Sidewall angle calculation on CD-SEM metrology

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ABSTRACT

Explore a method for measurement sidewall angle of the photomask pattern by device “CD-SEM (critical dimension scanning electron microscope)” that is a common widely used metrology CD measurement tool and it is one of the most common inspection methods in the semiconductor industry.

The CDSEM tool ZX had application advance techniques not only measurement line width (fig.1) but also scan build 3D model (fig.2). The CDSEM tool measurement method of sidewall angle that’s measure the top position and bottom position of the photomask pattern, according to these position data can be obtain their distance of horizontal and vertical. Use these data by algorithm equational to simulate slope value and calculate sidewall angle.

In order to verification the correctness of the sidewall angle value by CDSEM measurement, and the TEM (transmission electron microscopy) is an intuitive method of use a high-energy electron beam for catch high-resolution cross-sections images of larger materials as like as photomask. TEM is one of the common methods for analyzing the sidewall angle and thickness of thin films. This one method combines sample preparation techniques and used in material science and nanotechnology widely. Due to TEM implement cross section is destructive method that is an undesirable method for test product photomask In this study, we were collection simulated data from CDSEM and actual cross-section data from TEM then integrate these data cross comparison can get the corresponding relationship

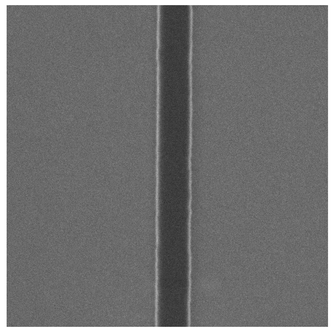

Fig. 1 metrology
CDSEM tool line width function

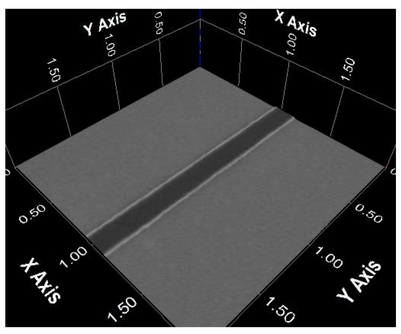

Fig. 2 metrology
CDSEM tool 3D SEM technology

METHODS

All material were used on 6x6 inch square 250 mil thick photomask substrates. Material was used HOYA TFC with Positive Chemical Amplified Resist (PCAR) and Negative Chemical Amplified Resist (NCAR). Line width structure design 240nm on reticle center.

TEM data collection

TEM can capture the level of materials clearly. The sample capture cross-section image too is by FEI-Talos F200X and magnification 150K then use metrology tool measure thickness and sidewall angle.

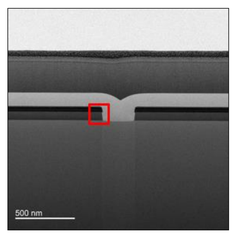

Fig. 3 TEM Mag : 11K

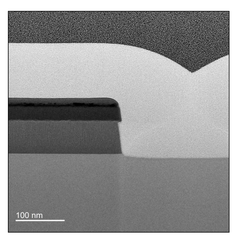

Fig. 4 TEM Mag : 46K

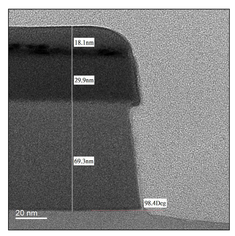

Fig. 5 TEM Mag : 150K

SEM data collection

CDSEM has an advance bird’s eye viewer function can scan pattern surface to build 3D SEM image, then use metrology tool measure distance, thickness and sidewall angle.

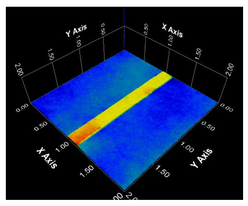

Fig. 6 3D profile

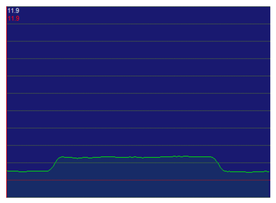

Fig. 7 SEM cross-section

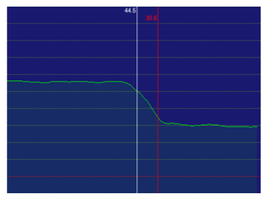

Fig. 8 SEM metrology meas.

Data integration analysis

The TFC material mainly has two layers, one is Cr and the other is Mosi. Their thickness are difference therefore by combining different combinations and cross-referencing data between TEM and SEM, the relationship between them is analyzed and identified.

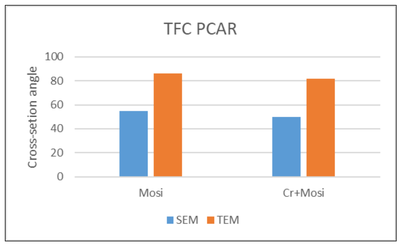

Fig. 9 TFC PCAR cross-section angle

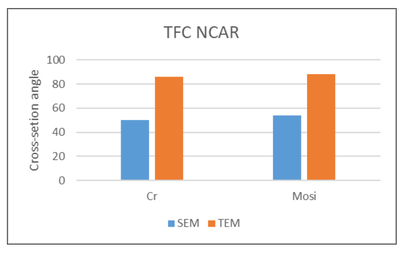

Fig. 10 TFC NCAR cross-section angle

RESULTS

Based on these results, that can be seen the cross-section angles measured by SEM about 53 degrees, while those measured by TEM are about 85 degrees. Although there are a difference value of about 32 degrees between them, but their trend are consistent. In this experiment, the difference values obtained from PCAR and NCAR are approximation. Therefore, by compensate for a constant(δ) value, the results may exist some measurement deviation but still can as reference by SEM infer result of TEM.

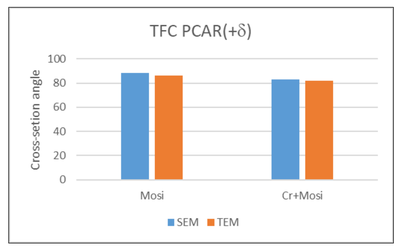

Fig. 11 TFC PCAR cross-section angle

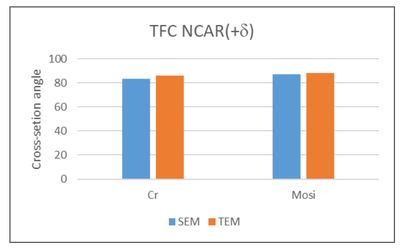

Fig. 12 TFC NCAR cross-section angle

CONCLUSIONS

1. SEM cross-section angle can obtain same trend as like as TEM. By compensate for a constant value in the SEM result, let value can be obtained approximation to TEM.
2. In difference process, PCAR and NCAR do not have a significant impact on the angle measurement of SEM because their compensation values are approximation.
3. When the material has different levels as like as TFC PSM, compared to TEM that SEM is less able to reveal the cross-section of the layers. Subtle changes and the structure of the layers are more difficult to clearly display for SEM.

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