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Chemical mechanical polishing performances by filtering and retreatment of used silica abrasives slurry

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Abstract

In order to reduce the high cost of ownership and cost of consumables, we have collected the silica abrasive powders by filtering method after subsequent chemical mechanical polishing (CMP) process for the recycling of abrasives. From this, we have studied the possibility of recycling reused silica abrasive through the analysis of particle size distribution and field emission scanning electron microscope measurements of abrasive powders. We annealed the collected abrasive powders to promote the mechanical strength of reduced abrasion force. Finally, we compared the CMP characteristics between self-developed KOH-based silica abrasive slurry and original slurry. Our experimental results show removal rate and planarity comparable to commercial products. Consequently, we can expect the saving of high cost slurry.
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Keywords: Chemical mechanical polishing; Slurry retreatment; Abrasive particles; Cost of ownership; Cost of consumables

1. Introduction

Chemical mechanical polishing (CMP) process has been widely used to obtain global planarization of inter-metal dielectric layer, Inter-layer dielectric and pre-metal dielectric layer. Also it was applied to several industrial processes, such as manufacturing of devices and materials [1–4]. In spite of significant effect of the CMP process on the global planarization, there are still many problems in applying this technique to practical process. Among them, one of the most critical

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problems is the higher cost of consumables (COC) such as pad, slurry, the backing film and pad conditioner, which is over 70% of cost of ownership (COO) [5]. Since a sufficient amount of slurry is required to get a higher removal rate and lower non-uniformity, the purchase of slurry is about 50% of COC for a typical CMP process [6]. Therefore, there have recently been studies about the recycling of slurry. The selection between silica (SiO_2) abrasive and removed particles of oxide after CMP process became an issue on oxide CMP process. Moreover, revivification into the concentration before process by recycling is the hardest problem to solve. The method of dilution of high cost slurry [7], and the method of re-using after mixed used slurry with undiluted slurry have been reported so far [8]. However, there is still no study about the recycling method of CMP abrasive in which silica abrasive from used slurry was filtered and retreated. In this paper, the possibility of recycling of used silica abrasive was studied through the analysis of particle size distribution and field emission scanning electron microscope (FESEM) measurements. The silica abrasive powder was collected by filtering method to recycle it after subsequent CMP process. Annealing process of collected abrasive powder was done to improve mechanical strength of the reduced abrasion force. CMP characteristic was evaluated after abrasive powder was diluted with DI water in the ratio of 1:10 in silica slurry.

2. Experimental

To compare the possibility of recycling of used abrasive using KOH-based silica slurry, four kinds of methods were carried out as follows:

1. *Original abrasive*. Silica abrasive was obtained from drying of aqueous solution of original slurry.
2. *No filtering abrasive*. Silica abrasive was obtained from drying of used slurry without filtering after CMP process.
3. *Filtering abrasive*. Silica abrasive obtained with filtering. The filter has 1.25 μm pores to get rid of large particles.
4. *Annealed filtering abrasive*. The silica powder after filtering was annealed for 1 h in the electric furnace (600 °C) and then was shattered.

Finally, a mixed abrasive slurry (MAS) was made after each abrasive (1–3 wt%) was added in the silica slurry which was diluted with DI water in the ratio of 1:10. The CMP experiments using MAS were performed on a G and P technology POLI-380 with Rodel IC1300/SubaIV composite pad. Table 1 shows the process condition of CMP equipment. A 4-in. blanket wafer was used after oxidation by subjected to a 1200 °C annealing for 6 h on HI-TXCH electric furnace. Sonic Tech ultrasonic wave homogenizer was used to disperse the silica abrasive which was added in undiluted slurry. The slurry was adequately mixed using a milling machine to prevent from aging affect and precipitation reaction. On post-CMP cleaning, the wafer was dipped in SC-1 chemical for 1 min and then dipped in DHF for 2 min. Finally, it was cleaned using an ultrasonic cleaner for 4 min. As shown in Fig. 1, the thickness of 9 points from the center to the edge was measured clockwise using a Spectroscopic Ellipsometer (J. A. Woollam).

Table 1
Process conditions of CMP equipment

Table speed	60 rpm
Head speed	60 rpm
Down force	300 g/cm^2
Slurry flow rate	30 ml/min
Polishing time	90 s
Post-CMP cleaning	SC-1 → DHF → Ultrasonic

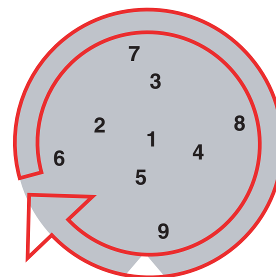

Fig. 1. Method of 9 points measurement.

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