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Tribological Properties of Co-Sputtered MoS_2 Films

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Tribological properties of co-sputtered Molybdenum disulfide (MoS_2)/Carbon (C) films were studied and compared with those of sputtered MoS_2 films. Friction tests were carried out using pin-on-disk friction testers to evaluate their friction and wear behaviors in a vacuum (10^{-5} Pa), air and humid air of 30, 50, 80% RH.

MoS_2/C (14%) composite films exhibited about 9 times longer wear life in a vacuum and about 6 times longer wear life in dry air than MoS_2 films did. They also showed stable low friction coefficient of about 0.02 in a vacuum. In humid air, however, MoS_2/C composite films hardly showed good tribological properties.

Keywords : Co-sputtering, Composite film, Molybdenum disulfide, Carbon

1. INTODUCTION

MoS_2 has widely been used as solid lubricant in space drive mechanisms. It shows excellent tribological performance in a vacuum, but not in dry and humid air. It was reported that co-sputtered films of MoS_2 with Au, Ti, Cr or WSe_2 presented good performances in humid air [1].

In this study, we tested co-sputtered films of MoS_2 with C in order to improve tribolpgical properties in air.

2. EXPERIMENTAL PROCEDURES

2.1 Specimens and Sputtering process

MoS_2/Carbon films were deposited on stainless steel disks made of SUS440C by RF magnetron sputtering apparatus schematically shown in Fig. 1. We deposited MoS_2/C films containing 8 to 31% Carbon. Sputtering duration was 90 minutes.

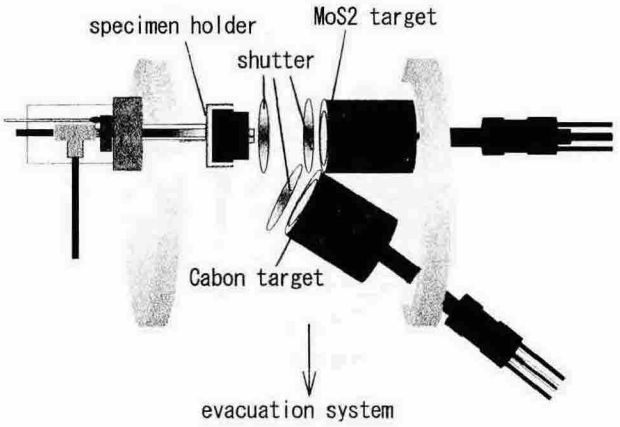


Fig. 1 Co-sputtering apparatus

2.2 Sliding Test

Friction tests were carried out using pin-on-disk friction testers. Test conditions are given in Tab. 1. Friction tests were carried out in a vacuum, dry and humid air (30, 50 and 80%RH). A SUS440C ball with a diameter of 5/16" was used as a slider. The wear life was defined as the number of revolutions until friction coefficient rose to 0.3 in a vacuum, and 0.4 in dry and humid air.

Tab. 1 Test conditions

Atmosphere	10^{-5}(Pa), dry air, 30%,50%,80%(RH)
Temperature	Room
Load	9.8(N)
Sliding speed	0.5(m/s)
Sliding friction diameter	24(mm)
Detection of film rupture	Friction coefficient≧0.3

3. RESULTS

3.1 Behavior of friction coefficient

Typical behavior of friction coefficient observed in a vacuum is presented in Fig. 2. The friction coefficient of sputtered MoS_2 films obtained at stable stage is 0.02 to 0.05. MoS_2/C composite films, however, showed friction coefficient of about 0.02.

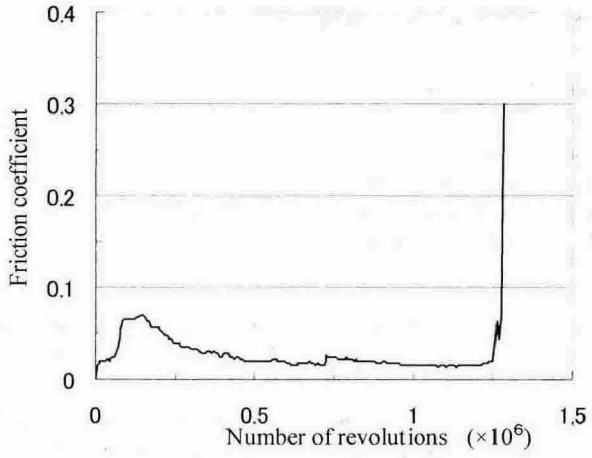


Fig. 2 Friction behavior of MoS_2/C film

3.2 Results of pin-on-disk friction tests

Fig. 3 shows the ratio of wear life of each MoS_2/C composite films divided by that of MoS_2 films. The wear life was calculated under the assumption that film thickness was proportional to life. A denominator of the ordinate was the average wear life of 30 MoS_2 films deposited under the optimum conditions obtained in advance in our laboratory. It was 0.71 million revolutions. In dry and humid air of 30, 50, 80% RH, the wear life of MoS_2 films was 0.20, 0.17, 0.16, 0.11 million revolutions respectively. In a vacuum, MoS_2/C (14%) composite films showed 9 times longer wear life than the MoS_2 films did. In dry air the same films showed 6 times longer wear life than the MoS_2 films did. In humid air, MoS_2/C composite films, however, showed shorter wear life than the MoS_2 films did.

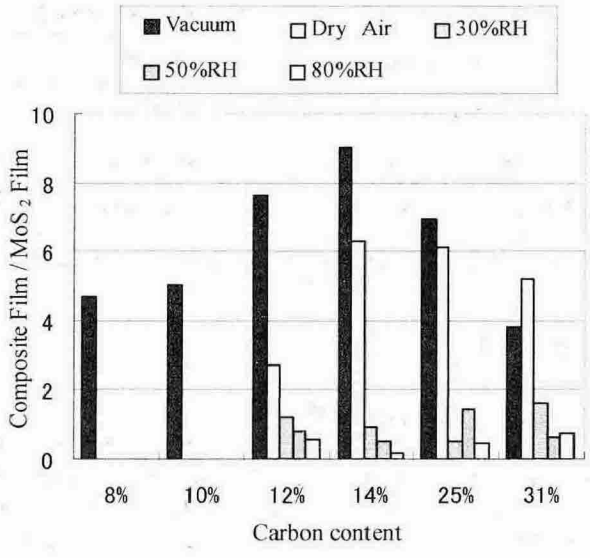
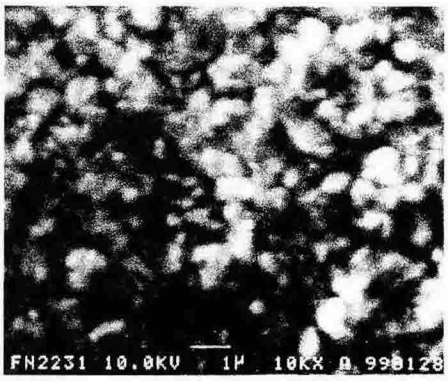


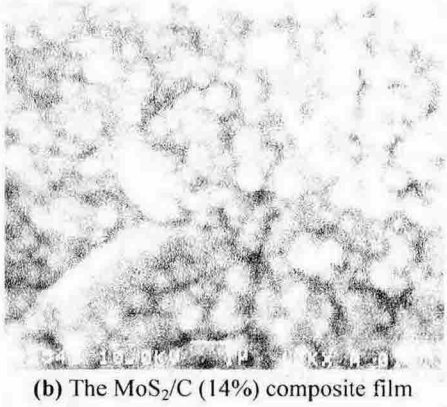
Fig. 3 The ratio of wear life

3.3 Surface observation by SEM

SEM pictures of the films are presented in Fig. 4. Fig. 4(a) is the surface of MoS_2 film and Fig. 4(b) is the surface of MoS_2/C (14%) composite film. Comparing figures 4(a) and 4(b), we observe that finer grains are deposited on the surface of 4(a) than the surface of 4 (b).



(a) The MoS_2 film



(b) The MoS_2/C (14%) composite film

Fig. 4 SEM images (×10.000)

4. CONCLUTIONS

Obtained results so far can be summarized as follows: MoS_2/C composite films gave longer wear life than MoS_2 films did in a vacuum and dry air, and lower friction coefficient of about 0.02 in a vacuum. MoS_2/C (14%) composite films showed 9 times longer wear life in a vacuum and 6 times longer in dry air than MoS_2 films did. But the life extension effect was not observed in humid air.

5. REFERENCES

[1] M. C. Simmonds., A. Savan., E. Pflüger., and H. Van Swygenhoven., .Mechanical and tribological performance of MoS_2 co-sputtered composites,. Surface and Coatings Tribology,. Vol.126, pp. 15-24, 2000