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A Study on Pad Surface Characterization and Design for Chemical Mechanical Polishing (CMP) -Fabrication Process and Prototype -

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Sponsored by UC SMART

Abstract— There are many elements affecting CMP performance such as slurry, pad, process parameters and pad conditioning. Among these elements, the pad is considered one of the most important because of its deterioration during polishing. A special purpose pad design, however, has not been tried yet. In this paper, a fabrication process and prototype are detailed using micro molding technology. These are applied to pad design optimization.

Keywords: Chemical mechanical polishing (CMP), micro molding, pad design.

1. Introduction

Chemical Mechanical Polishing (CMP) has been considered one of the most capable IC fabrication technologies to achieve the planar surfaces that are essential for very large-scale integrated circuits (VLSI). During the CMP process, a wafer is “faced” side down on a pad under high pressure. Wafer and pad rotate simultaneously. Pressure, rotational speed, and chemical-mechanical reactions enhanced by the chemical slurry result in a planarized surface.

Generally, the pad surface has numerous independent pores, which temporarily hold fresh slurry. The pores are separated by polyurethane wall structures that contain micro asperities on thin edge surfaces. This structure provides space for reactions between the wafer and pad. Additionally, it has several channels to help slurry flow into the middle of the wafer. Figure 1 shows the structures of a conventional pad. However, deterioration in the pad steadily occurs, mainly due to residues in the slurry that include wafer debris and abrasives. In practice, diamond grit conditioning is used to regenerate a new pad surface.

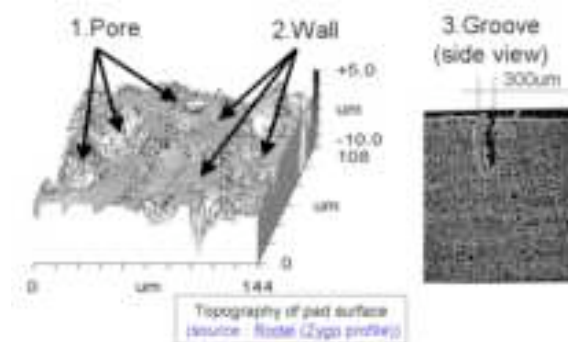


Figure 1. Conventional pad geometry.

The pad degradation mentioned above causes many problems such as removal rate drops, scratches induced by diamond grits loss, erosion, dishing, and so on. To investigate the pad deterioration mechanism, a pad design and fabrication with microstructures on the surface is necessary. In this paper, a pad fabrication process and prototype pad are introduced using micro molding technology.

2. Direct Casting

Direct casting implies a molding process, which uses an etched silicon wafer as a final mold for the pad.

2.1. Fabrication Process

A silicon wafer is etched in a deep reactive ion etching process. The pocket shape mold measures $200\text{ }\mu\text{m} \times 200\text{ }\mu\text{m}$ and has $50\text{ }\mu\text{m}$ spaces along each side. In the polymer casting process, the pockets are first filled with hard polymer, and then the excess material is squeezed. After curing the hard part, a soft material is cast. During the curing process, bubbles in the polymer are removed by a vacuum pump and the polymers are cured in an oven at approximately 50°C . Figure 2 shows the indirect casting process.

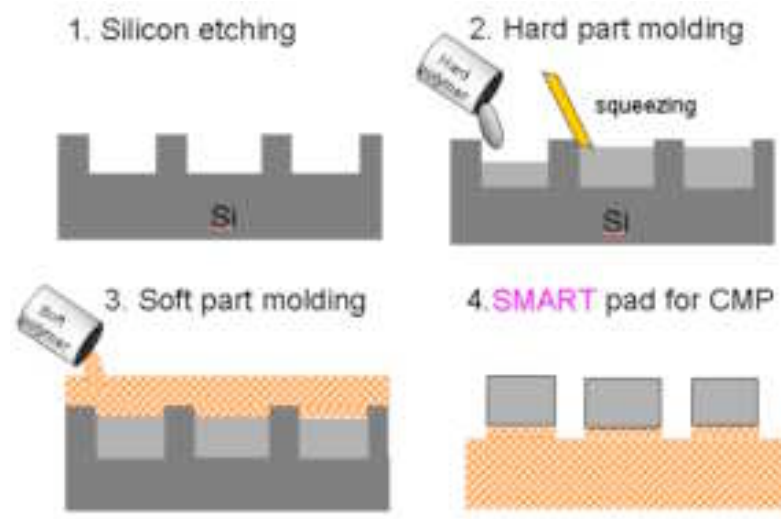


Figure 2. Direct casting process.

2.2 Prototype and Evaluation

A prototype is fabricated using micro mold technology. As indicated above, direct casting uses the patterned silicon wafer as a mold for a pad. Thus, the shape of the etched wafer is a main factor to be considered for perfect replication. The etching process can't provide, however, well-defined features when etching broad surfaces.

As Figure 3 indicates, the etched mold has “silicon grass” on the bottom area and the bottom area has a round shape. On the other hand, the polymer is not easily demolded because of high surface energy of the silicon mold.

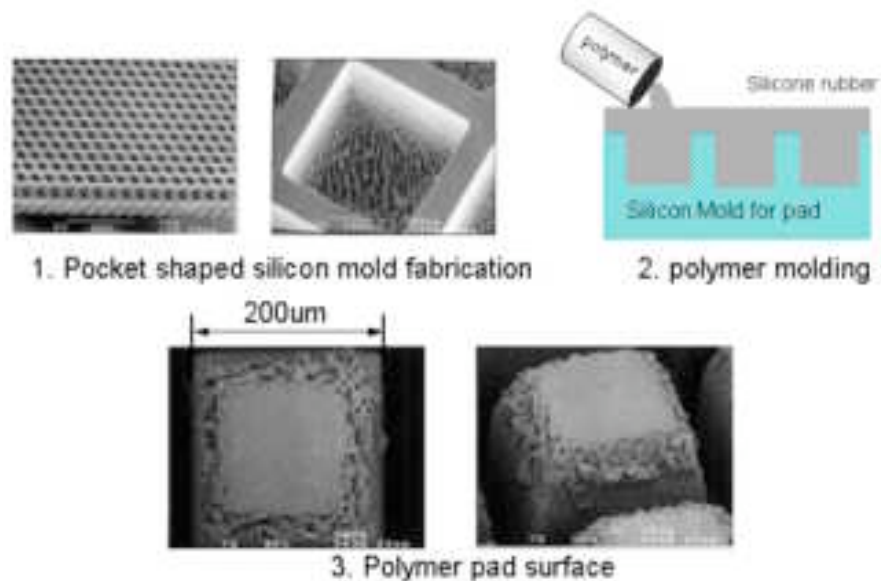


Figure 3. A prototype pad using direct casting.

3. Indirect Casting

Indirect casting means a molding process that uses a silicone rubber mold, copied from an etched silicon wafer, as a final mold for the pad.

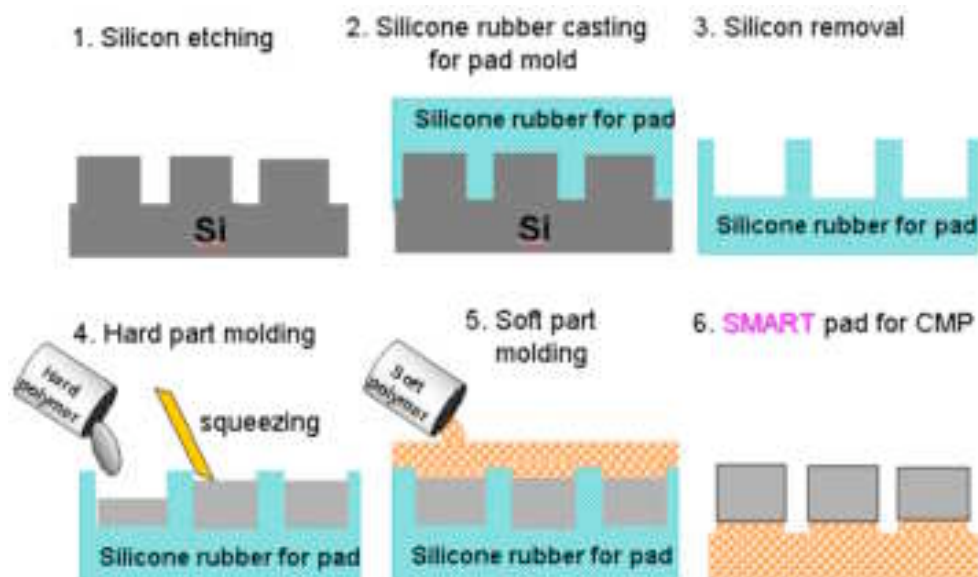


Figure 4. Indirect casting process.

3.1. Fabrication Process

The process is similar to direct casting. However, the etched silicon geometry is smaller and the patterned wafer surface is replicated by silicone rubber. Then the silicone rubber is used as the mold for the pad. Figure 4 details the indirect casting process.

3.2 Prototype and Evaluation

As Figure 5 depicts, the etched wafer has well defined features and these features are copied very well using silicone rubber. The polyethylene pad is molded using the rubber mold. The size accuracy is really good and the separation process is also easier than in the direct casting process.

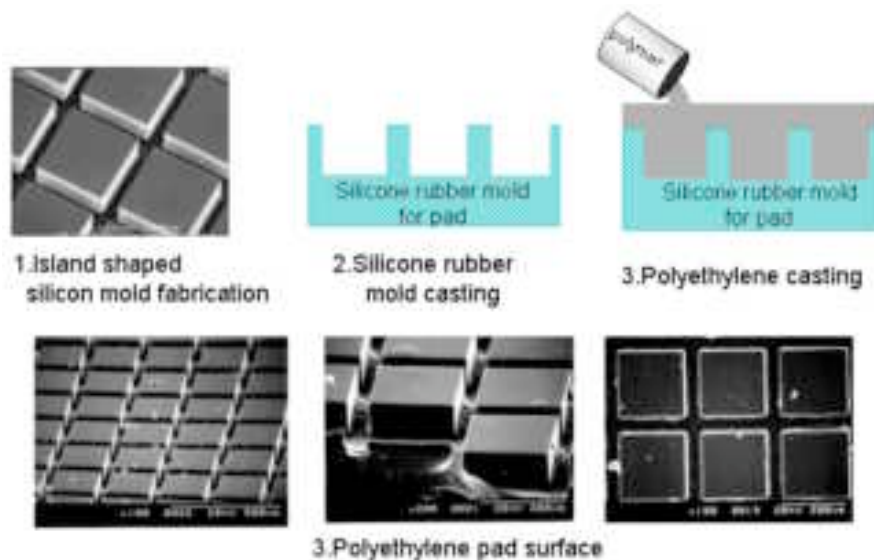


Figure 5. A prototype pad using indirect casting.

4. Summary and Future Work

In this paper, two types of casting experiments are performed and evaluated. As shown above, the indirect casting is suggested as a pad molding technology for better molding accuracy.

A pad deterioration mechanism will be investigated using the molded pads. Material removal rate vs. real contact area is also one of the research focuses. After evaluating pad surface effects, the influence of double layer will be considered as part of the SMART pad project.

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