CD Limits of Scatterometry[1]

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The semiconductor industry is moving to 7 nm node in 2018 with ~18 nm half pitch feature size. Noncontact optical metrology technology faces a significant challenge as the CD becomes much smaller than the wavelength and this has become an issue for the industry. The metrology technology studied in our research is angular scatterometry. Scatterometry is a fast, in-line, non-contact, non-destructive nanoscale metrology tool and is widely used in industry manufacturing process for qualify control proposes. In this presentation, we computational simulate the limits of optical angular scatterometry and assure it have the capability to monitor 7 nm node products.

Two different types of samples are simulated using rigorous coupled-wave analysis (RCWA). One is a Al-wire grid polarizer (WGP) structure and another is resist grating on a polycarbonate substrate made by roll-to-roll nanoimprint lithography. The sample structure is scaled in two ways: scaling the line width of the grating with fixed pitch, and scaling all linear dimensions of the structure simultaneously including pitch, line width and grating thickness. If the reflection difference for a 5% scaling variation is larger than the experimental noise floor, scatterometry has sufficient resolution to recover the metrology information. The noise level is first measured for current scatterometry experimental setup[2] because the limitation and resolution of scatterometry measurement is highly dependent on the baseline system noise. This noise level could be improved with further attention to system design.

In our study, scatterometry is more sensitive and has higher resolution for the WGP structure, as expected from the higher index contrast of this (air/Al/SiO_2) structure. Using a 405 nm source, scatterometry provides sufficient information to analyze a 20 nm pitch structure using a 405 nm laser source (wavelength / pitch = 20) while the minimum pitch of resist grating that can be measured is ~24 nm (wavelength / pitch = 16.8). The detectable feature size could be smaller when a 193 nm laser source is used instead of 405 nm. When the pitch of resist grating is around 20 nm, the RCWA simulation results become indistinguishable from an effective medium thin film calculation, indicating that all the detailed grating structure information is lost in the scatterometry measurement.

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[2] Ruichao Zhu, et al. “Scatterometry for nanoimprint lithography” *Journal of Vacuum Science & Technology B,* Volume 34, Issue 6, DOI: 10.1116/1.4967933

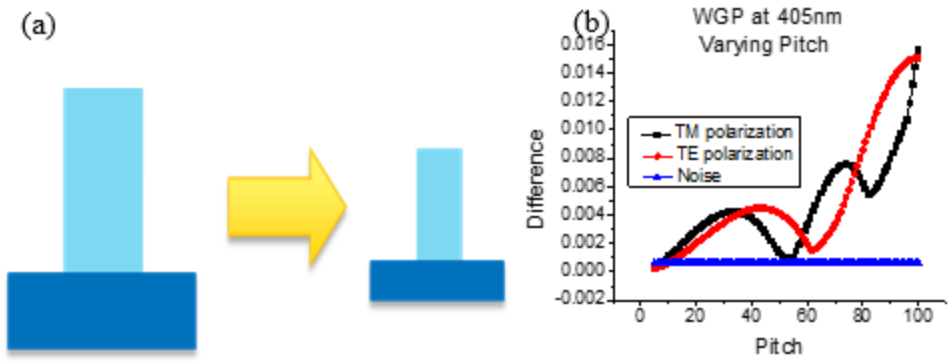

Figure 1: Limitation study for WGP structure by varying pitch with 405 nm laser source

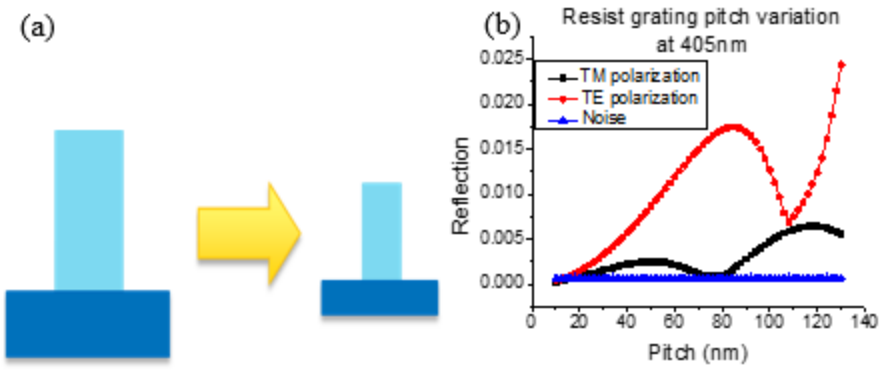

Figure 2: Limitation study for resist grating structure by varying pitch with 405 nm laser source

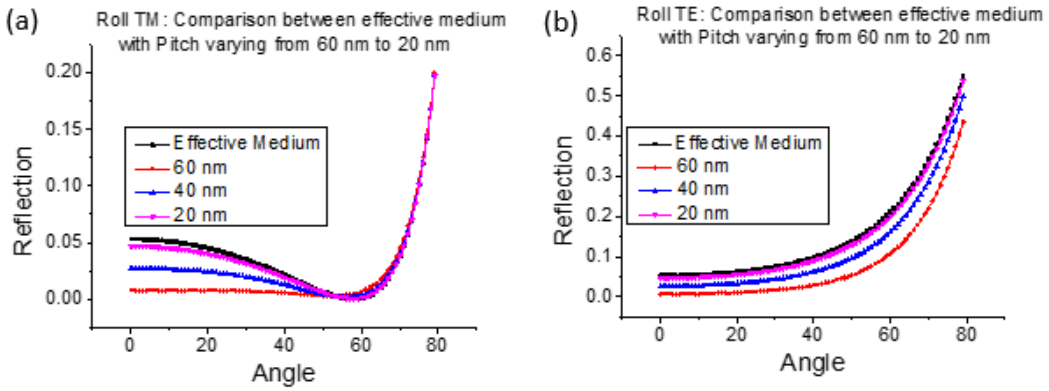

Figure 3: Comparison between simulations of resist grating structure and Maxwell effective medium approximation at 14 nm pitch with 405 nm laser source