Advanced confocal microscopy for rapid 3D analysis

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Introduction

Advanced Confocal Microscopy (ACM) is a relatively new technology combining high-speed parallel data collection with advanced modeling and measurement routines to acquire and render a comprehensive 3D model of the sample surface, with sub-micron detail, in seconds.

All confocal microscopy provides spatial resolution in the z-direction by using an aperture to exclude from detection light that does not originate in the focal plane of the optical system. To do so, it must acquire data sequentially as the aperture addresses all points in the object. Various confocal technologies accomplish this in different ways, but the sequential nature of the acquisition imposes a fundamental limit on speed. Disk-based systems offer a significant speed advantage, because they acquire data simultaneously from multiple apertures arranged in a spiral pattern on a rapidly spinning disk.

Advanced control, analysis and modeling software automatically generates a three dimensional model of the sample, allowing x/y/z metrology precision in the nanometers. Quickly acquired, with minimal sample preparation, the data rivals that obtained, destructively, from the most careful SEM cross section measurement.

Advanced confocal microscope

Developed by the original innovators of spinning disc confocal microscopy, the Hyphenated Systems ACM has begun to be applied for probe mark inspection and defect review. The degree of automation has progressed to a stage where acquisition of the large volumes of data necessary for statistical process analysis and control has become economically viable.

Operation of the current tool is similar in complexity to a regular automated microscope; the analysis may be performed in a standard cleanroom environment, without any unusual care in terms of temperature gradient and vibration isolation.

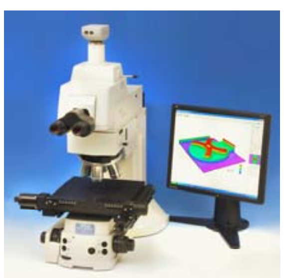


Figure 1.
The HS200A ACM, illustrated here, is also available on a 300mm platform

Method

Figure 2.
The 3-dimensional model may be cross-sectioned in any direction to measure the profile.

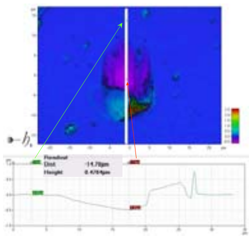
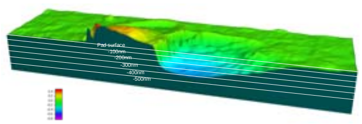


Figure 3.
The volumetric extent of the probe mark is equally accessible from the model.



Multiple measurements may be made without significantly adding to the acquisition time. If they can be performed under recipe control and the results exported for use, the tool becomes effective for defect review and for collection of large amounts of data for statistical treatments.

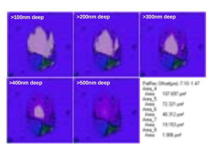


Figure 4.
Here, measurements are reported for multiple thresholds below the pad level.

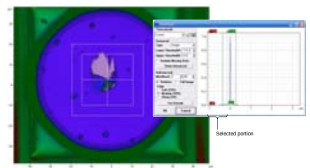
Areas detected below 500nm may be regarded as the "noise", resulting from regions where surface characteristics prevent the detection of any surface signal under the measurement conditions.

Application

After alignment, the wafer can be stepped around, using the stage, to bring any desired coordinate under the objective, with a Move-Acquire-Measure (MAM) time – without any particular optimization – of about 45 seconds.

Key to this process is the ability to automate measurement, under recipe control, of features that may show up on any part of the target pad. This is achieved by using pattern recognition (PR) tools to position the measurement tools over the probe mark.

Figure 5.
For the pattern recognition (PR), the probe mark is identified using the height histogram of pixels. The PR tool positions the measurement tools over the centroid (for instance) of the selected region.



Execution of the PR tools locates the probe mark within the field of view and centers the measurement tools so that they measure the feature in a standard way.

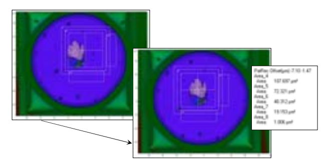


Figure 6.
During recipe operation, after data acquisition at each site, pattern recognition positions the tools, the reference level of the pad is determined and the scrub mark depth profile is stored to the results file.

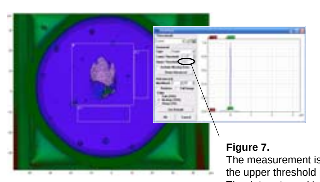
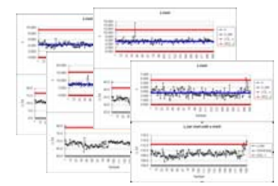


Figure 7.
The measurement is defined by the upper threshold parameter. The data returned is the volume of the probe mark that falls below this threshold depth and the area that is deeper than the threshold level.

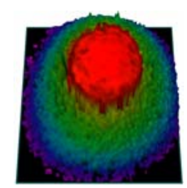
Conclusions

Previously, the investigation of the volumetric extent of probe marks has required that wafers be taken to the scanning electron microscope (SEM) for analysis. Furthermore, accurate depth measurement has required careful (destructive and time-consuming) cross-sectioning of the wafer.

Using the ACM, equivalent data is rapidly acquired. The wafer is not damaged and the volume of data that it is reasonable to collect is increased by several orders of magnitude: given a stepping pattern for a probe card, for instance, it is straightforward to set up a recipe to analyze all probe marks made by a particular tip on the card. Statistical process control applications begin to make sense.



The probe tips themselves are also accessible to analysis, on the same tool, with the potential of bringing many new parameters under engineering control.



Acknowledgments

Many thanks to those companies who provided the samples imaged in this poster, though they insist on remaining nameless.

For further information

Please contact *eddy@hyphenated-systems.com*. General corporate information on Hyphenated Systems and other applications of our technology may be found at http://www.hyphenated-systems.com; you will also find there a .PDF copy of this poster.