CONSIDERATIONS FOR IMPLEMENTING CMP PNAEL-LEVEL PACKAGING

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CMP is now being extended to enable improved structures in packaging technologies ranging from 2.1D to 3D integration to form structures including TSVs/TGVs, RDLs and hybrid bonds. This paper focuses on the key considerations for implementing CMP in panel-level packaging (PLP). These considerations include throughput, cost and technical challenges that must be addressed to achieve high quality and efficient productivity.

Assuming an annual production capacity of 100,000 panels with a size of 510mm x 515mm, this corresponds to a required throughput of 50 panels processed by CMP per hour. As an example of a Cu damascene process with a 10um of Cu film thickness during a two-step CMP process, the effective time per panel requires 4min for the successive process, resulting in a throughput of 15 panels per hour per CMP line. Therefore, at least 4 production lines are required to meet the target capacity. The primary bottleneck in the process is the bulk Cu CMP step. If the Cu film thickness is reduced to 3um through uniform electroplating, The bulk Cu CMP time can be shorten to 2min, This improvement increases the throughput to 30 panels per hour, therefore reducing number of CMP production lines to two.

For a 3min bulk Cu CMP process, the slurry cost is roughly USD 10 per liter, resulting in a slurry cost of about USD 30 for a single step. When a two-step CMP line is considered, including barrier CMP and cleaning, the cost can increase to as much as USD 70. Consequently, the total cost of consumables (CoC) for CMP of 100,000 panels may reach USD 7million. The primary bottleneck is the reduction of slurry cost. Slurry recycling or recirculation is not a viable solution due to pattern contamination and a reduction in CMP removal rate. Feasible approach to reducing CoC is shortening the CMP processing time, which simultaneously improves throughput. To achieve a uniform and thin Cu film, it is necessary to adopt selective electroplating or pre-CMP processes such as grinding, cutting or etching.

Fig.1 shows possible motion types for panel CMP including Oscar, rotary, and orbital motions for batch production, as well as scan motion for in-line production. Orbital motion offers the advantage of a small foot print; however, it presents challenges related to process uniformity and slurry supply. Rotary motion provides superior uniformity but requires a larger platen. Therefore, comprehensive comparisons are required in terms of panel size, footprint, consumable usage, removal rate and uniformity.

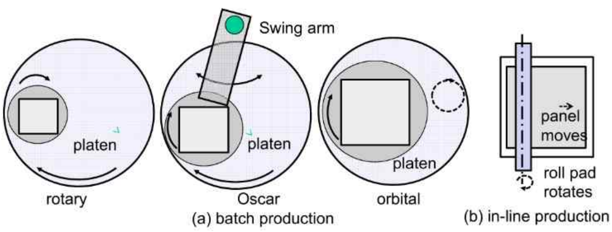

Fig.1 Possible motions for panel CMP

Removal rate and dishing during CMP can be controlled by temperature. A high removal rate of bulk Cu CMP can be achieved at elevated temperatures by heating either the platen or the slurry. In contrast, low Cu dishing can be realized at lower temperatures during the second step barrier CMP by minimizing material selectivity. Therefore, CMP equipment with temperature control system is recommended to enhance both productivity and quality. Removal uniformity is the most critical factor in selecting panel CMP equipment due to the panel's large size and rectangular shape, which differ significantly from those of wafer CMP tools. The sliding distance of a panel inherently varies between the center and corners, leading to degradation of removal uniformity. To compensate for this effect, zone control of the back pressure should be implemented. Fig.2 shows a Cu patterned panel on the Oscar CMP equipment and RDL structures after CMP.

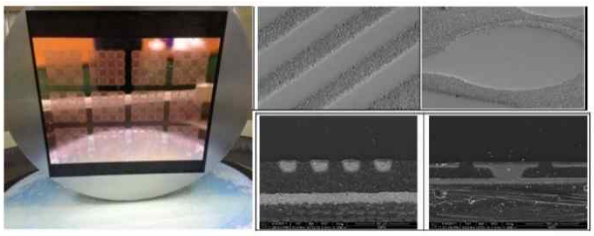

Fig.2 Example of Cu patterned panel and RDL structures after CMP

Cu damascene process has recently been developed to achieve smaller line and pitch of 2/2um or below using a two-step process. Compared with the standard SAP, which does not employ CMP, the damascene approach offers better resolution but at the expense of increased cost and process complexity. The objectives of damascene CMP are to achieve a high removal rate during bulk Cu CMP and to minimize dishing during the barrier CMP. Therefore, the slurry must be carefully selected or formulated for each process step. Also, temperature and friction force were monitored to determine the end point(EPD), which is critical for reducing the amount of dishing in the second CMP step.