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Structure and properties of plasma carbonitrided Ti–6Al–2Cr–2Mo alloy

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Abstract

The paper presents the results of glow discharge assisted carbonitriding of two phase titanium alloy Ti–6Al–2Cr–2Mo carried out in the N_2+CH_4 atmosphere. The carbonitrided diffusion layer is thus produced of the Ti(C,N)+Ti_2N+αTi(N) type with a hardness of 23 GPa. The outer zone of the layer contains the Ti(C,N) phase. This layer slightly increases the corrosion resistance and the fatigue strength limit of the titanium alloy, and essentially increases its frictional wear resistance.

Keywords: Plasma carbonitriding; Titanium alloy; Corrosion resistance; Wear resistance; Fatigue limit

1. Introduction

In the recent years, titanium and its alloys have increasingly been used for constructing parts of the machines and installations that operate under conditions of friction, cavitation, erosion and corrosion. The application range of titanium is widened systematically as the methods of fabricating and forming the products made of it are improved. Because of its extremely high resistance to corrosion and high relative strength, titanium is a very attractive constructional material. About 1/3 of titanium produced in the world is estimated to be used by the aircraft industry. The rest is utilized in the chemical, power, nuclear, cellulose and ship industries. The recent years have also seen an increased demand for titanium from the medicine and car industry. Certain properties of titanium are utilized in new unique applications, such as, for example, cryogenic installations, where the superconductivity and the very good mechanical properties of titanium demonstrated in the presence of a magnetic field at low temperatures are of great advantage [1,2]. Titanium alloys find increasing application also in the operations where the products are required to have good surface properties, such as a good resistance to frictional wear, erosion, cavitation and frictional corrosion (parts of pumps and turbines, dental and surgical instruments, valves of combustion motors intended for racing cars). Unfortunately, titanium alloys have poor tribological properties. The heat treatment techniques used for improving their surface properties do not give satisfactory results, and thus various other methods of surface treatment are increasingly employed [3–6].

As can be seen in the literature data, the wear of the machines and installations is due principally to frictional wear (50%) and adhesion failure (15%), less to erosion and frictional corrosion (8% each), and least—to stress corrosion (5%) [7]. The selection of the adequate surface treatment is quite difficult, since usually various wear mechanisms operate simultaneously. This is why various methods of improving the wear resistance of titanium are being developed, beginning from the chemical and electrochemical deposition by thermal spraying, through PVD methods, anodic oxidation, mechanical treatments to glow discharge assisted treatments [3–6] or ion implantation [8–13].

Among these techniques of improving the frictional wear resistance especially prospective processes seem to be nitriding, oxynitriding and carbonitriding carried out under

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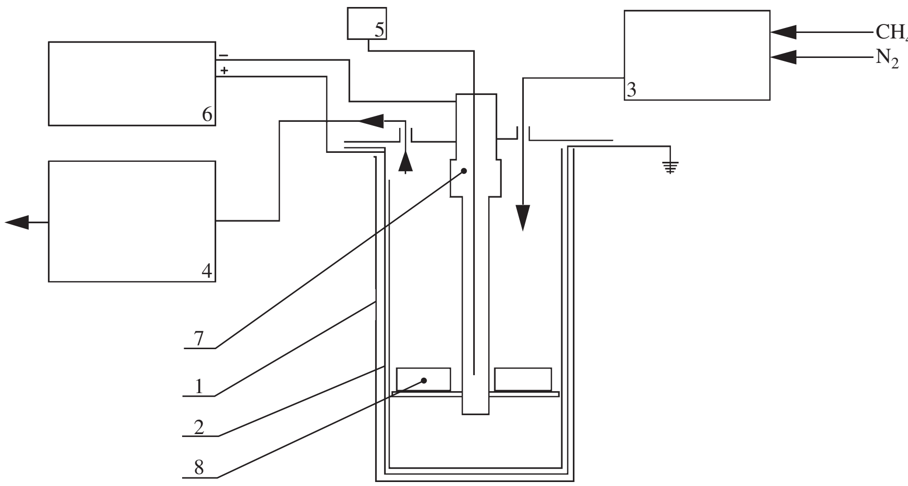

Fig. 1. A schematic diagram of the universal apparatus designed for glow discharge assisted treatments. 1—Reactive chamber, 2—internal screen, 3—gas dosing device, 4—pumping system, 5—temperature and pressure meter, 6—d.c. voltage supply unit, 7—electric current bushing, 8—treated parts [16].

glow discharge conditions because the diffusion layer with excellent adhesion can be obtained [3–6]. The literature only reports plasma assisted carbonizing of the Ti–33.5–Al–1Nb–0.5Cr–0.5Si alloy carried out in a methane and argon atmosphere at a temperature of 900 °C [14], which gave a Ti_2AlC layer 3 μm thick of a hardness of 8.52 GPa. The plasma assisted carbonizing was also reported to improve the mechanical properties of the alloy at room temperature as well as at elevated temperatures [15]. The present paper describes the glow discharge assisted

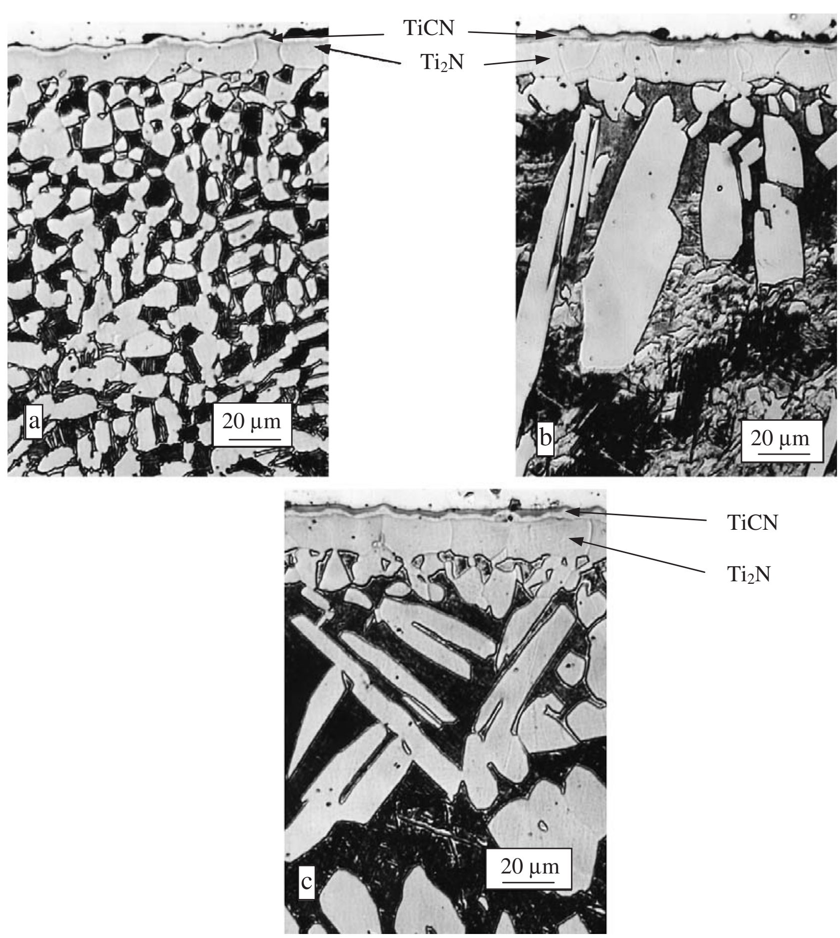

Fig. 2. Microstructures of the carbonitrided layers produced on the Ti–6Al–2Cr–2Mo titanium alloy 3 h (a), 6 h (b), and 12 h (c).