APPLICATION NOTE

infinitesima

EUV LITHOGRAPHY: LINE / SPACE CHARACTERISATION

For EUV lithography close to its resolution limits, current metrology techniques such as CD-SEM encounter severe challenges such as resist damage and poor contrast. Further, detailed evaluation of stochastic defects such as line breaks requires 3D information that current in-line techniques cannot extract. New solutions are required and AFM is a promising candidate, providing sub-nanometre resolution and full 3D information, but typically has not been considered for in-line metrology due to slow imaging speed.

In this note, the Metron^{3D} is considered as a solution to these challenges. It uses a breakthrough technology which increases imaging speed of AFM by up to 100x compared to conventional systems. The system therefore provides full 3D information at high data rates and with improved accuracy compared to TEM and CD-SEM imaging.

EXPERIMENTAL

Line pattern samples were evaluated at a nominal CD of 12 nm, and at a pitch of 24 nm. The **Metron^{3D}** system, a breakthrough high speed atomic force microscope was used for the evaluation, with comparison to TEM and CD-SEM.

CD METROLOGY

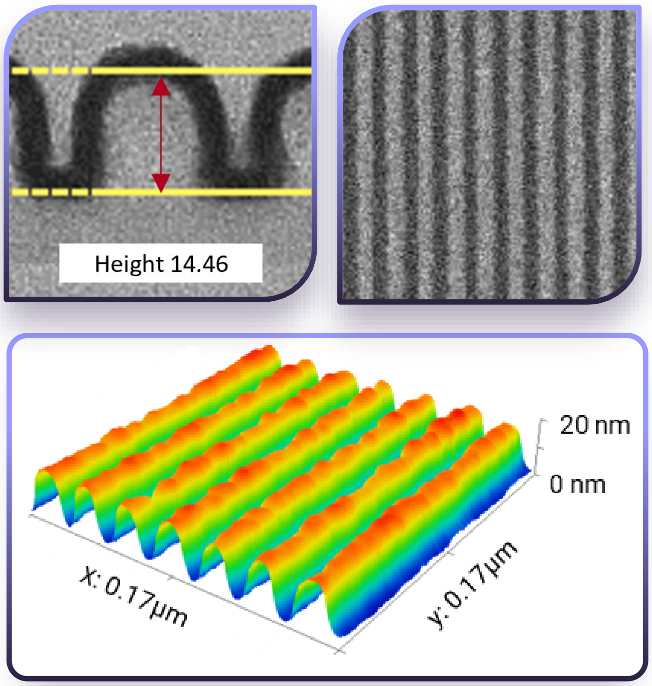
Samples were characterised using TEM and CD-SEM for correlation with the Metron3D performance results (Table 1). A linewidth of 10.56 nm and resist height of 14.46 nm was determined from the TEM cross-section, and a CD linewidth of 11.54 nm determined from CD-SEM. These resist sizes are on the order of that expected for initial nodes using high NA EUV.

High NA-EUV presents multiple challenges to current metrology techniques, with smaller features requiring increased resolution, lower resist height resulting in poor contrast for CD-SEM, and a higher risk of stochastic defects. Further, resist damage, which typically affects the top few nm of resist will result in higher resist shrinkage when considered as a percentage of the total resist height.

The **Metron^{3D}** system presents considerable advantages when considering these limitations. The high resolution and 3D information captured by the Metron3D (Fig. 1 bottom) is immediately apparent when comparing to the images obtained to the CD-SEM data (Fig. 1 top-right).

For this image a probe deconvolution algorithm was applied to elucidate the true profile and enable accurate sidewall angle to be visualised. In contrast to CD-SEM, minimal noise in evident in the image.

FIGURE 1
E-beam images (top) and AFM images from the **Metron^{3D}** system (bottom), scan area 200 nm x 200 nm.



The improved spatial resolution of Metron3D permits the extraction of many parameters not typically possible with current techniques. These include roughness profiles at the top, bottom and sidewalls of the resist (Table 1). A reduced measurement error suggests reduced error contribution from the metrology, with lower error achieved using the **Metron^{3D}** system as compared to TEM and CD-SEM.

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TABLE 1
Comparison of Metrology results across TEM, CD-SEM and **Metron^{3D}**.

	TEM		CD-SEM		Metron^{3D}	
	Value (nm)	+/-	Value (nm)	+/-	Value (nm)	+/-
CD Line Width	10.56	0.38	11.54	0.37	10.59	0.21
CD Resist Height	14.46	1.09	X	X	15.72	0.46
Line Edge Roughness Left	X	X	1.05	0.10	2.26	0.24
Line Edge Roughness Right	X	X	0.82	0.07	2.19	0.18
Line Width Roughness	X	X	4.82	0.62	3.52	0.25
Top Surface Roughness Ra	X	X	X	X	0.82	0.07
Top Surface Roughness Rq	X	X	X	X	1.05	0.10
Bottom Surface Roughness Ra	X	X	X	X	1.07	0.13
Bottom Surface Roughness Rq	X	X	X	X	1.38	0.17

X - NOT POSSIBLE TO MEASURE USING THIS TECHNIQUE

For both top line surface and trench bottom surface. Increased line edge roughness was also observed, possibly due to increased resolution, and hence higher sensitivity to roughness parameters.

DEFECT METROLOGY

Defect metrology was evaluated on a separate sample, with a measured CD of 22 nm, and a pitch of 46 nm. Evaluation using the **Metron^{3D}** enabled hyperlocal defect metrology parameters to be determined within a 200 nm x 200 nm scan area. A partial line break was observed (Fig. 2) and data analysis was performed to evaluate this defect.

In the defect, local necking of the resist was calculated at -10.6 nm at 50% of resist height, approximately 50% reduction in resist CD. Local thinning of the resist was calculated at -8.6 nm, approximately 40% reduction in resist height.

FIGURE 2
TEM x-section of the line structure showing resist thinning.

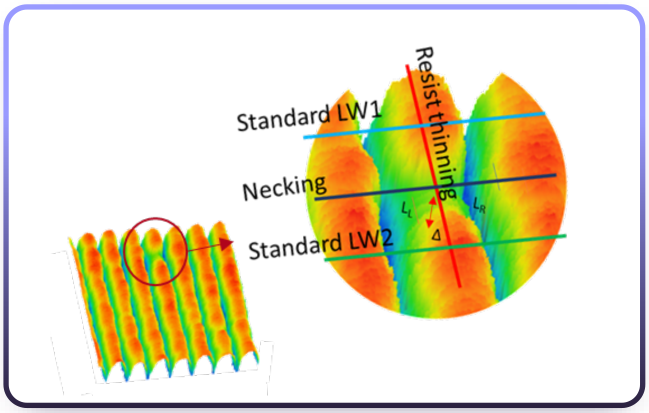
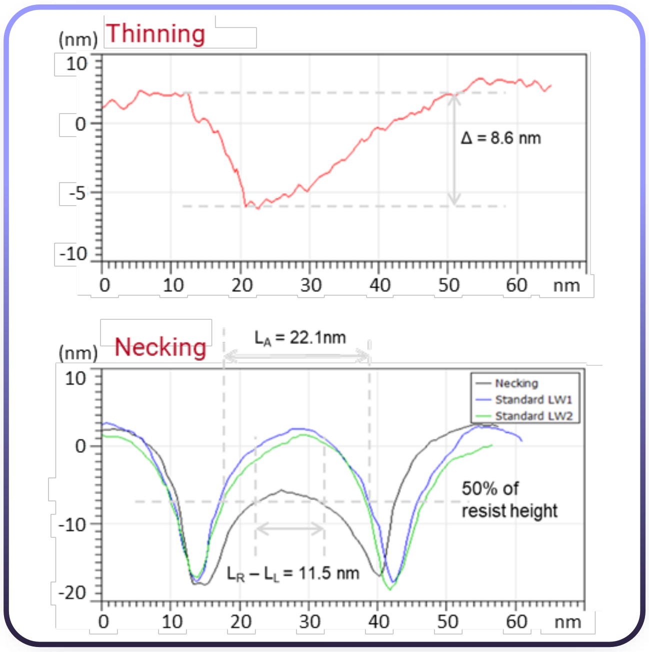


FIGURE 3
Line profiles across the defect for determination of defect metrology. Resist thinning (top) and resist necking (bottom).



FURTHER INFORMATION

This application note presents only a subset of data, and resist evaluation has been performed for a wide range of geometries, with varying resist thickness and CD. Contact Infinitesima for further data and to discuss application specific challenges.

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