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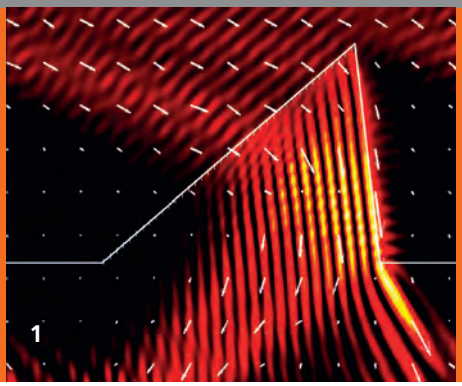
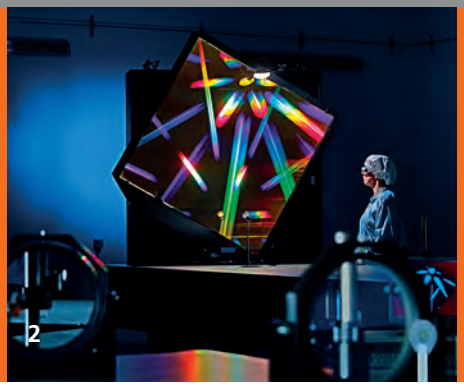
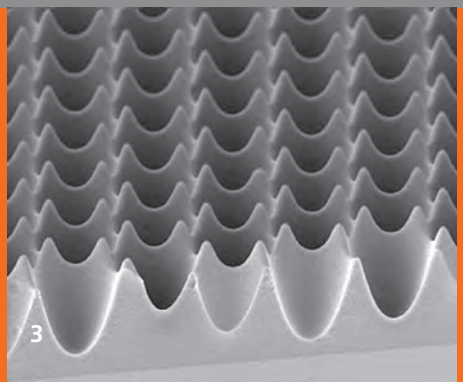
FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE







1 *Near field calculation of a micro prism array. The color scheme shows the intensity distribution, the white arrows depict the Poynting vectors.*
2 *In our interference lithography laboratory areas of up to 1.2 x 1.2 m² can be structured homogeneously.*
3 *SEM image of a hexagonal grating fabricated via interference lithography. This grating has a period of 8 µm and a height of 9 µm.*

MICRO- AND NANO-STRUCTURED SURFACES

Micro- and nanostructured surfaces can fulfill a variety of different functions. An important application field is photon management in optical systems.

In solar cells, micro or nano scale structures lead to efficient light trapping, enhanced incoupling and improved radiation conversion. In light sources they enhance light outcoupling and homogenity. In daylighting and artificial lighting elements they deflect light in the desired direction. In display applications they are used for antireflection, polarization management, light control or defined scattering.

Micro- and nanostructures also play a role in modifying non-optical properties, such as the wettability, adhesion or the surface friction coefficient.

The advantage of microstructured surfaces is that they can be replicated inexpensively in mass production by processes such as hot embossing, injection molding, casting or nanoimprint lithography. For example, many kilometers of microstructured films can be manufactured by means of UV replication in a roller embossing process.

The Fraunhofer Institute for Solar Energy Systems ISE advances the fundamental understanding of the optics of microstructured components, modeling, design, production as well as replication and characterization of large-area micro- and nanostructures.

With our wide-ranging expertise, we assist customers to optimally use micro- and nanostructures in optical and non-optical applications and to exploit new functionalities.

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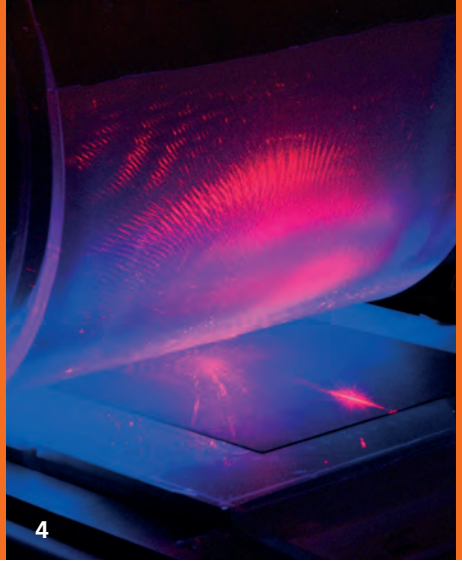

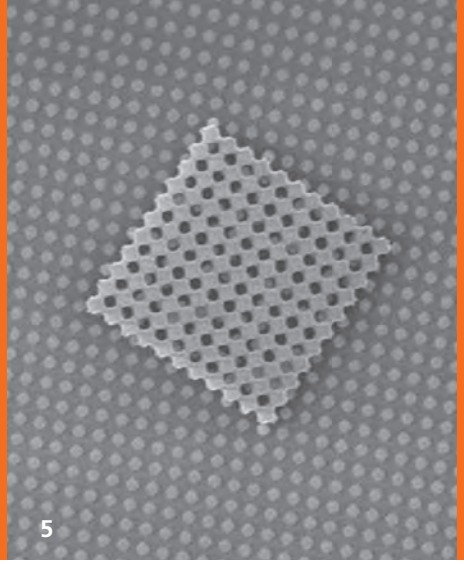

Modeling and Design

We make use of various modeling tools covering the entire range of optical effects from wave to ray optics. The objectives are to understand the optical characteristics of micro- and nanostructured materials and to design components or systems with customized functionalities. To this end we provide comprehensive knowledge on the potentials and limitations of the different modeling approaches, the selection of suitable tools and optimized combinations of simulation methods.

Interference Lithography

In interference lithography, ultraviolet laser beams are split, expanded and superimposed. A pattern of light and dark areas, the so-called interferogram, is formed in the superposition plane. The interferogram is used to expose photoresist, which is selectively etched in the subsequent development step. A surface relief structure results.

With interference lithography we are capable of producing customized, seamless micro- and nanostructures on areas of up to 1.2 x 1.2 m². Depending on requirements, the structure details can be as small as 100 nm or as large as 100 µm. We provide periodical or stochastical arrangements of structures as well as parabolic, binary or prismatic structure profiles. In addition, we can combine different structure geometries and dimensions in one master structure.

Replication

Microstructures are of particular interest when they can be produced cost effectively and in large quantities using micro-replication processes. We evaluate various replication techniques, each suitable for distinct applications.

One option is electroplating to fabricate multiple metal copies of one master structure (so-called shims). These shims can be used e. g. in hot embossing or injection molding processes. They also can be used to pattern UV-curing materials, which is even possible in roll-to-roll processes.

Direct replications from a photoresist or a metallic tool are possible in flexible, transparent or opaque materials (soft embossing) by using silicone materials. Structures made from such resilient materials enable special surface functionalities (e. g. the gecko effect) or can be used for further processing steps.

In nanoimprint lithography (NIL) high-resolution etching masks can be structured in a high-throughput process. We developed a roller-NIL tool that allows the patterning of such etching masks on uneven, stiff, brittle and opaque substrates (e. g. multicrystalline silicon) on large areas in a continuous process.

Characterization

One important aspect of characterizing micro- and nanostructures is measuring their geometry. We provide different measurement methods:

- atomic force microscopy (AFM)
- scanning electron microscopy (SEM)
- optical microscope

For optically functional surfaces it is important to characterize their optical behaviour. Here a combination of different measurement methods is required to ensure a comprehensive evaluation of structured samples. At Fraunhofer ISE we are able to combine several methods:

- spectrometry
- photogoniometry
- spectral ellipsometry

Customized Structures for Clients

Clients benefit from more than fifteen years of experience in developing customized structures. Our services range from modeling of production processes and optical functions through to the manufacture and characterization of micro- and nanostructured surfaces. We can provide the whole process chain or just one single part.

4 *Roller-NIL-setup for rigid substrates.*
5 *Metal nanoparticles produced by NIL and lift off (mask not competely removed).*
6 *Imprinted silicon wafer.*