Holography
Diffractive Optical Elements (DOEs)

Introduction

Eureca Messtechnik GmbH offers the development and production of customized Diffractive Optical Elements (DOEs).
Diffractive Optical Elements are a powerful way of combining compact optical setups with the maximum amount of flexibility being offered by a holographic approach, e.g. in generating very sophisticated structures for pattern projection and many other applications. We support our customers from the determination of feasible specifications to the calculation of DOEs and prototyping. We chose suitable partners for production, as well.

Notice: The image shown on the right is an artwork. The screen where the hologram is captured, the twin-image and the impact of the zeroth diffraction order is not shown.

Applications of DOEs

Possible applications of DOEs are widespread, the most important of them are listed below. In some cases, a combination of DOEs with additional refractive or reflective components can be useful or necessary.

- beamsplitting, i. e. spot-array generation using a single incoming laser beam
- beamshaping in general
- beam homogenization / diffractive diffusers
- pattern projection on flat or three-dimensionally shaped surfaces
- wavefront correction
- image multiplexing, e. g. to increase the focal depth of refractive lens systems
- diffractive lenses

Project Steps from Specifications to Production

When the development of a customized DOE is considered, the first step usually is the determination of precise specifications, e. g. regarding size of reconstructed pattern structures, homogeneity of illumination, signal-to-noise ratio, necessary diffraction angles and diffraction efficiency. In this step of development, numerical reconstructions from exemplary diffractive structures can help determine which specifications are required. At this point, Eureca's strong competences in image simulation are particularly important. Once general specifications are found, the best way of generating the required target structures is chosen.

Our detailed knowledge of physics and wide experience in using custom algorithms for wavefront propagation makes sure that precise and cost-effective ways of hologram-generation are selected. Eureca also utilizes different standard procedures for the generation of diffractive structures, among them FFT, IFTA and ASPW. The knowledge of Eureca regarding the different manufacturing processes for DOEs also ensures that all steps from first evaluations to final production are interrelated at its best.

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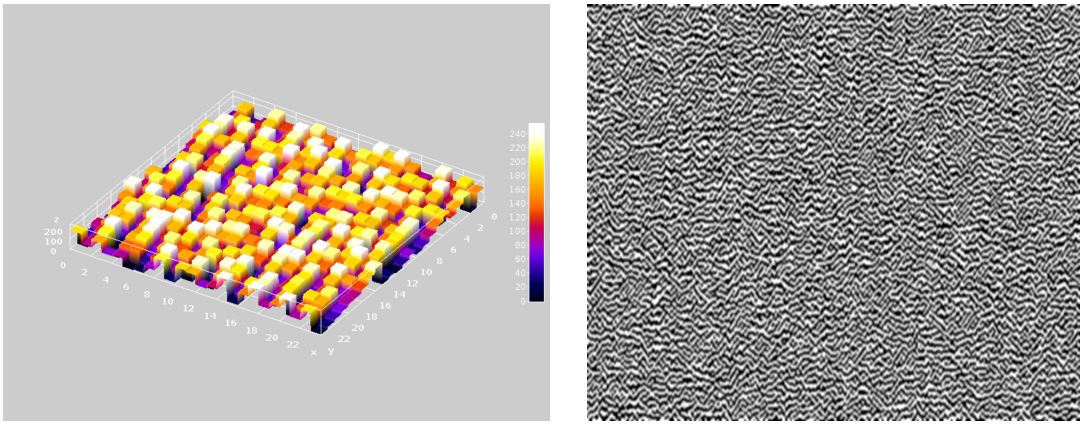
Ways of DOE Production from Proof of Concept to Final Product

Eureca offers a variety of ways of prototyping and manufacturing DOEs. For prototyping we utilize holographic displays, which allow for fast evaluations and proof-of-concept studies. High-resolution film based on silver halides are a powerful tool for prototyping and low-volume productions, as well. Eureca also offers prototyping and volume productions of thick phase holograms based on photopolymer.

As a medium suitable for productions from prototypes to high volumes we offer high-resolution binary amplitude masks. These masks are made of cromium on quartz glass, a resolution of 500 nm can be reached in the hologram plane. For higher-volume productions we also employ the lithographical production of binary and multi-level phase masks. An example of the appearence of such a mask is shown in the figure below. The utilization of phase masks has certain general advantages, e. g. regarding the suppression of unwanted diffraction orders and acchievable diffraction efficiency. However, chosing an amplitude DOE may have application-dependent advantages, e. g. regarding acchievable resolution and cost-effectiveness. A detailed discussion of such aspects is done in the earliest stages of product development.

General Aspects

In most cases, DOEs are combined with laser illumination since the requirements regarding coherence are fulfilled best for these sources. However, the feasibility of LEDs can be checked if required. The resolution and other properties of the reconstructed structures depend on the overall aperture and the resolution of the DOE. The beam characteristics of the source of radiation and the properties of additional lenses in the setup, e. g. used for collimation, also influence the overall achievable performance. These aspects have to be kept in mind when components are selected and combined. It is one of our major competences to survey that the entire product development is based on consistent assumptions leading to the best possible results.



General appearance of the phase-structure of a multi-level DOE: 3D-illustration (left), gray-scale image (right).