MODULATED DYNAMIC MASK FOR UNIFORM EXPOSURE IN MASKLESS PHOTOLITHOGRAPHY

J.S. Yoon, S.H. Song, W. Park*

Department of Electronics and Radio Engineering, Institute for Laser Engineering, Kyung Hee University, Republic of Korea

ABSTRACT

We report a method to simply and inexpensively generate uniform intensity distribution of ultraviolet light for maskless photolithography system. To take the uniform spread of ultraviolet light, we check the local intensity of the light reflected by the Digital Micromirror Device (DMD), using the power meter which can measure the energy of a specific wavelength. After that, using the energy spread, we make a revision table. The patterns or particles fabricated by using the revision table have lower variance of intensity and radius.

KEYWORDS: Uniform, Revision table, Photolithography, Digital micromirror device

INTRODUCTION

Photolithography has been widely used for selectively patterning a surface with photoreactive material or fabricating polymeric structures with masks. The size of effective exposure area in photolithography depends on the optical system. To generate uniform light intensity in an exposure area, expensive optical component are required and the components are precisely assembled. Practically, only a limited area of which intensity is relatively equivalent is used and the mask region where the equivalent light intensity pass through is used. In order to overcome this limitation, some complex processes were performed to get uniform distribution [1]. In this study, we introduce a simple method to obtain equally spread UV light by reflecting on dynamic mask thought.

EXPERIMENTAL

To produce uniform particles or patterns, we used optofluidic maskless lithography system (OFML)

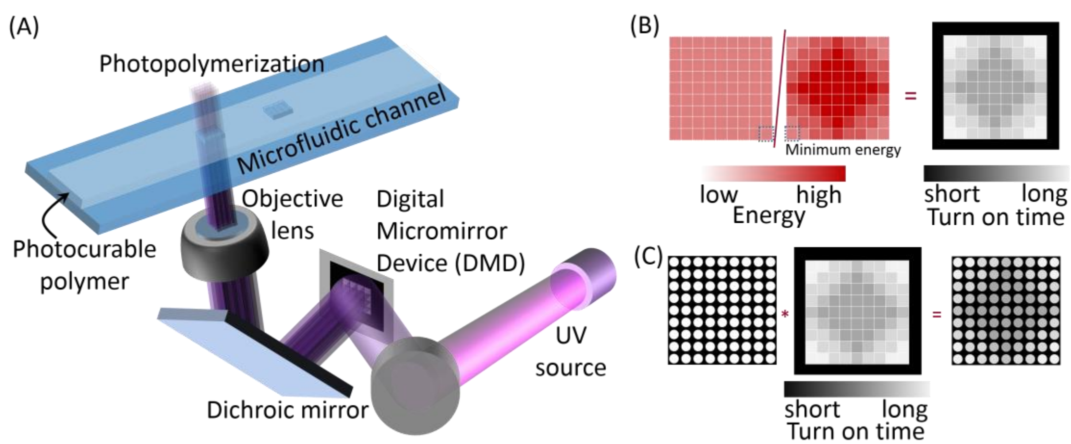

Figure 1: (A) The uniform particles or patterns are fabricated using revised UV light in optofluidic maskless lithography system (OFML). The uniform revised mask is loaded on Digital Micromirror Device (DMD). Bright fields of the mask are polymerized. (B) The process of making the revision table is shown. Using UV light measurement device, the local intensity of individual exposing area are checked (with using the microscope objective) and made into a table. Through the local intensity table and some mathematical concept, the revision table is built. (C) The process of making the revision mask is shown. The revision mask is generated by multiplying the formal mask and the revision table made in Fig 1B. This mask is going to apply to DMD in OFML and something uniform will be fabricated.

[2] composed of microfluidic and an optical lithography device (Figure 1A). First, we divided the exposing area, composed of 1024x768 mirrors. We divided it into 48 areas by 128x128 pixels and measured the local intensities of individual exposing area, using a UV light measurement device. A revision table was built, based on the UV light intensity of each local area (Figure 1B). Second, we used the feature of DMD to modulate light intensity by controlling the switching time of individual pixel on the DMD. We modulated a mask based on the revision table and create the modulated mask pattern (Figure 1C). In a microfluidic channel, using the revised mask, uniform particles or patterns were fabricated by photopolymerization of prepolymer solution. Furthermore, we used fluorescent-dyed acrylic monomer for visualization of crosslinking density of polymer after polymerization.

RESULTS AND DISCUSSION

We compared the radiuses and the intensities of microparticles generated with non-revised mask (1-bit Black and white pixel) to the particles fabricated with revised mask (8-bits pixels), as shown in Figure 2. In the case of the microparticles from non-revised mask, the intensities and the radiuses of the microparticles were not uniform. However, the microparticles generated with revised mask have more uniform intensities and radiuses. We assume that the equivalent intensity of UV light would induce the uniform the intensities and the radius of the microparticles. We quantified the intensities and the radiuses of the microparticles generated with the non-revised mask and the revised mask, using MATLAB. The quantified results were displayed in the histogram of the intensities and the radiuses (Figure 3). We found that the intensities and the radiuses of the microparticles from the revised mask were more narrowly distributed than those of the microparticles from the non-revised mask. This is because the revised mask strengthens the UV light in low intensity area and weakens the UV light in high intensity area in order to create even UV light illumination on the plane.

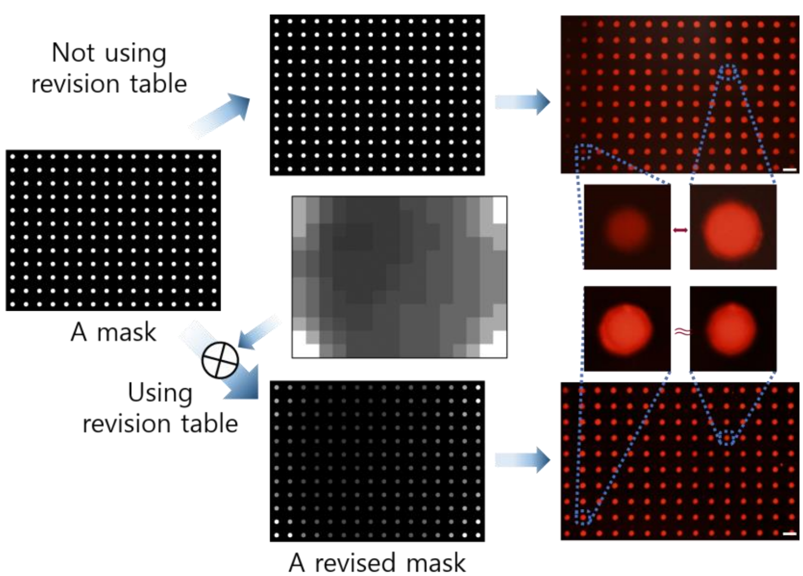

Figure 2: The top of figure is results from using formal mask and the bottom of figure is results from using revised mask. The revised mask that made by multiplying the revision table and formal mask is little strange, but the fabricated particles are better than the particles made by formal mask, through the radius of particles and intensity of fluorescence. To understand at a glance, some particles located in particular position are compared. The two particles made by the formal mask have different value of radius and fluorescence, but the two particles made by the revised mask have about same value of radius and fluorescence. (Scale bar: 200μm)

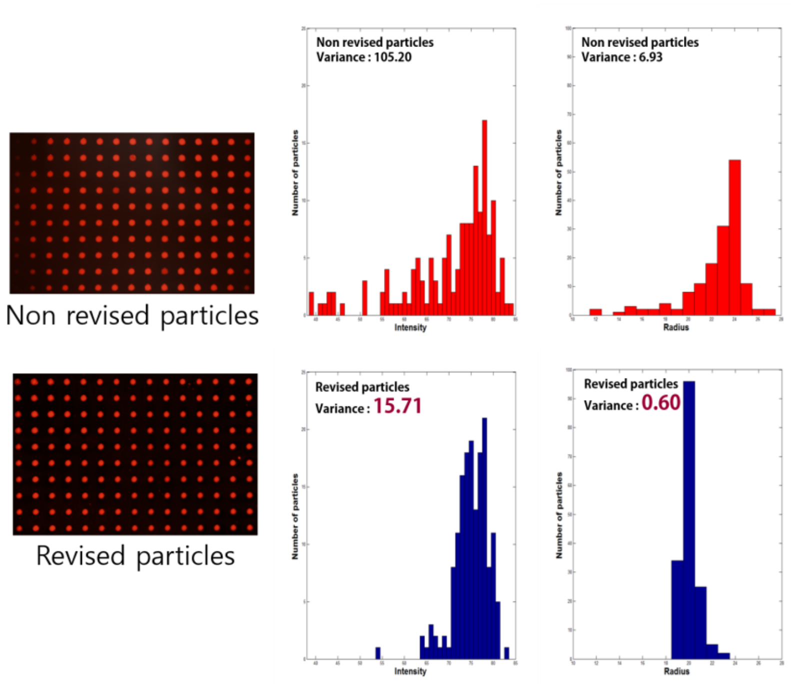

Figure 3: Red means non revised particles (formal particles) and blue means revised particles. The left side of histograms are shown the fluorescence intensity spread. The right side of histograms are shown the radius spread. As shown above, revised particles have quite lower variance than formal particles. That means high quality particles were fabricated by revised mask.

CONCLUSION

We proposed a method revising ununiformed UV light intensity on the target plane by utilizing a revised dynamic mask based on UV light intensity map, obtained by measuring the UV light intensities of each area on the plane. We expect that this method can be applied to uniformly encapsulate or immobilize DNA, proteins, and bio-compatible materials. Also, we hope this technique can be widely used to fabricate uniform microstructures and patterns in relatively large area where the intensity distribution is varied.

REFERENCES

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CONTACT

* Wook Park, tel: +82-31-201-3465; parkwook@khu.ac.kr; homepage: http://multiplexon.khu.ac.kr