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-12-0014

3-dimensional Surface Processing through Elimination by Mechanical Removing

Yoshitaka Nakanishi[1,#], Yutaro Doi[1] and Yuta Nakashima[1]

1 Faculty of Advanced Science and Technology, Kumamoto University, 2-39-1, Kurokami, Cyuo-ku, Kumamoto 860-8555, Japan
Corresponding Author / Email: y-naka@mech.kumamoto-u.ac.jp, TEL: +81-96-343-3733, FAX: +81-96-343-3733

KEYWORDS: Bio-inspired surface, Surface texturing, Mechanical removal process, 3-dimentional surface, Masking process

The 3-dSupremer (3-dimensional surface processing through elimination by mechanical removing) equipped a five-axis computer-controlled system, which can create a bio-inspired geometrical surfaces onto a wide range of three-dimensional surface. In the pre-processing, a masking processing is performed to increase machining accuracy, where a super ink jet or a micro dispensing system places an abrasion-resistant material onto a three-dimensional surface. In the post-processing, a mechanical removal processing is performed, where the MSJ (micro slurry jet) is applied in accordance with the pre-processed surface. Although the surface-processing accuracy of the system will be lower than that of a nanoimprint technology, the system can be used to create a texture design on a variety of materials.

NOMENCLATURE

3-dSupremer = 3-dimensional surface processing through elimination by mechanical removing
MSJ = micro slurry jet

1. Introduction

A 3-dimensional surface processing through elimination by mechanical removing (3-dSupremer) has been developed for creating bio-inspired geometrical surface onto artificial materials. The bio-inspired geometrical surfaces, which are learned from the nature (baby-skin, shark-skin, moth-eye & lotus leaf etc.), represent conspicuous effects compared to the conventional mechanical processed surfaces.

2. Materials and Methods

The 3-dSupremer equipped a five-axis computer-controlled system, which can create a bio-inspired geometrical surfaces onto a wide range of three-dimensional surface (Fig.1). The 3d-Supremer composes of both pre- and post-processing. In the pre-processing, a masking processing is performed to increase machining accuracy, where a super ink jet or a micro dispensing system places an abrasion-resistant material onto a three-dimensional surface. In the post-processing, a mechanical removal processing is performed, where a micro slurry jet (MSJ) is applied in accordance with the pre-processed surface.

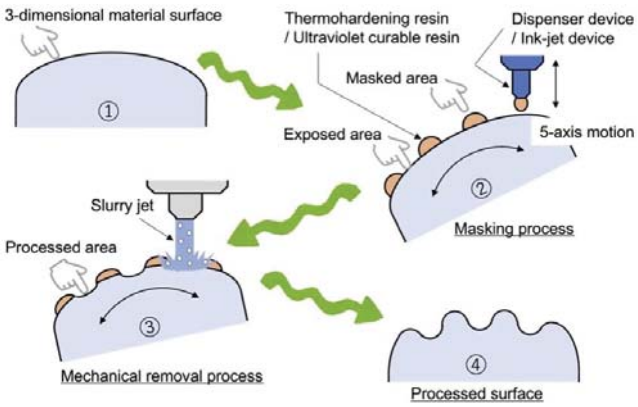

Fig. 1 Microfabrication process through 3-dSupremer[1)]

3. Results and Discussion

The 3-dimensional surface processing method achieved ultraprecision machining on the order of nanometers in the orthogonal direction on the material surface (Fig.2). Machining accuracy on the order of micrometers was realized in the parallel direction (Fig.3). A sharp-edge, ultra-smooth surface profile was also obtained (Fig.4). The bio-inspired surface of a Co-Cr-Mo alloy as a counterface material of polyethylene in an artificial joint increased the polyethylene particle size and reduced the total wear, preventing

adverse tissue reactions (Fig.5). The wettability of the processed surface on a glass was changed to prevent the retention of sebum and fingerprints on the surface (Fig.6). The developed process could remove microscopic cracks and other microstructural defects on a dental ceramic, resulting in improved bending properties and a smoother ceramic (Fig.7).

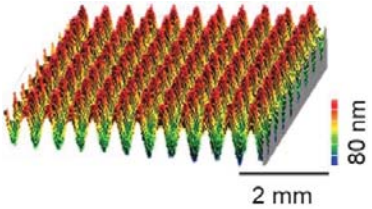

Fig. 2 Glass surface (shark-skin)[2)]

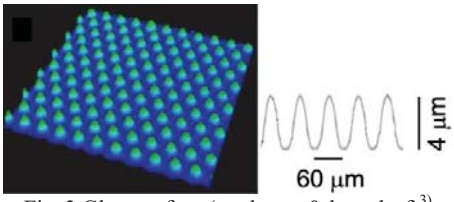

Fig. 3 Glass surface (moth-eye & lotus leaf)[3)]

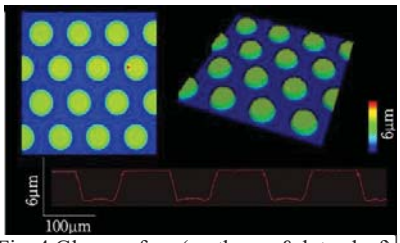

Fig. 4 Glass surface (moth-eye & lotus leaf)[1)]

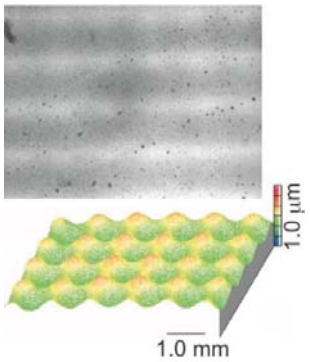

Fig. 5 Co-28Cr-6Mo alloy surface (shark-skin)[4)]

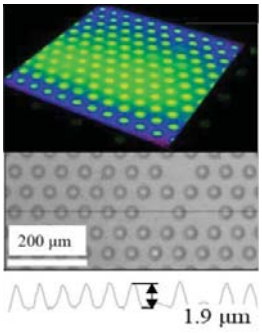

Fig. 6 Co-28Cr-6Mo alloy surface (moth-eye & lotus leaf)[5)]

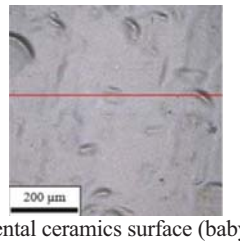

Fig. 7 Dental ceramics surface (baby-skin)[6)]

4. Conclusions

The 3-dSupremer is categorized into a top-down mechanical removal method, so that there are few restrictions on the type of materials for creation the bio-inspired surface. Although the surface-processing accuracy of the system will be lower than that of a nanoimprint technology, the system can be used to create a texture design on a variety of materials and will be applicable for a large-scale 3D surfaces. The system will contribute towards the application of a bio-inspired surface design onto a variety of industrial products.

ACKNOWLEDGEMENT

This work was supported by JSPS KAKENHI [grant number 19KK0096], the Environment Research and Technology Development Fund of the Environmental Restoration and Conservation Agency of Japan [grant number 1–1908], and the Interdisciplinary Research Project of the Institute of Industrial Nanomaterials (IINa) & the academic research promotion work in SDGs, Kumamoto University.

REFERENCES

1. Nakanishi, Y., “Surface Texturing by Mechanical Removal Process,” Tribologist, Vol. 67, No. 5, pp. 343-347, 2022.
2. Fujita, N., Yamaguchi, H., Kinoshita, T., Iwao, M., Nakanishi, Y., “Friction behaviors of elastic materials sliding on textured glass surfaces,” Tribology Int., Vol. 171, 107539, 2022.
3. Nakanishi, Y., Nakashima, Y., van der Heide, E., “Microstructuring glass surfaces using a combined masking and microslurry-jet machining process,” Precision Eng., Vol. 67, pp.172-177, 2021.
4. Nakanishi, Y., Nakashima, Y., Fujiwara, Y., Komohara, Y., Takeya, M., Miura, H., Higaki, H., " Shibata, K., Nakashima, Y., Nakanishi, Y., "Nakanishi, Y., Nakashima, Y., van der Heide, E., "Influence of surface profile of Co-28Cr-6Mo alloy on wear behaviour of ultra-high molecular weight polyethylene used in artificial joint," Tribology Int., Vol. 118, pp.538-546, 2018.
5. Shibata, K., Nakashima, Y., Nakanishi, Y., “Nakanishi, Y., Nakashima, Y., van der Heide, E., "Anti-fingerprint glass surface created by mechanical removal process," J. Biomech. Sci. Eng., Vol. 14, No.4, 19-00388, 2019.
6. Baba, T., Nakashima, Y., Takahashi, S., Matsubara, T., Yin, L., Nakanishi, Y., "Micro-slurry jet for surface processing of dental ceramics," Biosurf. Biotribol., Vol. 5, No.1, pp.8-12, 2019.