Evaluation of RE-800 as a negative tone chemically amplified resist for electron beam lithography

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Fast speed and negative-tone electron beam lithography (EBL) resists with sub-100 nm resolution are constantly needed for large area patterning in the applications for dense structures such as optical metasurfaces, gratings, 2D photonic crystals, etc. So far, a big variety of e-beam resists have already been commercially available. Among them, both UVN-30 by Shipley Ltd and NEB by Somitomo Ltd as chemically amplified resists (CARs) exhibit both high sensitivity to e-beam exposure and good resolution around 30–100 nm. The CARs' sensitivity is usually so high that any small variances in substrate, pattern geometry and size, resist thickness and preparation condition can totally shift the processing window, resulting in unreliability. On the other hand, negative tone resist such ashydrogen silsesquioxane (HSQ) owns much lower sensitivity and high resolution, its slow speed and poor performance in lift-off limit its applications for large area patterning. A new brand of resist with improved dose window, good speed and high resolution has been longed for decades.

In this paper, we report our evaluation work on a newly developed negative tone electron beam resist, RE-800, which has deliberately reduced its sensitivity but high resolution. RE-800 is a CAR with PHS resin as basic material which is recently developed by Han-Top Photo-materials Co. Ltd., Jiangsu, China. Figure 1 presents the thickness ranging from 250 nm to 150 nm, depending on the spin speed. A soft bake was then carried out at 140℃ for 3 min on a hot plate. E-beam exposure was carried out by JEOL 6300FS at 100keV with a beam current of 500 pA and an 8-nm beam spot size. After exposure, a post-exposure bake (PEB)was immediately done at 140℃ on a hot plate for 2 min, followed by a developing process in 2.5% water buffered TMAH at 23℃ for 1 min. Figure 2 shows the contrast curves of both RE-800, UVN-30 and HSQ for comparison. The sensitivity of RE-800 is measured from the contrast curve as 25μC/cm^2, which is 2 times slower than UVN-30 but 10 times faster than HSQ. Figure 3 presents single lines of RE-800, replicated by EBL in this work. Grating patterns with the pitch down to 250 nm have been achieved, as shown in figure 4. Resistance to oxygen plasma and lift-off property were also tested and compared to PMMA.

By summary, the EBL performance of the recently developed RE-800 has been evaluated and compared to the existing EB resists. The RE-800 has demonstrated the advantages over other CAR resists in much larger lithography window and high reliability in lift-off.

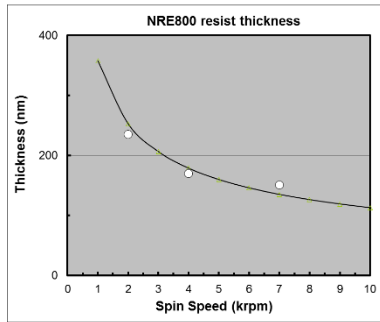

Figure 1,thickness vs. spin speed

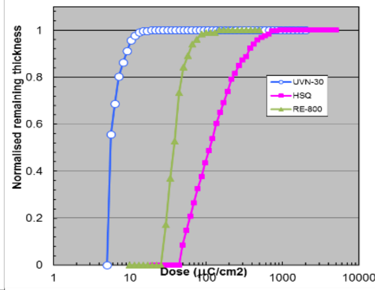

Figure 2, contrast curve of RE-800, UVN-30 and HSQ

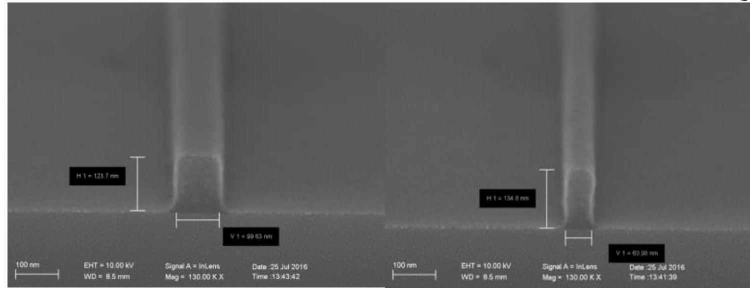

Figure 3(a) 100 nm single line. Figure 3(b) 50 nm single line

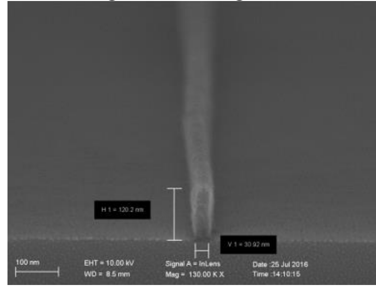

Figure 3(c) 30 nm single line.

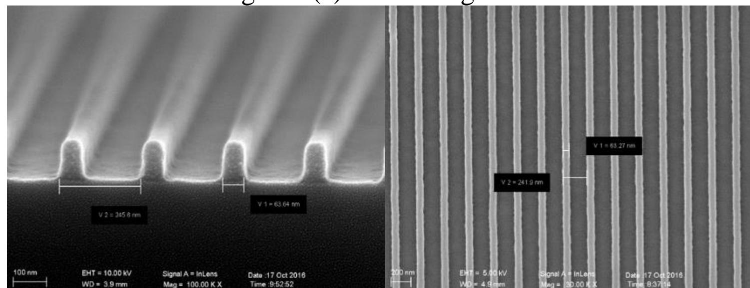

Figure 4(a) and 4(b) 60 nm gratings with 250 nm periods.

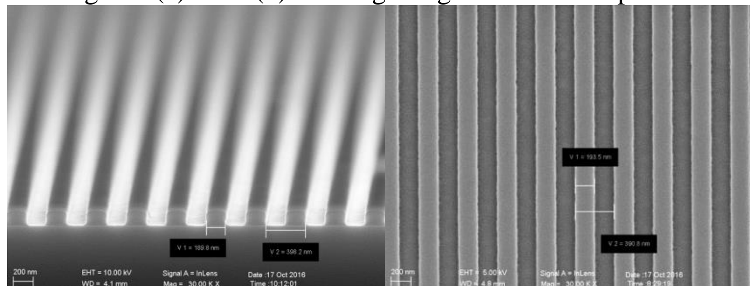

Figure 4(c) and 4(d) 200 nm gratings with 400 nm periods.