대형 비구면 평가를 위한 CGH 제작용 레이저 라이터
Laser writer for a large aspheric optical surface testing

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1. Introduction

The Space Optics Research Center at Korea Research Institute of Standards and Science (KRISS) has tested various large aspheric surfaces from 0.1 m to 1 m in diameter by using a series of computer-generated holograms (CGHs) [1-3]. The problem is every single aspheric surface requires a different CGH. If various surfaces are to be tested, it is necessary to fabricate various CGHs in the laboratory. To address this, we have developed a simple and precise laser writing system that uses cylindrical or circular coordinates. Most diffractive optics elements and CGHs have rotationally symmetric or asymmetric patterns. Therefore, a cylindrical-type writing system is more suitable than a rectangular one. The current leading-edge research group has developed a laser writing system, which is able to fabricate 0.5-µm patterns with maximum speed of 500 rpm within a 250-mm-diameter range. The 0.5-µm spatial resolution is better than ours, but their research is confined to binary-type CGH development because their simple triangulation auto-focusing method can only work on a horizontally flat surface. On the contrary, we aim to expand our system into hybrid optics fabrication, the base material of the hybrid optics has various slopes, in the near future by using our special auto-focusing scheme. In our system a 300-mm-diameter CGH is available with a 0.78-µm spatial resolution in radial direction. The writing source, an Ar+ laser beam that is stabilized by a laser power controller (LPC), gives us approximately 1 W at a 514.5nm wavelength and 0.3 W at 457.9-nm wavelength. This stabilized beam is controlled again by using an acousto-optic modulator (AOM) and a photodiode (PD) so as to make 256 different intensity levels. We also use the well-known auto-focusing technique with a couple of astigmatic lenses [10] in order to focus the writing beam on the material surface. The details of the intensity control, the auto-focusing scheme, the moving part of the system, and the operating software are presented in Section II. In Section III, we show some patterning results obtained by using our system.

To test various surfaces it is necessary to fabricate various CGHs in the laboratory. To address this, we have developed a simple and precise laser writing system that uses cylindrical or circular coordinates [2-5]. In our system a 300 mm diameter CGH is available with a 0.8 µm spatial resolution in radial direction. The details of the system are presented in Section II. In Section III, we shows a patterning result obtained by using the laser writing system.

2. System configuration

Figure 1 shows the configuration of our latest laser writing system, which includes the intensity stabilization and control part, the writing head with auto-focusing mechanism [6], and the moving and alignment part.

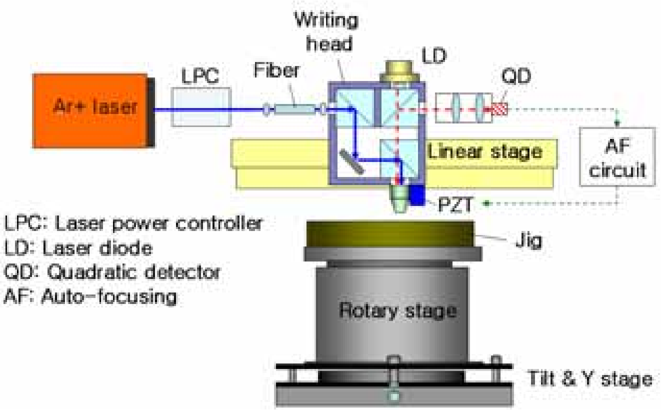

Figure 1. Configuration of the latest laser writing system

To stabilize the intensity of the Ar+ laser, we introduced the LPC, which can drastically suppress the fluctuation of the source, as shown in Fig. 2. The LPC consists of four components: an electro-optic modulator (liquid crystal modulator), a calibrated beam-splitter, a PD, and control electronics for monitoring and operating the first two elements. The source beam fed into the LPC passes through the modulator and then is divided into two parts by the beam-splitter. One is used at the writing system, and the other branch (a small portion of the beam) is used for the feedback control signal.

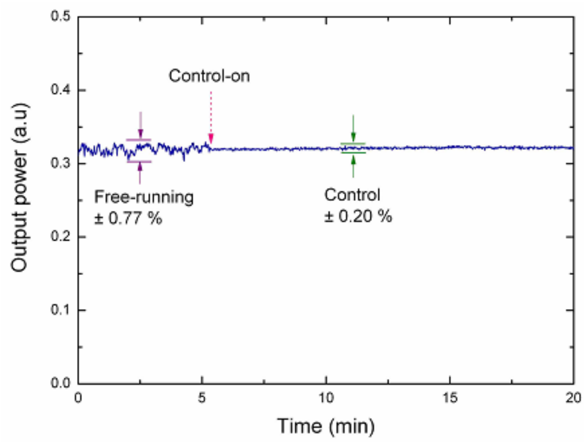

Figure 2. Stability of the Ar+ laser before and after operating the control loop.

The PD monitors the signal, and the electronic part stabilizes the output power. The values in Fig. 2 represent the root mean square (rms). We also use the intensity control with LPC for diffractive optics element (DOE) fabrication. The intensity level can be adjusted from 0 to 255 with a 0.4% noise level (rms value) within 10 ns.

For the best performance, the linear and the rotary stages (Fig. 1) were tuned up. Figure 3 shows the error map of the stages before and after tuning. After we tuned up the stages, the residual position error of the linear stage was reduced to 22 nm in peak-to-valley (PV) value within the whole 150 mm range and the residual position error of the rotary stage was reduced to 0.061 ^{o} in PV.

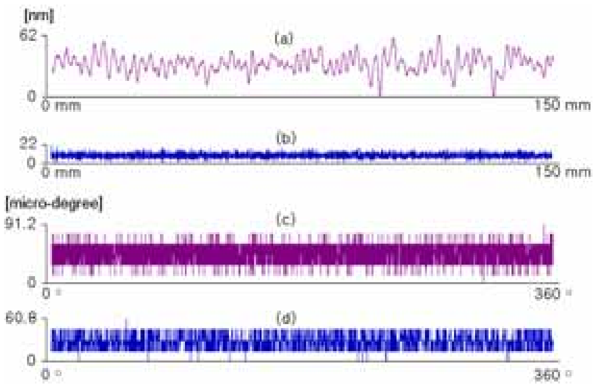

Figure 3. Error map of the linear stage (a) before and (b) after tuning. Total tuning range was 60 mm, and the number of data points was 8,0000. Error map of the rotary stage (a) before and (b) after tuning. Total tuning range was 360 ^{o}, and the number of data points was 8,0000.

3. Experimental results

To test the performance of the laser writing system, first we fabricated a 100 mm diameter circular grating as shown in Fig. 4.

Figure 4. Photographic view of the fabricated sample whose diameter is 100 mm.

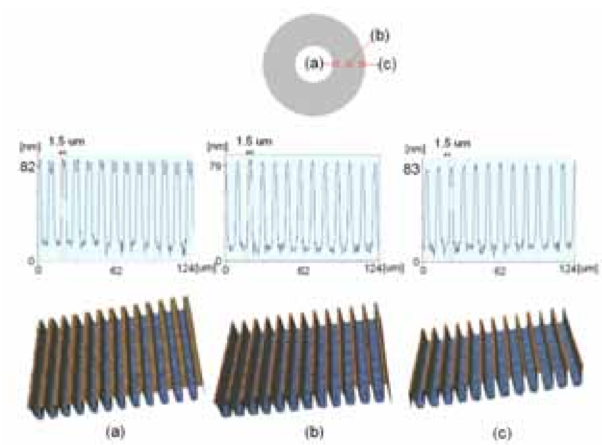

Figure 5. Circular grating patterns measured at (a) the left edge, (b) the center, and (c) the right edge area.

As show in Fig. 5, the fabricated patterns are very clear and their line width is sufficiently uniform within the whole 100 mm range.

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