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SCANNER-BASED DIRECT LASER INTERFERENCE PATTERNING

THE TASK

Functionalization of a technical surface by means of natural, biologically inspired structures is an innovation driver of the 21st century. The functionalities achieved are suitable for tribological applications in the automotive industry, for improved biocompatibility in medical and biotechnological industries, and for optical applications, such as product and trademark protection.

Established manufacturing techniques for structures in the nano- and micrometer range are either too expensive or time-consuming (electron beam lithography) or provide low structure resolution (direct laser writing). The Fraunhofer IWS has been and is developing the direct laser interference patterning (DLIP) technology to generate complex structures with high resolution and high process velocity and customizing them for industrial requirements.

OUR SOLUTION

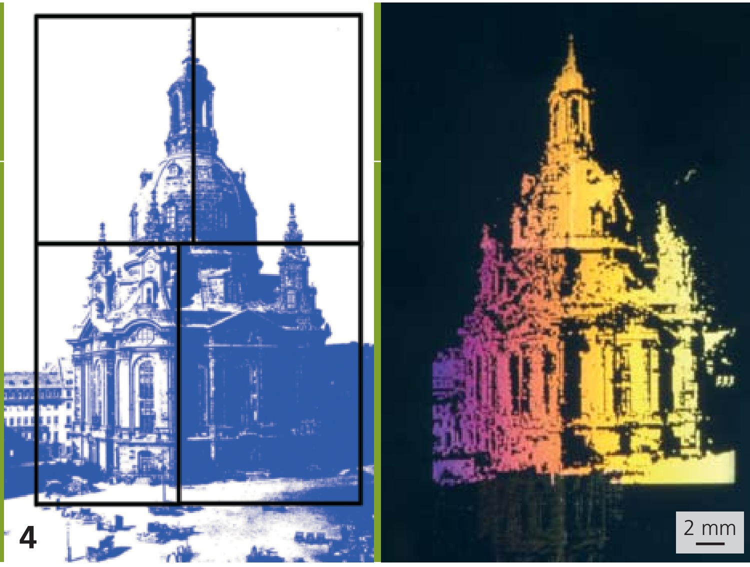
In direct laser interference patterning, a coherent laser beam is split into two or more sub-beams, which are superposed on the component surface. Defined structures can be applied to components due to interference (as periodic modulation of laser intensity) resulting from superposition.

Fraunhofer IWS scientists were able to fabricate constant structure geometries on large areas at rates of up to 1 m^2 min^{-1} by means of the DLIP technique. However, the generation of variable structure geometries at high process velocities makes it necessary to develop advanced solutions.

The Fraunhofer IWS has succeeded for the first time in developing a structuring procedure able to fabricate these variable structures in short process times. The solution arises from combining a DLIP processing head with a galvanometer scanner system (Fig. 1). The newly developed DLIP scanner system is compatible to the µFab systems of the Fraunhofer IWS, which are suitable for industrial use (Fig. 2).

Dimensioning the optical device to control several partial beams using the galvanometer scanner system and engineering of a holistic patterning concept was demanding. However, we were successful, so that high-power laser sources with frequencies up to the megahertz region can be applied to fabricate variable surface structures "on-the-fly".

In addition to the increase in possibilities for rapid prototyping, in-line structuring in roll-to-roll processes, as well as the processing of 3D geometries, all the advantages of the DLIP technique – such as direct processing of metals and polymers, without using expensive cleanroom conditions – are maintained.



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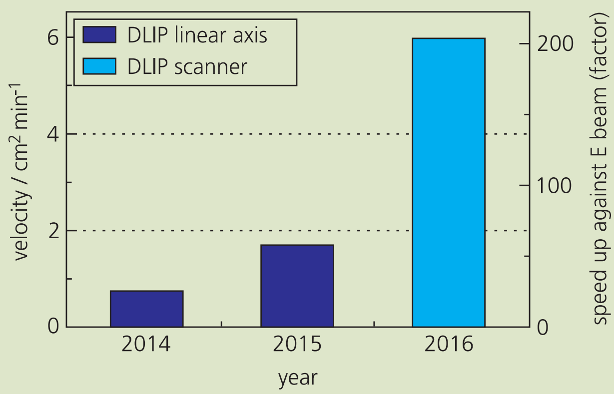
RESULTS

Comparing the process speeds of a DLIP system with linear axes and the newly developed DLIP galvanometer scanner system shows the obvious innovation potential for the reduction of process times (Fig. 3). We were only able to achieve low process speeds of approximately 1.5 cm² min^{-1} by means of a DLIP system with linear axes up to 2015.

The DLIP galvanometer scanner system enables significantly higher area rates of approximately 6 cm² min^{-1} (with 1 kHz pulse repetition rate of the laser system) due to its low inertia. Process speed, which is in general only limited by the pulse repetition rate of the laser system used (Fig. 3), can thus been increased.

A significant growth of the area rate from 60 cm² min^{-1} (@ 10 kHz) to 1500 cm² min^{-1} (@ 250 kHz) can be expected from more powerful laser sources in combination with the DLIP scanner system. This results in shorter process times (in many applications such as rapid prototyping) and thus competitive advantages.

Process speeds of various DLIP concepts



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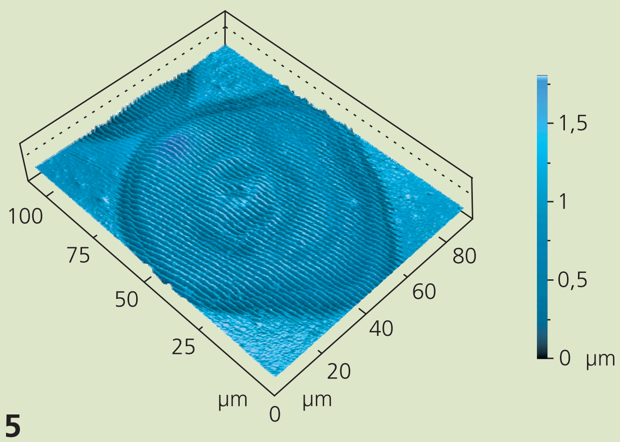
Larger sized surface regions are structured by means of optimized stitching methods: the regions to be structured are divided into several surface segments and are structured sequentially. This strategy can be used for the fabrication of decorative elements for product and trademark protection (Fig. 4).

The structures generated by the DLIP scanner system can be varied in their spatial periods and fabricated on several materials, such as polymers (Fig. 5).

Confocal microscopy image of a structured PET surface



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1 DLIP scanner head

2 DLIP-µFAB industrial system

4 Decorative theme: Dresden Church of our Lady

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