Characterization of interactive forces between CMP pad and ILD materials depending on post CMP clean

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For copper metallization chemical mechanical polishing is necessary to enable damascene processing. After removal of copper overburden and barrier a defined amount of ILD material is removed to ensure isolation of all individual copper structures. The polishing process itself is necessarily followed by a dedicated cleaning step (PCC). For the PCC step various commercial cleaning chemistries are available that balance mainly particle removal and prevention of corrosion between copper and barrier material [1]. For the aspect of particle removal, it is necessary to evaluate impact of leftover particles on the final product to ensure a clean as gentle as possible. In case of particle residuals affecting the overall performance, techniques are needed to understand the root cause of the particles and act accordingly. A standard SEM review gives insights on the type of particles e.g. silica abrasive particles or organic pad residuals. Based on this, further methods are required to understand the particle wafer interaction.
Different levels of post CMP wafer surface defects were observed on various ILD materials. SEM review revealed the particles to be mainly pad debris. For improvements in PCC performance the attachment between ILD surface and pad debris needs to be measured. As particle wafer interactions depend strongly on the surrounding medium it is crucial to perform any measurements including the correct ambient e.g. liquid cleaning chemistry. One of the few measurement techniques offering data on particle surface interactions including liquids is AFM force measurement. However, the technique is commonly used only for fundamental science and depends highly on good sample material [2]. To apply the technique for investigation of semiconductor production challenges, it is critical to use the exact materials.
In this work we show defect level data on different standard BEOL ILD materials for 28 nm technology node post copper CMP (Figure 1). A clear trend in defectivity depending on the ILD material can be seen for data on 300 mm wafer size. Based on this, AFM force measurements in between coupons coated with the ILD material and CMP pad particles were carried out and will be presented. To achieve suitable particles of the specific CMP pad material for attachment of the AFM cantilever LN_2 milling was performed (Figure 3). Attraction force measurements were carried out including the PCC chemistry (Figure 4). This measurement setup enables us to access the interaction force data between production standard materials (both ILD and pad) in process identical medium (PCC chemistry).

References

1. P. Wrschka et al 2000 J. Electrochem. Soc. 147 706
2. M. Kappl, H.-J. Butt, Part. Part. Syst. Charact. 19 (2002)

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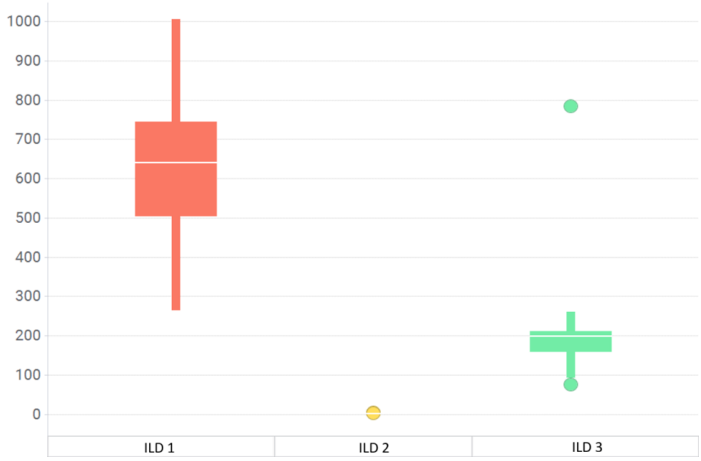

Figure 1: Defect level for different ILD materials after identical post CMP cleaning

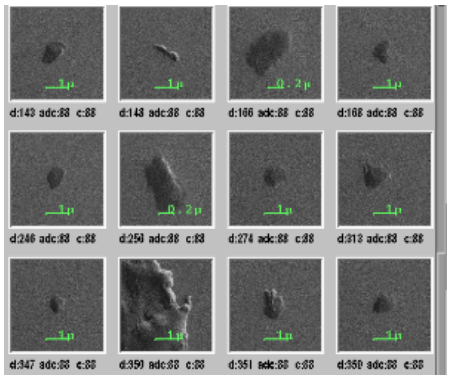

Figure 2: SEM review of defects on ILD material, showing pad debris

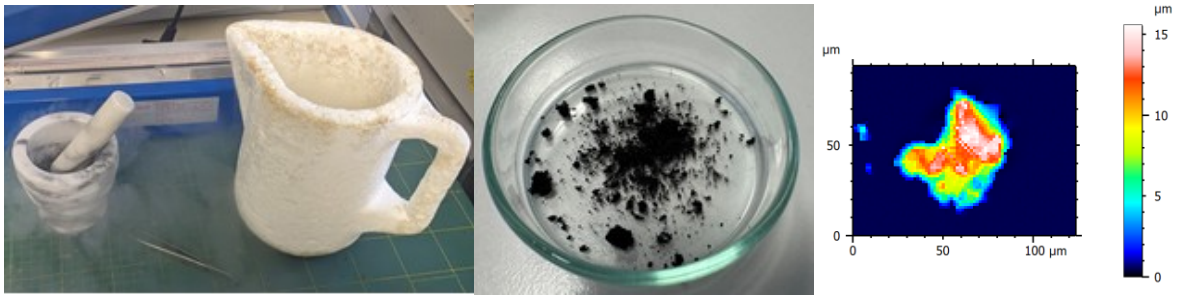

Figure 3: from left to right: LN2 milling of pad material; grinded pad material particles; confocal microscopy image of pad material particle

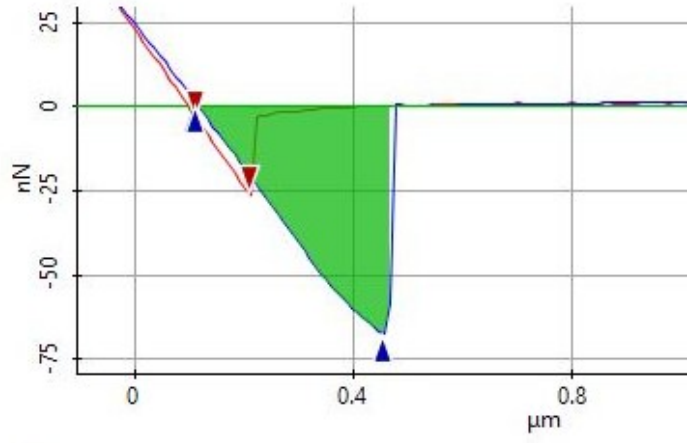

Figure 4: AFM force curve showing interaction of -70 nN between pad material and ILD