ECS Transactions, 27 (1) 575-580 (2010)
10.1149/1.3360677 ©The Electrochemical Society

Mosaic Diamond Pad Conditioners for Improved CMP Performance

James C. Sung[a,b,c,d,e], Ming-Yi Tsai[f], Yang-Liang Pai[a], Cheng-Shiang Chou[a]
Chih-Chung Chou[a], Zongqing Yang[g] ,Ying-Tung Chen[h], and Michael Sung[d,e]

[a] KINIK Company, Taipei, Taiwan
[b] National Taiwan University, Taipei, Taiwan.
[c] National Taipei University of Technology, Taipei, Taiwan
[d] Advanced Diamond Solutions, San Francisco, U.S.A.
[e] SinoDiamond, Haian, Jiangsu, China
[f] National Chin-Yi University of Technology, Taichung, Taiwan
[g] S&Y MicroElectronics, Shenzhen, China
[h] National Defense University, Taoyuan, Taiwan

A mosaic design of diamond disks that incorporates different cutting characteristics of diamond grits can allow faster polishing of wafers with less pad consumption. Larger diamond grits can make pad asperities with large peak to valley ratios for achieving high polishing rate. On the other hand, Sharp grits can shave the pad effectively as to eliminate the glazed layer.

The conventional diamond disks employ similar type of diamond grits across the entire disk. These grits cannot dress and cut the pad with optimization. By combining different types of diamond grits in a cocktail combination, the pad asperities can be controlled to enhance removal rates of the wafer. The glazed layer may also be removed cleaner so wafer defectivity is minimized.

CMP Challenges

Diamond disks for pad conditioning is becoming the limiting factor for advanced CMP that requires low stress polishing at local sites, but with high removal rate across the wafer surface. This is particularly so for polishing various sized IC interconnects (e.g. 32 nm node). Moreover, the dielectric layers are becoming delicate (e.g. low k dielectric) that can be damaged with conventional CMP practice.

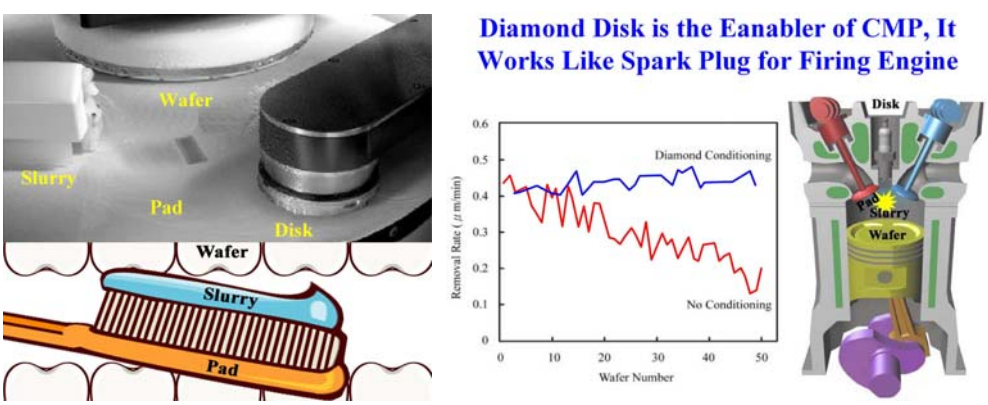

Figure 1. The CMP analogy (left diagram) and the diamond disk's function (right diagram).

During the CMP operation, a wafer is pressed against a rotating pad. The load is supported by asperities of the pad top. The distribution of the pad asperities and the morphology of them can not only determine the polishing efficiency, but also the wafer uniformity. Moreover, if killer asperities are present, scratches of the expensive wafer are inevitable. Since diamond disks are responsible for the creation of pad asperities for polishing each wafer, the design of the diamond disks is becoming critical for achieving fast and uniform polishing of wafers without causing defectivity. This is particularly true with the increase of the wafer size (e.g. 450 mm wafers to make debut scheduled in 2012).

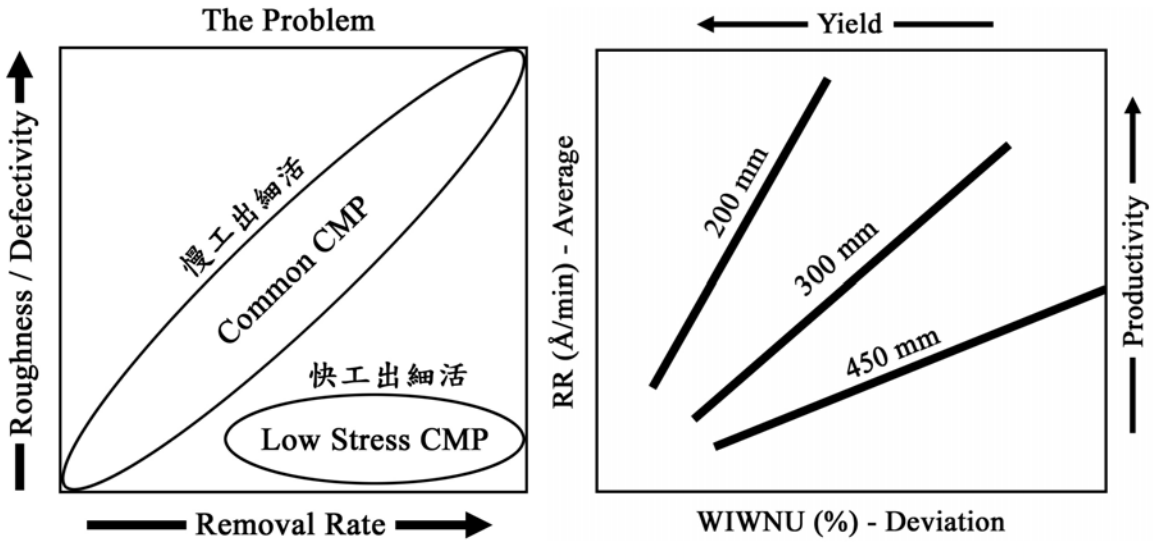

Figure 2. The non-compromising requirements of CMP (left diagram) and the difficult to polish larger wafers (right diagram).

Mosaic Diamond Disks

Diamond grits come with different sizes and shapes. The larger the diamond grit, the rougher is the dressed pad formed by the indentation of the grit. On the other hand, the shaper the diamond, the cleaner is the pad top due to the shaving action of the grit. The conventional diamond disk holds one type of diamond grits on all locations of the disk. Consequently, roughness and cleanness of the same pad surface cannot be compromised. However, by making segments with different types of diamond, a mosaic disk can be assembled.

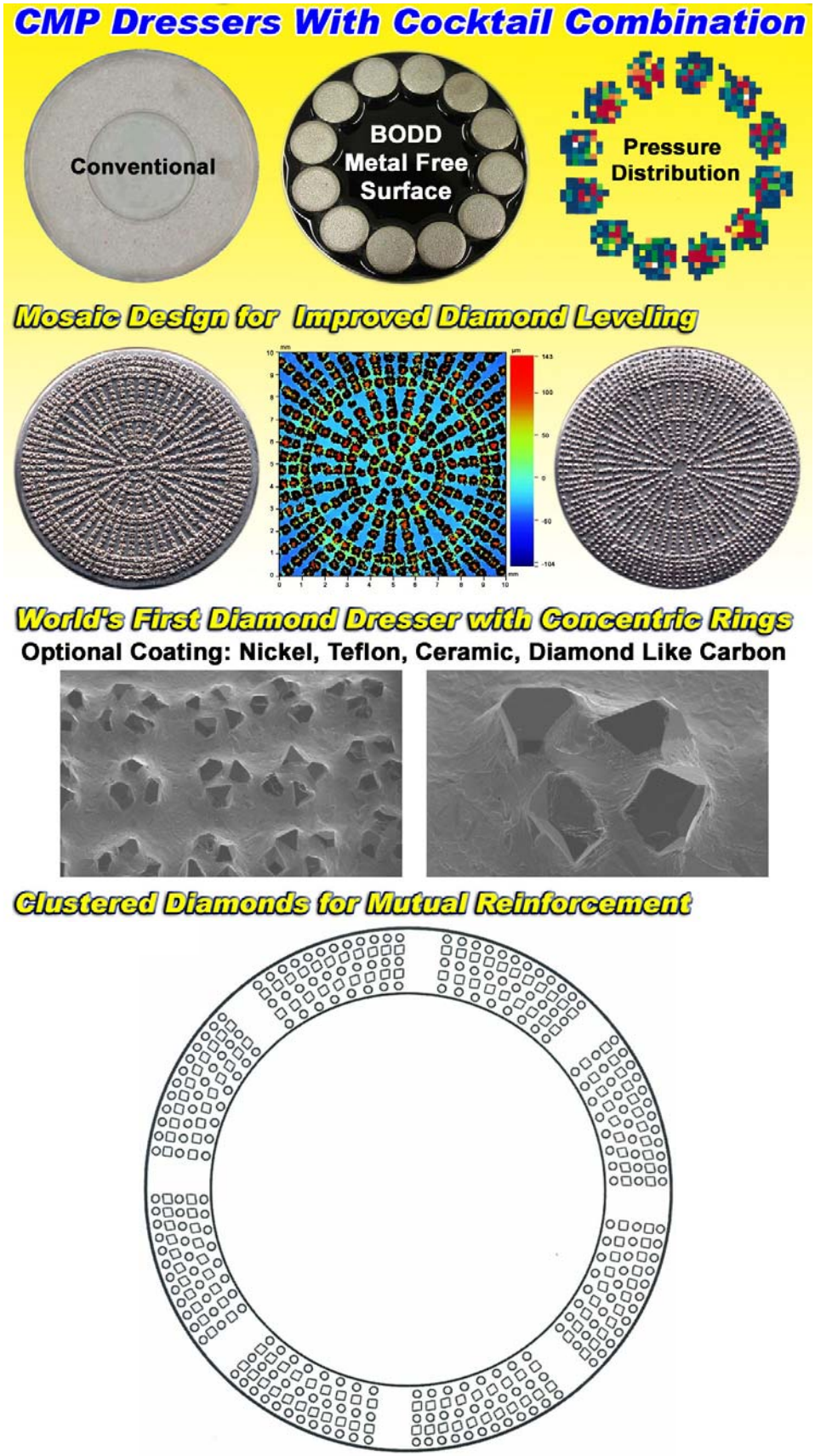

Figure 3. The mosaic diamond disks of brazed-organic diamond disk (BODD).

The Dressing Characteristics

The mosaic diamond disks can be assembled at room temperature by using an organic binder (e.g. epoxy). In this case, the diamond tips can be leveled by compressing with a flat plate. This solves the largest problem of the conventional diamond disks with uneven tip distribution due to the variation of diamond sizes and shapes, in particular when employing a high temperature process to bond the diamond (e.g. by brazing).

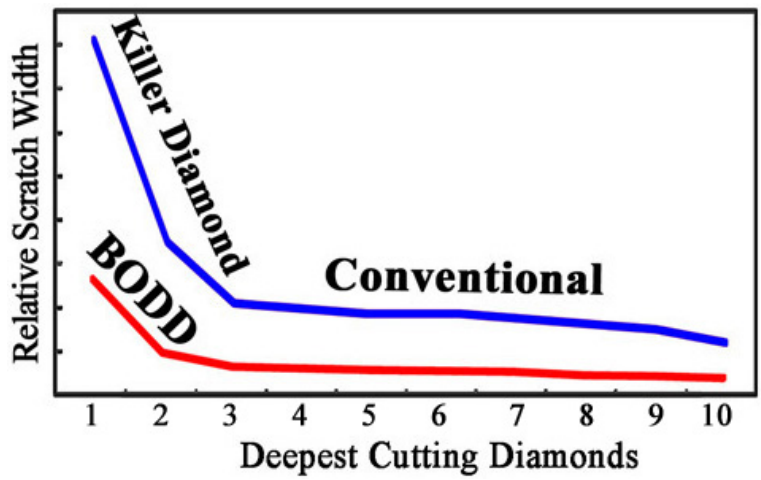

Figure 4. The BODD with low temperature diamond tips leveling can eliminate the killer diamond that may break due to high stress dressing. The killer diamond can generate killer asperities by deep penetration. In both cases, the IC wafer may be scratched.

Due to the improved diamond tip leveling the mosaic disk can achieve more uniform dressing than conventional disks. Moreover, the dressing action is smoother as reflected by the lower and consistent dragging resistance encountered during dressing.

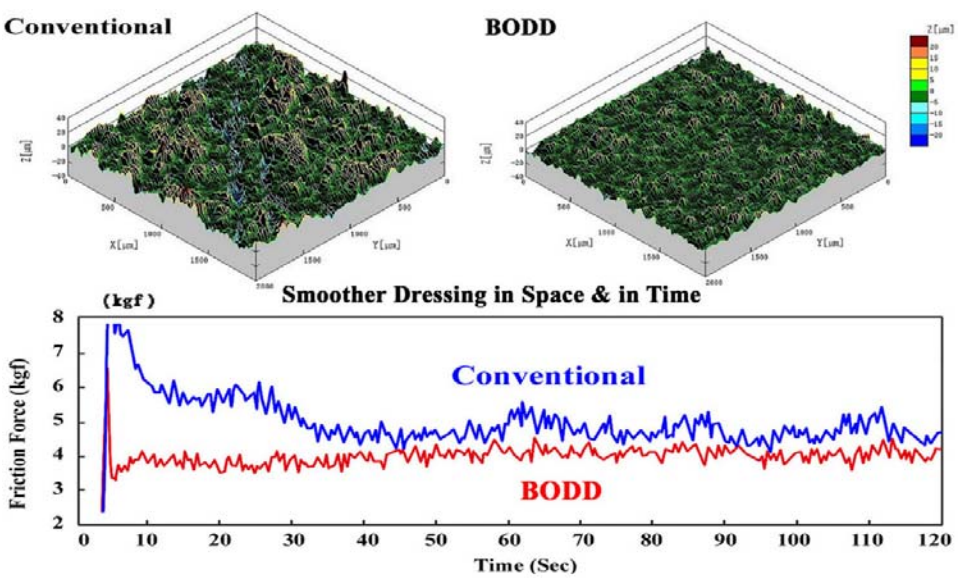

Figure 5. The contrast of pad asperities (top diagrams) and dragging resistances (bottom diagram) achieved between conventional disk and mosaic disk during dressing.

The major advantage of using mosaic design is to achieve a higher removal rate of wafer at lower cut rate of pad. This is because the asperities are optimized by using different types of diamond so excessive dressing is avoided.

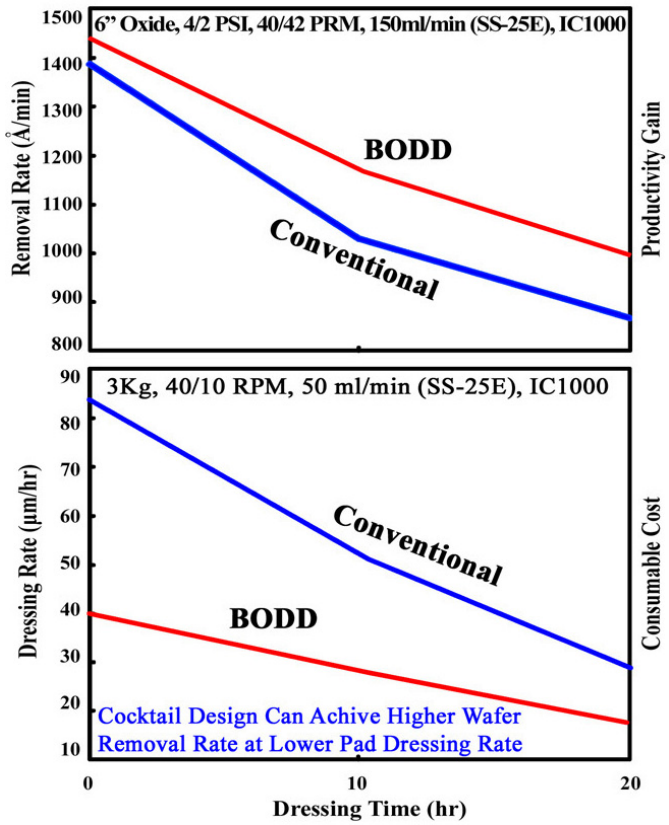

Figure 6. The removal rate of the wafer can be achieved by less dressing of the pad by the mosaic design of the diamond disk.

The Dressing of Pore Free Pads

Most CMP pads incorporates excessive amount of pores to soften the contact with the wafer, and also to provide slurry reservoir for polishing.

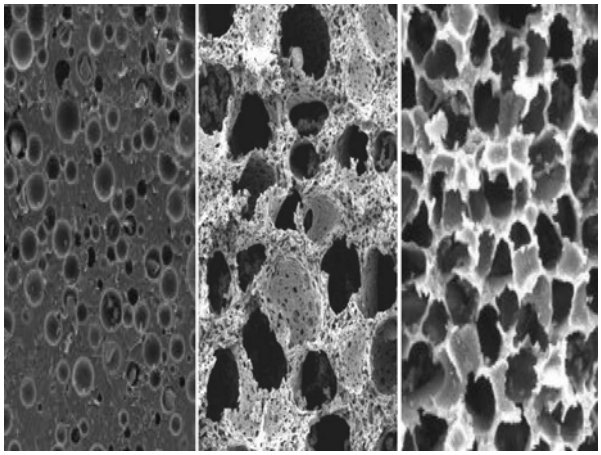

Figure 7. The CMP pads with different sizes and distributions of pores.

However, the segregation of light expansor for making pores in heavy liquid of polyurethene has been an intrinsic problem for the process of pad manufacturing. As a result, CMP performance can be erratic when the wafer is pressed on pad with different solid contact areas. On the other hand, the pore free pad does not come with slurry pockets so the removal rate can be slow. This problem may be overcome by the cocktail design of diamond disks. Large and sharp diamond grits may be used to cut slurry channels with different depth. Since the diamond tips are leveled, the killer asperities are avoided.

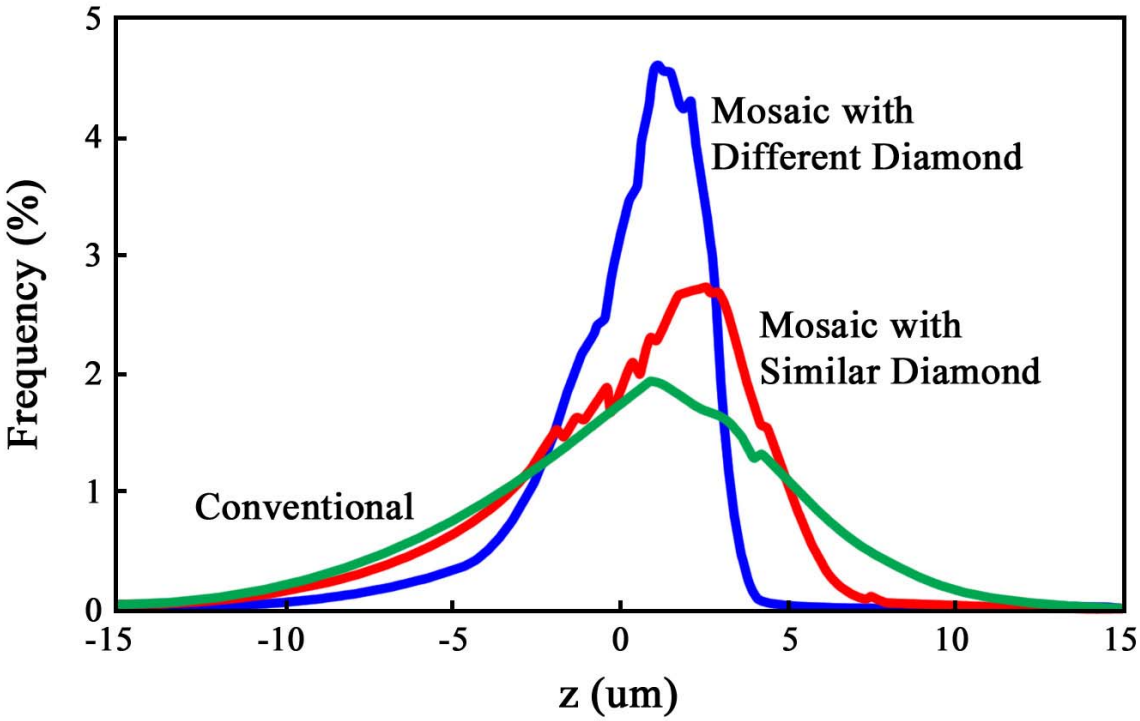

Figure 8. The mosaic design is uniquely capable to tune the pad asperities to achieve skewed distribution in a pore free pad.

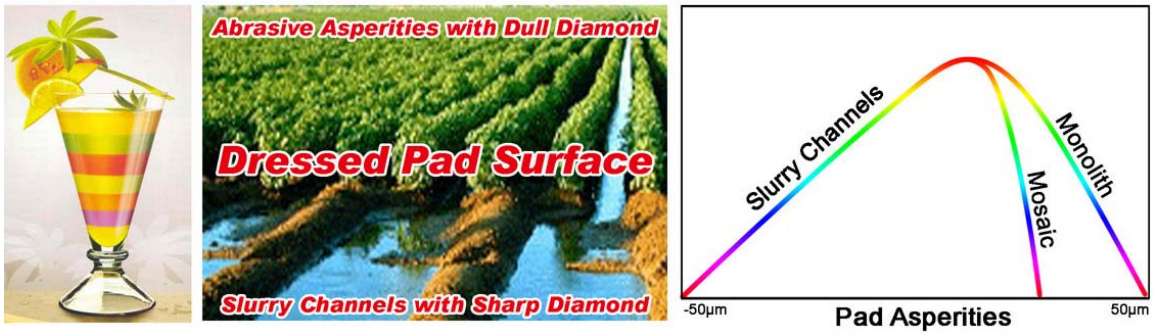

Figure 9. The cocktail design of diamond disk can tailor the distribution of pad asperities with the slurry channels cut in real time just before the polishing contact of the wafer. Therefore, the use of mosaic diamond disks may eliminate the need to incorporate pores in the pad.