Micro-abrasion resistance of W-Co-C sputtered coatings

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INTRODUCTION

Nowadays a large number of coatings are widespread used in industrial applications in order to improve the hardness, the elastic modulus and/or the mechanical properties of components at high temperature. Such excellent properties render the coated materials to be applicable in a variety of adverse situations, such as high loads and high friction. When submitted to high load values, coatings with high residual stress levels and some surface defects can contribute to the increase of some preexistent surface micro cracks given rise to a debris formation. High hardness and small tail debris can be easily entrapped in the contact surfaces. This phenomenon is increased by the lowest hardness of the counterpart surfaces.

The present paper concerns the slurry abrasion performance of W-Co-C sputtered films with different cobalt contents, deposited on high speed steel (AISI M2), in order to established the influence of structure on abrasion behavior. This allows possible insight a suitable abrasion model for coatings, very helpful to mechanical design.

EXPERIMENTAL DETAILS

The coatings were produced by sputtering sintered tungsten carbide targets, containing different percentages of cobalt (6, 10 and 15 wt%), using a r.f. magnetron equipment. The films were produced on an argon atmosphere with a deposition pressure of 1 Pa and a power density of 6.25 $W.cm^{-2}$. Negative bias was applied to the substrate during the deposition in the range from 0 to 400 V. Deposition time was 60 minutes and the mean film thickness was 3.0 μm.

The substrate bias and the target composition allow to different properties of the deposited coatings. Table 1 shows the structure, cobalt content and hardness of the films as a function of substrate bias and the target cobalt content.

Wear tests

The wear study was carried out with a ball cratering test system with a slurry of SiC 1200 Grit as abrasive. The equipment used was a homemade apparatus of free ball type that uses the cinematic of a conventional lathe. The geometry and turn speed were selected in order to obtain the test parameters shown on table 2.

In each sample, craters were performed using five cumulative rotations: 100, 200, 300, 500, 700. The tests were carried out three times, so each specimen had a total of 15 scars. Before tested the samples were ultrasonically cleaned in acetone.

Table 1. Coating characteristics

Substrate bias (V)	Target wt Co%	Structure	Film at Co%	Film Hardness (HV)
-400	15	Amorphous	18	2550
-100	15	Amorphous	26	2063
-50	15	Amorphous	29	2258
0	15	Amorphous	30	2131
-400	10	W_2C+WC_{1-x}	6	3120
-200	10	W_2C+WC_{1-x}	6	3242
-50	10	Amorphous	20	2222
-400	6	W_2C+WC_{1-x}	2	3710
-200	6	W_2C+WC_{1-x}	3	3950
-50	6	WC_{1-x}	12	3479

Table 2. Ball cratering test conditions.

Specimens	W-Co-C thin films
Sphere material	Steel AISI 52100 ball bearing
Sphere radius	25 mm
Sphere turn speed	80 rpm (neglecting slip)
Normal load	0.25 N (neglecting friction)
Slip speed	0.1 m/s
Test duration (turns)	100, 200, 300, 500, 700
Abrasive	F1200 Grit SiC slurry
Abrasive hardness	2600 Hv
Solvent	Distilled water
Preparation	Acetone ultrasonic cleanning

RESULTS AND DISCUSSION

Cobalt content on W-Co-C sputtered coatings results from the superposition of the cobalt content on the target and the substrate bias during the deposition ,as has been reported elsewhere[1,2]. The cobalt content was the main influence on the amorphous or crystalline film structure. A threshold of cobalt content was determined beyond that the film was amorphous.

After abrasion tests crater measurements were performed. In order to obtain the wear coefficients for both coating and substrate, the ball cratering test results was been analyzed using the method derived by Kassman et. al [3] and Rutherford and Hutchings [4]. The mean values of the coating wear coefficients are plotted in figure 1.

For all targets, the coatings with the higher substrate bias, -400 V, show the highest values of wear coefficients. This seems to be related with the effect of bias on the increasing of coating residual stresses. In spite of the low loads used in the tests, the particle specific load, together with the coating residual stresses, are enough to promote the film spalling. Thus, the wear scars, observed by scanning electron microscopy reveal clear signals of abrasion, particularly in the crystalline films.

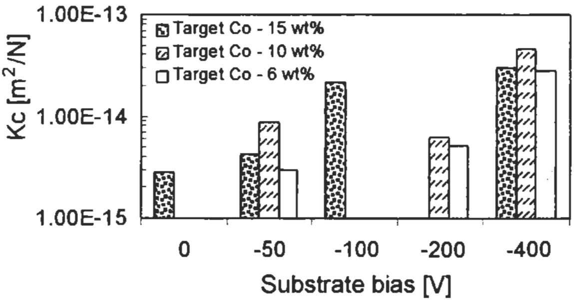

Figure 1. Coating wear coefficient of W-Co-C coatings tested by ball cratering.

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