours of operation data. Several lasers are running 24/7 in high-end fabrication or diagnostic tools in the semiconductor industry. Scaling of power and repetition rate with the RAPID lasers has made high-end micromachining also cost effective, enabled new processes, and opened new markets. Some examples are: Semiconductor industry (e.g. wafer structuring and dicing), solar cell fabrication (e.g. thin film removal), electronics (e.g. memory repair), and printing industry (direct ablation).

The development of the RAPID ps lasers involved extensive fundamental research over the recent years that led to significant progress in laser technology, documented by patents and scientific publications. The major achievements were:

a) a new mode-locking scheme that provided high oscillator output power
b) a new switching technology for fast electro-optic modulators, enabling high repetition rates well above 1 MHz
c) a novel pumping scheme for scaling the power of Nd:Vanadate lasers by a factor of five.

Project Management
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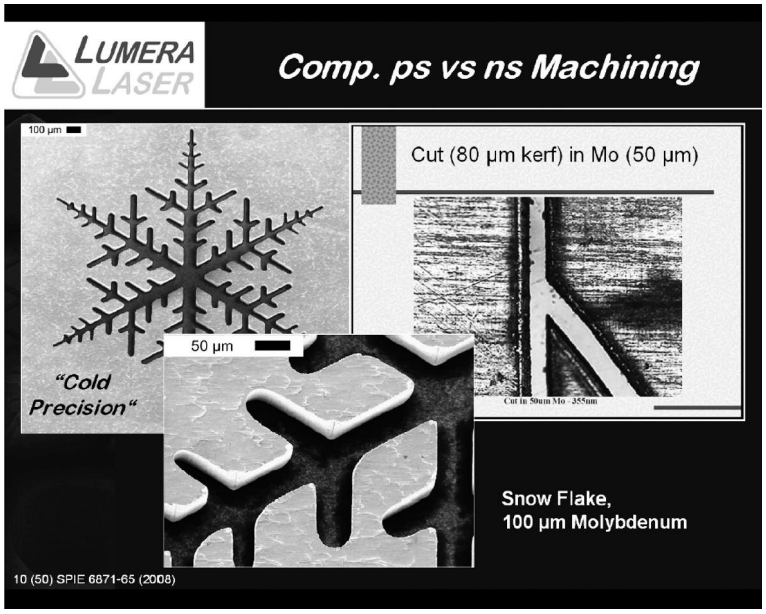
Area of Application
Micromachining in electronics, semiconductor, medical and solar-cell industries

Technological Impact
New ultrafast laser source
Improved quality in laser micromachining



Comparison: Micromachining of thin Mo-sheets with conventional laser technique (Y-shaped cut with 355 nm-nanosecond laser in 50 µm Mo on the right) and with a RAPID picosecond laser (complex shape in 100 µm Mo on the two left pictures). (Photo: LUMERA LASER GmbH)