Development of CMP Conditioning System with Varying Contact Area

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1. Introduction

The chemical mechanical polishing (CMP) process is one of the key technologies in semiconductor fabrication and is a planarization process by removing chemical and mechanical materials [1,2]. In the CMP process, consumables such as slurry and polishing pad are used, and the management of the consumables is directly linked to the polishing result. In particular, the polishing pad is highly related to the uniformity of the material removal rate (MRR), and it is important to control the flatness and surface roughness of the polishing pad. Lee et al. [3] observed the MRR and its uniformity change due to the shape change of the polishing pad and found that the higher the deviation of the height of the polishing pad, the worse the MRR and its uniformity. In this study, we designed a novel CMP conditioning system that can change the contact area between diamond disk and pad. We also investigate the planarization characteristics of the polishing pad using kinematic analysis.

2. Development of conditioning system

The conventional CMP conditioner has a pressing structure behind the disk on which the diamond particles are deposited on the disk. Therefore, the polishing pad has the same pressure and contact area while reciprocating on the polishing pad, and as a result, the polishing pad becomes closer to the 'W' shape over time. The system was designed so that the inner diamond disk and the outer diamond disk can be moved up and down to independently. Fig. 1 shows a schematic diagram of a conditioning system designed for this study. The rotation of the two diamond disks is accomplished simultaneously using belt drive. Two air cylinders are mounted to apply pressure to the two rings, and are driven independently. The conditioner in Fig. 1 is mounted at the end of the swing arm of a conventional CMP unit. The lower part of the conditioning system is equipped with a magnet for mounting a separate diamond disk, which allows the diamond disk to be detached and attached. The swing arm conditioning system is divided into eight sections over the polishing pad and controlled to control the speed at each section. Fig. 2 shows a schematic diagram of a swing arm conditioning system.

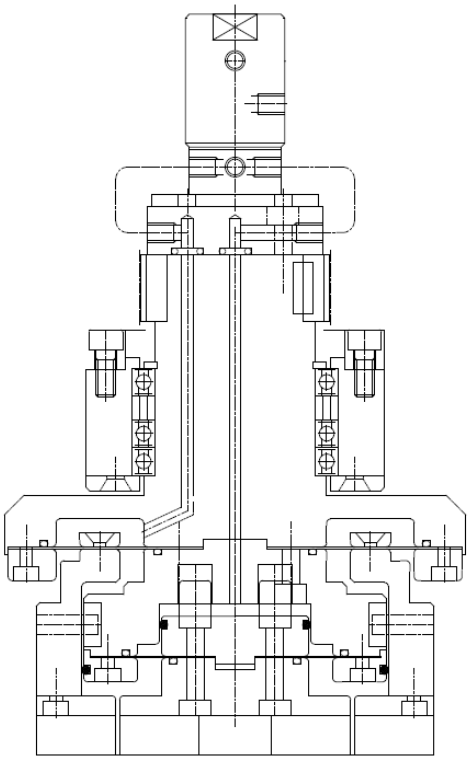

Fig.1 Schematic diagram of a conditioning system designed for this study

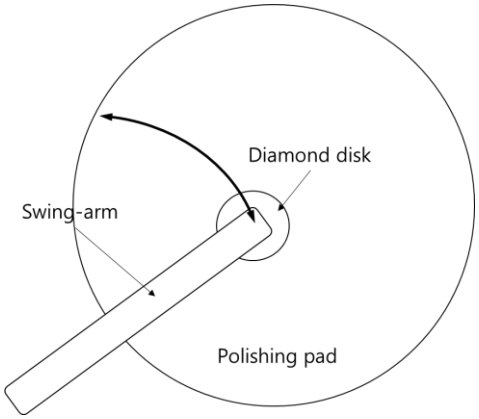

Fig.2 Schematic diagram of a swing arm conditioning system

3. Analytical condition

The rotational speed of polishing pad was 87 rpm, and the rotational speed of conditioner was 103 rpm. The swing start radius and swing end radius were 250 mm and 30 mm, respectively.

Table 1 Simulation condition

Rotational speed of pad	87 rpm
Rotational speed of conditioner	103 rpm
Swing start radius	250 mm
Swing end radius	30 mm
Process time	66 sec
Sweep per minute	10
Conditioner diameter(inner+outer)	100 mm

The diameter of diamond disk was 100 mm in total. And, the process time was 66 seconds.

The dimension of diamond disk is shown in Fig. 3.

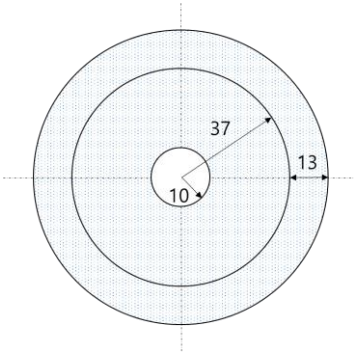

Fig.3 Considered diamond conditioner in this study

The non-uniformity of polishing pad after conditioning was calculated as below.

$$WIPNU = \frac{STD_{pad}}{AVG_{pad}} \times 100(\%) \quad (1)$$

4. Results and discussions

The area of the conditioner was divided into two parts. The sum of particles to the inner and outer conditioners was assumed to be the same as the number of conventioneer conditioner's diamond grits. According to kinematic analysis of CMP conditioning, The WIPNU value of polishing pad was 14.61 %.

It can be seen that the WIPNU value is less than 20% through the proposed conditioning method compared to more than 20% in the general conditioning process. This is because the conditioner proposed in this study seems to control the wear of the polishing pad by changing the contact area when the conditioner passes over the polishing pad.

5. Summary

This study devised a system that can change the contact area between diamond disk and polishing pad during CMP conditioning of a polishing pad and predicted the results through kinematic analysis. In order to stabilize the system proposed in this study, it is necessary to study more various types of diamond disk, and it seems that the swing condition should be optimized.

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