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3D micro-structuring of large scale metal surfaces for embossing and printing applications with high power ultrashort pulse-lasers

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Areas of application
Major sectors of industry which are profiting from the innovation:

- Roto-Gravure printing industry: packing-, security- and electronic-printing, intaglio printing
- industrial sectors that use micro-embossing technologies for functional surfaces or security applications

Technological impact

- Reduced manufacturing costs for existing products
- Improved quality in existing products
- New product features
- Reduced process costs
- Improved working conditions
- Improved quality assurance

Abstract

Laser ablation with ultrashort pulses allow a superior machining quality, compared to laser machining with longer pulses. The high precision and resolution of the structures achievable with ultrashort pulse laser systems are of major interest in the printing, gravure and embossing industry (i.e. security printing, electronic printing, display and smartphone manufacturing). Finest three dimensional structures can be generated directly and melt-free by lasers into copper, nickel, aluminium and steel surfaces. However for surface structuring of large embossing rolls with diameters of 100mm and larger and lengths exceeding 1m, high structuring speeds and high laser ablation rates are needed to allow an economically production. With currently available picosecond-laser systems using pulse repetitions rates below 1 MHz the ablation rate is limited to ~1mm³/min. New high-power laser systems with high repetition rates in the multi MHz area offer the possibility to significantly increase the laser ablation rate. However with current laser scanning devices only spot movements in the range of 5 m/s at small spot sizes can be achieved, which results in a large pulse overlap at high laser repetition rates. This leads to a high local thermal accumulation and a pulse-plasma interaction on the metal surface with a low machining quality that can be classified between ps- and ns-pulse regimes. As a consequence, new high speed scanning techniques are required to use the full potential of high power ultrashort pulsed lasers for high machining quality.

In order to enable fast and economic surface structuring of large rotating cylinders, with less thermal effects several innovations had to be developed in combination:

- A picosecond laser using multi-pass cell for generating a pulse rate of 10MHz
- A high power amplifier to boost the ps-pulses to an average power of 400W
- A material selection and process strategy that enables use of such high power
- A fast scanning technology
- A machine and software control that can combine and synchronize these components

Within the public funded BMBF-project PIKOFLAT, Schepers GmbH and the entire project team developed new scanning and ablation techniques that allow scan speeds of up to 50 m/s. Using a rotating cylinder as fast moving workpiece and an additional fast beam scanning device based on acousto optic deflectors, picosecond laser pulses of 10 MHz and higher could be used for high quality micro machining. The project team has built a 400W picosecond MOPA laser system based on a 10.6 MHz laser seeder and a slab based laser amplifier. The laser system and the new scanning system was integrated in the Digilas machine technology and forms a new type of machine which exceeds all current rotational gravure systems in matters of machining quality. With this system, for the first time ablation rates in metals of up to 20 mm³/min can be realized using ultrashort pulsed lasers.

Figure 1: 3D surface of a leather and calotte embossing tool structured with picosecond lasers
(Photo: Schepers GmbH & Co KG, Vreden, Fraunhofer Institute for Laser Technology ILT, Aachen)

Figure 2: With picosecond-laser 3D structured printing cylinder (diameter 100mm)
(Photo: Schepers GmbH & Co KG, Vreden, Fraunhofer Institute for Laser Technology ILT, Aachen)