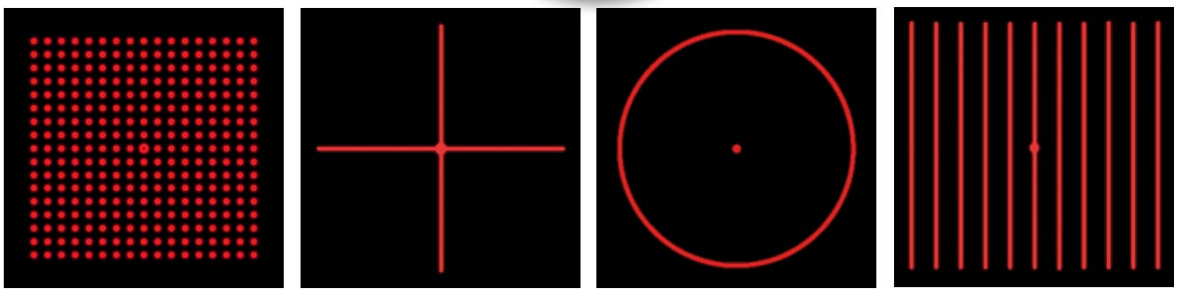
DOE

Diffractive Optical Elements

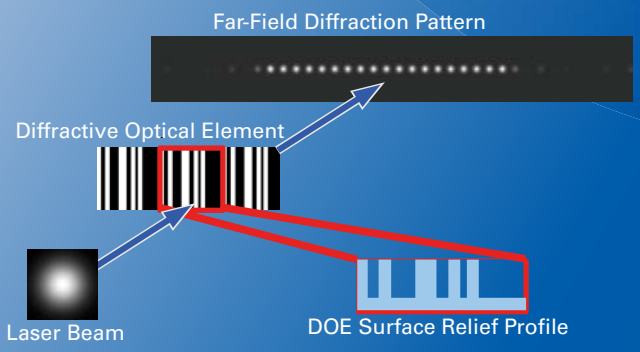


HOLOEYE

Pioneers in Photonic Technology

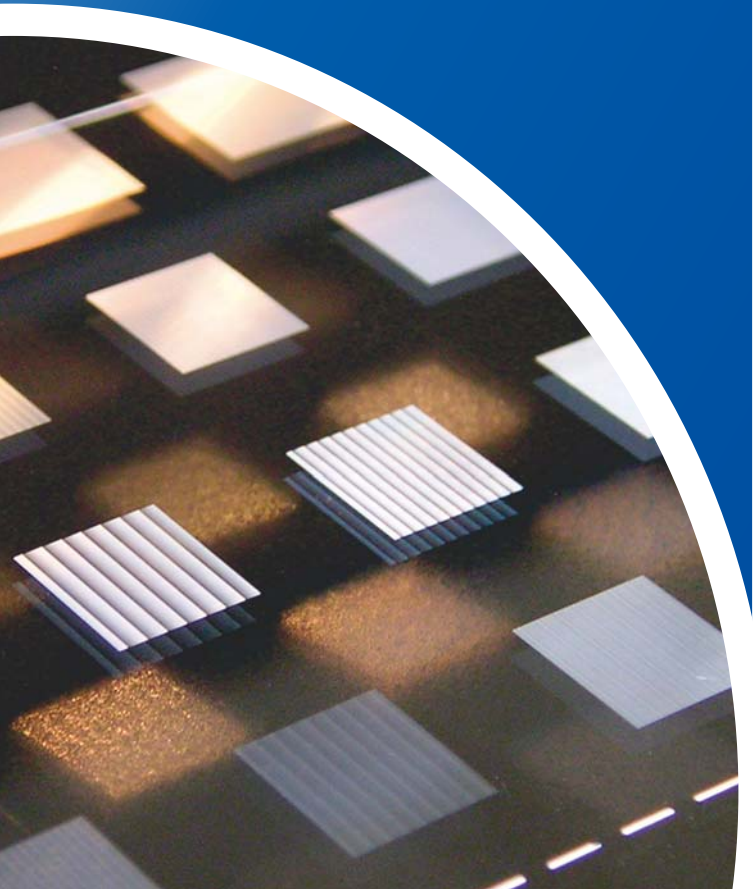
Functionality of Diffractive Optical Elements

A Diffractive Optical Element (DOE) utilizes a surface with a complex microstructure for its optical function. The micro-structured surface relief profile has two or more surface levels. The surface structures are either etched in fused silica or other glass types, or embossed in various polymer materials.



Properties of Diffractive Optical Elements

The different types of DOEs (beam splitters, Fourier holograms, beam shapers, diffusers and various grating structures) act like optical processors, splitting or reshaping light to almost any desired distribution. Additionally, diffractive optics can realize almost the same optical functions as refractive optics such as lenses, prisms or aspheres, but they are much smaller and lighter. DOEs are not limited to laser applications; partially coherent light from LEDs or other light sources can also be modulated.



Problem Analysis & Feasibility Studies

The first step is the work towards a specification that contains all relevant parameters. In some cases, a feasibility study is required. HOLOEYE offers a range of off-the-shelf diffractive optical elements. Proof-of-concept experiments with these elements are often helpful for the derivation of the specification. In addition, as a supplier of spatial light modulator (SLM) technology, HOLOEYE also has the capability to demonstrate optical functions of DOEs experimentally using SLM devices as switchable optical elements.

Steps towards the solution:

- ⊗ System analysis
- ⊗ Feasibility studies
- ⊗ Experimental investigation with HOLOEYE DOE standard products or SLMs
- ⊗ Custom design of diffractive elements according to customer specifications
- ⊗ Fabrication of prototypes
- ⊗ Tooling for DOE replication
- ⊗ Replication of diffractive elements
- ⊗ Optical performance tests

Design & Simulation of Diffractive Optical Elements

HOLOEYE uses computational design methods like

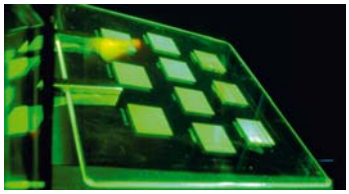
Iterative Fourier Transform Algorithms (IFTA), direct binary search (DBS) algorithms, gradient search algorithms and methods based on the determination of geometrical map transformations. We can design DOEs for patterns on inclined surfaces and with arbitrary angles of diffraction. This allows us to precisely place diffraction spots freely on a target surface. The obtained element design will be verified in scalar or rigorous wave-optical simulations prior to fabrication.

Fabrication of DOEs

The fabrication technology should be carefully chosen depending on the specification and the target production volume. Fabrication options include

(A) High-quality fabrication by lithography for single pieces or low element numbers
(B) High-precision low-volume to medium-volume replication
(C) High-volume low-cost replication

First the design data is optimized for minimum fabrication



error dependency. The lithography technology will be chosen to meet specifications on the one hand and to minimize cost on the other hand.

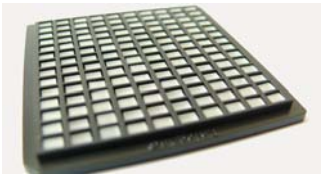
For diffractive structures with pixel sizes down to 50nm, it is necessary to use e-beam direct writing lithography. For diffractive structures with more coarse structures (feature sizes >1µm) the necessary resolution can be reached with laser lithography and a shorter writing time.

After the sequential writing process, etching techniques like

reactive ion etching or ion milling are used to create surface relief structures in the substrate material. With electroplating it is possible to generate tools for replication processes like injection molding or nano-imprinting

The fabrication of a master component with an optical microstructure can be very costly. Therefore, replication technologies represent a major economic success factor in diffractive optics, because replication significantly reduces the cost of each single optical element.

HOLOEYE offers high-precision replication of small



quantities for applications in technical optics at reasonable cost. Replication is possible in many different materials in order to account for:

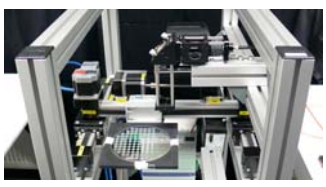
⊗ Different substrate materials and shapes
⊗ Variation of light source wavelength (e.g. for ensuring eye safety)
⊗ Different environmental conditions (temperature, humidity)

For high-volume applications, the price of the optical component can be lowered by injection molding technology. Based on our experience, we are commited to make a competitive offer for your high-volume applications while still meeting the quality requirements and are willing to adapt our handling and packaging procedures to fit with your assembly processes.

The diffractive optical elements are delivered in the customers' requested shape and size and optionally can be integrated with a customized mechanical holder.

Quality Assurance and Implementation Support

After fabrication, HOLOEYE will validate the compliance of



the DOEs with the specification experimentally. When replicating elements in larger numbers, optical key properties will be monitored using automated equipment.

Upon customers´ request, we are ready to visit the customer´s laboratories and provide assistance regarding the actual implementation of the DOE into the customer´s system.

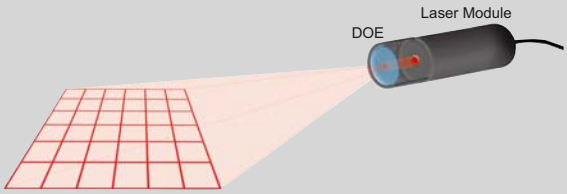
We need to know the following parameters for the development of your customized DOE:

Light Source:
Type (cw laser, pulsed laser, LED, other),
Wavelength (center and bandwidth)
Polarization
Power/Energy (average and/or peak)
Beam profile (diameter, divergence, M² quality)

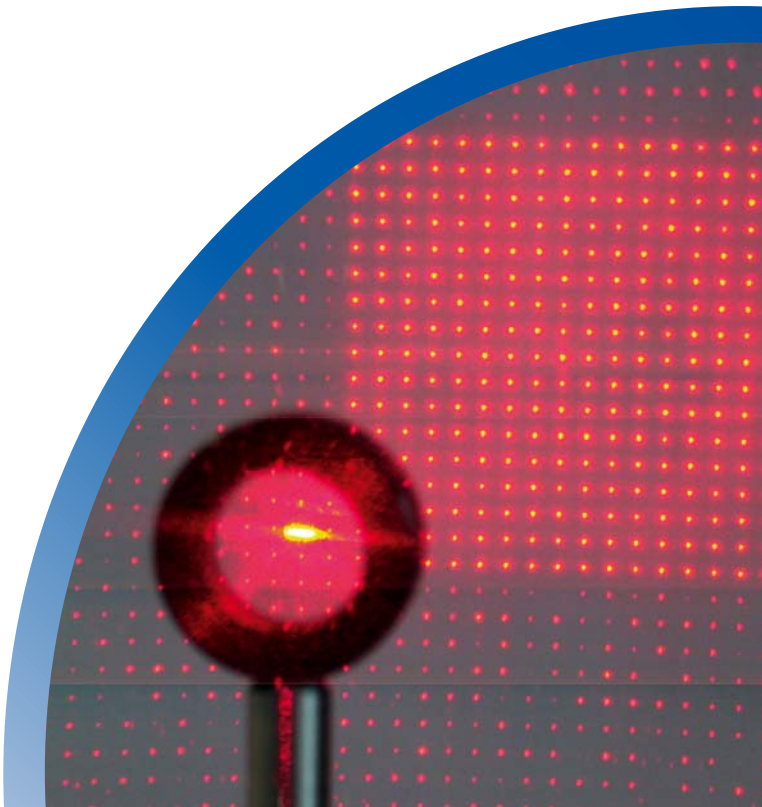
Optical Function:
Desired light field distribution (shape, uniformity)
Working distance
Field of view / Diffraction angles
Target surface inclination and/or shape

Application:
Eye Safety requirements
Element form factor (size, shape)
Element material
Environmental conditions
Packaging of elements
Sensor and/or screen type for light field (CCD/CMOS/ human eye/…)

Last but not least, the target annual production and a price target are required to choose the best solution.



Application Example



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DOE– Rev. 1.0 – Specifications are subject to change without notice