Metrology
White paper

Metrology for Semiconductor Lithography

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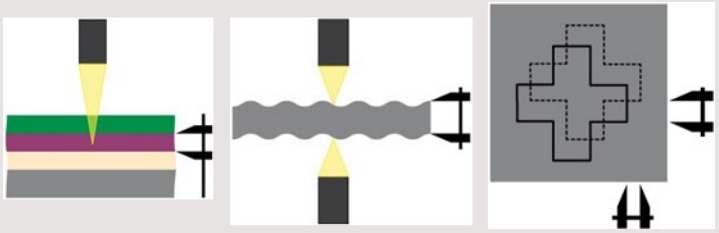
Advanced Packaging - Multi-Sensor Metrology for Every Process Step

- For production, process control and optimization quality assurance and R&D
- 3D topography, profiles, photoresist thickness and roughness, coating uniformity …
- Fast and reliable CD and Overlay determination with high resolution and accuracy
- High flexibility thanks to multi-sensor concept
- Combination of various measurement tasks using different sensors to run fully automated in one hybrid task
- Very fast 3D mapping or profiles with optical metrology
- Non-contact and non-destructive
- Manual as well as fully automated measurement



The fabrication of an integrated circuit (IC) requires a variety of physical and chemical processes performed on a semiconductor (e.g., silicon) substrate. By creating structures of various components, millions of transistors can be built and wired together to form the complex circuitry of a modern microelectronic device. Fundamental to all of these processes is lithography.

Optical lithography is a photographic process in which a light-sensitive polymer, called a photoresist, is exposed and developed to form 3D relief images on the substrate. In general, the ideal photoresist image has the exact shape of the designed or intended pattern in the plane of the substrate, with vertical walls through the thickness of the resist. Thus, the final resist pattern is binary: parts of the substrate are covered with resist while other parts are completely uncovered. This binary pattern is needed for pattern transfer since the parts of the substrate covered with resist will be protected from etching, ion implantation, or other pattern transfer mechanism.

The general sequence of steps for a typical optical lithography process is as follows:

1. substrate preparation
2. photoresist spin coat
3. prebake, exposure
4. post-exposure bake
5. development
6. post bake

However, lithography as it is optimized for IC technology has a strong 2D nature. After all, the IC fabrication process flow comprises a sequence of stacking many virtually two-dimensional high precision process layers. The layout of each layer is designed in terms of XY positions and dimensions, defining either opaque or transparent areas.

Camtek

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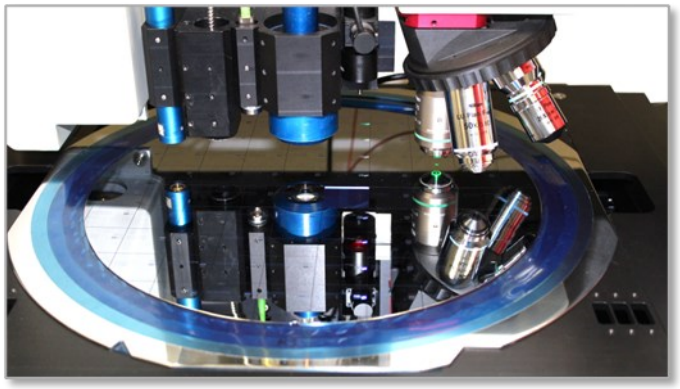
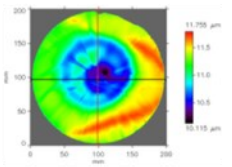
Detailed information on the homogeneity of the photoresist layer deposited on a wafer is required under aspects of process control and optimization. Measuring the thickness and homogeneity of photoresists, which can be up to several hundred micrometers in thickness, is a major challenge for most non-contact optical techniques.



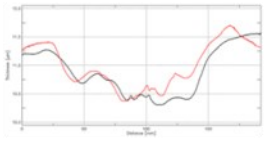
MicroProf®

The MicroProf® with its wide range of interferometric sensors offers the optimal solution to measure photoresist thicknesses. It uses the interferometric sensors for highly precise, spatially resolved coating thickness measurements. In a multi-sensor arrangement with an interferometric measuring head and a confocal chromatic topography sensor, the customer has an extraordinarily powerful measuring system for fast, spatially resolved layer thickness and topography measurements. With the MicroProf® a high-resolution 3D measurement of the homogeneity of the photoresist on wafers up to 300 mm can be carried out. The wafer as a whole is recorded quickly and non-destructively. The degree of automation ranges from manually operated measuring systems such as the MicroProf® 300, which automatically execute predefined programs, to fully automated wafer handling including automatic pre-alignment and fine alignment in the MicroProf® AP.

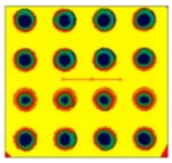
Example of a Camtek FRT multi-sensor configuration



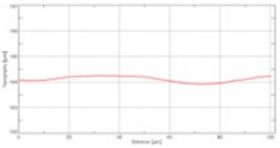
Full thickness map of a photoresist coating on a wafer



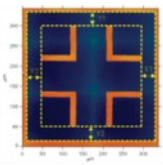
Control of layer thickness via profiles along the red and black line



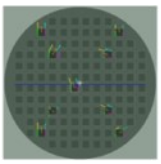
Area measurement of a transparent photoresist layer



Profile extracted from area measurement for roughness analysis, Ra=3.8 nm



Automatic recognition of marks and determination of overlay shift



Example of graphical visualization of overlay errors vector field of misalignment

Overlay, the result of an alignment-exposure-development process, is one of the key benchmarks for a lithographic process. A precise characterization of overlay requires large amounts of measurements over the wafer hence the overlay measurement tools are usually automated. The measurement principle of optical overlay measurements is based on pattern recognition of customized features thus the alignment performance depends on the optical quality of the marker images.

A specialized software package for Acquire Automation XT offers fully automated measurement and analysis of the overlay offset in x- and y-direction as well as the rotation of microstructures. The function can be used on high resolution camera images as well as Camtek FRT's field of view sensors like the CFM (DT) and WLI FX. This software feature combined with Camtek FRT's powerful sensor range efficiently helps manufacturers of modern 3D IC components to improve processes and increase production yield.

Whether for laboratory, development, quality assurance or production – Camtek FRT offers the right measurement technology for your application from Advanced Packaging. Do not hesitate to contact us if you have any questions. Our experts will be glad to support you in solving your measurement tasks by creating the best possible system configuration for you.

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