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Tribological Charateristics in 40 μm Dimple Pattern for Hexagonal Array

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Hexagonal 배열 40 μm Dimple 패턴의 트라이볼로지적 특성

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Abstract – 본 연구에서는 pin-on-disk 마찰 시험기를 통하여 Hexagonal 배열 40 μm Dimple 패턴의 효과를 실험하였다. 마찰 실험은 미끄럼 속도가 0.06~0.34 m/s로 하였으며 마찰하중은 20~100 N의 범위로 하였고, Dimple의 밀도는 10~25%의 범위로 제작하여 실험을 행하였다. 일반적으로 속도가 증가하고 하중이 감소할수록 마찰계수는 감소하는 경향을 나타내었으며, Dimple에 의한 마찰저감 효과는 속도가 0.14~0.26 m/s의 범위에서 나타났다. 40 μm Hexagonal 배열 Dimple 패턴의 마찰 특성에서는 밀도가 12.5%에서 가장 좋은 경향을 나타내었다.

Key words – friction coefficient, surface texturing, dimple pattern

1. Introduction

Surface texturing is one of the method to reduce the friction in tribology[1]. Also surface texturing is a kind of technology to improve of function and performance by maching in the surface by chemical or mechanical varied method. It has been studied that engineered surface was showed since 1940's.

Recently the research are doing in the contact area within pattern mode by developing semi-contact material process. Nano pattern on the silicon wafer was reduced the striction during the sliding contact motion. It's known that technology to decrease the friction coefficient and seizure on the SiC ceramic material by micro dimple pattern using the razer.

The mechanism of surface texture were devided by wear partical trapping, lubricant reservoir and hydrody-

Table 1. Experiment conditions

Parameters	Conditions
Contact type	Pin-on-Disk
Disk material	Bearing steel
Pin material	Bearing steel
Size of dimple for pin [μm]	40
Density of dimple for pin [%]	10~25
Depth of dimple for pin [μm]	2
Surface roughness - Pin before fabrication [μm]	0.008Ra, 0.016Ra
Surface roughness - Disk [μm]	0.039Ra, 0.052Ra
Diameter of pin	4 mm
Diameter of sliding track	40 mm
Normal load range [N]	20~100 N
Pressure range [MPa]	0.25~2.05
Speed range [m/s]	0.06~0.34
Lubricant	Parafin oil
Temperature	Room temperature

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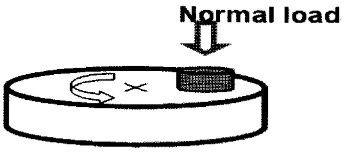


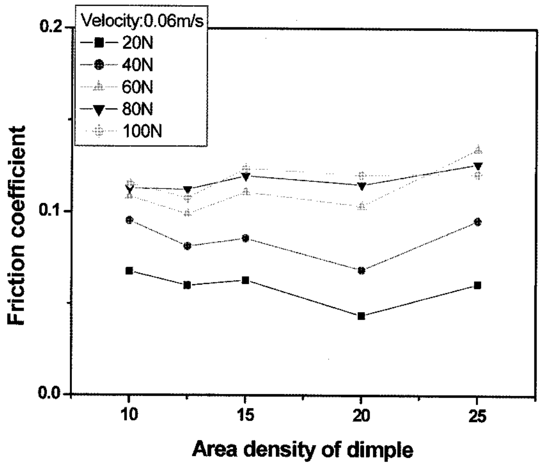
Fig. 1. Schematic illustration for pin on disk type.

namic. But there are depend on the size, density, depth of pattern even if each theory are resonable[2]. Therefore there are not surfacing comprehense for surface texturing. The present study will test friction coefficient for the 40 μm surface dimple pattern. The mechanism of surface texture is decided by a wear partical trapping, lubricant reservoir and hydrodynamic. But each theory has propriety, they are depend on the density, depth, dimension of the pattern. Thus there are not completely study of surface texturing[3-8].

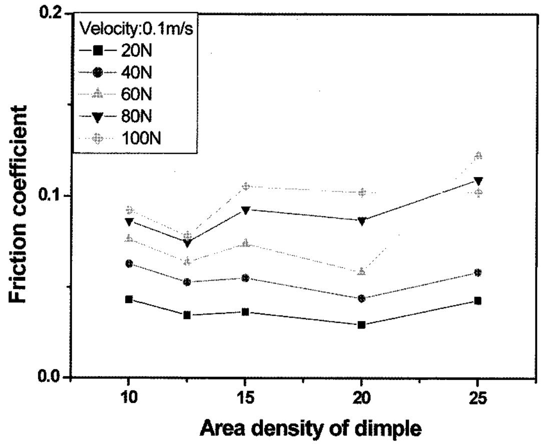
In this study we investigated the friction coefficient in 40 μm hexagonal array Micro-scale dimple pattern.

2. Testing Method and Testpiece

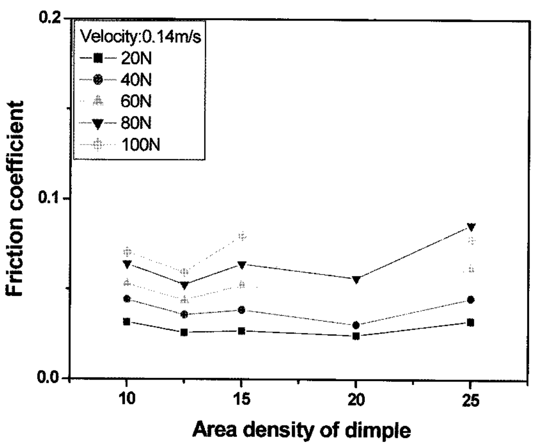
Pin specimen is pearing steel which is 4 mm diameter and 1 mm thickness on the surface was Micro-dimple pattern. The method of dimple pattern on the



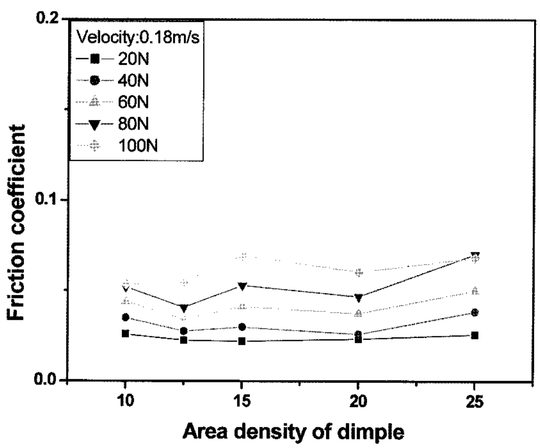
(a) 0.06m/s



(b) 0.1m/s

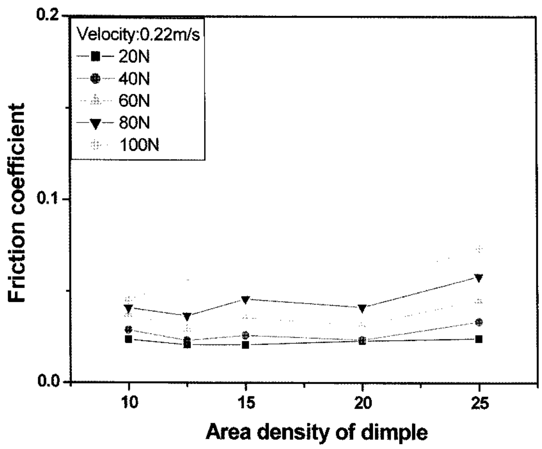


(c) 0.14m/s

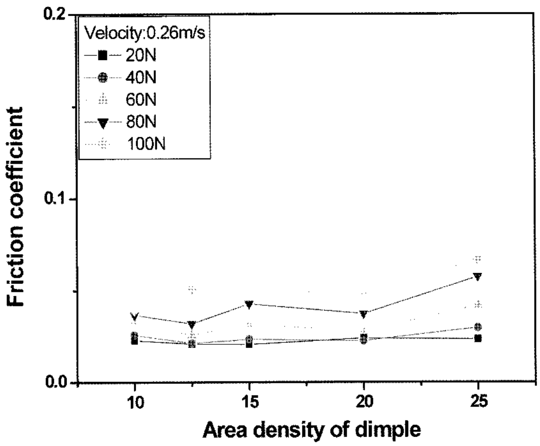


(d) 0.18m/s

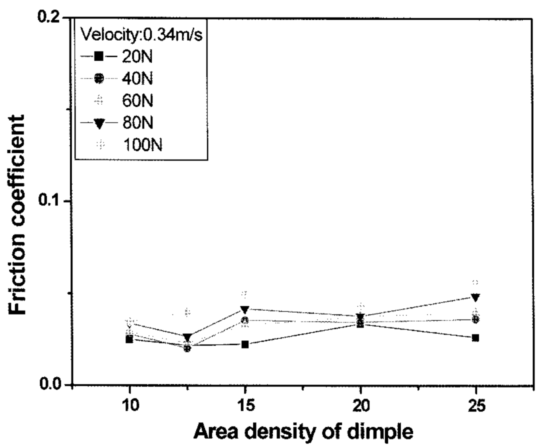
Fig. 2. Friction coefficient as a function of density for various normal load of micro dimple.



(e) 0.22m/s



(f) 0.26m/s



(h) 0.34m/s

Fig. 2. Continued.

surface of the pin was made by photolithographly using wet attaching. A dimple diameter of prepared film photomask has been designed 40 μm. The testpiece was made by using NaCl electro-liquid. And the dimple depth was about 2 μm within hexagonal array pattern. The disk material is bearing steel which is 60 mm diameter, 5 mm thickness. Also surface roughness was 0.039 mmRa after polishing.

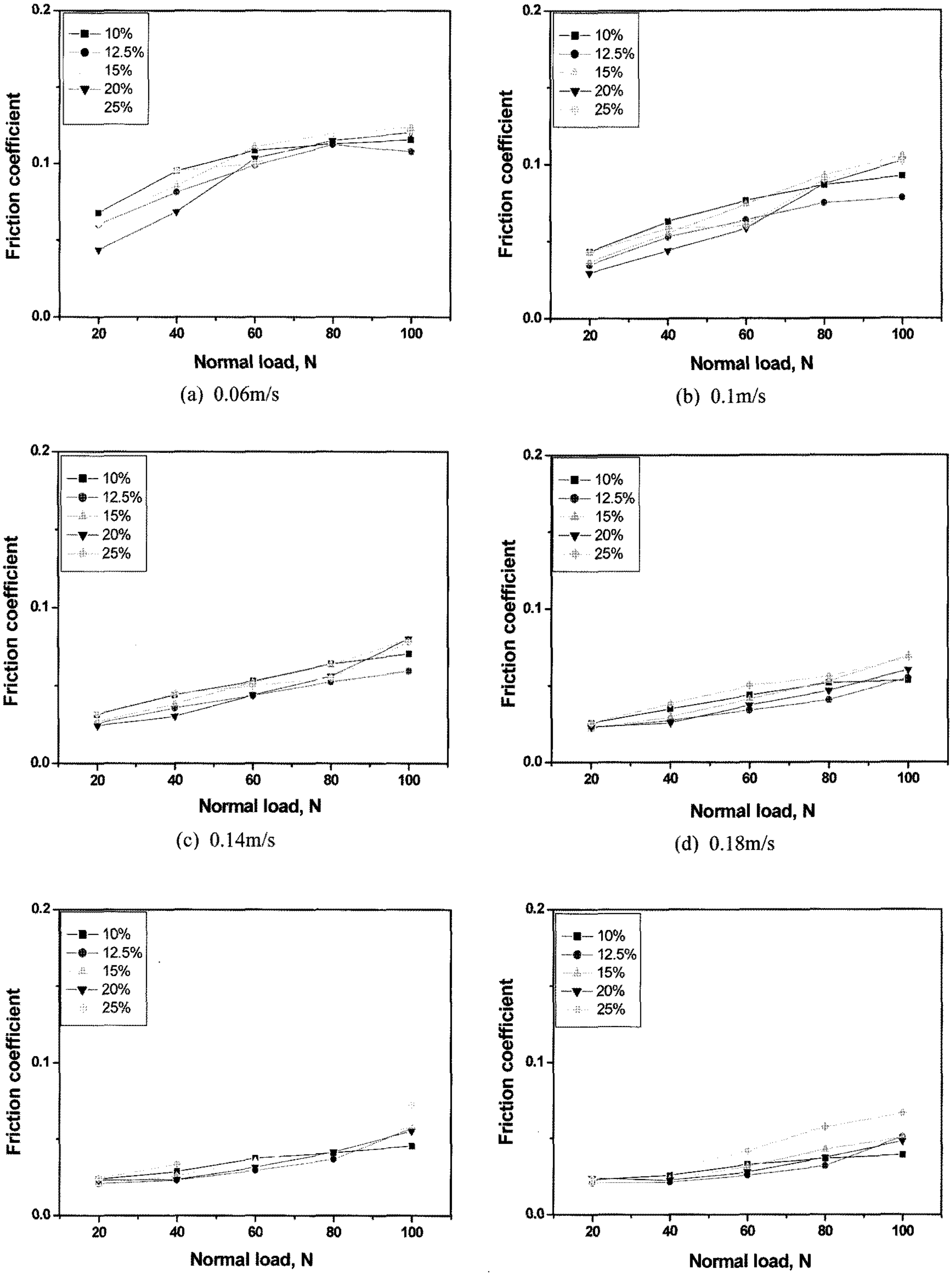
The test conditions were on shown that Table 1, in density range of 10~25% and in the velocity range of 0.06~0.34 m/s.

3. Experimental Result

3-1. Friction coefficient of density

Fig. 2 shows the friction coefficient on a function of density for various normal load and velocity of micro dimple. In low loads regine and low sliding velocity, the coefficient of friction of many dimple pattern pairs starts to decrease with on increase in area density by 20%, Fig. 2(a).

It increase the velocity, the coefficient of function generally decrease lower than 0.1 for all dimple pattern, Fig. 2(b)-(h).

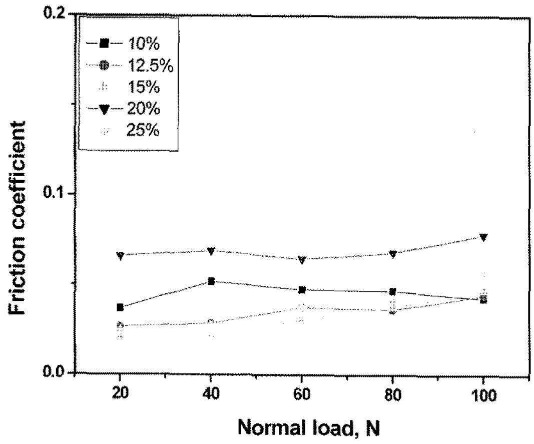


(a) 0.06m/s (b) 0.1m/s

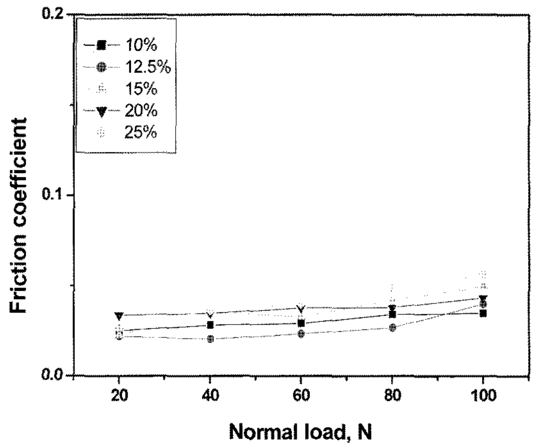
(c) 0.14m/s (d) 0.18m/s

(e) 0.22m/s (f) 0.26m/s

Fig. 3. Friction coefficient as a function of normal load for various density of micro dimple.

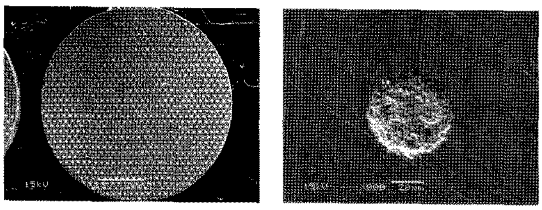


(g) 0.3m/s



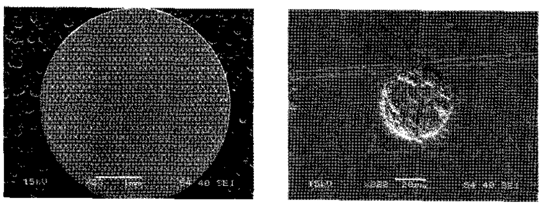
(h) 0.34m/s

Fig. 3. Continued.



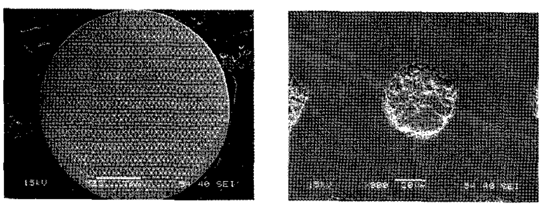
(a) 10% (×23) (b) 10% (×800)

Fig. 4. SEM image of dimple 10%testpice after test.



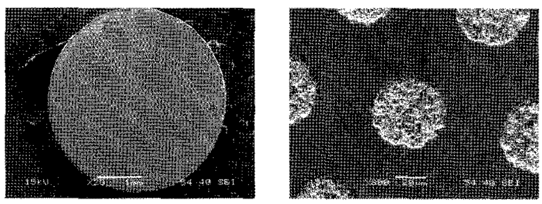
(a) 12.5% (×23) (b) 12.5% (×800)

Fig. 5. SEM image of dimple 12.5% testpice after test.



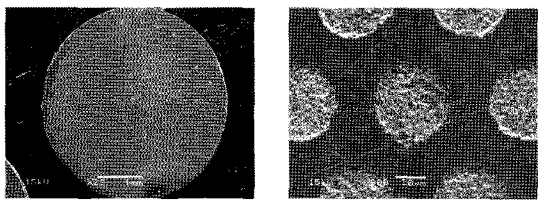
(a) 15% (×23) (b) 15% (×800)

Fig. 6. SEM image of dimple 15% testpice after test.



(a) 20% (×23) (b) 20% (×800)

Fig. 7. SEM image of dimple 20% testpice after test.



(a) 25% (×23) (b) 25% (×800)

Fig. 8. SEM image of dimple 25% testpice after test.

3-2. Friction coefficient of normal load

Fig. 3 presents the coefficient of friction obtained in normal load for various density of micro dimple. Friction coefficient increase in higher load depend on the sliding velocity, Fig. 3(a)-(b). Fig. 3(c)-(f) shows friction coefficient were different from the density of dimple increase the loads. It means the effect of the density of dimple see the clearly in the velocity range.

3-3. SEM image

Fig. 4 ~ Fig. 7 shows the SEM images of the dimple pattern after test on the density of area.

4. Conclusion

This work could obtain the fellowing results from the test of 40 μm dimple pattern for hexagonal array.

1) The friction coefficient generally decrease with on increase in velocity independent on the area density.

2) Area density effect occurs in the middle of speed range for 0.14 ~ 0.26 m/s with on increase sliding load.

3) The friction coefficient of 12.5% density of dimple pattern was the most effective in velocity and load condition.

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