Electron beam lithography for distributed Bragg reflectors in SU-8

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Bragg reflectors consisting of periodically alternating quarter-wave layers with different index materials can find wide applications in a number of optoelectronic devices, such as vertical-cavity surface emitting lasers, Fabri-Perot modulators, microcavity light-emitting diodes and resonant-cavity photodectors. In addition, the Bragg reflectors have also been used to confine the photon modes in 1-D and form semiconductor quantum microcavities. However, these applications are so far still limited in expensive III-V materials grown by molecule beam epitaxial (MBE) method. In this paper, we have initiated a nanofabrication technique to fabricate distributed Bragg reflectors (DBR) in an epoxy-based resist, SU-8 supplied by MicroChem. SU-8 is sensitive to both e-beam and UV lights with very high sensitivity and low viscosity, and hence has attracted broad attentions for nanophotonic structures and MEMS due to its excellent optic properties (e.g. 98% transmission at wavelengths above 400 nm and the refractive index is 1.59 at λ=600nm).

Two different types of DBRs have been succeeded in this work by electron beam lithography (EBL). One is horizontal DBR mirrors with a grating structure in the waveguide of SU-8 (figure 1a), and the other is fibre DBRs with periodical disturbance in height (figure 1b). To achieve these two different configurations, two e-beam exposure procedures were adopted (figure 2). The pitches close to 516 nm and 200 nm were used in the Bragg gratings, corresponding to the emission light of 1.55 μm and 400 nm, respectively. The heights of the waveguide and the Bragg gratings were carefully measured and controlled (figure 3) Challenges encountered in the development of the EBL are: the width of each line in the grating should be $\lambda/4$, which was carefully controlled by the e-beam exposure dose; surface roughness due to the residual resist on the waveguide and the grating may cause the loss of wave, which was reduced by optimizing the exposure dose, and the verticality of the gratings is critical for high quality reflection of waves. The performance of the fabricated DBRs are being characterized at our laboratory. The success of this work will surely open up a broader area for the technical development for SU-8 based optoelectronic devices, filters, resonators, etc.

In conclusion, we have successfully developed an electron beam lithography process for the fabrication of SU-8 based distributed Bragg reflectors (DBR). The optical properties of the SU-8 waveguide and DBRs need to be further characterized before the SU-8 based components are widely applied.

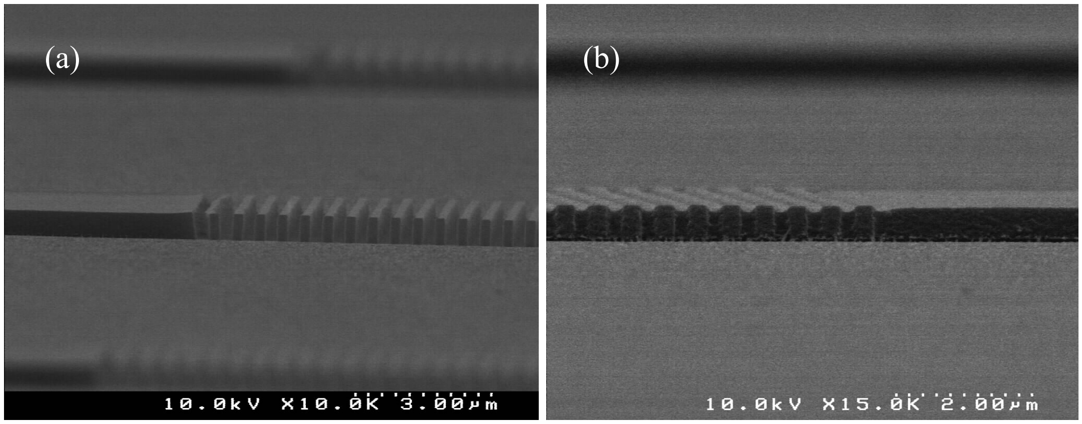

Figure 1. The fabricated SU-8 based Bragg reflection structures. (a) Distributed Bragg reflector. 2) Fibre Bragg reflector.

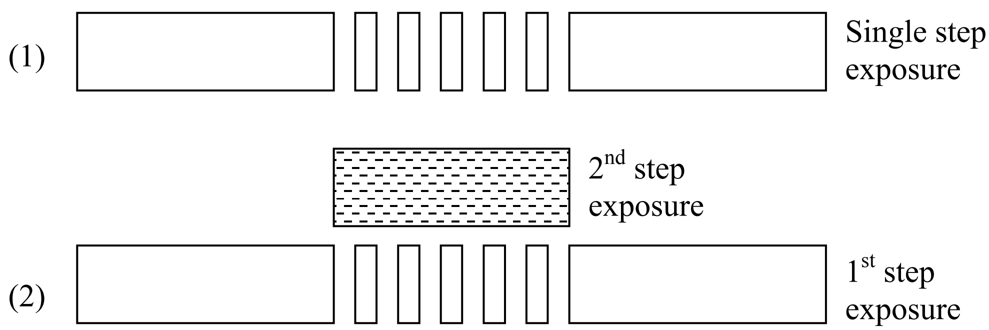

Figure 2. Two different writing procedures for DBRs and Fibre Bragg reflector, respectively. (1) A single step exposure defines the DBR configuration; (2) A two-step exposure procedure defines the fibre Bragg reflector.

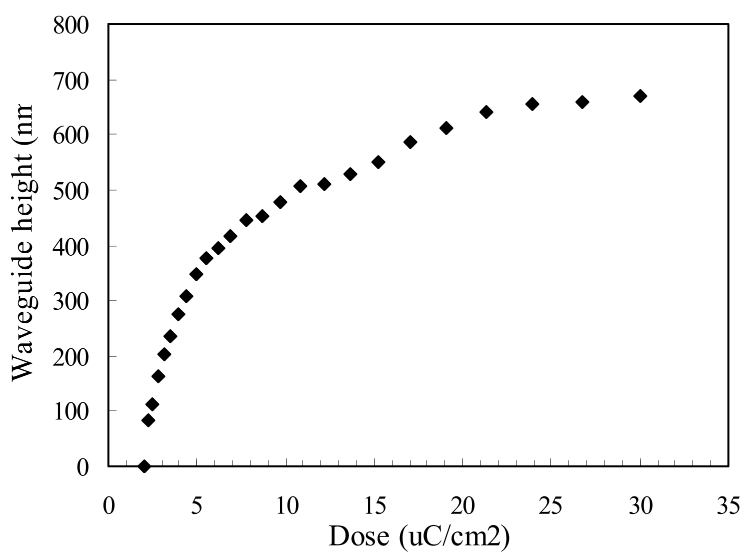

Figure 3. The height of the waveguide under different e-beam exposure dose.