New Slurry-flowback Mechanism Stabilizing Slurry Flow to Improve Removal Rate for CMP

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Abstract

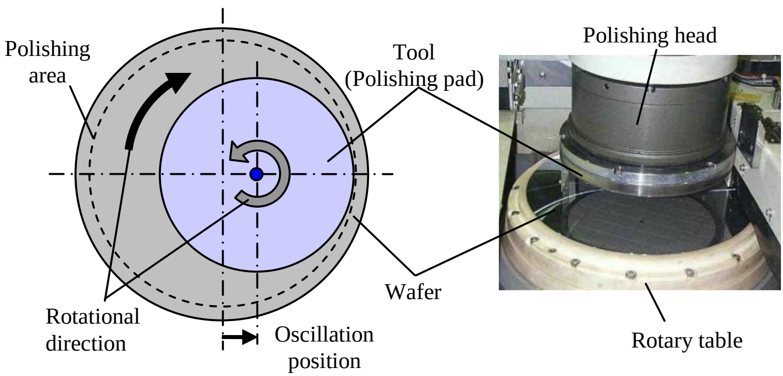
In the CMP process, the stability of slurry flow influences the amount and distribution of the removal rate. The present paper describes the effect of a new slurry-flowback mechanism on slurry flow and the removal rate under a high rotational velocity of a tool. Experimental results revealed that the newly developed slurry-flowback tool can cause the slurry to circulate to the polishing area through the interior of the tool. As a result of the stable slurry flow generated by the new flow mechanism, the removal rate increased under the high rotational velocity of the tool of 500 min^{-1} such that polishing pads with ordinary lattice groove patterns are unable to polish a wafer.

1 Introduction

Research and development into the change in wafer diameter from 300 mm to 450 mm in the semiconductor production process are proceeding. In the CMP process, slurry flow and removal rate are significant polishing characteristics. Since a higher removal rate is attained by a higher rotational velocity of the wafer and polishing pad, the polishing slurry must flow efficiently into the polishing area, especially for large wafers. However, the removal rate decreases with the increase in rotational velocity because slurry is scattered outside of the polishing pad area by centrifugal force. Therefore, it is necessary to develop an efficient slurry supply method for the polishing area, which is the contact area between the wafer and the pad. The present paper describes the effect of the slurry-flowback mechanism, which is a new slurry supply method devised to resolve the above-mentioned problem. The slurry flow rate generated by the proposed method is measured. In addition, the removal rate obtained using the proposed method is compared to that for ordinary methods.

2 Slurry-flowback mechanism

Oscillation-speed-control-type polishing is an effective method to planarize a large wafer [1]. Figure 1 shows a schematic diagram of this polishing method and a photograph of a polishing machine (PNX-400, Okamoto Machine Tool Works Ltd.). Unlike in an ordinary CMP machine, in the polishing machine used in the present study a polishing pad is situated on the wafer and the pad is smaller than the wafer. Slurry is supplied from the center of the pad or is dropped directly onto the wafer. Since this polishing machine has high corrective polishing ability, this machine can attain a flatness of 0.1 μm over the entire surface of a wafer of 300 mm in diameter. In this type of polishing method, the groove patterns on the polishing pad enables the slurry flow condition between the wafer and the pad to be changed easily [2]. A spiral groove pattern generates centripetal force and maintains slurry between the pad and the wafer, counteracting the centrifugal force. However, the problem with this type of groove pattern is that the strength of centripetal force varies with rotational velocity. The newly devised tool consists of a pad with a spiral groove pattern and a base plate with internal flow channels. Figure 2 shows a schematic diagram of the slurry-flowback mechanism. The slurry-flowback tool realizes the slurry-flowback mechanism whereby the slurry supplied on the wafer is concentrated in the center of the pad by the centripetal force generated by the spiral grooves. The slurry flows to the periphery of the pad through the inside of the tool, and is resupplied to the polishing area. Therefore, abundant slurry is supplied during polishing, and the polishing area does not have need of slurry even if the rotational velocity increases.



(a) Schematic diagram (b) Polishing machine

Figure 1: Oscillation-speed-control-type polishing

Figure 3 shows a photograph of the slurry-flowback tool. The pad is constructed of polyurethane (IC1000, NITTA HAAS Inc.). The tool has a lattice groove pattern and a spiral groove pattern. There are eight radial channels from the center of the base plate. Figure 4 shows the slurry flow rate through one channel. The relative rotational velocity is defined as the difference in rotational velocities between the tool and the wafer. The slurry flow rate increases linearly as the relative rotational velocity increases. This tool has been demonstrated to realize the slurry-flowback mechanism.

3 Polishing characteristics

The effect of the slurry flowback tool was investigated through a polishing experiment for a silicon wafer of 300 mm in diameter. Table 1 shows the experimental conditions. Figure 5 shows the average removal rates for three types of tools, namely, a slurry flowback tool, a lattice groove pattern tool, and a spiral groove

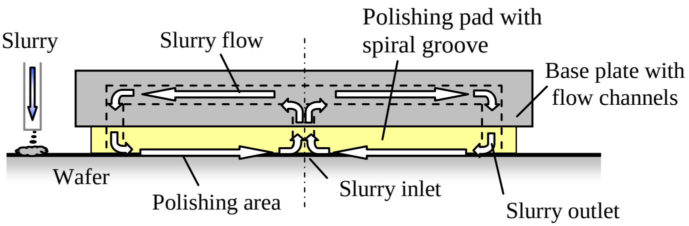


Figure 2: Slurry flowback mechanism

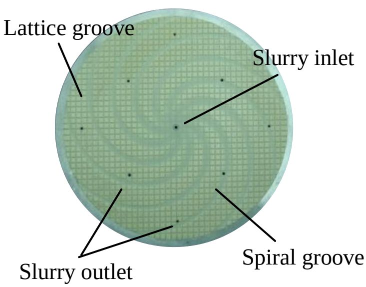


Figure 3: Slurry flowback tool

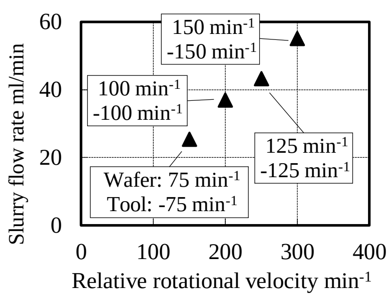


Figure 4: Slurry flow rate through one channel

Table1: Experimental polishing conditions

Wafer size		300 mm	Oscillation position	25 mm
Pad size		200 mm	Polishing pressure	20 kPa
Rotational velocity	Wafer	100 min^{-1}	Polishig time	5 min
	Pad	-100, -300, -500 min^{-1}	Slurry flow rate	100 ml/min

pattern tool. The average removal rate of the slurry-flowback tool increases under the high relative rotational velocity of 600 min^{-1}, under which polishing pads with ordinary groove patterns can hardly polish a wafer. Figure 6 shows the average removal rate with respect to the slurry flow rate. The average removal rate at each relative rotational velocity is approximately the same, even if the slurry flow rate changes. Figure 7 shows the removal rate distributions for two types of tools under a tool rotational velocity of 300 min^{-1}. The removal rate over the entire wafer surface with the slurry-flowback tool was significantly improved compared to that for the lattice groove pattern tool because a stable slurry flow was achieved by the new tool.

4 Conclusions

A novel slurry-flowback mechanism was devised in order to supply polishing slurry stably. It was demonstrated experimentally that the new tool can achieve a high removal rate under the condition of a high tool rotational velocity of 500 min^{-1}.

References:

[1] K. Yoshitomi, A. Une and M. Mochida, Highly Efficient CMP Planarization Using a Ring Polisher with Oscillation Speed Control, Proc. of the 4th International Symposium on Advances in Abrasive Technology (ISAAT), 259-262 (2001).

[2] K. Yoshitomi, A. Une and M. Mochida, Groove Patterns of Pads for Oscillation Polishing under High Rotational Velocity and Low Slurry Flow Rates, Proc. of the 10th ISAAT, 435-440 (2007).

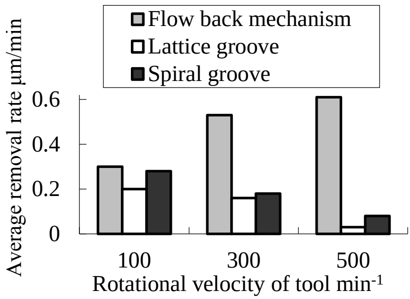


Figure 5: Influence of tools

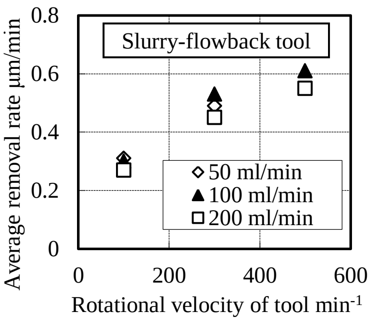


Figure 6: Influence of slurry flow rate

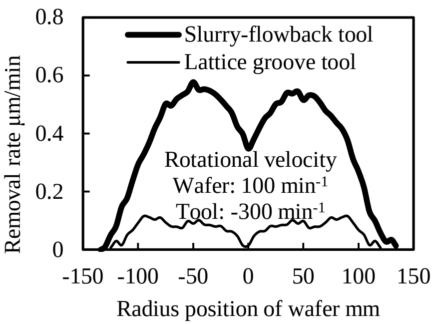


Figure 7: Removal rate distribution