

Market study on the enabling technology of computer generated holograms

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Computer generated holograms (CGHs) are used in interferometric testing to enable the high-quality production of non-spherical optical elements. Today the CGH production is mastered by a few manufacturers only. To provide CGH users with an overview on the corresponding market, this market study was raised. A table of commercial and institutional CGH suppliers has been created.

1 Introduction

A small series of market studies on optical and astronomical technologies was raised at Aschaffenburg University of Applied Sciences [1] [2] [3]. The presented work on the market of computer generated holograms was a bachelor thesis within the degree program "International Technical Sales Management" [1]. The related topic is also one dedicated work package of the INTRAASST project, a German acronym for "industry transfer of astronomical mirror technologies" [4].

2 CGH measurement principle

As depicted in figure 1, the CGH adapts the incoming wave front of the interferometer to the aspherical measurement object, which reflects the incident beam in itself. Thereby deviations from the calculated ideal aspherical shape can be detected. The alignment CGH is reflecting the incident light directly back to the interferometer to orient the CGH into its correct position. [5]

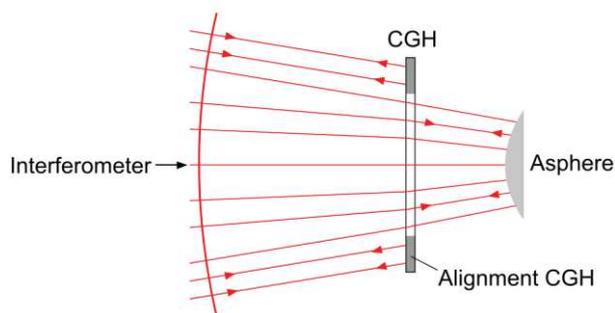


Fig. 1 CGH measurement principle according to [5]

A CGH is designed to test one specific asphere. To measure objects with a different shape a new CGH need to be produced. Therefore the advantage of precision interferometric testing should be carefully traded against the manufacturing costs before considering a corresponding purchase. A visual impression of a commercial CGH is given in figure 2.

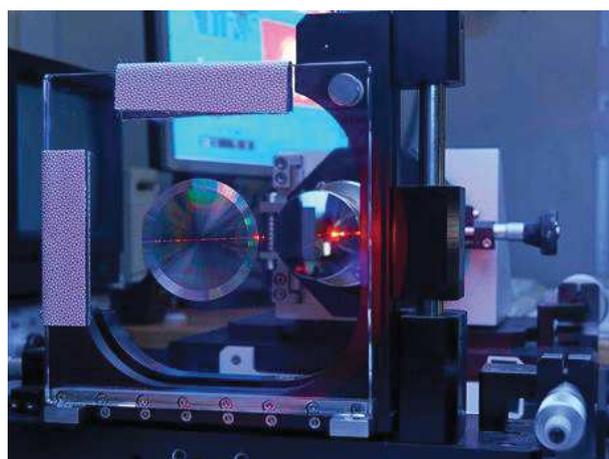


Fig. 2 Picture of a CGH (Courtesy: Jenoptik AG)

3 Market of computer generated holograms

The interviewed manufacturers are producing CGH for different kinds of applications. In detail the measurement of aspheres is the main market. Thereby the questioned suppliers quantify the share of CGHs for aspheric measurement between 45% and 80% of all their produced computer generated holograms. The rising demand of aspheres in modern optics could lead to the assumption that the market of CGH for interferometric testing of aspheres would intensively prosper in the future. Despite this growing demand, manufacturers of this technology seem not to believe in a strong growth of corresponding sales due to the availability of alternative measurement methods for aspheres, like new types of interferometers.

Based on the market transparency by the provided list, users of interferometric testing of non-spherical shapes could decide between different suppliers of the required CGH. Thereby the manufactures can be mainly differentiated by the possible size of the CGH, the quality of the diffractive optical element and the price for the CGH. Some companies offer also support in research and development as well as selling the necessary equipment. The prices for CGHs for testing aspheres are typically ranging from 7,500€ up to 18000€. For a CGH which is designed to measure a free form shape the cus-

tomers usually has to consider a higher price level.

CGH manufacturer	Country	CGH types	Remark
Jenoptik AG	Germany	A, C, F	Company
Fraunhofer IOF	Germany	A, C, F	Institute
ITO Stuttgart	Germany	N	Institute
IMS-Chips	Germany	N	Institute
Dioptric GmbH	Germany	A, C, F	Company
University of Erlangen	Germany	N	Institute
Holoeye Photonics AG	Germany	N	Company, spatial light modulators
CDA GmbH	Germany	N	Company, uses plastic substrates
Optocraft GmbH	Germany	N	Company
Zeiss SMT	Germany	N	Company, Production until 2015
Swissoptic	Switzerland	N	Company, Production for own use
Süss Microoptics	Switzerland	N	Company
Diffraction International Ltd.	USA	A, C, F	Company
Toppan Photomasks Inc.	USA	N	Company
Arizona Optical Metrology LLC	USA	N	Institute
IAE Institute, SB RAS	Russia	A, C, F	Institute
Technical Univ. Moscow	Russia	N	Institute
PJSC Diffraction	Russia	N	Company
Nanjing University of Science & Technology	China	N	Institute, mainly doing CGH design
Holo/Or	Israel	N	Company
Enable K.K.	Japan	N	Company, trader only
Japan Laser Co. Ltd	Japan	N	Company, trader only

Tab. 1 List of identified CGH suppliers.

Explanation of abbreviations: A = CGH for aspheres, C = CGH for cylindrical optics, F = CGH for free-form optics, N = no information available.

Manufacturers of computer generated holograms can be classified into companies and institutes. These suppliers are mainly located in Germany, USA and Russia. Typical manufacturers are not only producing CGHs, but also other optical components. Due to the fact that the market of CGHs is very small with a limited number of suppliers,

which are producing CGHs as a part of their business only it may be possible that additional manufacturers are existing. Companies like Swissoptic are producing CGHs for own use only and not for the market; former manufacturers like Zeiss SMT have the necessary knowhow to enter the market again. The authors would welcome any information on additional CGH manufacturers, not identified in this paper yet.

The greatest obstacle for new manufactures which want to enter this market is the necessary expert knowhow of the technology. This entrance barrier, as well as the unknown future growth of sales is the main reasons for the limited number of manufactures to our understanding.

4 Conclusion

Computer generated holograms are mandatory for the interferometric testing of complex geometrical shapes like high precision aspheres. Manufacturing of CGH requires expert knowhow of this technology and on the application of diffractive optical element. These are the reasons for the limited number of CGH suppliers identified. All of the requested suppliers are able to deliver CGHs with additional functions. The provided list of CGH manufacturers allows market transparency; users of such technology are now able to select between different suppliers.

5 Acknowledgement

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6 References

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