Tribological properties of Ti(CN)x hard coating on titanium alloy by pulsed plasma electrolytic carbonitriding process

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1. Introduction

Due to the poor tribological properties under dry friction, the application of titanium alloys is limited in tribological components. Many surface engineering technologies such as oxygen diffusion treatment, diffusional carbonitriding et al. have been developed to improve the wear resistance [1,2]. Plasma electrolytic carbonitriding (PEC/N) technology can fast deposit hard cabonitriding layers on metal surface at near-ambient temperature, obviously improving the surface hardness and wear resistance [3,4]. In this paper, the PEC/N coatings were deposited on titanium alloy and the tribological properties were investigated.

2. Experimental details

Ti6Al4V alloy plates (Φ20mm×2mm) were used as substrates. For PEC/N treatment, a pulsed high voltage power supply was employed with the cathode of Ti6Al4V alloy plate and the anode of graphite plate. The electrolyte was a mixed aqueous solution of formamide and KCl. The applied voltage, pulse frequency and duty cycle were fixed at 250V, 10kHz and 40%, respectively, and the samples were treated for 40-80min. The phase components, morphologies and hardness were analyzed with XRD, FESEM and Vickers indenter using the load of 100g. Friction tests were carried out with ball-on-disk tribometer (1N and 0.1m/s) under dry friction. The wear rate was calculated by the weight loss.

3. Results and Discussions

Fig.1 shows the XRD patterns of the PEC/N samples treated for different time. It is obvious that the layer consists of complex Ti(CN)x phase and the intensity of its peaks increase with the increase of discharge time. The roughness of Ti(CN)x coating increases owing to the plasma discharge at the substrate surface. With the increase of discharge time, small cracks appear in the coating (Fig.2). Fig.3 shows the variation of friction coefficient and wear rate of PEC/N sample under dry friction. The friction coefficient of PEC/N coating increases quickly at the initial stage; however, it keeps stable at 0.4 during the sliding process, which is lower than the untreated sample (Fig.3(a)). Compared with the untreated sample, the PEC/N coating shows a great improvement in wear resistance, especially with the increase of treated time. After sliding about 20min, the wear rate of PEC/N treated samples decreases to 1.8×10^{-4}mm^3/N*m ～ 3.5×10^{-4}mm^3/N*m, which is obviously lower than the untreated samples, about 7.1×10^{-4}mm^3/N*m (Fig.3(b)). Compared to the substrate with the hardness of $340HV_{0.1}$, the average surface micro-hardness of PEC/N coating significantly increases to $478HV_{0.1}$ after 80min treatment.

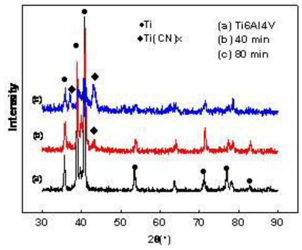

Fig.1 XRD patterns of PEC/N samples

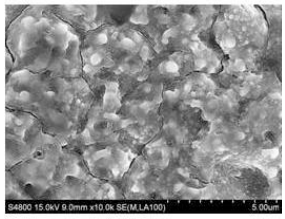

Fig.2 SEM photograph of PEC/N sample, 80min

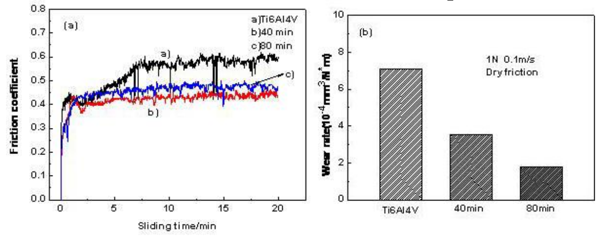

Fig.3 Friction coefficient and wear rate of PEC/N samples

4. Conclusions

Ti(CN)x hard coating were deposited on Ti6Al4V alloy by plasma electrolytic carbonitriding process in a mixed formamide electrolytic solution. The average micro-hardness of PEC/N coating increases with the increase of discharge time. The friction coefficient and wear rate decrease obviously compared to the substrate. The results demonstrate that PEC/N treatment can obviously improve the surface hardness and wear resistance of Ti6Al4V alloy.

5. References

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