Z-Height Measurement with Non-contact Sensors

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1 Introduction

Z-height measurement, or any high-resolution, high-accuracy non-contact measurement of critical position in one axis, is a common need in many industries. Many engineers have struggled with trying to get an accurate measurement with high resolution while coping with design requirements and implementation problems caused by limited space, temperature changes, vacuum, target surface interference, and damage to measurement probes resulting from incidental contact with the target. Capacitive and eddy-current non-contact displacement sensors are becoming a standard technology for z-height measurement because of their small size, flexibility, ease of use, high resolution, non-contact nature and robust design. Capacitive and eddy-current sensors can also be easily customized to fit in specific z-height measurement applications.

2 Technologies

Many technologies have been applied to these **z-height measurements**, each with its own set of challenges. Contact gauging can damage target surfaces. Optical gauging can suffer from thermal sensitivity, inconsistent reflectivity of the target material, and may be difficult to fit in the space required. Some capacitive products can suffer damage to internal electronics if the end of the probe touches a grounded surface (We supply capacitive displacement sensors that do not have this problem).

We deliver capacitive and eddy-current sensors that are robust, thermally compensated, can have resolutions less than one nanometer, and bandwidths as high as 15 kHz. They can be used in vacuum and their low power dissipation will not add heat to your sensitive environment. They can also be customized for a perfect fit. Capacitive sensors provide the absolute highest resolution but must be used in a clean environment. Eddy-Current sensors can be used in wet environments while still providing resolutions below 100 nm.

3 Applications and industries

Z-Height measurement is common in industries requiring precise positioning for optical and non-optical processing. Some of the many applications include: semiconductor wafer processing and inspection, microlithography, optical and non-optical microscopy, focus and pre-focus, mask positioning and alignment, scanning control, and planarization. These applications often require critical positioning where nanometers matter. They also can include challenging environments from slurry filled environments of chemical-mechanical planarization to the vacuum environments requiring low outgassing and low power dissipation.

4 Mask alignment z-height

Masks used in semiconductor processing must be precisely aligned to achieve today's circuit densities. Four non-contact probes can be mounted to monitor z-height and parallelism of the mask relative to the wafer. Maintaining equal outputs from the sensors provides parallelism while the actual output value indicates the critical gap dimension.

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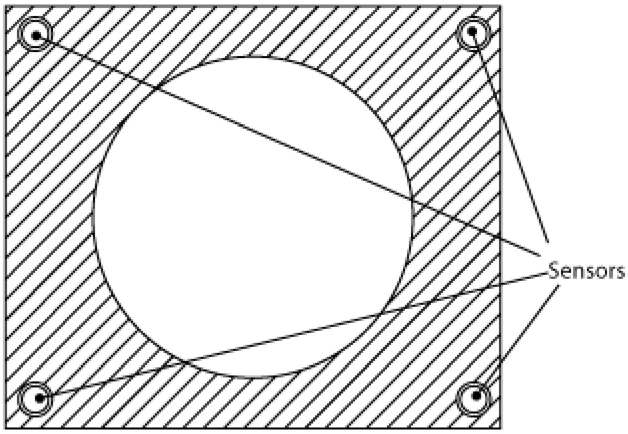
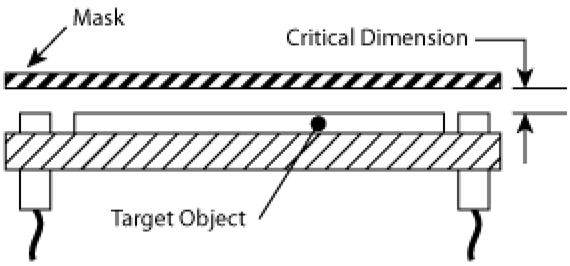
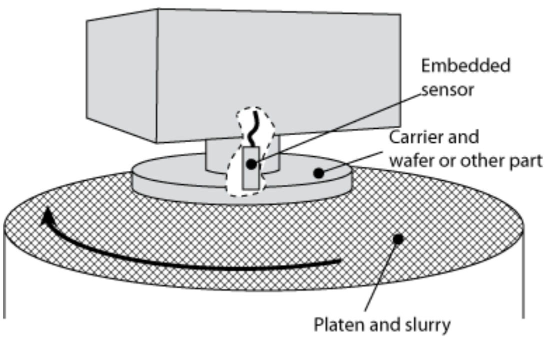




5 Chemical-mechanical planarization (CMP z height)

A precise lapping process is used in semiconductor, disk drive, and other industries that require accurately controlled depth of material removal. The chemical-mechanical planarization process uses an abrasive slurry on a precision platen that turns against the object to be lapped. As material is removed, the carrier holding the object being lapped moves closer to the platen. Eddy-current sensors do not detect the slurry and thereby provide a precise measurement of the relative position of the platen to the carrier (z-height) to determine how much material has been removed. High resolution of the sensors enable measurements to within 100 nm. For semiconductor wafers, the eddy-current sensors can “see through” the wafer and the slurry to measure the distance to the platen.



6 Focus/pre-focus

Optical and non-optical microscopy require precise **z-height positioning** to maintain proper focus. While optical algorithms exist for controlling focus, they can be slow while searching for the correct focus. Non-contact sensors

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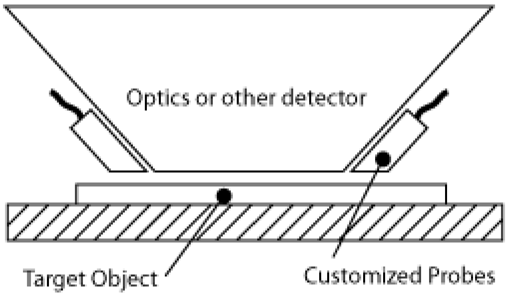
can be used to quickly move to a position at the precise focal length where the optical algorithms can more quickly complete the process.

Because of limited space and extreme demand for performance in many microscopy applications, there are significant advantages to using custom designed probes; this drawing shows capacitive probes configured at 45°.



7 Scanning

Some processing and inspection applications use a scanning head to treat or inspect across the surface of the target We supply capacitive and eddy-current sensors with wide bandwidths of 15 kHz, and as high as 80 kHz when required. The fast response time and excellent phase response enable precise and stable servo control in dynamic applications.