High-precision Generation of Parallel Long-axis Focused Beams for Fabrication of Diffraction Gratings

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1. Introduction

The internal modification of materials (refractive index change and defect region) by ultrashort pulse laser processing is widely used for the fabrication of diffraction gratings, optical waveguides, photonic crystals, optical storage, and chemical etching guides. In the fabrication of diffraction gratings using the internal refractive index change by ultrashort pulse laser processing, it is necessary to realize high-throughput simultaneous parallel processing by parallelizing focused beams and to fabricate thick diffraction gratings with high diffraction efficiency by elongating the axis of the focused beam. The holographic laser processing method using computer-generated holograms (CGHs) displayed on a spatial light modulator (SLM) solves this problem by spatially shaping the laser beam [1]. In this study, we generate parallel long-axis beams by combining a CGH for generating parallel beams and a CGH for generating a long-axis focused beam and generate beams with high precision in the processing optical system.

2. High-precision generation of parallel long-axis focused beams

For high-precision generation, the CGH for array beam generation is updated so that the plasma emission intensity of each spot generated during laser processing is made uniform. CGH is optimized while observing the processing situation, achieving high-precision processing. shows the change in uniformity of each spot due to the optimization process.

By using a hologram with a uniform beam profile in the axial direction for long-axis processing, processing can be performed while freely changing the distance in the axial direction. Axial beam generation was performed using a three-dimensional weighted iterative optimization (WGS, Weighted Gerchberg - Saxton) algorithm [2].

1) Y. Hayasaki, T. Sugimoto, A. Takita, and N. Nishida, “Variable holographic femtosecond laser processing by use of a spatial light modulator,” Appl. Phys. Lett. 87, 031101 (2005).
2)Nami Kuroo and Yoshio Hayasaki, "Design framework of a computer-generated hologram that performs volumetric beam shaping for advanced laser processing," Opt. Continuum 3, 1244-1253 (2024)

Short biography:

Koichi Takahashi was born in 2001 in Nasu, Tochigi Prefecture. He graduated from Tochigi Prefectural Kuroiso High School in March 2020 and entered Utsunomiya University in April. In 2021, he moved on to the Information Electronics and Optics Course in the Faculty of Engineering. He is a member of Hayasaki Laboratory in Center for Optical Research and Education (CORE). His research field is holographic laser processing.