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Friction Characteristics of Nanostripe Surfaces under "Wide" Point Contact

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In friction tests using nanoscale patterns under lubrication conditions, wear and unsecure contact cause the difficulties to determine the friction characteristics. The former issue has been solved using nanostripe surfaces, enabling to remain nanogrooves under wear conditions. For the latter issue, we have tried to realize secure contact for wider area by applying nanostripes on cylindrical surface. First, nanostripes of Cu and Ag consisting of micro and nanogrooves were fabricated on thin Si wafer, which was subsequently elastically deformed into hemicylinders. Then, it was brought into contact to another hemicylinder so the generatrixes of hemicylindrical surfaces were crossed. Friction characteristics of nanostripes were examined under liquid lubrication conditions at the sliding speed of 1 to 50 mm/s under the load of 0.1 to 1 N.

Keywords: surface texturing, nanogroove, cross cylinder configuration, friction coefficient, lubrication

1. Introduction

Nanostripe surfaces fabricated on silicon wafers by photolithography consist of highly periodically arranged nanoscale grooves (or nanogrooves) with a depth of the order of several nanometers to several tens of nanometers [1]. The friction properties of these surfaces have been investigated by rubbing them with a smooth spherical surface. It was reported that nanogrooves are effective in reducing the friction coefficient [9,24]. However, these measurements were performed under a limited set of conditions, and the properties of such nanoscale grooves are not yet fully understood. In this study, we have tried to increase secure contact area using cross cylinder configuration to investigate lubricating characteristics for various arrangements of micro/nano grooves.

2. Experimental

Figure 1 shows the schematic of arrangement of two hemicylinders for measuring the friction characteristics. The upper specimen of nanostripe is supported parallel leaf spring, which deformation gives a value of friction force when the lower specimen of cylindrical lens is oscillated. Figure 2 shows examples of the nanostripe.

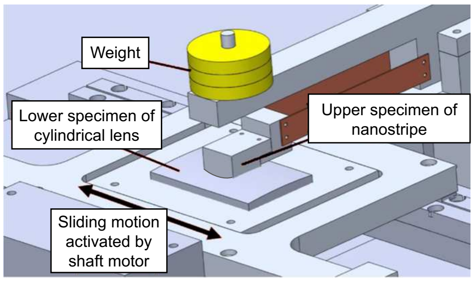

Figure 1: Schematic of testing configuration

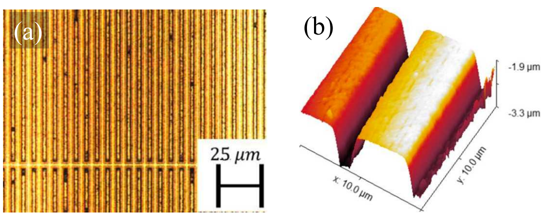

Figure 2: Appearance of nanostripe observed by optical microscope (a) and AFM (b).

3. Results and Discussion

Figure 3 shows the relation between friction coefficient and sliding speed by load measured under lubrication condition. Poly-α-olefin (VG68) containing 0.3 % of acid phosphoric ester was used as lubricant. Three kinds of nanostripe were used in the measurement. After the friction tests, the nanostripe surfaces were observed by AFM (atomic force microscope), which revealed that the nanogrooves on Line 1 were vanished while those on Line 2a and 2b were remained. That suggests that the nanogrooves reduced the friction coefficient at the lower sliding speed and higher load region.

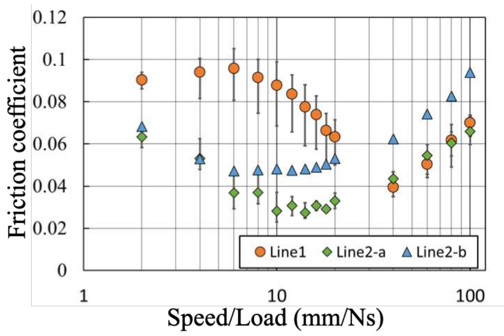

Figure 3: Friction coefficient of nanostripes measured at sliding speed of 1.0 to 50 mm/s under load of 0.5 N.

4. Conclusions

We have applied the nanostripe on hemicylindrical thin Si wafer and rubbed it against another hemicylinder as the generatrixes of hemicylindrical surfaces were crossed. The friction coefficient was strongly affected by nanogrooves at the lower sliding speed and higher load region and was reduced by nanogrooves.

5. References

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