Characterization and Control of Copper/Barrier Chemical Mechanical Polishing In Damascene Processing Using Non-contact Capacitive Measurements

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The use of non-contact capacitance probe measurements for monitoring the thickness, flatness and shape change during oxide and tungsten CMP has previously been surveying (1, 2). This paper extends the application of this technique to copper damascene processing.

Full wafer scan measurements were performed nondestructively on blanket and patterned 200 mm wafers with exceptional spatial resolution and speed with an ADE 9700 UltraGage™ which permit approximately 16,000 measurements to be performed The measurements were conducted both prior to and subsequent to CMP. The raw data was stored and later analyzed. The copper film was electrodeposited using a Novellus Sabre Plater and later furnace annealed before polishing. Plating was performed on a PVD Cu seed layer which was deposited on a PVD Ta film.The PVD processes were conducted in a Novellus Inova. The Copper CMP process was performed with an Applied Materials Mirra Tool. The copper was removed on the first two platens using an alumina based slurry and a commercial polyurethane pad. Endpoint detection when appropriate was performed on the second platen. The Ta barrier layer was removed on the third platen with a silica based slurry and a softer pad. Both 4-point probe sheet resistivity and photoacoustic measurements were performed to derive comparative thickness information.

The thickness information enables removal rates and uniformity to be measured. The advantage is the high density of data which can be measured. This data can be displayed as full wafer maps or as diameter scans. Figure 1 shows that the copper thickness correlation between the thickness measured directly from the capaciatance probe data and that derived from 4-pt data is excellent. The sheet resistance values which were measured by the 4-pt probe technique were converted to thickness values by a correlation factor derived from multiple SEM cross sectional measurements. For the comparison in Figure 1 the Cu seed layer thickness was subtracted.

The global parameters of bow and warp are especially of interest. Large differences in these parameters were found at various processing steps. Refer to Figure 2. Thus, these global parameters provide a means to insure that all processes, especially those involved with film depositions or removal, as is the case in CMP, were conducted in a controlled and reproducible manner

The site data is also of great interest from a lithographic perspective and, thus, will also be covered in this paper.

The use of noncontact capacitance probe measurements for the detection of delamination caused by CMP is also considered. The prevention of delamination is a focus area in the development of advanced dual damascene processes which use low K dielectric films.

REFERENCES

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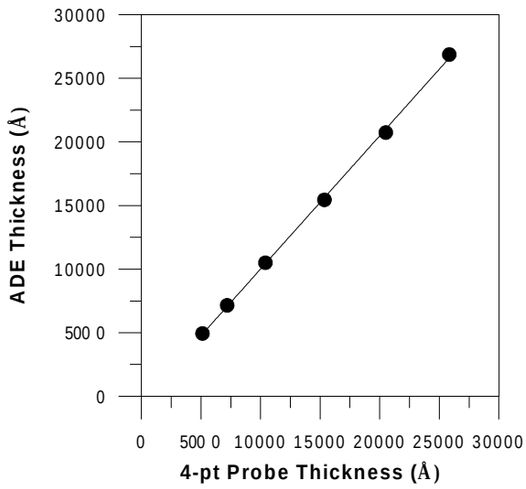

Figure 1. Correlation between Cu thickness measurements performed by 4-pt probe and capacitance probe measurements

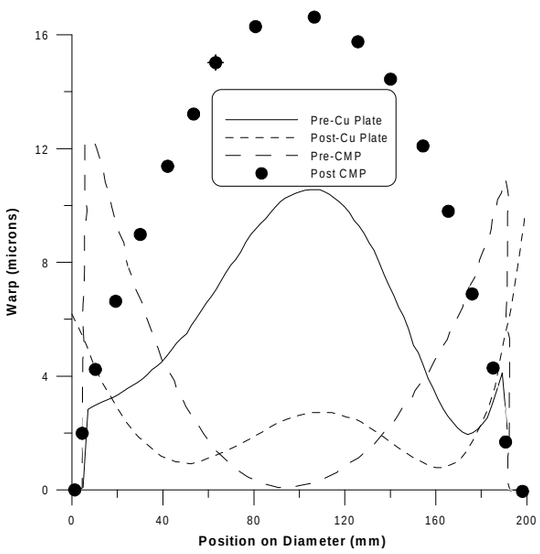

Figure 2. Diameter Scans of warp during different process steps