Theoretical study of amorphous MoS_2 formation condition by DC cathode sputtering evaporation

ABSTRACT

The deposition of MoS_2solid lubricant on metal surfaces by non-acid deposition is the most widely used method in aviation and space. The MoS_2 film formed by the non-acid deposition is amorphous when the temperature of the matrix is 160 ° or less, and becomes crystalline when the temperature is higher. [2] The amorphous film has a smaller friction coefficient than the crystalline film. [3] In this study, the amorphous film formation conditions of MoS_2 were determined theoretically and the friction coefficient was measured in DC cathodic deposition.

KEYWORDS

MoS_2, DC cathode sputtering evaporation

1. Experimental apparatus and method

1) Experimental apparatus

The device used for the experiment is SCD005 type cathode scattering device. The specimens were made of Beck Cr15 steel with a hexagonal shape with a size of 4mm × 6mm × 7mm. The specimens were machined and then polished to 8th grade.

2) Experimental method

In the non-acid deposition experiment, it proceeds to the four steps of installation of the anode and the specimen, the scattering distance (distance between the anode and the cathode), vacuum exhaust, and scattering. Install the material to be scattered on the cathode. The scattering material is a disc of MoS_2 having a diameter of 8 mm and a thickness of 5 mm. The specimen installation is carried out by placing the specimen on the bipolar plate. The flywheel control moves the bipolar plate downward to move the distance scale on the sample chamber wall. Evacuate the vacuum, reach the required vacuum and proceed with the scattering.

2. Amorphous film formation condition of MoS_2 in DC cathode scattering deposition

Theoretical analysis for determining amorphous film formation conditions of MoS_2 in direct current cathode scattering deposition was carried out. In the non-acid deposition, the following relation holds between the matrix and the temperature. [2]

$$T = \sqrt[4]{\frac{W}{\varepsilon\sigma}} \tag{1}$$

Where the temperature of the T-base material

W-calories entering the matrix material

epsilon - the rate of replication of the base material

σ -Boltzmann constant

The incident heat is expressed as W = u it by the scattered voltage u, the scattered current i, and the scattering time t.

$$T = \sqrt[4]{\frac{uit}{\varepsilon\sigma}} \tag{2}$$

According to Passansen's law, the scattered voltage u is given by

$$u = \frac{B(pl)}{(\ln(pl) + \ln(A/(\ln(2-1/\gamma))))} \tag{3}$$

Here, the number of secondary electrons generated when the γ-cations collide with the cathode

A-constant (14 for Ar gas)

B-constant (180 for Ar gas)

If equation (3) is substituted into equation (2), the following equation is obtained.

$$T = \sqrt[4]{\frac{B(pl)it}{\varepsilon\sigma(\ln(pl) + \ln(A/(\ln(2-1/\gamma))))}} \tag{4}$$

2 = 1, 2, 3 when Ar gas molecules collide with the MoS2 target, A = 14, B = 180 when Ar gas, ε = 0.2 and σ = 1.38 × 10-23 J / to be. Putting these values into Eq. 14 gives the following equation.

$$T = 1.57\sqrt[4]{(pl)t} \tag{5}$$

As shown in Equation 5, the temperature T is proportional to the square root of the enemy of pl and t. Drawing a graph of pl and t functions for T is shown in Figure 1.

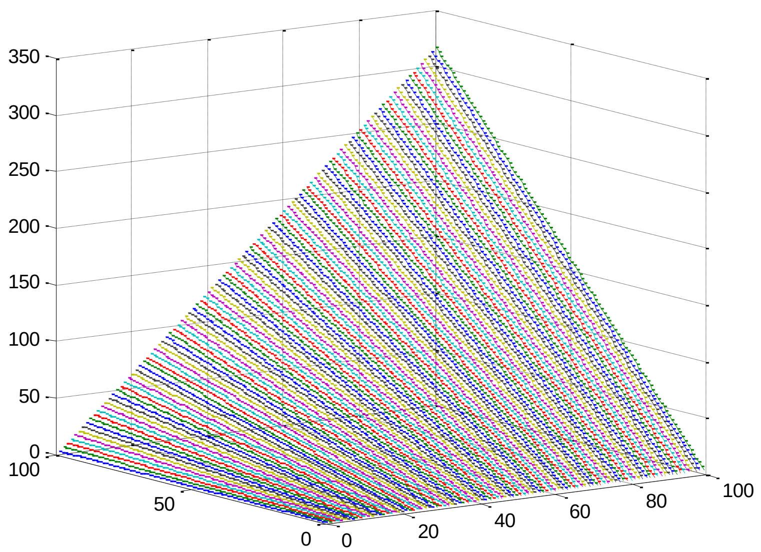

Figure 1. Graf of the T function for pl and t

As shown in the figure, the larger the pl, the longer the t, the larger the value of T. Figure 1 shows that when the coating of MoS_2 is carried out on Be Cr15 steel by cathodic scattering, if the temperature of the matrix material is lower than 160 ℃, the scattering time is over 12 minutes when the value of pl is less than 1.9 × 10-2 Pa · m You can see that you should not.

When the Ar gas is injected, the gas pressure at the time of MoS2 scattering is 0.7 to 0.8 Pa, and the working distance at this time is 23.8 to 27.1 mm.

From this, it can be seen that the scattering conditions in which the amorphous film is formed in the MoS_2 coating of Be Cr15 by cathode scattering is a working distance of 24 to 28 mm, a scattering time of 12 minutes or less, a pressure of Ar gas of 0.7 to 0.8 Pa and a scattering current of 120 mA.

3. Characteristics of MoS_2 amorphous films formed by DC cathode scattering deposition

The characteristics of MoS_2 amorphous films formed by dc deposition were clarified. The base material is Be Cr15 steel, and the scattering conditions are 25mm of working distance, 10 minutes of scattering time, 0.78Pa of Ar gas pressure and 120mA of scattering current. Scanning electron microscopy and X - ray diffraction analysis were performed to analyze the state of the film surface and the bonding state and phase structure of the film. Figure 2 shows a scanning electron microscope image of the surface and cross section of the cathode scattered MoS_2 layer.

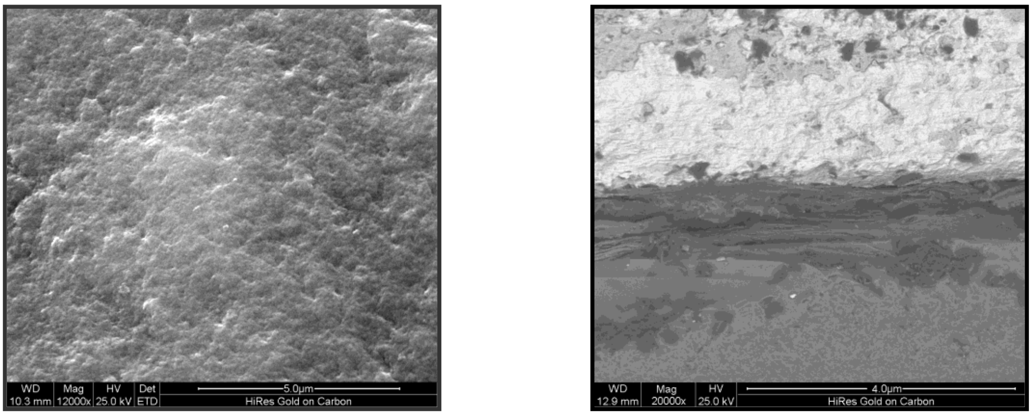

Figure 2. Scanning electron microscope images of the surface and cross section of the MoS_2 laye (A-table, b-section)

As shown in Fig. 2 (a), the surface of the MoS_2 layer due to cathode scattering is dense.

It can be seen that b) of Fig. 2 formed a firm bond at the interface between the matrix material and the MoS_2 layer.

Figure 3 shows the results of X-ray diffraction analysis of the MoS_2 scattering layer. The figure shows that the MoS_2 scattering layer is amorphous.

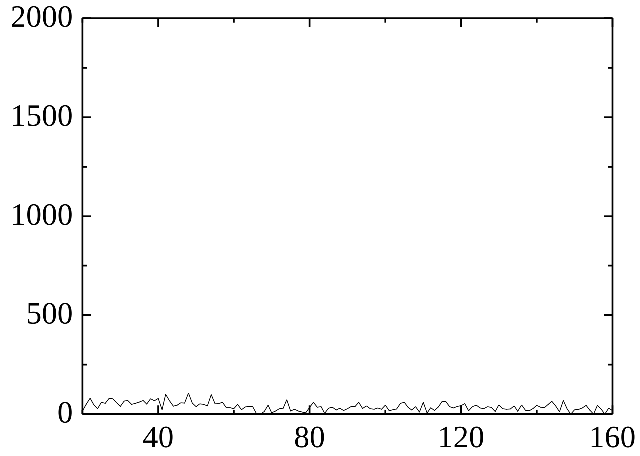

Figure 3. X-ray diffraction analysis results of the MoS_2scattering layer

The abrasion test of the non-acid deposited MoS_2 film was carried out and the results are shown in Table 1 in comparison with that before the non-acid deposition. The base material is Ber Cr15. The friction ratios were determined by measuring the amount of wear.

Conclusion

The amorphous film formation conditions of MoS_2 in direct current cathode scattering deposition are 24 to 28 mm in working distance, 12 min or less in scattering time, 0.7 to 0.8 Pa in Ar gas pressure, and 120 mA in scattering current.

Under these conditions, the friction coefficient of the MoS_2 film deposited on the CrCr15 steel cathode decreased to 1/5 of that of the uncoated film.

References

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