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Application of Double Polishing Pad for Shallow Trench Isolation Chemical Mechanical Polishing Process

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1. Introduction

Chemical mechanical polishing (CMP) process has been widely used to realize the global planarization of inter-metal dielectric (IMD) layer, inter-layer dielectric (ILD) and pre-metal dielectric (PMD) layer [1,2]. Also it was applied to several industries such as manufactures of devices and materials. In spite significant effect of the CMP process on the global planarization [3,4], there are yet many varieties of issues to apply to practical ULSI process [5,6]. There are four consumables in CMP process such as polishing pad, slurry, backing film, and pad conditioner. Among them, the polishing pad plays an important role in order to obtain the reproducibility of CMP process. The structure and material property of the polishing pad are notably affected in the removal rate (RR) and non-uniformity (NU%), and planarity of CMP process. Harder polishing pads allow a higher RR and worse NU%, whereas softer pads allow better NU% and lower RR [7-9]. Therefore, composite pads stuck with both a soft pad and hard pad are commonly used to make up for each drawback [8]. In this work, the effects of composite pads on shallow trench isolation (STI)-CMP process were investigated. The effects of pad hardness and composite type on RR, NU%, selectivity and scratch numbers in STI-pattern wafer were determined. According to the results, we could select the optimum polishing pad sets to bring about the improvement of device yield and process throughput.

2. Experimental Details

STI-pattern was begun with deposition of the thermal oxide (150Å) in furnace and nitride layer (2000Å) by LPCVD on blank wafer. Trench depth of 3500Å was formed by moat patterning and dry etching, and linear oxide (270Å) was deposited on the trench in furnace. And then, trench was filled with the APCVD-oxide of 8000Å. Finally, STI structure was built up after annealing. Thickness of polished pattern wafer was measured on large field oxide (50 $\mu m \times 50\ \mu m$ square) and dense field oxide (10 $\mu m \times 12\ \mu m$ square). In order to investigate the effect of pad property on STI-CMP characteristics, three types of double-composite pad were prepared. As the upper pad was fixed up with IC1000, bottom pad was set up with Suba-IV, IC1000, and JR111 according to the hardness (Suba-IV < IC1000 < JR111), respectively. Upper and bottom pads was stuck together using PSA-II. Oxide thickness measurement was carried out using Nano Metrics M8000X and Rudolph Ellipsometer. And the defects and scratches were inspected using KLA-Tencor 6420 system. After the sample was polished using IPEC Avanti 472 Polisher, the post-CMP cleaning was rinsed by SC-1 chemicals and diluted HF (DHF). After the rinse, surface of wafer was dried by spin rinse dry (SRD).

3. Results and Discussion

Figure 1 shows the RR, NU%, and selectivity of oxide to nitride layer with different pad sets. The composite-pad of IC1000/Suba-IV showed the lower RR than other pads. Although RR of IC1000/IC1000 pad was the highest, its selectivity was relatively lower. The use of IC1000/JR111 produced an appropriate result. It had not only high selectivity, but also had high RR of oxide. NU% of every pad was controlled below 7% and there was no difference of them through repetitive tests. On the selectivity between oxide and nitride layer, both JR1111 and Suba-IV showed high rates of 15:1. Although the selectivity with Suba-IV was higher, it will take a long polishing time to polish a higher density-moat area due to its lower RR. Hence, IC1000/Suba-IV composite-pad is not suitable for present STI-CMP process, which requires high RR.

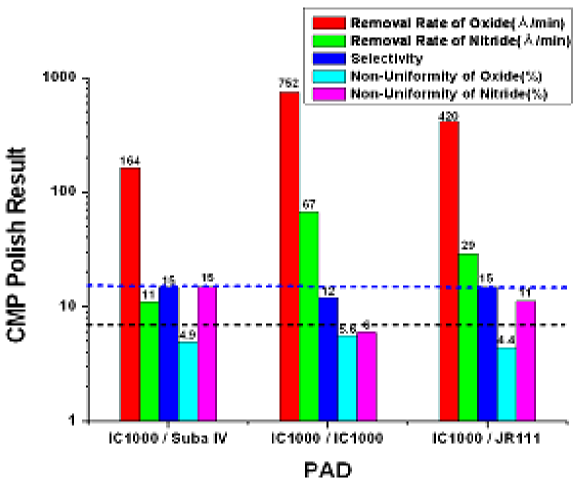
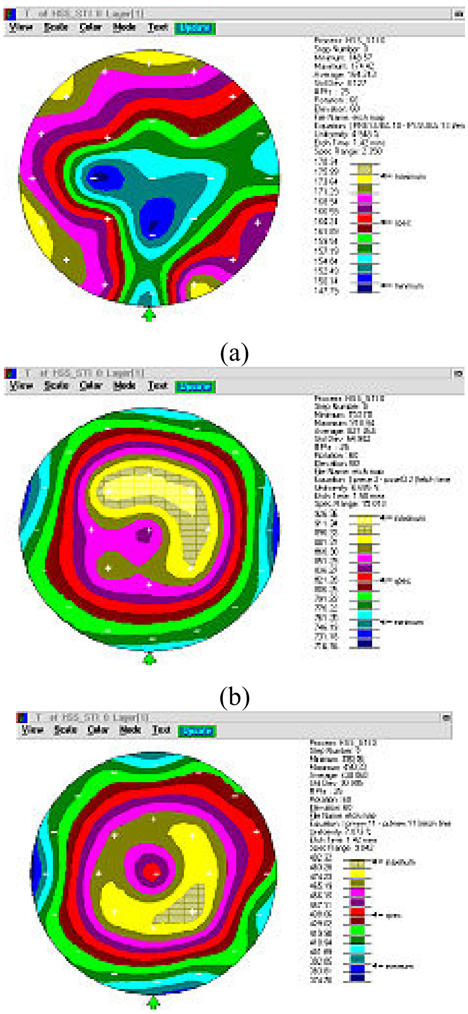


Figure 1. Comparison of CMP results as a function of three different sub-pads.

Figure 2 illustrates the 2D wafer map of RR using different pad sets. When the soft pad like Suba-IV was used as bottom pad, the edge-fast type was notable. On the other hand, the center-fast type was stood out by the use of hard pad such as IC1000 and JR111. As harder bottom pad was, the center-fast type increased; however, the edge-fast type became more intense with softer bottom pad. As the process repeatedly went on, the defect distributions of IC1000 (hard) and JR111 (soft) were different from each other. Even though JR111 had few defect in the early process, the number of defect increased as the process carried out. On the contrary, the defect using IC1000 decreased with the progress of the process. Hence, JR111 pad had a better performance than the others due to its higher RR and lower defects in the early process. On using IC1000, there is no scratch during the measurement regardless of the defect number. Inversely, one or two scratches were detected when JR111 was used as the bottom pad.



(a)

(b)

(c)

Figure 2. 2D Map of polished wafer as a function of 3-different pads. (a) IC1000/Suba-IV, (b) IC1000/IC1000, (c) IC1000/JR111.

Figure 3 showed thickness of dense and large field areas as a function of the number of run-times using of IC1000 and JR111. The scale of dense field area was set 10 ㎛ × 12 ㎛ square, and that of large field area was set 50 ㎛ × 50 ㎛ square. The result of IC1000 was which polished 3500 Å of STI and that of JR111 was which polished 5000 Å of STI. The repetitiveness was sufficient since the polished thickness with both IC1000/IC1000 and IC1000/JR111 were about the same in 3 times tests.

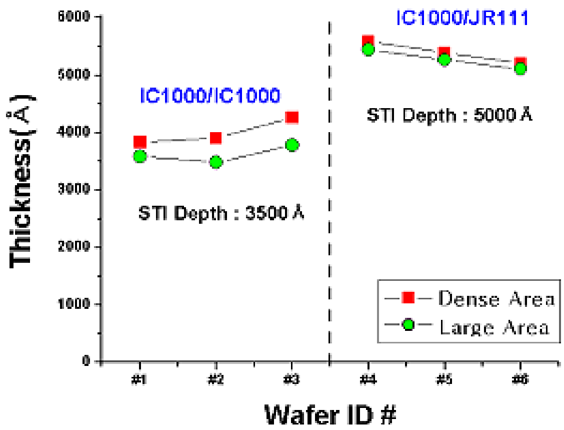


Figure 3. Comparison of polished thickness with different field oxide area.

4. Conclusions

We could conclude that IC1000/JR111 set is more superior than IC1000/Suba-IV set. The wafer map of hard pad set showed the center-fast type, and the soft pad set showed the edge-fast type. The defect level has shown little difference, however, the scratches were defected less than 2 on JR111 pad. IC1000/IC1000 pad set and IC1000/JR111 pad set gave a good reproducibility in STI-pattern wafers.

Acknowledgements

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