Single photon direct laser writing using high power laser diode to fabricate diffractive optical elements

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Diffractive optical element (DOE) comprises a variety of small features of micron size to manipulate the phase of incident light to form an intended beam shape. [1] Moreover multiple level DOE which has different pattern depth to generate more complicated beam shape are widely studied in engineering fields.[2] The photolithography accompanied by etching process will be prominent process, and laser ablation method is also a good established tool. However, recent requirement to enhance efficiency and accuracy of DOEs drives researchers to devise alternative technique which has high speed and can cover millimeter area. The most important function is how small pattern can it make, especially down to tens of nanometer scale.

Recently the stimulated emission depletion and two-photon polymerization techniques make direct laser writing process more powerful in fabricating three-dimensional polymer structure. [3] We implemented a compact and economical laser writing system using laser diodes shown in Fig. 1. It uses 488nm wavelength laser diode (Nichia, 25mW) for single photon polymerization. The Olympus 100x oil immersion objective focuses the laser on a surface coated with the photoresin (NK Ester BPE-100) which is mixed with the photoinitiator (camphorquinone), the coinitiator (ethyl 4-(diemthylamino) benzoate), and the photoinhibitor (tetraethylthiuram disulfide). The other branch of the system is for 375nm wavelength laser diode (Nichia, 70mW) for photoinhibition. There is a vortex phase plate (RPC Photonics Inc.) in the middle of the 375nm laser path, and it makes the donut shape inhibition beam centered at the 488nm laser spot. Fig. 2 shows the simple line pattern based on single photon polymerization process. The power of the 488nm laser is about 200nW at the focal point and the power of the 375nm laser is 10 times stronger than the polymerization laser. The first target of this project to make an infrared wavelength filter comprised of crosshair pattern of 1~2 micron scale and this compact system will be useful for a large area patterning system used in display industry.

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[1] D. C. O'Shea, T. J. Suleski, A. D. Kathman, and D. W. Prather, *Diffractive Optics : Design, Fabrication, and Test*, SPIE Press (2004)

[2] E. Neiss, M. Flury, L. Mager, J. Rehspringer, A. Fort, P. Montgomery, P. Gerard, J. Fontaine, and S. Robert, Opt. Lett. 16(18), 14044-14056 (2008).

[3] J. Fischer, T. Ergin, and M. Wegener, Opt. Lett. 36(11), 2059-2061 (2011)

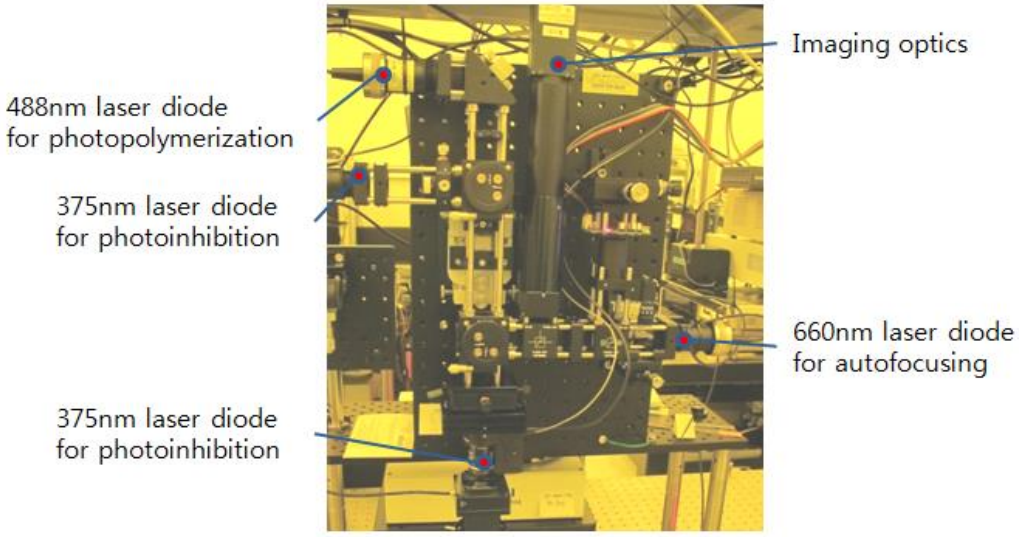

Figure 1: Direct laser writing system based on single photon polymerization using laser diodes.

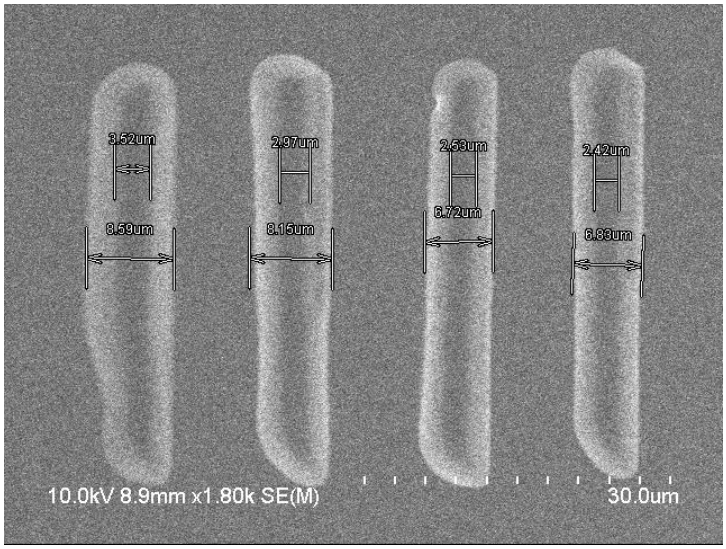

Figure 2: Line pattern by single photon polymerization process