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TRIBOLOGICAL CHARACTERISTIC EVALUATION IN A VACUUM OF A COATING FILM USING 0.5 μM TUNGSTEN DISULFIDE POWDER

TRACK OR CATEGORY

Materials Tribology I Solid Lubricants, Coatings, and 2D Materials

AUTHORS AND INSTITUTIONS

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INTRODUCTION

Space crafts are required to work at harsh environment without maintenance. So some driving parts of space crafts have to treatment by lubrication to prevent from any problems. We have been considering about tungsten disulfide for space equipment at elevated temperature in the vacuum. The WS_2 substrate were fabricated by the shot peening using 0.5 μm powder for comparison before result what is 2.0 μm powder WS_2. Friction experiments were carried out to investigate the friction characteristics by the pin-on-disk type of tribometer inside of vacuum chamber. Lubricating mechanism of WS_2 is known to a sliding on the (0002) basal plane of the hexagonal layered structure [1]. We would like to suggestion about reason of make low friction coefficient as under 0.1 using result of Imaging Plate X-ray Diffraction (IPXRD) after friction test at room temperature using by two types of shot peening WS_2.

EXPERIENTIAL PROCEDURE AND TESTED SPECIMEN

WS_2 coatings on the SUS316L stainless steel disc were conducted by means of the shot peening method using WS_2 powder of 0.5μm with a coating pressure of 8.0 MPa in open air. The average thickness of the WS_2 coating was less than 0.5 μm. A pin-on-disk type friction test was carried out using a rotary type tribometer to investigate the friction characteristics of WS_2 in a 10^{-5} Pa vacuum with load of 10 N (Surface pressure : 1.96 GPa) and 10mm/s friction speed. A friction test was interrupted when the frictional force became high.

After friction test, the surfaces of both disc and ball were observed by an optical microscope and measured crystallographic structures by the IPXRD shown in Fig. 1. Since IPXRD is possible to concentrate the X-way beam size to 0.3mm, diffraction image can be obtained from the coating surface. Geometry between incident X-ray beam angle and the sample stage were set to 45°. The diffraction pattern obtained as a two-dimensional diffraction image by imaging plate. It is possible to get whole 360 ° Debye-ring, therefore, a quantitative analysis of diffraction pattern can be achieved. Furthermore, It was measured that the half width of Debye ring of (0002) plane obtained by IPXRD.

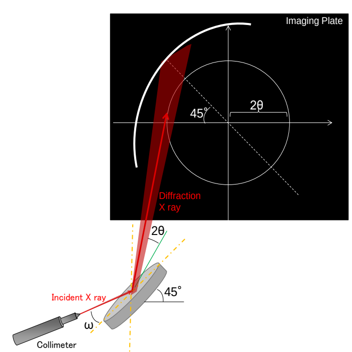

Figure 1. Geometry between incident X-ray beam angle and the sample stage in IPXRD equipment.

RESULTS AND DISCUSSIONS

Results of friction coefficients taken using 0.5-µm WS_2 shot peening and 2-µm WS_2 by pin-on-disk friction test in a vacuum shown in Figure 2. The endurance life of 0.5-µm was around 6000 that is shorter than another type of coating. However, Friction coefficient of 0.5-µm WS_2 was lower and more stability than 2-µm WS_2.

Figure 3 show the microscope observations of counterpart and disk surface, and further measured surface roughness on the wear point of the both powder size WS_2 specimens after friction tests. Wear characteristics of both cannot observe any apparent difference.

We had tried to find about reason of make low friction coefficient by comparison analysis of IPXRD at (0002) plane of two kind of coupon show in Figure 4 and 5. We have confirmed the tendency of half width of (0002) Debye ring of WS_2 shot peening coating before friction test (after coating) and after friction test that are almost same points [2]. Figure 4 shows relation of both grain size of WS_2 have not changed after coating and after friction. The half width of (0002) plane Debye ring by 0.5µm-WS_2 is bigger than a WS_2 having a higher coefficient of friction. Diffraction peak intensity of (0002) plane normalized by that of $(10\bar{1}3)$ planes indicates degree of planer perfections. According to Figure 5, specimen which has lower degree of the aligned (0002) plane, the low friction coefficient shows also lower by the result of the friction experiment shown in Fig.2. Therefore, it is able to suggestion that a low friction coefficient of WS_2 is attributed by the crystallographic irregularity on (0002) plane.

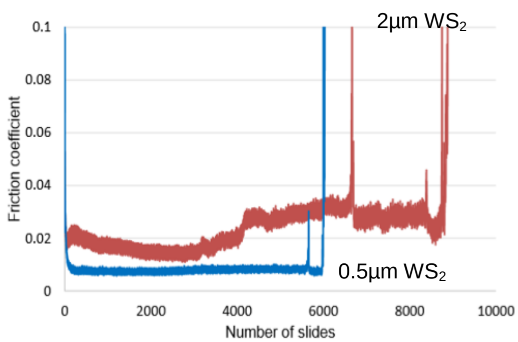

Figure 2. Friction coefficient behaviors of 0.5µm and 2µm powder WS_2 in a vacuum.

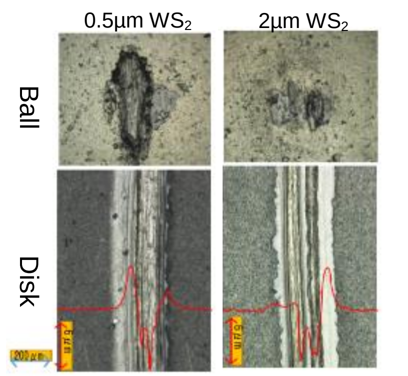

Figure 3. Microscope observation and measured surface roughness on a wear track of after friction test.

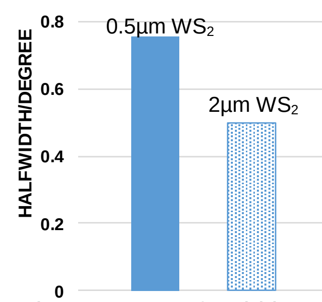

Figure 4. Half width of (0002) peaks.

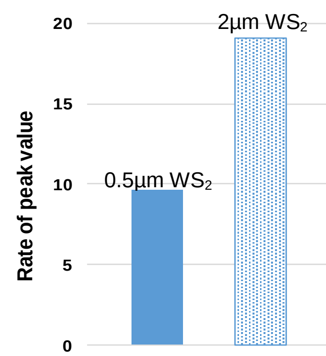

Figure 5. Ratio of peak value by beta diffraction of (0002) plane Debye ring.

CONCLUDING REMARKS

・In case of smaller grain size, friction coefficient was low.
・A friction coefficient of 0.5µm powder WS_2 was less than 0.01.

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[2] Ayaka Takahashi, Josaphat Tetuko S S and Keizo Hashimoto·,2018, “Evaluation of Friction Characteristics and Low Friction Mechanism of Tungsten Disulfide for Space Solid Lubricant at Elevated Temperature in a Vacuum," Proceedings of the 44th AMS.

KEYWORDS

Solid lubricant, Tungsten disulfide, vacuum, XRD