Feeding of Submillimeter-sized Microparts along an Asymmetric Surface Using Only Horizontal Vibration: Evaluation of Micro-Fabricated Surface Using Femtosecond Laser Process

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***Abstract*— Microparts can be fed along an asymmetric surface using simple planar symmetric vibrations, because they adhere to the surface asymmetrically. We assessed an asymmetric surface microfabricated by femtosecond laser process. The tribological characteristics were evaluated by measuring the angle of friction of these capacitors. Using the results of feeding experiments of these capacitors, we assessed the relationship between driving frequency and feeding velocity.**

I. INTRODUCTION

We have previously shown that an asymmetric fabricated surface with simple planar and symmetric vibrations can be used to feed microparts [1]. Because of the asymmetry of tribological characteristics, microparts adhere more strongly in one direction than in the other. We assessed the movement of **0402**-type capacitors ($0.4\times0.2\times0.2$mm, 0.1mg) using an asymmetric surface fabricated by a double-pulsed femtosecond laser process technique. Tribological characteristics of the fabricated surface were evaluated by the angle of friction of these capacitors. Using the results of feeding experiments of these capacitors, we assessed the relationship between driving frequency and feeding velocity.

II. ASYMMETRY OF FABRICATED SURFACE

Fig. 1 shows a microphotograph of the micro-fabricated surface using the **AFM** system. There were many periodic convexities on the surface of the material. The averaged inclination of the left side of these comvexities was 0.43, while it was -2 at the right side, which had asymmetry that differed by 32% between the two sides of these convexities. From the expmerimental results of the angle of friction (**Fig. 2**), the angle of friction in the positive direction was smaller than the negative direction, and also fell number in the positive direction was larger than the negative direction, regardless of ambient humidity. That is, the fabricated surface has directionality in tribology. These microparts adhered to the no fabricated surface more strongly than the fabricated one, which indicated that adhesion reduced by the fabrication.

III. FEEDING EXPERIMENTS

Using the fabricated surface, we performed feeding experiments of **0402**-type capacitors. **Fig. 3** shows the relationship between driving frequency and feeding velocity of capacitors at vibration amplitude $A = 0.5$ mm with square wave. Experiments at each frequency were performed four times using 10 capacitors under ambient humidity of 70 % and temperature of 25℃. The maximum averaged velocity was 5.1 mm/s realized at a frequency of $f = 124.0$ Hz, which could provide 765 parts par minute.

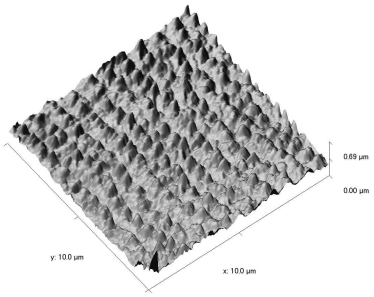

Fig. 1. Micro-fabricated surface profile

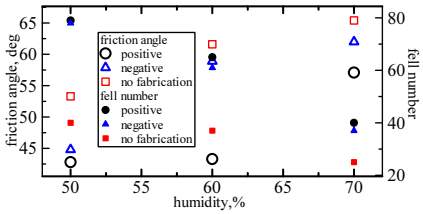

Fig. 2. Friction angle and fell number

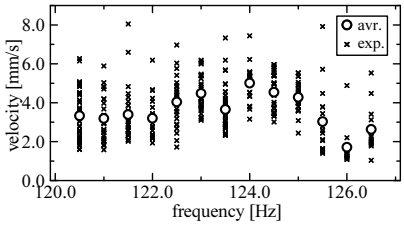

Fig. 3. RelFeeding velocity of **0402**-type capacitor

IV. CONCLUSION

We applied an asymmetric fabricated surface by the femtosecond laser process for feeding along submillimeter-sized microparts. Future works include the optimization of fabricated surface using the double-pulsed femtosecond laser irradiation technique.

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REFERENCES

[1] A. Mitani, N. Sugano, and S. Hirai, "Micro-parts feeding by a saw-tooth surface", *IEEE/ASME Transactions on Mechatronics*, Vol.11, No.6 pp. 671-681, 2006.