Plasmonic Effect of Process Parameters on 10-nm Patterning in Computational Lithography

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Lithography technology has been developing the semiconductor industry according to Moore's Law over 40 years. The current immersion ArF lithography locates at the crossroads of a decision on the next generation lithography (NGL) technology in terms of the improved limit of exposure wavelength and numerical aperture (NA) in Rayleigh's equation. As a favorite successor of immersion ArF, extreme ultraviolet (EUV) lithography has been researching for 1x-nm technology nodes. Multiple patterning such as quadruple patterning is confronted with the huge increase of cost of ownership (CoO) and the difficulty of overlay. Under such conditions, the high transmission through a subwavelength size metal-aperture has been tremendous interests for maskless plasmonic lithography (MPL). The physical origin of this enhanced transmission is the excitation of surface plasmon polariton (SPP), which is the coupled mode excitation of an electro-magnetic wave and free charges on a metal surface. MPL has advantages for low cost, the high-intensity nanometer-scale light spot beyond diffraction limit, and applicability of conventional light sources and resist materials.

In this paper, MPL process is modeled and simulated for 15-nm critical dimension (CD). The near-field intensity with the plasmonic phenomena of aperture shapes is described due to aperture parameters by using the rigorous coupled-wave analysis (RCWA) method [1] and the finite difference time domain (FDTD) method [2]. MPL parameters of bowtie structures are optimized and improved for the imperfection of the resist pattern. The most dominant parameter on critical dimension is gap size of bowtie by Taguchi method.

Figure 1 shows MPL modeling, which are illumination system, prebake, exposure, post-exposure bake (PEB), and development. The imperfection of resist pattern is possibly attributed to the imperfect of bowtie patterns and the roughness of the metal surface. Hence, this resist pattern can be further improved by optimizing lithography conditions. Figure 2 shows intensity linewidth due to structure parameters of metallic bowtie. Bowtie structure can provide intensity linewidth of 1x-nm using optimized structure parameters. However, the sufficient aspect rate of critical dimension is required for etch process. Figure 3 shows the sensitivity of simulation parameters in bowtie structure. The most dominant factor is the gap size of bowtie structure.

REFERENCES

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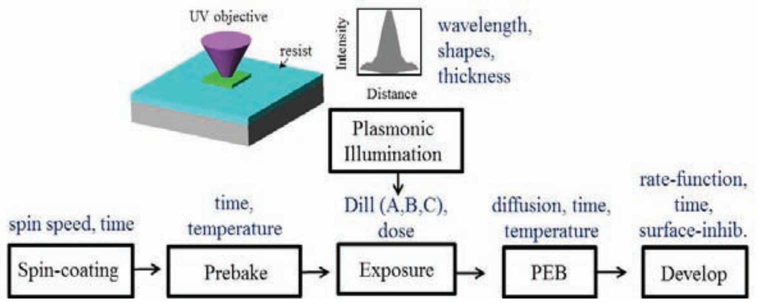

Fig. 1. Schematic flow of maskless plasmonic lithography: spin-coating, prebake, plasmonic illumination, exposure, post-exposure bake, and development.

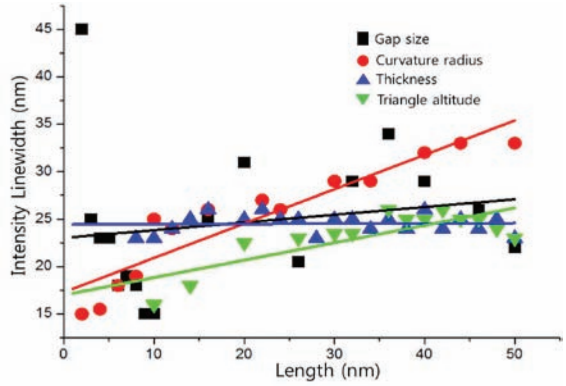

Fig. 2. Simulation results of intensity for gap size, curvature radius, thickness, and triangle altitude in the optically resonant metallic bowtie nanoantenna. Linear graph is a fitting function of y = Ax + B for each of simulation results. Insert is bowtie structure.

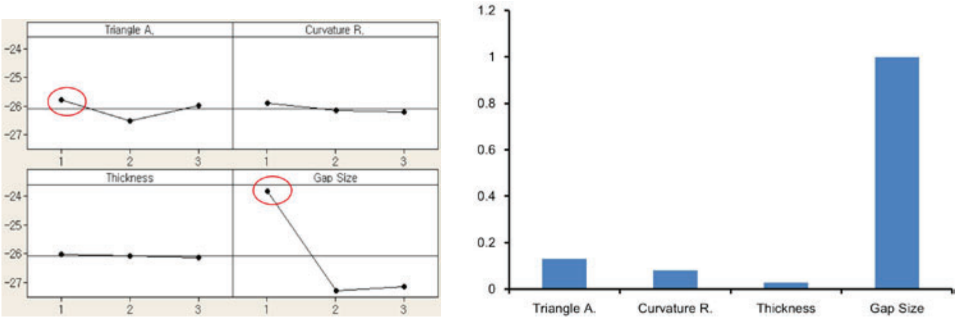

Fig. 3. Parameter sensitivity of simulation parameters on intensity linewidth. Parameters sensitivities are normalized by the sensitivity of gap size.