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## Precision Manufacturing Group

### Title

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# Design Rules for the Development of a New-Concept Pad

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Sponsored by UC SMART

**Abstract**— In order to address new concerns in the CMP process, a new-concept pad with a composite structure and controlled geometries is proposed.

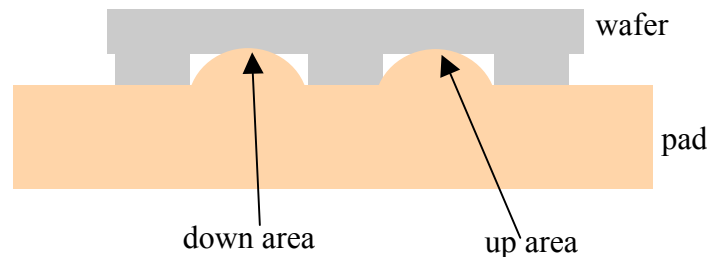
Keywords: CMP, pad, pores, walls, grooves, composite.

## 1. Introduction

Ever since the initial CMP patents were filed by IBM in 1985, opportunities for expanding use of CMP in existing chip-making technology have continued to flourish. However, inasmuch as the expanding use of CMP, challenges ahead for CMP technology to keep pace are formidable, because increasing concerns about improved within-wafer non-uniformity, better planarity, and lower defectivity levels are or are likely to be requirements for advanced sub-micron devices. In order to effectively address these new concerns, a new design for the polishing pads is proposed in this report.

## 2. Problems and solutions

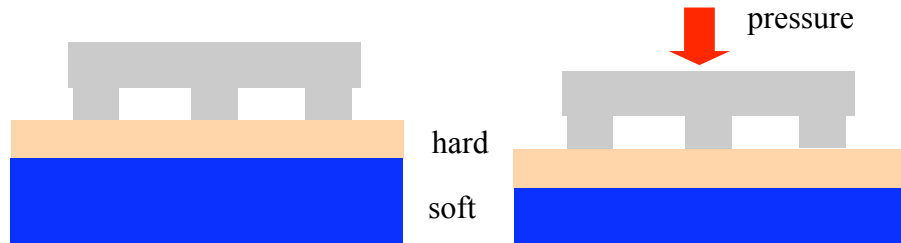
Polyurethane-based polishing pads that have mainly been used in the past. contributed significantly to make CMP an enabling technology for the integration of copper in the integration circuits, and the introduction of shallow trench isolation as an isolation method. Nevertheless, it is undeniable that some inherent problems associated with the polishing pad are responsible for time-dependent and non-uniform material removal



*Figure 1. Problems with pad contact.*

across a wafer, and are accountable for dishing, erosion, or thinning, which are commonly seen in the copper damascene process and shallow trench isolation process. It is speculated that these problems have a lot to do with contact between the pad and wafer.

A pad glazes continuously during the CMP process because of its contact with the wafer; it means that walls and pores, which temporarily hold slurry, are closed, thus are no longer functional. Even though conditioning with diamond grits to make open walls are currently being used, shapes and distribution of walls and pores do not remain the same because they are not originally controlled in the pad fabrication process. Therefore, it is proposed that the whole layout including walls, pores, and grooves (which ensures uniform slurry distribution) needs to be tightly controlled based on design rules. On the other hand, the pad, which is softer, deforms according to the load, and makes a contact with down-areas as well as up-areas on the wafer. In spite of lower pressure on the down-areas and slurry selectivity, the down-areas in contact with the pad will be removed while the up-areas are being polished, as shown in Figure 1. These undesirable natures with the pad can be overcome by introducing the concept of a composite pad. A schematic diagram shown in Figure 2 explains how this composite pad structure can solve the



*Figure 2. The concept of a composite pad.*

problem. A pad deforms depending on its materials properties as well as the load applied during polishing; if the pad consists of two layers, most of the deformation can be confined to the softer layer of the two. As demonstrated in Figure 2, the harder layer makes a contact with a wafer, and the soft layer backs up the harder layer; hence, the soft layer will be responsible for most of the deformation; thus, the contact area between the pad and wafer will be more or less constant. This composite structure concept also helps reduce the degradation of material properties of a pad.

### **3. Design Rule**

For the fabrication of a composite pad having controlled geometries, design rules for the main three elements – pores, walls, and grooves – should be established. Even though conventional pads have uncontrolled geometries, there is an unwritten rule on the scale issues in CMP, as introduced in Figure 3; hence, pores, walls, and grooves need to be designed in such a way that they can facilitate appropriate chemical or mechanical reactions.

As a starting point, a mold for a pad with 10 $\mu$ m pores, 10 $\mu$ m walls, and 100 $\mu$ m grooves will be fabricated, and its feasibility evaluated. The layout is schematically shown in Figure 4. The fabrication method will take advantage of established silicon process

technology. A two-mask process – one for pores and walls, and one for grooves – will be adopted using silicon dioxide as a sacrificial layer.

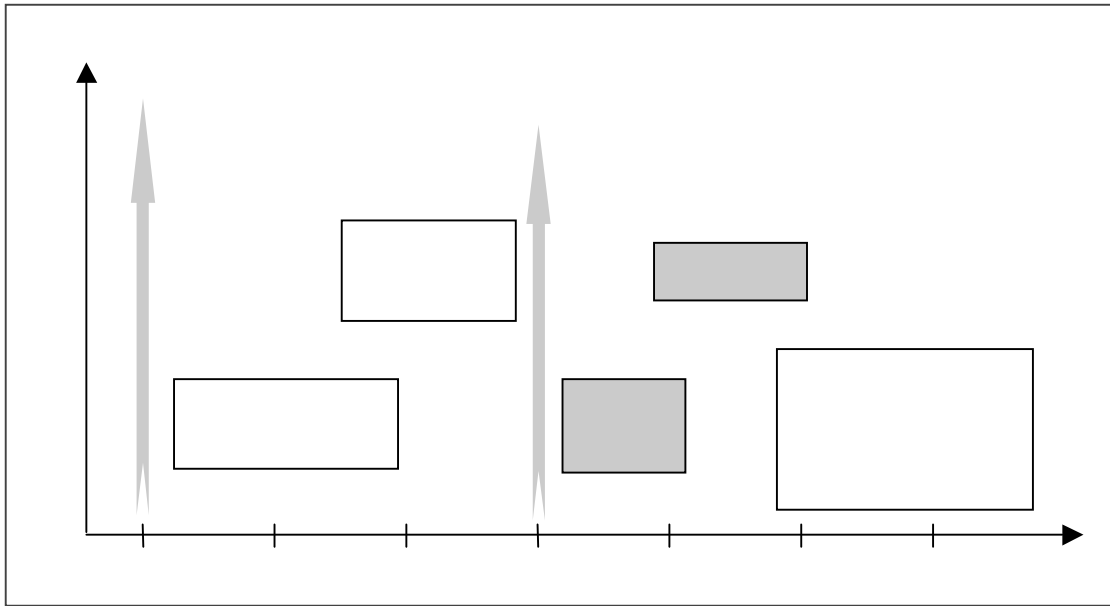


Figure 3. Scale issues in CMP.

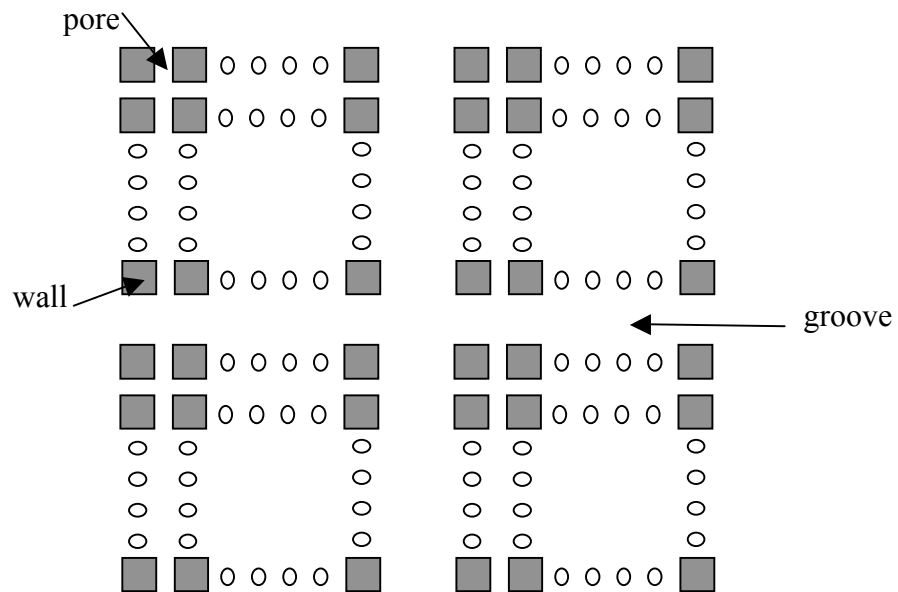


Figure 4. Layout for mold fabrication.