Laser interference lithography with a spatial light modulator for arbitrary pattern fabrication

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A new free pattern fabrication method combining laser interference lithography and wavefront control has been proposed. Conventionally, two coherent beams are superimposed to generate the interference fringes in the laser interference lithography. However, the pattern shapes are restricted to simple stripes due to the principle, and it has not been an easy task to control the position of these fringes. To solve this problem, in this paper, a method of applying the phase delay to one of the coherent beams by placing a spatial light modulator in front of the interferometer is proposed. As a first approach for achieving the goal of this study, the experimental evaluation results of the feasibility of moving interference fringes by introducing a spatial phase modulator into a one-axis non-orthogonal Lloyd's mirror interferometer are reported.

In recent years, the demand for fine structures with μm-level patterns has been increasing in the field of optics, biomaterial, and microelectromechanical systems (Kim et al., Nat. Commun., 2023). For example, diffraction gratings are often used in positioning sensors and CMMs (Gao et al., CIRP Ann. Manuf. Technol., 2015). In addition, micropatterns are also used in cell culture, cell analysis, surface profiling, and so on (Gupta et al., Lab on a Chip, 2010). Electron beam lithography, which uses electron beams to draw microstructures one by one, and photolithography, which uses a photomask to create arbitrarily shaped microstructures, are good examples of typical methods for generating such fine patterns. However, it is not easy to generate microstructures over large areas in a short time. Meanwhile, laser interference is a candidate technology capable of fabricating such micropattern structures over a large area in a short time. A non-orthogonal Lloyd's mirror interferometer, which is one of the techniques of optical interference lithography, is known for its ability to generate microstructures over a large area by superimposing coherent laser beams, and its simple structure enables stable pattern exposure (Shimizu et al., Precis. Eng., 2019). However, interference fringes to be generated by the method have been limited to simple ones. It has therefore been desired to develop a method capable of creating free micro-patterns based on laser interference lithography.

In response to the background described above, a new method for the batch fabrication of free patterns has been proposed based on laser interference lithography combined with a wavefront control technique (Takahiro et al., Opt. Lett., 2023). In this paper, experiments are extended to further verify the feasibility of the proposed method for the control of the position of interference fringes and the generation of two-dimensional patterns by a spatial light modulator.