Improvement Bar Sitting Process Step in Air Bearing Surface Patterning By using Micropallette

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Abstract

A read/write head of the Hard Disk Drive (HDD) has to go through several process steps from reader/writer fabrication process and then to wafer dicing into bars containing several read/write heads. These bars will have to go through Air Bearing Surface (ABS) forming process in order to ensure that the read/write head does not touch a spinning media. At the very beginning of the ABS formation process, the bars need to attach to a substrate so called a pallet in order to simulate a flat wafer surface for the purpose of photolithography process. The problem comes in when the glue which adhering the bars to the Micropallette shrinks and causes stress on the bars. This results in bar bending and renders the photolithography to be difficult and give low throughput. Therefore, a technique called Micropallete is use to fix the bars such that they do not bend when glue is cured. The Micropallette is invented and presented herein.

Keywords: Air Bearing Surface, Grayscale Lithography, Multi-Film Thickness Mask, Multi-exposure, Photomask, 3-D lithography

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Introduction

The Air Bearing Surface (ABS) of the read/write head is formed after the reader and writer of the head are fabricated in a wafer fabrication. The fabricated read/write head wafer is sliced into smaller bars along the flat orientation. In one bar, there can be form 20 to 50 read/write heads. Then the side of the bar is placed on a metal pallet by a robot arm. The bars adhere to the pallet by way of glue. However, due to content lost, cure induced force of the glue acts upon the slider bars. This causes bending of the bars.

The bending of the bars renders the alignment in the photolithography process more difficult. Each bar will need to have 2-4 alignment steps since the sliders are not all aligned in a straight line on the same bar. This definitely lowers the throughput in the lithography process. One way to increase the throughput is to increase number of Stepper which is the pattern generator in the process line, however this way will increase the overall cost of manufacturing. This paper focuses on how to align the bars so that the alignment can be done once for each bar by patterning the metal micropallette. The pattern on the pallet indicates the position on the pallet for the bars to place on.

Background

A. ABS manufacturing

The purpose of Air Bearing Surface (ABS) on the read/write head of HDD is to ensure that the read/write head does not touch the media when it is spinning (United States Patent 6137656.). The read/write heads are fabricated on an wafers of diameter 6 inch. Then the wafer is sliced into several bars, which comprises 20-50 read/write heads as shown in Figure 1. When forming ABS, one of the sides of the bars are flipped to top as shown in Figure 2 (United States Patent 20030199228). A high precision robot arm places the bars on the pallet as schematically seen in Figure 3. The pallet is pre-laminated with an adhesive film so the bars are attached when they are placed on the pallet (United States Patent 20050191418), as depicted in Figure 2.

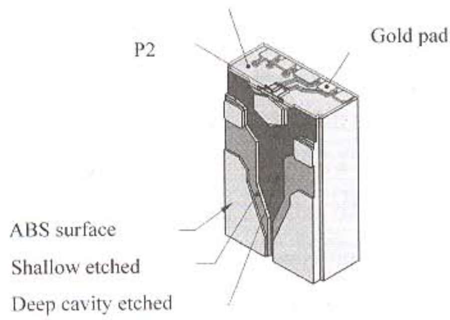

Figure 1. Completed Read-Write Head.

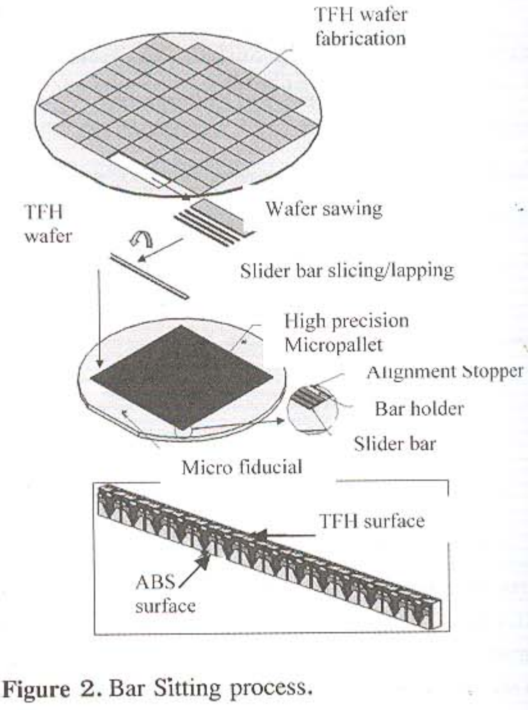

Figure 2. Bar Sitting process.

B. Micropallette fabrication

The patterning process on the pallet or micropallette comprises of 3 steps; (1) pattern designing (2) transferring the design from the photomask onto the micropallette (3) testing the patterned micropallette.

Step 1 is a typical layout design using Computer Aid Design (CAD) file and then converted into a format recognized by a pattern generator. Step 2 is a common lithography process except that it is done on a micropallette substrate. Ultra-violet (UV) light is exposed on the photoresist coated on the photomask. Then the exposed photoresist is then dissolved in a developer chemical and the rest remains on the micropallette. Then hardbake the remaining photoresist on the photomask. Finally, the uncovered chromium film on photomask is etched away. After that, remained photoresist film is stripped away. The process step as shown in Figure 3. Step 3 Use the finished photomask to transfer the patterns on the micropallette which could be metal, ceramic, or polymer as shown in Figure 4.

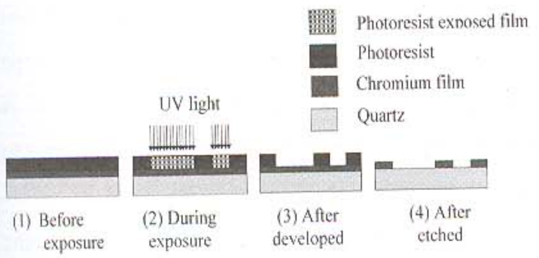

Figure 3. Photomask fabrication.

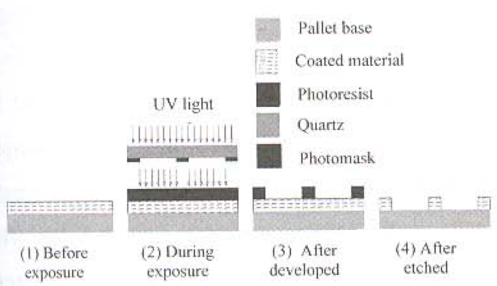

Figure 4. Micropallette patterning.

C. Sample sitting on Micropallette

Once the pattern on the photoresist coated on the micropallette is formed, either glue or adhesive film is applied on the surface of the micropallette. The sliced bars are then placed on the micropallette. The glue and the micropallette are then cured on a hotplate. This is to ensure good adhesion to the micropallete. Then the spaces between bars are filled with liquid glue. The glue is then cured at predetermined temperature for a certain period of time.

After the glue is cured, the surface of the bars is cleaned with a chemical and the excess glue on the surface is also removed to ensure smoother surface for later lithography process as shown in Figure 5.

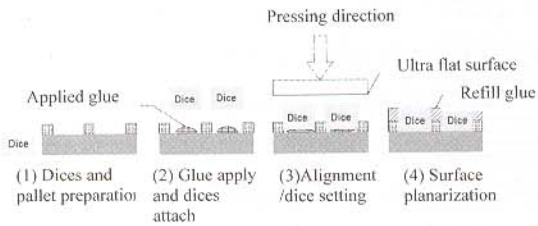

Figure 5. New concept for bar sitting process.

Experimentals

D. Photomask making process

The design of the 5x5 mm^2 micropallette pattern comprises small 49 squares of which the dimension is 5.050X5.050 mm^2. The spacing between the squares is 50 micron. The design file is converted into Direct Write Laser-233 (DWL-233) recognizable.

The photomask used in this work is a 3x3 $inch^2$ with pre-coated photoresist. The photoresist is 5000 angstrom thick. The DWL-233 projects He-Cd source laser with wavelength of 442 nm and energy of 120 mW/cm^2. The photoresist resist film is then developed after exposed in Shipley MF-26A which contain Tetra Methyl Ammonium Hydrate (TMAH) 2.37% for 1 minute and then hard baked at 120°C for 90 seconds. The Chrome which is not covered by the photoresist is etched away using Microchrometechnology CEP-200 for 1 minute.

E. Micropallette patterning

The fabricated micropallette is built on a Printed Circuit Board (PCB) substrate which is made of 1.5 mm thick Epoxy Glass Fabric, on top of which, 70 micron thick copper (Cu) is deposited on. The PCB is cut into a small 3x3 inch^2 piece and cleaned in Isopropyl Alcohol (IPA) or Acetone. The PCB is now ready for photolithography process. The PCB is firstly coated with photoresist film, Clariantz AZ-P4620, with thickness of 7.5 microns. The coated PCB is prebaked at 90°C for 90 seconds. The exposure is done in a Mikasa Mask Aligner M/A-1. This tool has a Mercury arc lamp light source with wavelength of 365 nm and the energy of 258 mJ/cm^2. After exposure, PCB is developed with Shipley MF-26A for 90 seconds and hardbake at 120°C for 90 seconds. Then it is etched copper film by Cu-etchant for 30 minutes at room temperature. The remaining photoresist is stripped off with Acetone.

F. Sample sitting on Micropallette

The fabricated micropallette is tested with silicon square bars which has cut manually by using diamond pencil with dimension 5,000X5,000 mm^2. By starting with applying glue on the PCB micropallette or adhesive film laminated on the micropallette PCB, then place the 49 silicon bars on the top-left of the micropallette where there are trenches for the bars to fit into. The purpose of this is to use it as reference. The trenches on the micropallette are arranged such that all 49 bars are aligned in the X-Y plane. After place the bars into the trenches with adhesive applied on, the micropallette with bars are brought onto a hotplate and press the bars tightly to the micropallette using a piece of glass or any smooth object.

When the bars adhesion to the micropallette is ensured then in this experiments, the spaces between bars are not filled up with liquid glue because it will be a charging effect during SEM image caption. Then cure the sample at the pre-determined temperature and time. Finally, the surface of the bars is cleaned and the excess glue or contamination is removed to make the face as clean and smooth as much as possible for later lithography process.

Results and Discussions

The experiment of micropallette patterning on a photomask and the actual pattern transfer on the PCB results are as shown in Figure 6. The errors of the pattern on the PCB and the pattern on the photomask with reference to the design are in the micron order less than 10% from the design. Additionally, the quality of the lines on PCB are measured with Scanning Electron Microscope (SEM). It is found that the base of the PCB is porous due to the nature of polymer, in contrast to smooth texture of the copper on the PCB.

The Copper is wet etched which is isotropic etching, i.e. etch the copper in all directions. The wet etch is done for 30 minutes. This is long enough for undercut to take place and render the inner corner of the lines slightly curvy as illustrated in Figure 7. When placing a 5x5 mm^2 silicon sample on a micropallette, it is found that the silicon sample fits very well to the trench on the micropallet. The only limitation in the experiment is the silicon sample size cannot be controlled very accurately due to the limited capability during dicing the sample by manually. Therefore, when placing the silicon sample on the micropallette, there is a space left as shown in Figure 8. Even through the trench formed by the thickness of the copper on PCB is 70 microns , it can hold the silicon sample of which the height is 600 microns as shown in Figure 9.

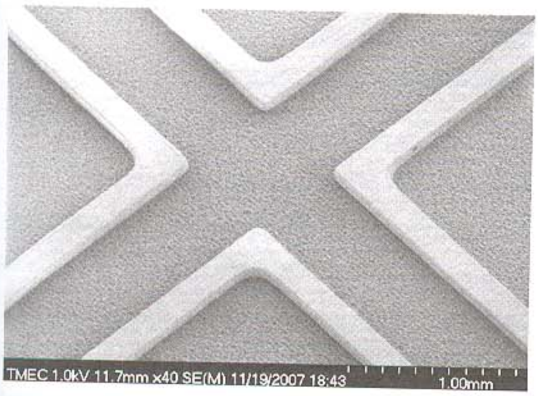

Figure 6. Copper micropallette pattern array on PCB.

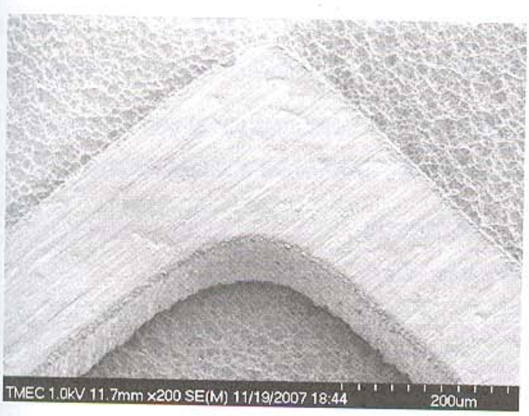

Figure 7. Copper micropallette pattern at 200x magnification.

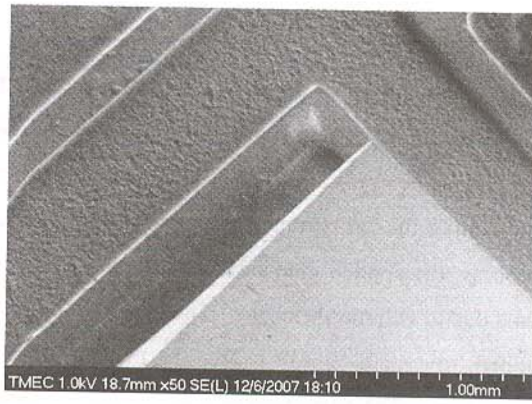

Figure 8. Wafer attached on Micropallette.

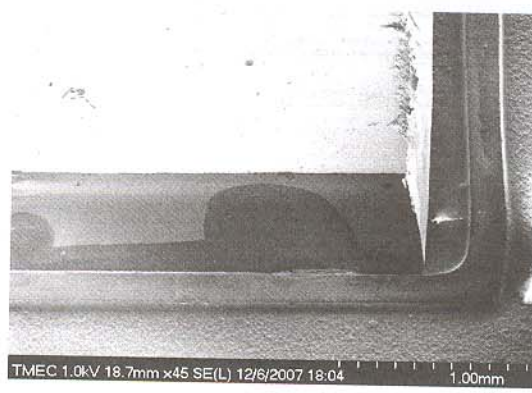

Figure 9. The silicon sample is placed in a mciropallette, this figure shows the height of the silicon sample compared to the edge of the Cu micropallette trench.

Conclusion

This paper demonstrates the application of the photolithography in one of the Hard Disk Drive process. The application try to solve the addressed problem of the bar-sitting process. In the bar sitting process, the applied glue asserts stress on the slider bars due to volume shrinkage. The invented tool, so called, micropallette can reduce the bending of the slider bars. The micropallette is made from a typical PCB. Copper on the PCB is patterned such that it becomes trenches to hold slider bars in place. Wet isotropic etching was used in the experiment and caused undercut in the copper. This could be solved by replacing the wet isotropic etching with dry anisotropic etching.

References

United States Patent 6137656, "Air bearing slider"

United States Patent 20030199228, "Lapping carrier for use in fabricating sliders"

United States Patent 20050191418, "System, method, and apparatus for multilevel UV molding lithography for air bearing surface patterning"