비평면 입자분사 가공을 위한 마스크의 제작
Fabrication of the Rapid Mask onto 3D Non-Planar Wafer for Micro Abrasive Jet Machining

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1. Introduction

Micro-abrasive jet machining (AJM) process is advantageous in various aspects such as high degree of flexibility as well as less heat generation [1]. The micro-carving action onto wafer surface is very much demanding because this technology requires a micro-patterned mask and micro-particles for micro-scale fabrication (Fig.1). SU-8 is a negative, epoxy based, near-UV photo-resist highly transparent in the ultraviolet region, allowing fabrication of relatively thick (hundreds of micrometers) rapid mask structures with nearly vertical side walls [2].

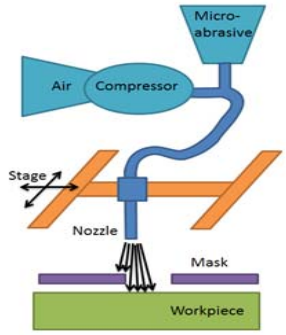

Fig.1 Schematic diagram for micro-carving process

Previous studies on the mask fabrication as well as micro-AJM process were mainly focused on planar wafers and it was difficult to adapt the fabrication technology directly to materials with 3D curved surfaces. Recently, Kim et al [3] introduced an algorithm modeling 3D mask that can be used to protect striking of the abrasive particles onto unwanted area of 3D wafer during micro-AJM process. However, until now the application algorithm and techniques have not been tested and verified through experiments. In this work, a rigorous verification of these techniques has been carried out and successful results are reported in this paper.

2. Fabrication process

From many literature reports, the imperative mask fabrication steps as well as the effect of each step are still not well-known. Some of the recommended fabrication steps [3] are awkward and not viable; therefore, through author's intuition the most vital steps have been proposed (Fig.2) and experimentally verified. For the reason that spinning process for the 3D non-planar wafer is sometimes unfeasible, in this research, the spinning issue has been consciously analyzed and worked-out through dilute of the concentrated SU-8 with Cyclopentanone (C_5H_8O).

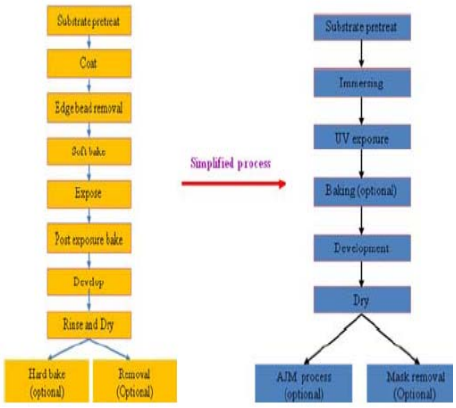

Fig. 2 Proposed overflowing fabrication steps

3. Experimental results and Taguchi Analysis

In this work, various rapid mask shapes and sizes have been fabricated onto 3D curved glass and tungsten carbide (Fig.3). Preliminary experimental results in this research work demonstrated that micro-AJM action is strongly affected by the mask hardness and surface quality. Following that, the SU-8 mask hardness and surface quality have been measured by using micro-Vickers and Non-contact surface roughness instruments respectively.

Fig. 3 Fabricated SU-8 rapid mask

Analysis of the mask properties through Taguchi approach showed that the most effective controlling parameters were the scanning speed and UV power for the surface roughness, and dilute ratio and area factor for mask hardness (Fig.4 and Fig.5).

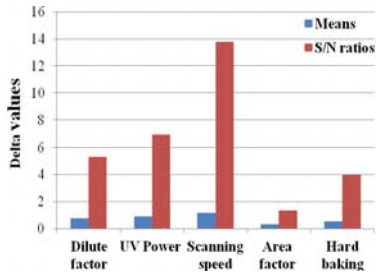

Fig.4. Surface roughness parameter's ranks

4. Validation of mask properties

In this research, the effectiveness of the mask hardness as well as the surface quality has been validated through micro-AJM process. Successful micro-carving results are shown in the Fig.6.

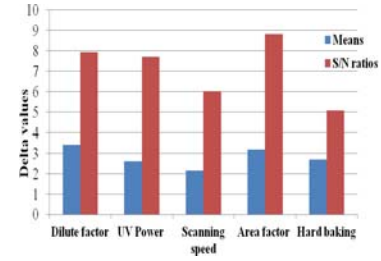

Fig. 5 Mask hardness parameter's ranks

Fig.6 Carved shapes onto 3D non-planar wafer

5. Conclusion

In the previous work, an algorithm modeling rapid mask that required for micro-AJM process has been introduced. The developed algorithm and fabrication techniques were expected to be subjected to testing and verification through mask fabrication experiments. This paper reported the successful mask results for verification of these techniques as well as micro-AJM results onto 3D non-planar wafer for validation of the rapid mask properties.

References

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