Significant Improvement of Disk/Pad Life and Polishing Performance by Using a New Pad Conditioning Disk

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Introduction

Four different pad conditioning approaches have been reported to improve polishing performance. The first approach is eroding the polishing pad with an abrasive disk. Many disk manufacturing processes have been reported to prevent diamond loss and/or to improve chemical resistance.(1) However, little extended-run and production data have been published. Improved polishing performance has also been reported by controlling pad topography by optimizing speed, dwell time and other process parameters.(2-3) The second approach is vacuum-cleaning the pad.(4) More data is needed to evaluate this approach in terms of its polishing performance compared to other approaches. The third approach is vibrating the pad with ultrasound.(5) This approach has yet to be evaluated to show better uniformity and edge exclusion than those achieved on a lapping tool. The fourth approach is cooling the pad. This approach has been implied by the studies on the polishing rate as a function of temperature. Little data has been reported.

Experimental

In this work, we used a new abrasive disk for pad conditioning on a MIRRA CMP tool after screening 5 different commercial disk products. The new disk was fabricated by using a proprietary high temperature Ni-Cr brazing process which enhances the bonding of evenly distributed 100-grit diamond crystal particles with the Ni-Cr matrix on a stainless steel disk. Throughout this work, 200mm wafers were used.

Results and Discussion

We studied the new disk as compared to a conventional disk widely used in industry. The comparison studies were carried out using the process parameters optimized through designed experiments. The results showed that the conventional disk caused significant wafer scratching during polishing due to diamond loss. The disk life is only 15 hours (900 wafers). In contrast, the new disk extended disk life more than 3 times (50 hours and 3000 wafers) at a superb non-uniformity (<5%), edge exclusion (3 mm), a stable removal rate, and defect counts which are comparable to those using the conventional disk with all other variables kept constant (see Figure 1). The pad life was more than doubled at 3 mm edge exclusion (1200 wafers, Figure 2) as compared to the conventional disk (500 wafers, Figure 3). When the new conditioning disk was tested (Figure 2), the pressure was increased to compensate a lower removal rate which is characteristic for the new disk at a low pressure. The results of significant improvement of disk/pad life and polishing performance by using a new pad conditioning disk have been verified in extended-run tests and beta-site tests at a DRAM production line.

Scanning electron microscope (SEM), optical microscope, and profilometer have been used in evaluating the morphology/topography of the new and conventional disk and the pad before and after polishing for varying length of time to understand the mechanism of the improvement of polishing performance by the new disk. Improved disk life and uniformity are attributed to improved flatness of substrate and better process control in both distribution of diamonds and their adhesion to the substrate. A SEM picture of the new diamond disk is shown in Figure 4A. The uniform diamond distribution and the stronger adhesion force between diamond and Ni-Cr matrix assured even pressure during conditioning and complete elimination of diamond loss which caused micro-scratching on wafers. Figure 4B showed that there is no diamond loss at the end of disk life for the new disk. In contrast, the conventional disk always has some protruding diamond particles above the diamond plane formed by majority of diamonds as shown in Figure 4C. The protruding diamond particles were created by the irregular distribution of irregularly shaped diamonds and the inconsistent diamond orientation in the electroplated Ni matrix. As a result, the loss of the protruding diamond and/or the diamond weakly-bonded to Ni matrix is unavoidable for the conventional disk. Improved pad life was attributed to even pad wear assured by the new disk.

Conclusion

On a MIRRA tool, the new pad conditioning disk extended disk life more than 3 times (50 hours and 3000 wafers) at a superb non-uniformity (<5%), edge exclusion (3 mm), a stable removal rate as compared to the conventional disk widely used in industry today. The pad life with the new disk was more than doubled at 3 mm edge exclusion (1200 wafers) as compared to the conventional disk.

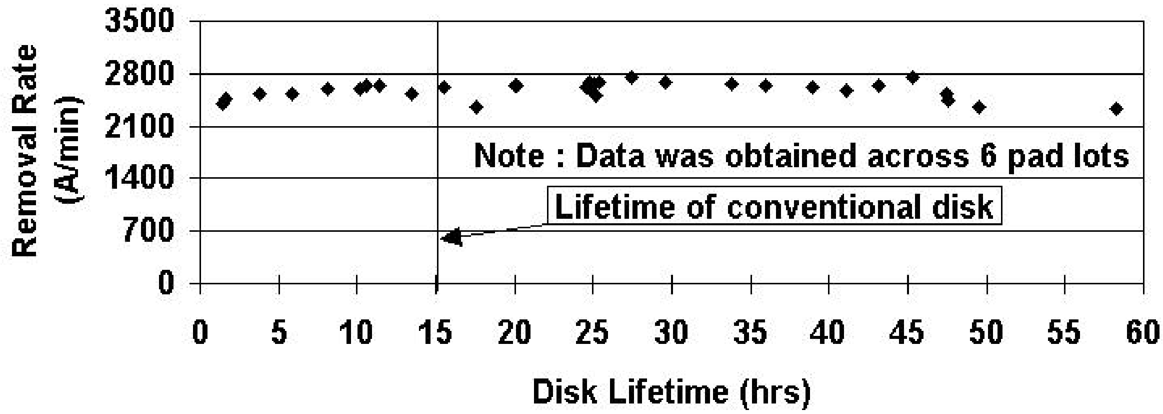

Fig. 1. Thermal oxide polishing removal rate as a function of disk life for a new conditioning disk. Pressure (psi): 4/4.6/4 membrane/retaining-ring/inner tube. Speed (rpm): 93/87 platen/head. Slurry: SS12. Slurry flow rate: 200 ml/min. Pads: IC-1000/Suba IV, K-groove and 50 mm thick.

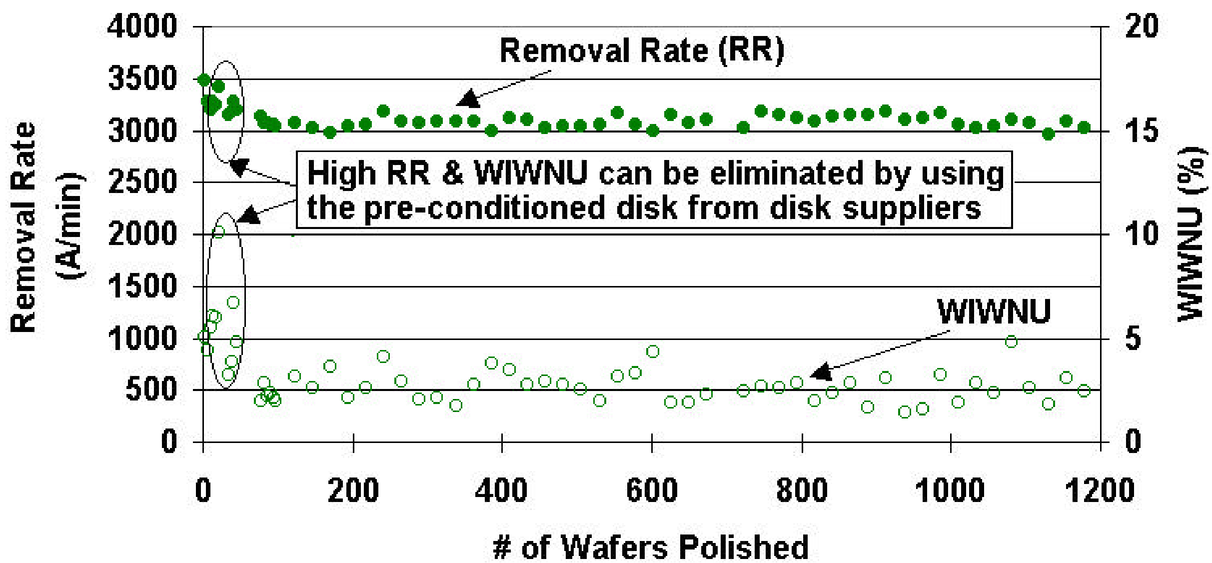

Fig. 2. Thermal oxide polishing removal rate and within wafer non-uniformity as a function of number of wafers polished using a new conditioning disk. Pressure (psi): 5/5.8/5 membrane/retaining-ring/inner tube. Others: the same as Fig.1.

Acknowledgment

The help by R.W. Evans in collecting the SME results of incoming disks is gratefully acknowledged.

References

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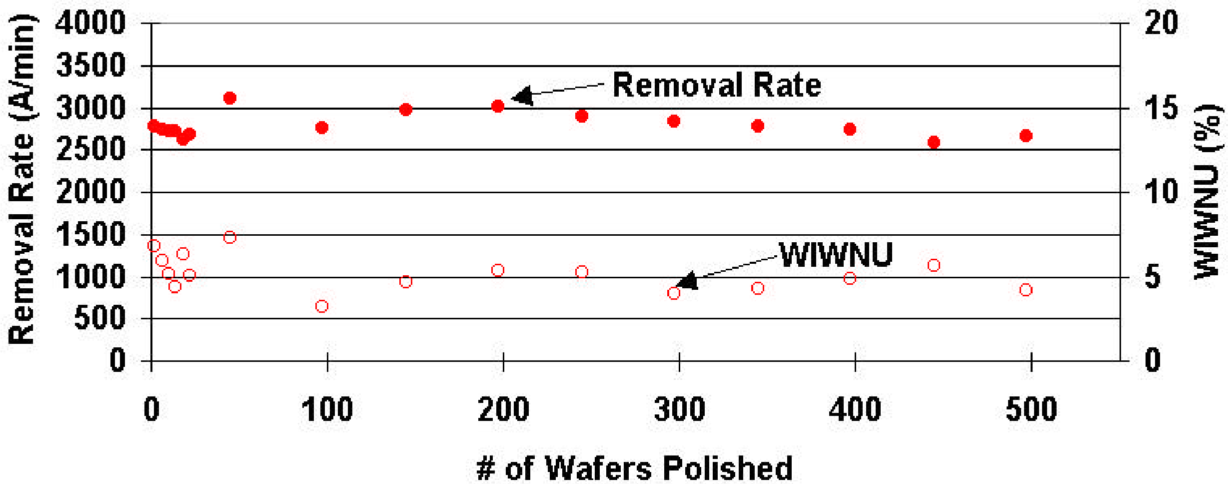
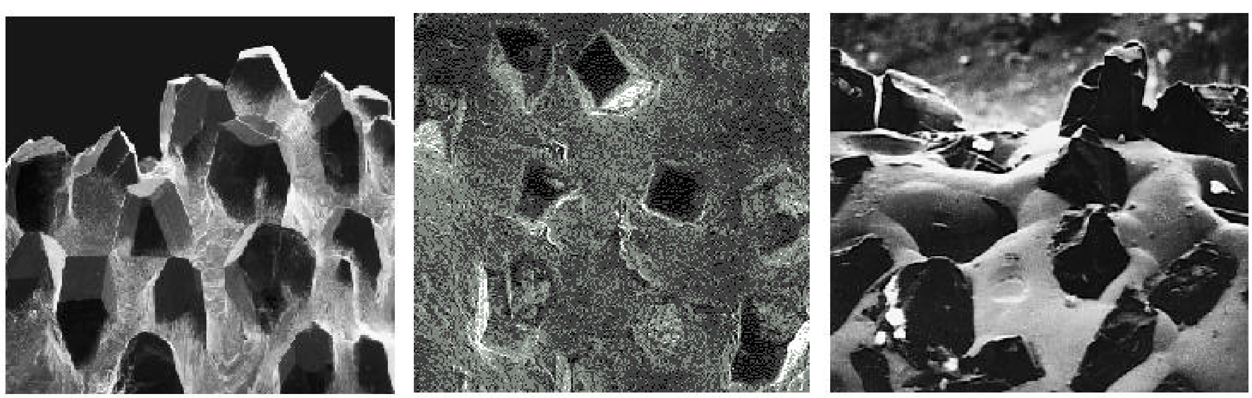


Fig. 3. Thermal oxide polishing removal rate and within wafer non-uniformity as a function of number of wafers polished using a conventional conditioning disk. Pressure/others: the same as Fig. 1.



A B C

Fig. 4. SEM micrographs of a new diamond disk (tilted view) before pad conditioning [A], a new diamond disk (top view) after pad conditioning [B], and a conventional diamond disk (tilted view) before pad conditioning [C].