Abstract for NANOMAN2024(500 words) A new approach of disturbance cancellation for 3D surface measurements using two-cantilever atomic force microscopy

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In the field of chip manufacture, as high-end processes upon 5nm tech-note become more and more advanced, the number of inspection processes in the process flow has increased dramatically, and the demand for quantitative 3D wafer surface inspection has further increased and requests a quantitative analysis of structural defects on surface below 20nm under online high-speed conditions.

At present, optical inspection and/or scanning electron microscopy are commonly used for surface metrology in chip industry. Optical inspection suffers from limited spatial resolution (generally about 50 nm) and Scanning electron microscopy is not a three-dimensional surface detection, moreover it could damage non-conductive samples due to surface charge accumulation. In contrast, scanning probe microscopy provides non-contact, non-destructive 3D measurements of surfaces with extremely high resolution (≤1nm), but only with a significant slow measurement speed. Simply increasing the measurement scanning speed will lose the signal-to-noise ratio and affect the measurement quality. In addition, the measurement will be inevitably disturbed by the environmental noise (acoustic and vibrational disturbance), which makes the major contribution to false measurement results. The usual passive and active vibration reduction approaches like vibration isolation are not able to eliminate sufficiently the environmental disturbance. Environmental disturbances will not only reduce the resolution of measurement, but also generate some "pseudo defects" resulting false images.

In this work, an atomic force microscopy (AFM) using two active probe cantilevers for simultaneous measurements is used to improve high resolution imaging by eliminating environmental disturbance, thus realizing high-speed and high-precision measurement. Two active cantilever probes are simultaneously positioned closed to the sample surface, one of them performing 3D surface measurement, while the second cantilever acquires noise resulted from the instrument environment. The disturbance signal mixed in the 3D surface morphological signal in the first probe signal is subtracted by the environmental noise measured by the second cantilever using differential method, so that the surface morphology with strongly reduced environmental disturbances is finally obtained. Compared to single-cantilever AFM, the two-cantilever measurement involved in this work could increase the disturbance reduction by more than 5 times. Furthermore, in a future approach, the measurement speed can be increased by increasing the number of parallel cantilever, approaching industrial use.

The two-cantilever AFM with high disturbance cancellation effect based on this work also makes the technical fundament for achieving higher precision in the fields of scanning probe lithography (SPL) technology and probe positioning technology.

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