DESIGN CONSIDERATIONS OF NEXT GENERATION CHEMICAL MECHENICAL PLANARIZATION EQUIPMENT

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Introduction

Structural changes of semiconductor devices still continues to nanopatterns [1D] for higher integration, 450mm diameter wafer [2D] for higher throughput and lower cost of ownership, and multilevel heterogeneous chips [3D]. The structure of advanced semiconductor devices also affects on the structure of peripheral I/O devices, especially on pattern shrinkage less than 10 ㎛. CMP technology is now facing to new era to expand to non-IC application fields such as MEMS, display, printed circuit, flexible organic device, etc.

This paper deals with future prospects of the CMP equipment for micro- and nanopatterns on different types of substrate which are on demand. It means equipment makers need to make opportunities to think about more diverse kinematics adaptable to substrate size and shape. This paper describes basic design considerations according to substrate size and shape, and shows a couple of examples for not only large sized wafer, display panels and printed circuit boards, but also thin, flexible and continuous films.

Substrate Classification

The substrate can be defined as the physical base material upon which a device pattern is applied in electronics. The substrate can be classified with 4 different groups in terms of its size and shape which can be described with practical examples as,

1) Large circular; 450mm wafer batch production
2) Ultrathin; package substrate batch production
3) Large rectangular; display panel in-line production
4) Flexible continuous; filter film in-line production

Fig. 1 shows micro patterns on a large rectangular substrate which has appearances of LCD display panel before and after CMP process.

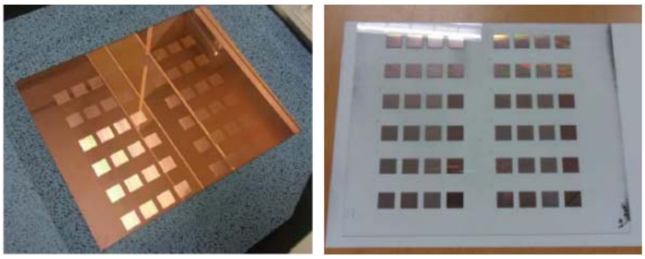


Fig.1 Micropatterns on a display panel before and after CMP

Design Considerations for future CMP equipment

The CMP equipment has become more sophisticated with simple rotary motion for 300mm wafer applications. When considering larger 450mm sized wafers, the conventional rotary CMP equipment has a couple of issues including equipment footprint, cost of consumables, and removal uniformity.

However, orbital or Oscar motion can save the footprint and pad and slurry consumptions as shown in Fig.2. The removal uniformity on these tools can be improved by uniform slurry flow with the aid of optimum positions of nozzles and groove designs on the pad.

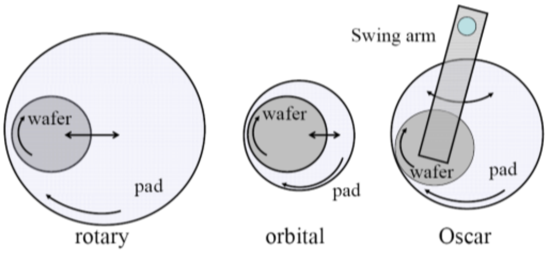


Fig.2 Comparisons among rotary, orbital and Oscar motioned tools

Edge profile control (EPC) ring can be one of the solutions to reduce edge exclusion which is important for larger wafers because number of chips around the peripheral area increases with wafer diameter. The EPC ring can be designed to be positioned between wafer and retaining ring, and is pressed at the same pressure with the wafer by a flexible membrane to reduce pressure discontinuity between the wafer edge and retaining ring as shown Fig. 3.

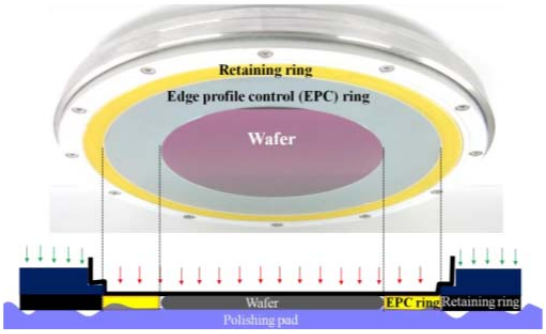


Fig.3 Schematic of CMP carrier structure with EPC ring

Thin and light designs are required for compact mobile phones and notebook products. Technical innovation of package substrate manufacturers steps into

CMP application. Electroplated copper filled in trenches on flexible substrate needs to be planarized for multilevel wires less than 10 ㎛ as shown Fig.4. When considering equipment design, it is necessary to make a head system to hold uniformly thin substrate less than quarter millimeter, and temperature controlled platen. Loading and unloading for thin large substrate are also required to be systemized with quick and precise motion.

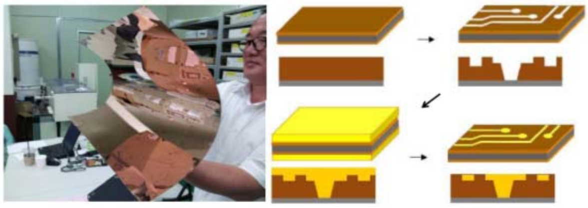


Fig.4 Thin flexible package substrate (left) and its process flow including laser trenching, Cu plating and CMP (right)

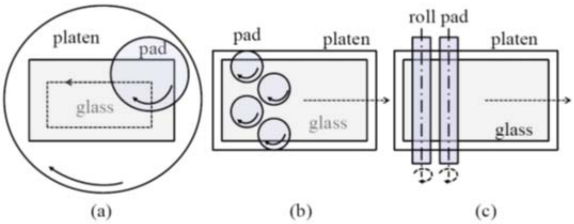
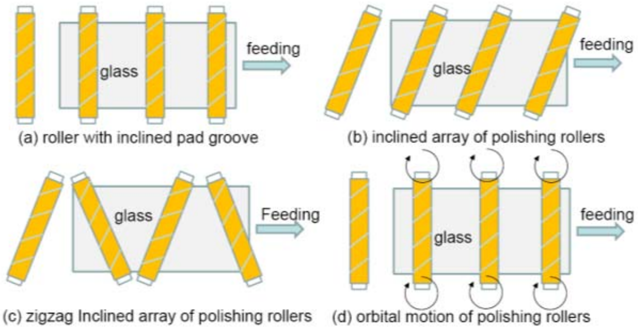


Fig. 5 Possible CMP systems for patterns on large glass substrate

Micro metal patterns are required to be clear by CMP planarization on a rigid glass substrate larger than area of 1m by 1m. In most cases, small pads push down a large substrate which is placed on the platen due to its size and weight. Traditionally, glass substrates have been polished by the motion shown in Fig.5 (a). This method requires much larger platen than the substrate in a batch production, resulting in low uniformity and long loading time.

The CMP system for micro patterns on the glass substrate can be newly proposed by Fig.5 (b) or (c). The patterns can be continuously polished by rotary pads under multi-heads or by rolling pads during the large substrate moves slowly on linear stage. The roll type linear CMP system has many advantages by an automatic process without loss time. However, its removal rate is quite low by the line contact mechanism. Line defects in moving direction and non-uniform removal in rolling width are still required to be improved. Fig.6 shows a couple of feasible methods to remove directional line defects, and enhance the removal rate in roll type linear CMP system.

Recently micro patterns are required to be fabricated on flexible polymer films for many devices of a flexible smart phone. The whole production of polymer film is basically realized on a roll-to-roll system. So, the CMP system for micro patterns on continuous film is also built on the roll-to-roll structure as shown in Fig.7. This system should be designed in order to remove line defects in length direction and improve uniformity in film width direction. Fig. 8 shows a cross section of EMI filter after sequential processes of base film imprinting, nickel electroless plating, CMP and copper electroplating.



(a) roller with inclined pad groove (b) inclined array of polishing rollers

(c) zigzag Inclined array of polishing rollers (d) orbital motion of polishing rollers

Fig. 6 Feasible methods to remove directional linear defects and increase removal rate in linear CMP

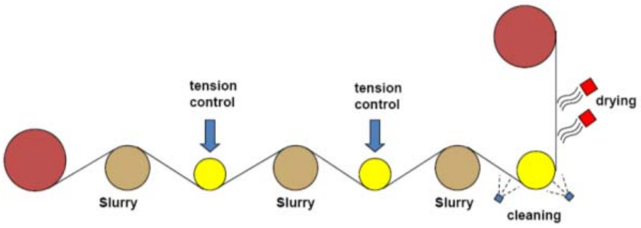


Fig. 7 Roll-to-roll CMP system for patterns on flexible film substrate

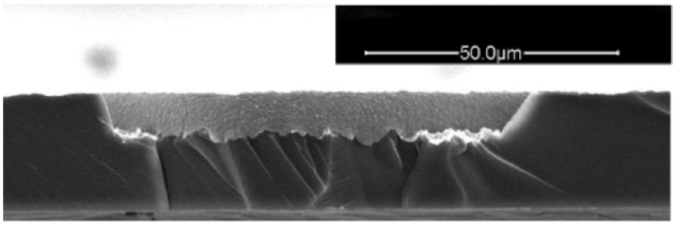


Fig.8 Cross section of EMI filter after sequential processes of base film imprinting, nickel electroless plating, CMP and Cu electroplating

Conclusion

In this paper, basic design considerations were compared according to substrate size and shape, such as 450mm wafer, package substrate, glass panel and polymer film. Finally, we hope that the design considerations for future CMP equipment make many discussion and solutions to achieve higher quality and throughput in the field.

References

1)Y. Park, J. An, H. Kim and H. Jeong: Impact of edge profile control ring on wafer removal rate and uniformity in chemical mechanical polishing, proceedings of International Conference on Planarization/ CMP Technology 2011, P.647-652.