システム内最適化されたホログラムを用いた単一ショットで３次元レーザー加工

Single-shot three-dimensional laser processing with an in-system-optimized hologram

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A computer-generated hologram (CGH) displayed on a spatial light modulator (SLM) can be used for parallel laser processing with high throughput and high light-use efficiency [1]. And we have demonstrated a method of in-system optimization that continuously optimizing a CGH during laser processing to dynamically compensate for unknown imperfections and sudden disturbances in the practical laser processing systems [2]. Based on the technology demonstrated in our previous work that a new method for 3D reconstruction optimization [3], it enables the system to realize the high-quality single-shot three-dimensional laser processing with an in-system optimized hologram, and can be applied to many applications due to its high-stability and high-precision.

Figure 1 shows the temporal intensities of the 15 diffraction spots in color-lines which measured with a CCD image sensor (Imaging Source, DMK23U274) carried by a linear stage (SIGMA, SGSP-25ACT) to different focal positions, and the UI curve of the uniformity in black-dot line. Obviously, the differential intensities gradually uniformized within 30 times in-system optimization and the UI curve reached a maximum value of 97% from the initial value of 5%.

Figure 2 shows the 15 parallel micro-holes laser fabrication while applying in-system optimization of the CGH. It can be seen from the fabrication result, as the parallel focus beams gradually became uniform, the scale of 15 processed micro-holes also tended to be consistent. According to the boxes highlighted in columns, the micro-holes shown in the red boxes, the orange boxes, and the blue boxes represent the fabrication areas on different layers inside the glass, respectively. In addition, the spacing between the parallel layers was 4.80 μm. And the rows of the figure represent the processing results according to the 1st, 7th, and 30th iterations order of the CGH optimization, respectively. As can be seen from the figure, the greater intensity of the 1st, and 2nd layers leading to a larger scale than the 3rd layer. Then at the 7th fabrication, the scale of all the micro-holes shown a tendency towards consistency due to the uniformity was improved from 0.05 to 0.48 which derived from the reduction of the 1st and 2nd layers and the increment of the 3rd layer. Finally, at the 30th fabrication, all of the micro-holes came to be consistent with a uniform scale of 1.65 μm.

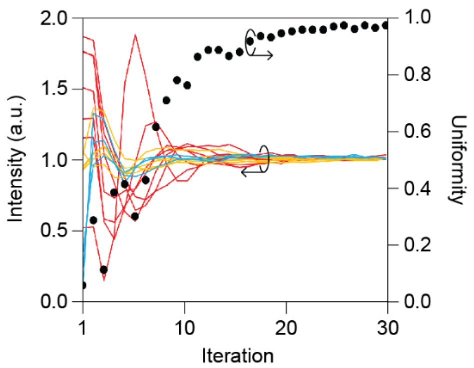

Fig. 1 Temporal intensities of the 15 diffraction spots in colour-lines and UI curve in black dot-line.

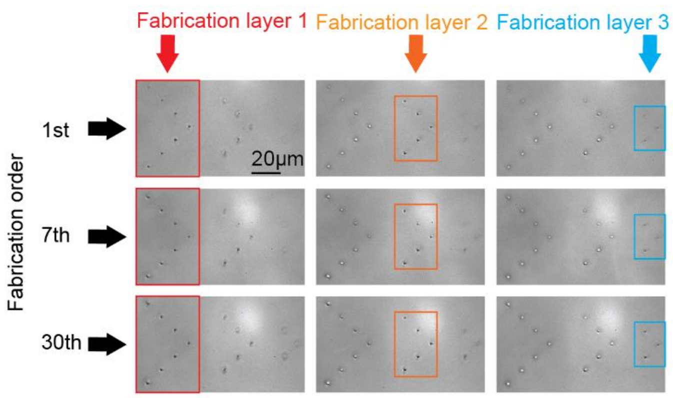

Fig. 2 3D fabrication on 3-layers inside of the glass.

References

[1] Y. Hayasaki, et. al., Appl. Phys. Lett. **87**,031101(2005).
[2] H. Zhang, et. al., Opt. Lett. **45,** 3344 (2020).
[3] H. Zhang, et. al., OSA-OSJ-OSK Joint Symposia, 14pEJ4 (2020).