Fraunhofer IWS Dresden

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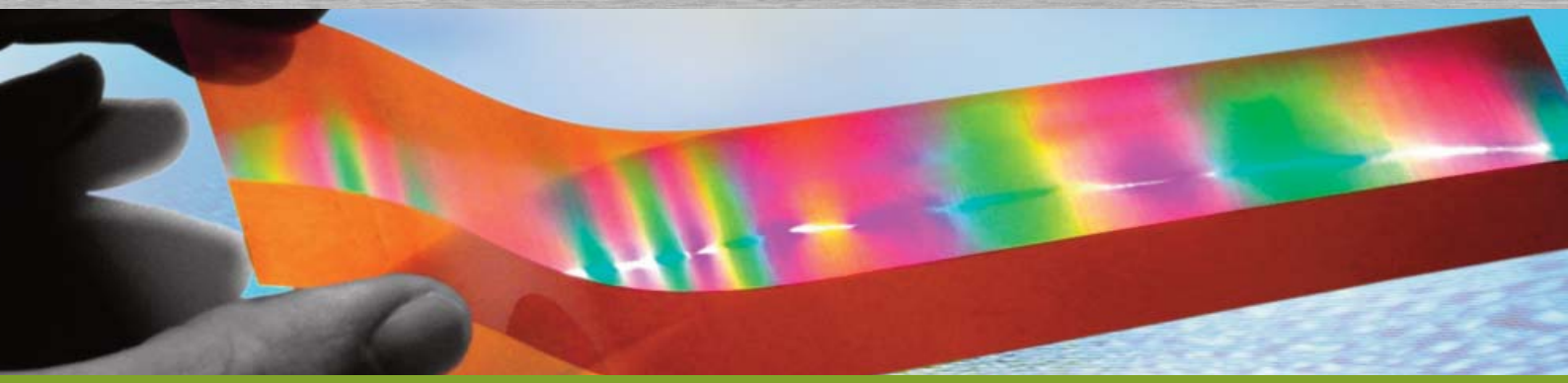

LARGE-AREA FABRICATION OF MICRO AND SUB-MICROMETER SURFACE STRUCTURES

Surface functionalization using Direct Laser Interference Patterning

DLIP µFab

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Task

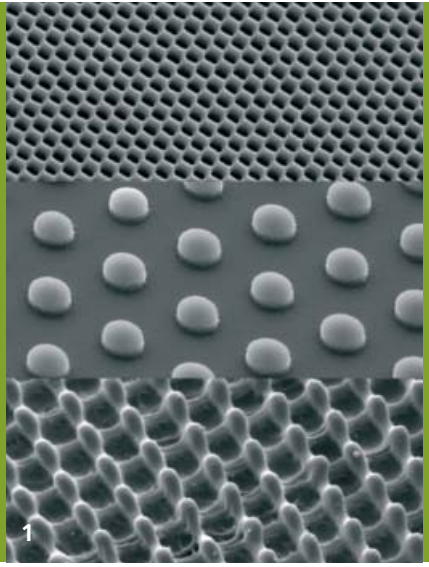
Periodically patterned surfaces do not merely provide unique properties, but act as intelligent surfaces with multiple functionalities with applications in biomaterials, surface engineering, and photonics. Numerous techniques have been explored and applied to fabricate such micro- and nano-features (e.g. nanoimprint lithography, laser writing and optical lithography). However, only few of them are suitable for the fabrication of periodic structures in a single processing step on large 2D and 3D surfaces.

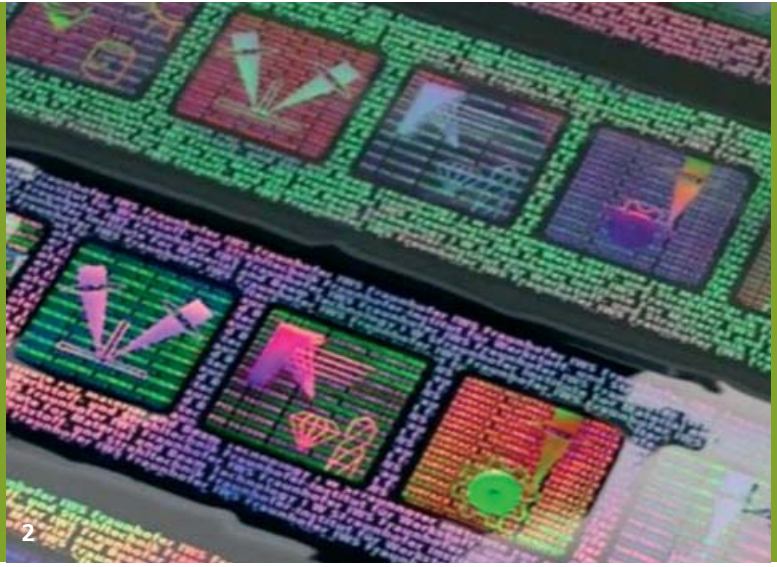
The Fraunhofer IWS offers a powerful and competitive process for direct surface structuring. Compared to conventional patterning methods, it generates a large number of topographically complex structures in one process step.

Solution

Fraunhofer IWS engineers achieved drastically shortened processing times at increased resolution by using Direct Laser Interference Patterning (DLIP) method. Making a periodic structure requires at least two coherent laser beams, which superimpose on the substrate surface. Interference occurs throughout the entire superposition volume of the beams (Principle of DLIP).

The method transfers sub-micrometer structures in one step into metals, ceramics or polymers or coatings. A single laser pulse can process a surface area of up to several square centimetres, which leads to an effective structuring speed of several square centimetres per second, depending on the processed material.





DLIP patterning systems

Fraunhofer IWS developed DLIP systems and compact optical heads (Fig. 3). The systems can be adapted to the customer's wishes in order to precisely fabricate micro or sub-micrometer arrays on large areas.

Additionally, different laser systems can be integrated into the DLIP systems, which can fulfill the customer's requirements such as processing speed, structure geometry as well as capability to pattern 3D parts. The typical specifications of these systems are given in Table 1.

One system, several solutions

The newly developed DLIP heads (Fig. 3) permit to vary the structure period and pattern orientation during the structuring process. Therefore, a large variety of surface structures can be produced with only one system.

Furthermore the personalization of motives patterning of rolls for embossing applications and surface structures for product protection can be realized. Structure examples of processed metal and polymer substrates are shown below.

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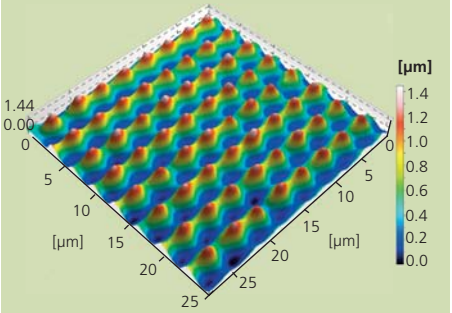
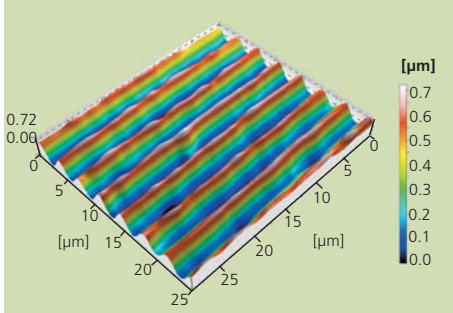
Periodic hexagonal structure on PET



Periodic line-like structure on stainless steel



Principle of DLIP: superposition of two laser beams

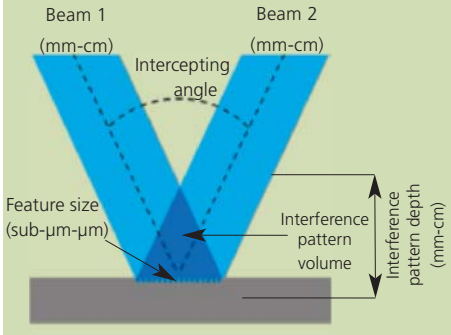


Table 1: Specification data of DLIP systems

Working distance:	5 - 60 cm (defined by customer)
Working area:	up to 500 x 500 mm²
Laser wavelengths:	1064, 532, 355 and 266 nm
Repetition rate:	10 Hz - 50 kHz (depending on application)
Optical head dimensions:	150 mm x 200 mm x 300 mm
Structure period:	from ~150 nm to 30 µm
Fabrication speed:	0.001 - 0.700 m²/min (material-dependent)
Processable geometries:	2D and 3D parts
Processable materials:	polymers, ceramics, metals, coatings

1 Patterned polymer surfaces

2 Exmple for decorative applications

3 DLIP optical head developed at Fraunhofer IWS