Optical Inspection System for Adaptive Embossing Patterning Technology

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Abstract

This paper deals with the development of a novel optical inspection system for an adaptive and flexible patterning process for the manufacturing of complex optical microstructures. The development aims at both in-line and off-line inspection of patterned substrates in order to evaluate certain process parameters, such as tool misalignment, tool state or rough embossing performance. These inspections are intended to increase the micro-embossing technology know-how. Anyhow, a major step towards the manufacturing of the future is the development of the component performance evaluation system, which will analyse the behaviour of the embossed substrate and will feed an algorithm for adaptive re-embossing, in order to reduce rejects and defects in the manufacturing process. This system is focused on Diffractive Optics Elements (DOE's), which show several specifications that can be solved through the development of the present work. On the one hand, the size of the structures to be embossed is a major challenge for the development of an inspection system, as these structures range from 5 microns up to 1 millimetre, and common components will be fully functional for all sizes in that range. On the other hand, the size of the substrate to be embossed is expected quite large, so that large flat substrates can be manufactured for the newest large TV screens in the market nowadays. This will also be a major challenge, as the patterning process of such large substrates with micrometer range structures requires high accuracy over a large area. The development of this inspection system is a must for the future of several key strategies defined world wide, such as the energy consumption efficiency or the implementation of Information Technologies in the society and the production processes, as the use of Diffractive Optics Elements (DOE's) is the next step in the

generalization of low consumption displays and illumination devices. The conjunction of the systems to develop will introduce a major scientific step in the development, as the relation between structural analysis results and the performance evaluation of the structures will permit an improvement in the knowledge of light behaviour when DOE's are used. Thus, this development includes major steps both in the scientific field and in the technical field.

1 Optical inspection system

1.1 Optical metrology system

The optical metrology system is intended to assess the functionality of the embossed surface through luminance measurement and luminance angular distribution when light is input in the substrate as in the final part would be. Besides, along with this performance assessment, the images captured by the inspection system will be used to obtain a rough tool working performance evaluation. This evaluation is based in the fact that it's a replication process which is performed, and thus, distinctiveness in a specific structure is the result of improper tool performance. The following image shows one of these structures observed with the inspection system:

Figure 1: an 8 µm structures array observed with the inspection system

The device developed for this inspection system is based on a camera and objective system, with two possible illumination inputs: a centred light source obtained from optical fibre directly pointing through the system to the inspection point, or a light ring surrounding the inspection area. This camera system with the optical fibre can be observed in figure 2, along with a luminance measurement, ranging from 5,000 cd/m^2 next to the LED source in the bright left side to below 1,000 cd/m^2 in blue.

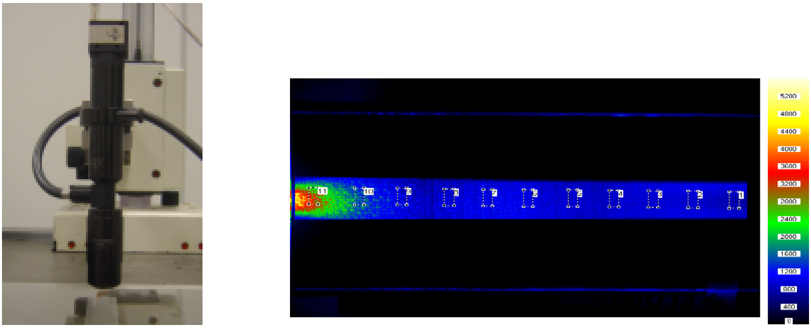

Figure 2: camera, objective and illumination optical fibre for the inspection system, and luminance measurement (cd/m^2) of a light guide on PMMA substrate.

1.2 Tool metrology system

Along with the functionality inspection system, a tool inspection system is incorporated, as the tool alignment and structural state are to be inspected in order to prevent embossing with a misaligned or fractured embossing head. This system will be used off-line when the tool is to be exchanged, in order to guarantee the correct placement of the new tool to be used. As several different embossing heads–with several structures on each– are available, a common alignment marks system is used to inspect alignment, while images of proper embossing heads will be used for comparison, to analyse the structural state of the tool.

1.3 Dimensional metrology

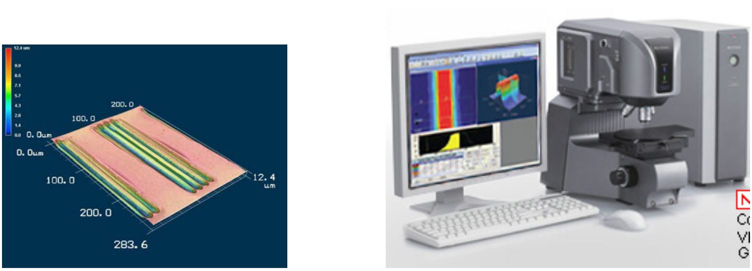

Figure 3: dimensional inspection of the structures using the VK 9700 confocal microscope

For the inspection of the structures, a dimensional metrology microscope has been incorporated to the inspection system. This system is used to increase the know-how of the process while under development, by analysing the embossed structures. A 3D representation of the dimensional inspection performed by the confocal microscope on the smallest of the structures can be observed in figure 3:

2 Adaptive embossing technology

The main challenge of the development is the capacity of the system to fully solve the unavoidable errors committed during manufacturing of the DOE's by adapting the parameters which allow foreseeing a fully functional component. These parameters include the new position and density of structures in order to guarantee that the luminance value is uniform all over the substrate. By these means, the light out coupling performance of each structure type –v's, u's, pyramids, etc…– can be assessed, and thus a change in structure type can also be included as a possibility to reduce rejects. But in order to fully implement this system, a positioning machine must be developed with a 5 µm accuracy within the FlexPAET project

3 Conclusions

Illumination evaluation during manufacturing process is possible, and low real-time requirement guarantees its implementation capabilities in DOE's manufacturing machines. Accuracy of these machines and algorithm testing are possible, and necessary for this system implementation and full functionality.

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