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Patterning Dependency on Extreme Ultra Violet Wavelength and Bandwidth.

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1. Introduction

•In EUVL (Extreme Ultra Violet Lithography), a 13.5 nm radiation wavelength generated by EUV source is used to print circuits. Most EUV is strongly reflected at this wavelength from the multilayer mask. However, the bandwidth of EUV source is very broad compared with currently available 248 and 193 nm source, which is in the order of 0.1 pm. Thus the broad bandwidth of EUV might give strong influence on the patterning even though EUVL uses mirrors for the imaging instead of lenses.

•For analyzing the effect of EUV wavelength and bandwidth to the image quality we used commercial S-litho of Synopsys as a simulation tool. And we could get the simulation result such as reflectivity, image contrast, NILS (Normalized Image Log Slope), and Iso-Dense bias with respect to the change of central wavelength and bandwidth.

•This paper presents the patterning dependency of 22 nm node dense patterns and 25 nm contact holes on the change of central wavelength and bandwidth in EUV source. By changing the central wavelengths (13.4, 13.5, and 13.6 nm), there were noticeable differences.

•The contrast and NILS of 13.4 nm wavelength was better than those of 13.5 nm in 22 nm line and space pattern and 25 nm contact hole pattern. Changing the bandwidth (FWHM, Full Width at Half Maximum, 300 ~ 1550 pm), also showed different simulation result. According to our simulation, the effect of EUV wavelength and bandwidth should not be neglected for better EUV patterning.

2. Simulation

Using S-litho™ simulation tool, we simulated the patterning dependency of 22 nm node dense patterns and 25 nm contact holes on the change of central wavelength and bandwidth in EUV source.

- **Simulation 1**
  : Simulate the image quality(image contrast, NILS, reflectivity, Iso-Dense Bias) on the change of central wavelength (13.4,13.5 and 13.6 nm)
- **Simulation 2**
  : Simulate the image quality(image contrast, NILS, reflectivity, Iso-Dense Bias on the change of bandwidth (Full Width Half Maximum 300,550,1050,1550 pm)

3. Simulation Conditions

Table 1. Imaging conditions

Imaging conditions	
22 nm Line & 44 nm Space	25 nm Contact Hole
• NA : 0.25 • Illumination : Dipole (offset 0.6/ radius 0.1/ 0˚) • Pattern size : 22 nm width 1:2 L/S • Resist thickness : 80 nm • Mask : 50 nm thickness Al_2O_3/Ta/on 40 Mo/Si. • CRAI(Chip Ray Angle of Incidence) : Phi: 6˚, Theta 90˚ • 3D mask algorithm : Waveguide	• NA : 0.25 • Illumination : Conventional (sigma 0.3) • Pattern size : 25 nm width 1:2 L/S • Resist thickness : 80 nm • Mask : 50 nm thickness Al_2O_3/Ta/on 40 Mo/Si. • CRAI(Chip Ray Angle of Incidence) : Phi:6˚, Theta 90˚ • 3D mask algorithm : Waveguide

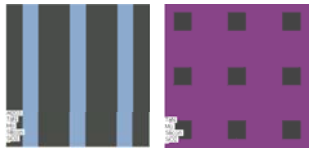

Fig. 1 22nm L&S, 25nm contact hole

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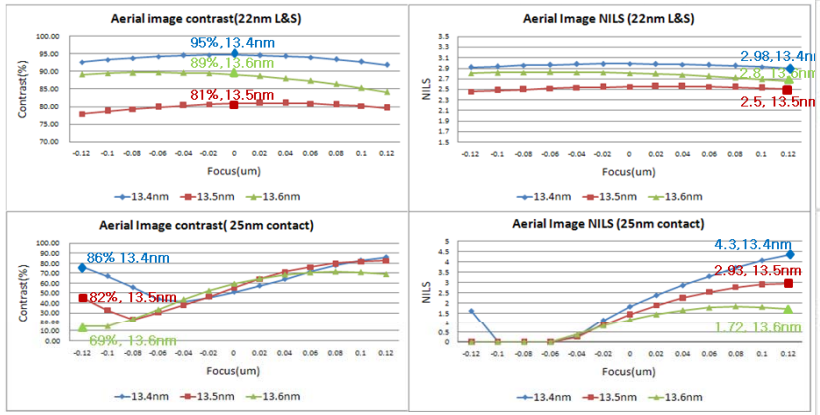
4. Result and Discussion

Fig.2 Aerial image contrast & NILS at 22 nm L&S by wavelength split



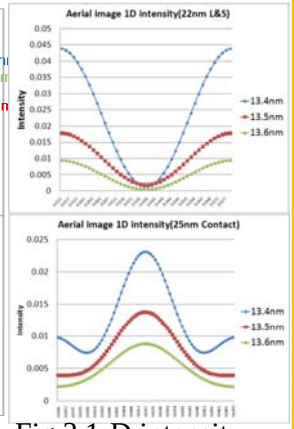
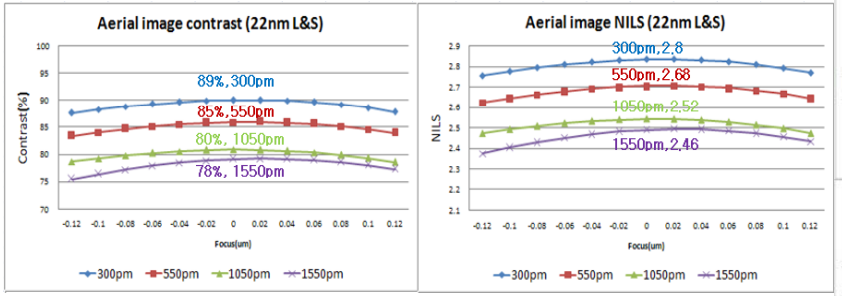


Fig.3 1-D intensity

Fig.2 shows that EUV wavelength affects the image quality of 22 nm L&S and 25 nm contact hole pattern. The contrast and NILS of 13.4 nm wavelength was better than those of 13.5 nm in 22 nm line and space pattern and 25 nm contact hole pattern. Fig.3 shows 1D intensity profile of 22 nm L&S pattern and 25 nm contact hole pattern. The wavelength of 13.4 nm shows best intensity profile on 22 nm L&S and 25 nm contact hole pattern.

Fig. 4 Aerial image contrast & NILS at 22 nm L&S by bandwidth split



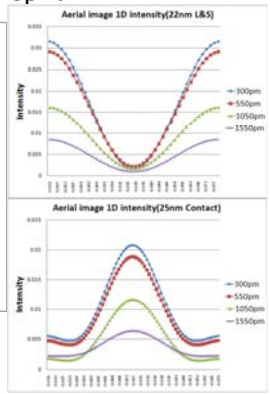


Fig.5 1-D intensity

Fig.4 shows that EUV bandwidth(FWHM, Full Width at Half Maximum) affects the image quality of 22 nm L&S and 25 nm contact hole. As EUV bandwidth become shorter, The image quality of 22 nm L&S and 25 nm contact hole pattern was predicted better. Fig.5 shows 1D intensity profile of 22 nm L&S and 25 nm contact hole pattern. The bandwidth 300 pm shows best 1D intensity profile among 300 pm, 550 pm, 1050 pm, and 1550 pm.

Fig. 6 Iso-Dense Bias induced by central wavelength and bandwidth.

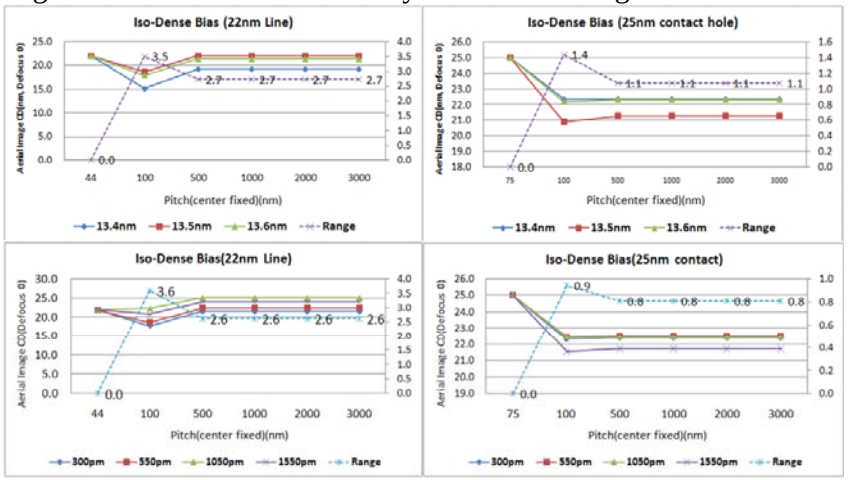


Fig.6 shows that EUV central wavelength and bandwidth affects Iso-Dense Bias of 22 nm L&S and 25 nm contact hole pattern. Dotted line shows the range of CD difference among central wavelength or bandwidth. The CD difference among central wavelength is 1.1~3.5 nm. And the difference of Iso-Dense Bias among central wavelength or bandwidth is 1 nm.

5. Conclusion

- The simulation result shows that the central wavelength and bandwidth change in EUV source affects the image quality of 22 nm node dense patterns and 25 nm contact holes. According to our simulation, the effect of EUV wavelength and bandwidth should not be neglected for better EUV patterning.

- The contrast and NILS of 13.4 nm wavelength was better than those of 13.5 nm in 22 nm line and space pattern and 25 nm contact hole pattern.

- The contrast and NILS of relatively narrower 300 pm bandwidth (FWHM) were better than those of wider bandwidths (550,1050,1550 pm).

- By changing the central wavelengths and bandwidths, there were noticeable difference of Iso-Dense Bias. (1.1~3.5 nm).