A Challenge to half-pitch 22 nm using Near-field Lithography

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Near-field lithography (NFL) is a novel photolithography technique that uses optical near-fields whose spatial distribution is directly controlled by a design of a photo mask. Near-field light is a localized one that exists within 10~100 nm from illuminated objects and concentrates in a much smaller volume than the diffraction limit of a propagating light.

In our previous paper, we reported on NFL incorporating a tri-layer resist process combined with an i-line sensitive chemically amplified resists (CARs)[1]. We have also reported on the selection of amorphous Si as a light absorber material on the mask[2], which enables a fabrication of a very fine photo mask pattern and also improves near-field distribution for the lithography. A proof of concept exposure tool was built to demonstrate a large area tight contact of a membrane supported near-field photo mask (Fig. 1) and an excellent uniformity of the lithography[3]. An electromagnetic analysis of the mask and the resist stack layers indicated that a total thickness between the mask and reflective substrate is a key to maximize an optical contrast of the near-field distribution. The effect of the layer thickness was experimentally confirmed as an improved resist pattern[4]. We have also designed a novel positive-tone resist system based on photo deprotection of o-nitrobenzyl (NB) phenol ether. The resist is monodispersed and consists of single component; polyphenol compound partially protected by NB[5]. The reaction is completed during the exposure process and needs no PEB. Therefore, the NB phenol resist never encounters the problem of the diffusion inherent in the CARs.

Hp 32 nm L/S pattern of 10 nm deep was successfully transferred to the 100 nm thick bottom-layer resist through the tri-layer resist process as shown in Fig. 3. Hp 22 nm L/S pattern shown in Fig. 4 was also fabricated on the top portion as deep as 10-15 nm of a single-layer NB phenol resist. These results demonstrate the potential high resolution obtainable with the NFL.

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[3] Y. Inao et al. Microelectron. Eng.(in press).
[4] T. Yamaguchi et al. Microelectron. Eng.(in press).
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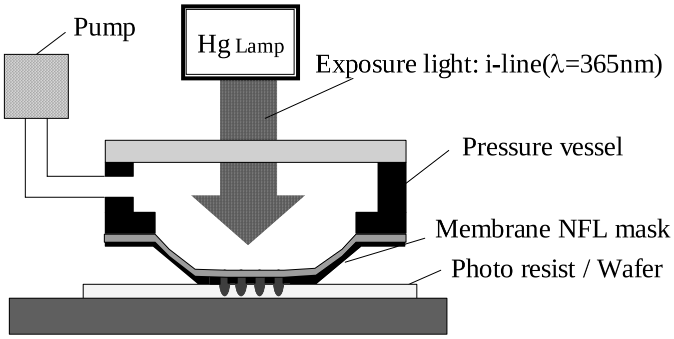

FIG. 1. Schematic illustration of the near-field lithography.

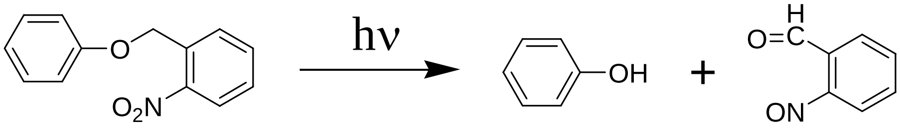

FIG. 2. Photo-deprotection reaction of o-nitrobenzyl phenol ether

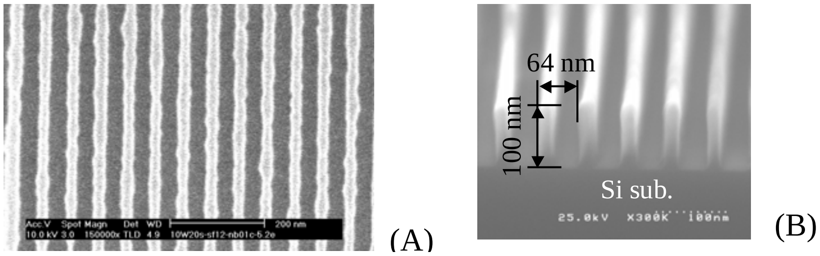

FIG. 3. SEM images of hp 32 nm L/S bottom-layer resist pattern,
(A) a top view and (B) a cross-sectional view.

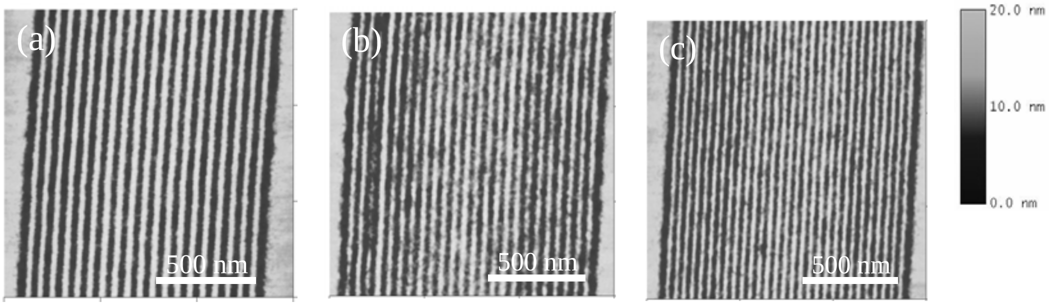

FIG. 4 AFM images of hp (a) 32, (b) 27, (c) 22 nm L/S patterns. The exposure dose was 1.40 J/cm^2 for each. The resist thickness and the pattern depth was 190 nm and 15~10 nm, respectively.