CD Matching between CD-SEM and Scatterometry Metrology

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As the feature sizes of semiconductor devices keep shrinking in the decades, there are continuous requirements for the enhancement of CD metrology. As a widely used tool, CD-SEM is treated as a criterion in semiconductor metrology. However, as the development of sub 32 nm node, CD-SEM meets a great challenge that the low throughput seriously limits its capability in the process monitor and control. To realize the real time process control, many optical based metrology tools were induced. In this paper, we will investigate the performance of optical scatterometry and compare with the CD-SEM.

The scatterometry we are using is YieldStar (YS) from ASML. It is a model based metrology tool and the correctness of the metrology result high depends on the recipe we choose. In this case, the CD-SEM data can be used as a reference to optimize the YS recipe. As a comparison, two YS recipes are supported (YS1, YS2). The linear correlation between YS and CD-SEM data are calculated, as shown in Fig.1. It is obviously that the metrology data by YS1 is more consistent with CD-SEM data.

In Fig.1, we can see the CD offsets between CD-SEM and YS data, and they are mainly caused by the different edge detection algorithm and resist shrinkage in the metrology. To analyze the difference between the recipe YS1 and YS2, instead of comparing the absolute CDs, we would like to calculate the corresponding dose & focus sensitivity as below:

$$E - Sens(E_0, F_0) = E \left. \frac{dCD}{dE} \right|_{E_0, F_0},$$

$$F - Sens(E_0, F_0) = \left. \frac{dCD}{dF} \right|_{E_0, F_0}.$$

The dose sensitivity for the FEM wafer is shown in Fig.2 and focus sensitivity in Fig.3. For both dose and focus sensitivities, the difference between YS2 and CD-SEM is larger, especially at large defocus.

We can come to the conclusion that the recipe YS1 is better than YS2, when using CD-SEM as the reference. YS and CD-SEM can realize a good CD matching with an optimized recipe.

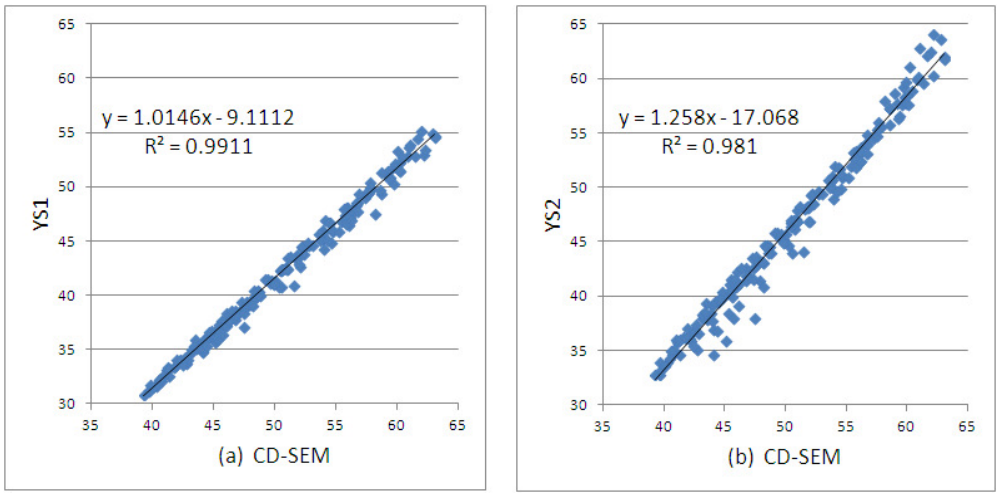

Figure 1: Linear correlation between YS and CD-SEM data

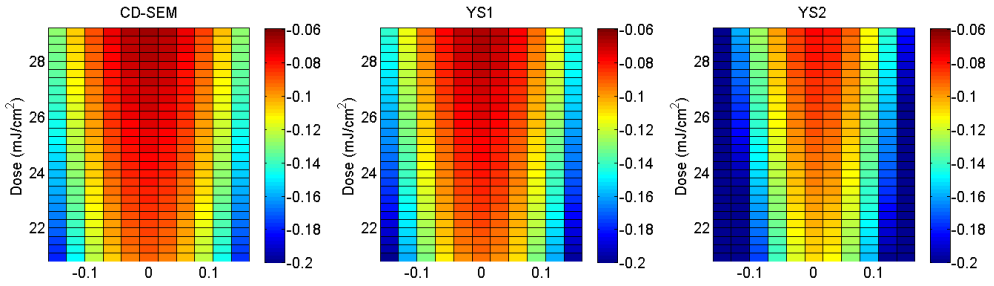

Figure 2: Dose sensitivity

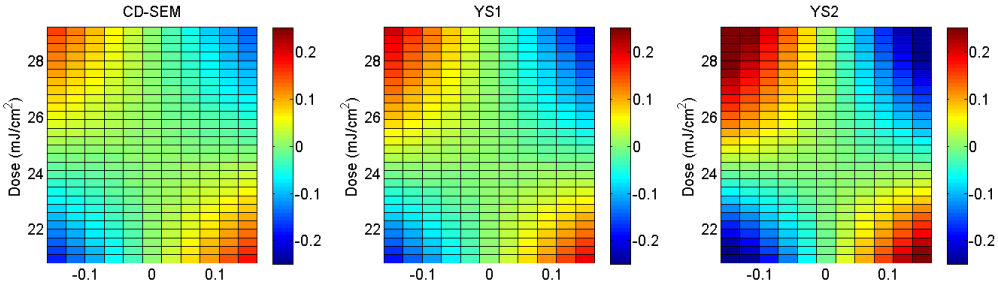

Figure 3: Focus sensitivity