Proc. of the 9th Intl. Conf. of Asian Society for Precision Engg. and Nanotechnology (ASPEN 2022)
15–18 November 2022, Singapore. Edited by Nai Mui Ling Sharon and A. Senthil Kumar
doi://10.3850/978-981-18-6021-8_OR-12-0088

Surface Micromachining by Micro Slurry-jet and Masking Process

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KEYWORDS: Bio-inspired surface, micromachining, Surface texturing, Mechanical removal process, Masking process

We investigated methods for the direct fabrication of bio-surface-inspired microstructural patterns on a variety of material surfaces. As a mechanical removal process, a wet-blast-like Micro slurry-jet method with alumina particles was employed to be applicable to a wide range of materials. A masking system was adopted for the entire process to improve the machining accuracy in the horizontal direction. Micro-machining is carried out by masking the material surface at the micro level and mechanically removing only the exposed parts of the material surface. A surface micromachining system equipped with the above system has been developed. Dot and line patterns were created as different micro-patterns on soda-lime glass. It was shown that the proposed microfabrication method is capable of microfabricating various patterns on brittle materials such as glass, without loss of transparency.

1. Introduction

Bio-inspired geometric surfaces in nature (e.g. baby skin, shark skin, moth eyes, lotus leaves) have been found to exhibit various functions such as, light reflection suppression[1)] and hydrophilic/hydrophobic properties[2)] compared to surfaces produced by conventional machining processes. The aim of this research is to develop a surface micromachining device that can reproduce such bio-inspired surfaces on various material surfaces. Various microstructure patterns were actually fabricated by the developed surface microfabrication equipment and discussed together with processing examples.

2. Methods

2.1 Micro Slurry-jet and Masking process

A wet-blast-like micro-slurry jet method (MSJ method)[3)] was used as the mechanical removal process for minimizing the effects of heat, in which a slurry containing alumina particles was injected through a nozzle together with compressed air (Fig. 1). The MSJ does not use chemical reaction, the method can be applied to a wide range of materials. Brittle materials such as a glass can be processed, as well as highly hard metal materials. The nozzle hole is designed with a diameter of 1 mm because of the wear caused by alumina particles, which makes horizontal micromachining difficult.

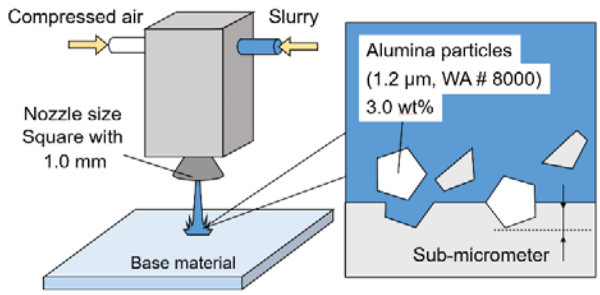

Fig. 1 Mechanical removal process

To improve processing accuracy, it was proposed to use the method of combination with micro-level masking (Fig. 2). The exposed area except for masking was processed by the MSJ.

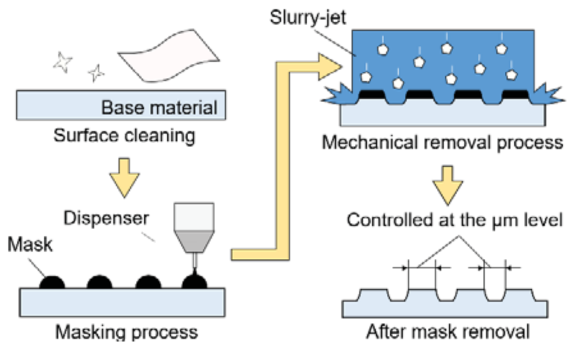

Fig. 2 Combined masking process.

2.2 Equipment structure

The 3-dSupremer (3-dimentional Surface Processing through Elimination by Mechanical Removing) was designed to develop the numerical controls of masking process and MSJ process. The 3-dSupremer equipes five-axis motions, which enable to process various shapes. The masking system or the MSJ system was attached at the main axis.

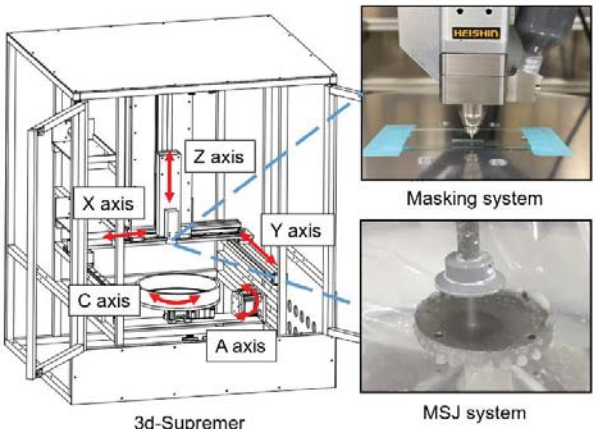

Fig. 3 3-dimentional Surface Processing through Elimination by Mechanical Removing

2.3 Making Patterns

Figs.4 show masking patterns applied to the surface of a s oda lime glass. A dispencing machine (Mohno Dispenser, Heishi n, Japan) was used for the masking process. an abrasion-resistan t resin was placed onto the surface by using the progressing ca vity pump. The nozzle diameter used for the dispenser was 100 μm. MSJ processing was carried out after the masking operatio n. The target surface after processing was observed using a conf ocal laser microscope (LEXT OLS5000, Olympus).

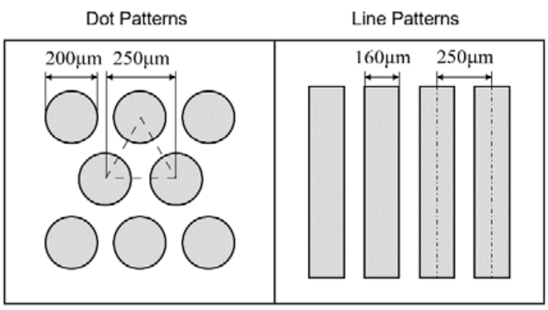

Fig. 4 Dimensions of the masking pattern

3. Results and discussion

Figs. 5 and 6 show the surface profiles after the mechanical removal process. It was confirmed that the microstructure was formed on the surface after the machining process. The transparency of the glass was not impaired after the mechanical removal process.

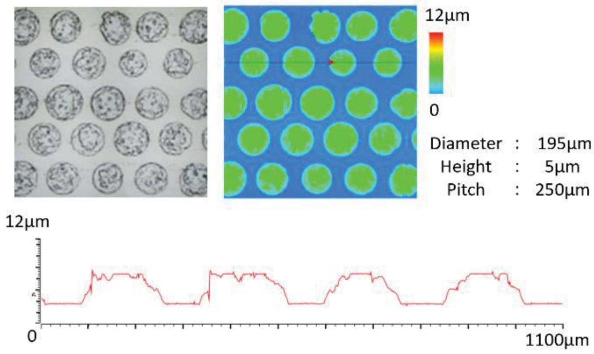

Fig. 5 Dot pattern surface profile

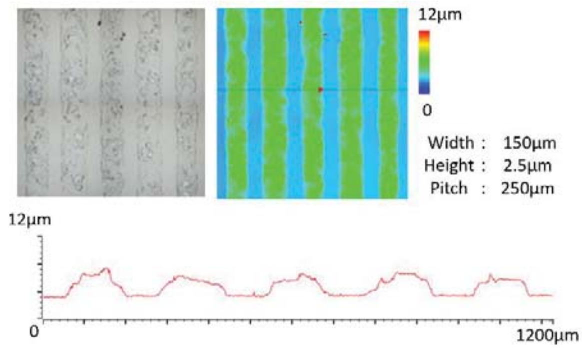

Fig. 6 Line pattern surface profile

The processed sizes of convex structures were smaller those of the masking patterns with abrasion-resistant resin. This is thought to be due to the fact that the edges of the mask were removed first during the MSJ process.

4. Conclusions

Although the processing accuracy of this system is inferior to existing nanoimprinting techniques, it is considered possible to realize bio-inspired surfaces on a wide range of materials. The system should contribute to the application of bio-inspired surface design to a variety of industrial products.

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