Holographic beam shaping for material laser processing

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Holographic beam shaping achieved with a rewritable capability of a spatial light modulator (SLM) displaying a computer-generated hologram (CGH) is very useful in a variety of applications, primarily material laser processing [1]. The accuracy of the beam shaping is degraded according to static and dynamic imperfections in the optical system. To compensate for the imperfections, an in-system optimization method that performs the optimization of the CGH in the optical system was developed [2, 3].

A holographic laser processing machine is mainly composed of a laser diode-pumped Yb:KGW femtosecond laser with a maximum power of 10 W, a center wavelength of 1030 nm, a repetition frequency of 10 kHz, and a minimum pulse duration of ~155 fs, the LCOS-SLM (X10468-03, Hamamatsu), a microscope objective, an axially moved piezo stage, a cooled CCD imager.

Figure 1 shows the in-system optimization for 40 diffraction spots. The optical reconstructions were detected at focal positions of 206mm, 212mm, 218mm, and 224mm from the lens. The diffraction efficacy was 91.5%. The 40 diffraction spot intensities gradually became uniform with the optimization iteration. The sample was a slide glass (white crown glass). A single femtosecond laser pulse performed the microfabrication with a laser energy of 17.8 μJ on the sample plane. So, the average energy of the focal spots was 0.44 μJ, which was a little higher than the threshold energy of 0.30 μJ. This slight difference is a fantastic value that means a high uniformization of the parallel beams. It can be seen from the fabrication result that as the parallel focus beams gradually became uniform, the scale of 40 machining micro-holes also tended to be consistent. In the 30th fabrication, all of the micro-holes came to be consistent with a uniform scale of 1.80 μm at a uniformity of 0.96.

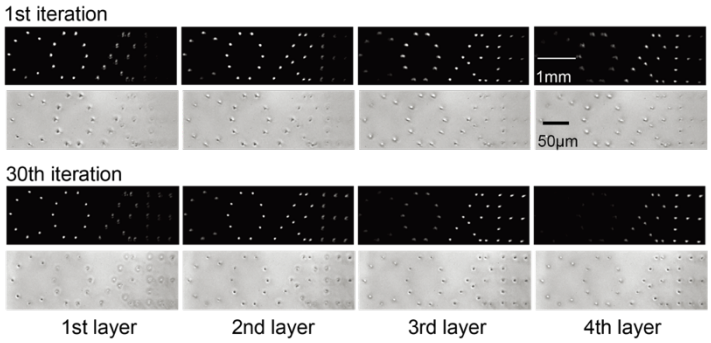

Fig. 1 3D optical reconstruction of 40 parallel beams on the four different layers and micro-hole fabrications in the side of the glass using the reconstructions of the CGH with the in-system optimization.

References:

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