STUDY OF FILM DEFECTS FORMED DURING THE DEFORMATION OF TITANIUM NITRIDE COATING ON AISI D6 TOOL STEEL SUBSTRATES

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Abstract. *TiN thin film has been produced on the surface of AISI D6 tool steel by using a titanium interlayer. TiN films were obtained by conventional cathodic arc technique. In this work are shown and discussed the permanent defects induced on TiN film surfaces deposited on AISI D6 tool steel. The depositions were performed at 220^{o}C and 450^{o}C. The samples were manufactured in agreement to ASTM E 855-90 proceeding statement to make the four-point bending tests. These tests have been used to make a analyses of the adherence film-to-substrate. The surfaces of these samples after bending tests were observed by SEM.*

Keywords: AISI D6 tool steel, TiN thin film, Cathodic arc technique

1. INTRODUCTION

Now its possible obtain modified surfaces of materials by films using several technique combinations that result in an excellent chemical and physical homogeneity, appropriate film adherence on substrate surface and excellent control of modified layer thickness (Conrad et al, 1987 and Nono et al, 1999). Steels and their alloys with the modified surfaces are widely used in a large variety of important technological applications (Nono et al, 1999). These include cutting tools, machine components and molding dies, where the surfaces of these materials are submitted to physical and/or chemical erosions.

Titanium nitride thin film has been widely employed in cutting tools to extend their working life and in decorations for its golden color. TiN is an important material in advanced surface protective coating area for steel (Iqbal et al, 1998; Kola et al, 1996; Schulz et al, 1997 and Staia et al,1995). Moreover, studies on the TiN properties have solved significant problems, such as the reduction of the usefulness of the TiN films for corrosion resistant coatings and for diffusion barriers in the films (Morita et al, 2001). The main field of their applications is in the machine industry as refractory materials and as hard and wear resistant films on machine tools and mechanical parts. However, the adherence of TiN films on steel substrate is not well known yet. Nowadays, TiN thin films deposited by plasma vapor deposition have become of great importance due to their increasing use in cutting tools, as a protective coating and decoration (Iqbal et al, 1998; Kola et al, 1996 and Schulz et al, 1997). The cathodic arc deposition is a useful method to deposit TiN films.

In this work are shown and discussed the permanent defects induced on TiN film surfaces deposited on AISI D6 tool steel substrates by using a titanium interlayer. The adherence of titanium films on steel substrate has been demonstrating good adherence results (Vieira et al, 2002).

2. EXPERIMENTAL DETAILS

The AISI D6 samples were manufactured in agreement to ASTM E 855-90 proceeding statement to make the four-point bending tests. The deposition of Ti thin film interlayer and TiN film on AISI D6 substrate was carried out by conventional cathodic arc technique. The deposition were performed in a cylindrical reaction chamber, 0.65 m in diameter and 0.90 m in height. The dimensions of titanium target utilized was 1m height, 0.17 m width and 0.014 m depth. A turbomolecular pump was used to evacuate the chamber down to $5x10^{-3}$ Pa. The coating material was Ti (99.95%) and the reactive gas was industrial nitrogen (99.99%). Before the deposition process the substrates were bombarded with Ar ions for 10 min. Titanium thin film with a thickness of 0.1 μm approximately were first deposited on polished surfaces of AISI D6 tool steel substrate. After that, TiN films were deposited on Ti film-AISI D6 substrate system by varying the substrate temperature (220°C and 450°C) and keeping the bias voltage (= -80V) and the nitrogen flow rate (= 1200 sccm) constant in this process. The base pressure in the deposition system was $3x10^{-1}$ Pa. Each deposition process was performed at a substrate temperature. After bending tests the surfaces of these samples were observed by SEM.

3. RESULTS

The AISI D6 sample surfaces with TiN films deposited at 220°C after having submitted to four point bend test are shown in Fig. (1). This TiN film presented the unidirectional and orthogonal cracks formation to the sample length, with a larger concentration near of the applied load area (Fig. 1). As can be seen in this figure, there is some unsticking on the film. In the center of the sample (in the area between the applied load), it didn't happen cracks formation.

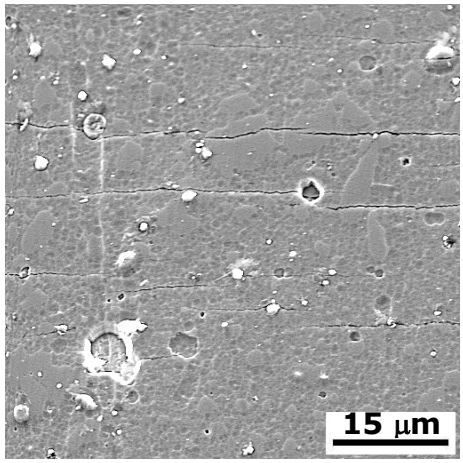

Figure 1. SEM micrographs of AISI D6 with TiN film deposited at 220°C submitted to four-point bending test in area around the load application point on TiN film (2000x)

As can be observed in Fig. (2), the AISI D6 samples surfaces with TiN films deposited at 450°C was observed by SEM after four point bend test. This TiN film also presented the unidirectional and orthogonal cracks formation to the sample length. However, this film presented a larger concentration near of the applied load area (Fig. 2) than that one produced at smaller substrate temperature (Fig. 1). In the center of the sample (in the area between the applied load), it didn't happen cracks formation.

These results suggest that TiN films deposited at higher temperature presented a better adherence because they have the largest interface area produced during the deposition step (Vieira et al, 1999, 2000 and 2004). This TiN-Ti-D6 tool steel interface was formed due to the interdiffusion process of the ions from film and AISI D6 tool steel substrate forming a solid solution.

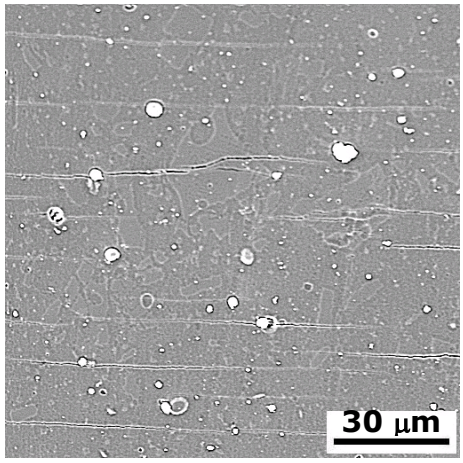

Figure 2. SEM micrographs of AISI D6 with TiN film deposited at 450°C submitted to four-point bending test in area around the load application point on TiN film (2000x)

4. CONCLUSION

In this work, the permanent defects induced on TiN film surfaces deposited on AISI D6 tool steel has been studied.

Results show that only in the area around the points of load applications presented unidirectional and orthogonal cracks with several sizes. Moreover, the AISI D6 with TiN film deposited at higher temperature submitted to four-point bending test showed the larger number of cracks than that one deposited at lower temperature. However, the TiN films deposited at higher temperature presented a better adherence.

The TiN-Ti-D6 tool steel interface was formed due to the interdiffusion process of the ions from film and AISI D6 tool steel substrate forming a solid solution.

5. ACKNOWLEDGEMENTS

The authors would like to thank FAPESP for financial support.

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