Detection and classification of post-CMP defects with a laser surface scanning system.

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With increasing device shrinkage, intermetal dielectric planarization issues become more and more prominent. Chemical Mechanical Polishing (CMP) is one of the responses to the question the technology problem of planarization has been posing in the last few years to engineers.

CMP process control implies not only knowledge of the parameters impacting the process itself, but also device integration and defectivity control. Traditionally, heaviest post-CMP defectivity issues are related to 'microscratches' (also indicated by the symbol µ-scratches), i.e. small and shallow scratches induced on the dielectric layer surface by the dragging of a small particle due to the rotating action of CMP heads.

In commercially available laser surface scanning tools, µ-scratches real-time defect classification is accomplished through an analysis of the scattering behaviour of CMP defects. The SP1^{TBI} (fig. 1), manufactured by KLA-Tencor Corporation, is able to collect the light scattered by defects in two different angle ranges, called respectively 'wide channel' (25°-70° from the normal) and 'narrow channel' (5°-20° from the normal). Traditionally, microscratch scattering behaviour is thought to be such that the light scattered in the wide channel is more than in the narrow. If channels are correctly calibrated, this results in bigger defect sizes measured in wide channel with respect to narrow. Thus, by taking the size ratio, µ-scratches can be easily detected.

A number of post-CMP defects as measured by SP1^{TBI} have been reviewed using a scanning electron microscope (SEM) as well as optical review system (with laser confocal review option). Statistical analysis of the narrow-to-wide channel ratio yielded an interesting histogram (fig. 2) which seems to indicate that it is possible to separate all the defects in two classes: particles (ratio equals 1) and µ-scratches (ratio below unity). After review, the defects whose narrow-to-wide ratio was below unity have been classified in different types: µ-scratches or similar ('µ-holes') defects (fig. 3), slurry residues (fig. 4), and others.

Thus, rather than a 'µ-scratch' defect class, it should be more appropriate to speak of 'post-CMP' defect class, which is based upon the 'wide-to-narrow ratio below unity' approach. These real-time defect classifications can be instrumental in CMP process control.

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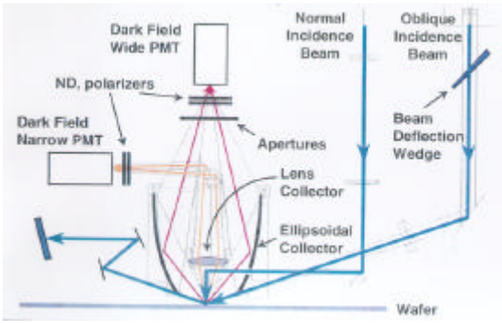

Fig. 1. SP1^{TBI} schematics.

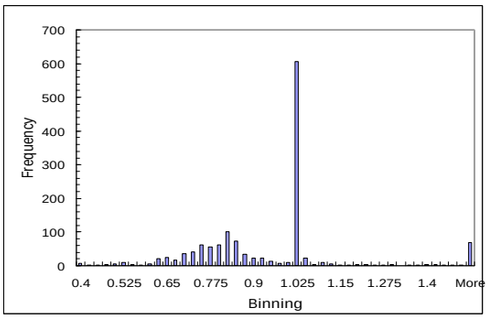

Fig. 2. Histogram of defect ratio binning.

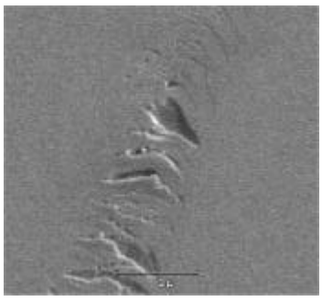

Fig. 3. Typical post-CMP µ-scratch.

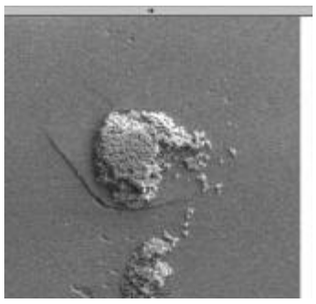

Fig. 4. Slurry residue.