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# Micromilling for Mold Fabrication

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**Abstract**— A method for manufacturing a new type of CMP pad is presented. The goal is to create a mold containing micro sized features that can be used in vacuum casting to produce the polymeric polishing pads. To achieve this, a positive mold is cut from PMMA using micro milling techniques. An opposite mold is then created by electroplating nickel onto the mold and separating the metal from the polymer.

Keywords: chemical mechanical polishing (CMP), micro milling, micro mold fabrication.

## 1. Background

Lee [1] has proposed a new type of chemical-mechanical polishing (CMP) pad that will eliminate many of the defects that occur during conventional CMP operations. The proposed design, shown in Figure 1, is similar to other dual layer pads that contain fixed abrasives. The difference is that the fixed abrasives that make up the hard layer are all independent of each other. This allows the pad to remain in constant contact with the wafer and thus achieve better planarity.

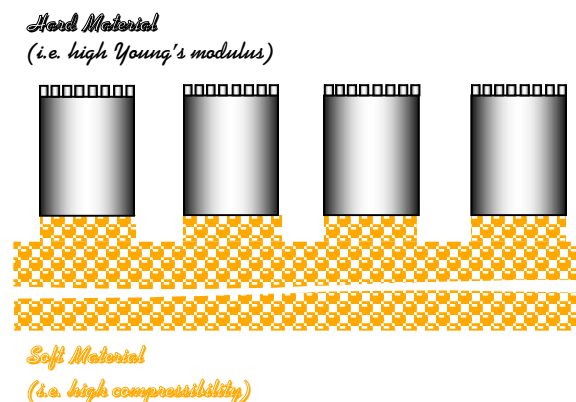


Figure 1. Design of SMART Pad.

## 2. Development of new CMP pad mold

The process of developing the mold begins with milling a positive mold, using a 127 mm diameter endmill. A top view of the design is shown in Figure 2. This design was chosen for its ease of implementation, because slots can be cut in the horizontal direction and then in the vertical direction, leaving squares in the dimension shown in the figure. Due to the small size of the mills and the amount of cutting required for a mold, a proper material must be chosen in order to maximize tool life. Metals, such as steel and aluminum, tend to cause excessive tool wear and require a large amount of time to machine. Therefore, polymethylmethacrylate (PMMA) was chosen because it can be quickly and easily machined with minimal wear on the cutting tool.

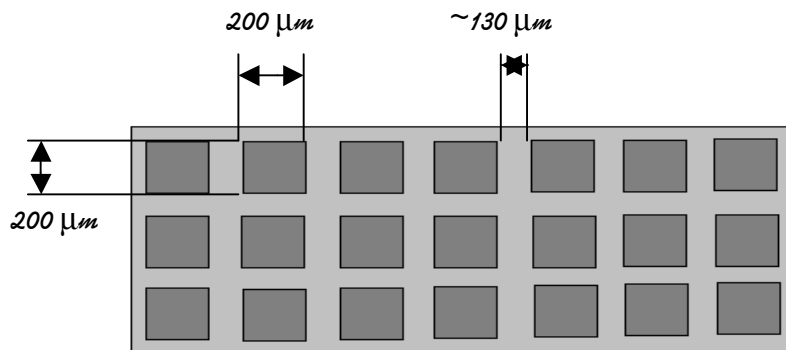


Figure 2. Pattern of CMP pad mold.

Once a positive mold has been machined, a negative must be created from it that can be used for making polishing pads. To do this, a very thin layer of metal is deposited on the surface of the mold by sputtering. This conductive surface on the polymer is then electroplated to build a thick layer of metal that conforms to the desired shape of the mold. Once this is completed, the metal can be separated from the polymer by placing the mold into an acetone bath, which softens and degrades the PMMA. The result is a negative mold made of nickel that can be used in a vacuum casting process to produce CMP pads.

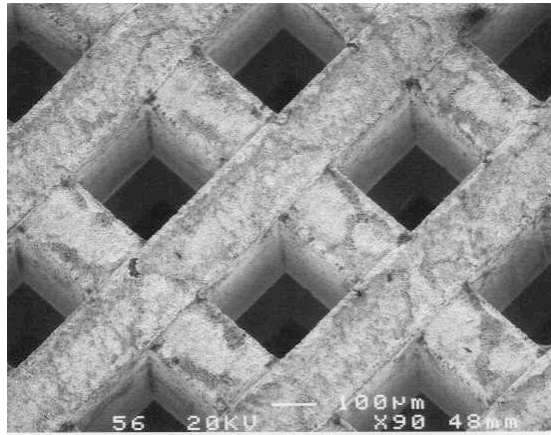
## 3. Conclusions

The first nickel mold created was able to successfully recreate the dimensions of the surface of the original PMMA mold. There is one problem caused by the method in which the seed layer was deposited. Since sputtering coats all surfaces of the mold, including the walls, the top edges of the raised features tend to electroplate faster, leaving voids in the middle of the nickel. This phenomenon is depicted in Figure 3. These voids are problematic because they weaken the mold and can cause the mold to break during the vacuum casting process. A revised method was used to solve this

problem by removing the seed layer from the tops of the square features. This allows the slots to completely fill with nickel before covering the tops of the features. Figure 4 shows the result of this new method. The metal coating is much more even and results in a much stronger part that does not contain the errors found in the first part.



*Figure 3. Voids left after electroplating the sputtered seed layer.*



*Figure 4. SEM photograph of electroplated mold.*

## **References**

- [1] Lee, S., Hwang, E., "SMART Pad Fabrication for CMP", *LMA Research Reports*, Apr. 2002, pp. 100-104.