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Perspective Article

Aspects of the practical application of titanium alloys after low temperature nitriding glow discharge in hydrogen- free -gas media

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ABSTRACT

X-ray diffraction analysis, X-ray photoelectron spectroscopy, and Electron Auger-spectroscopy investigation of phase transformation on the surface of the VT8 titanium alloy after a low temperature hydrogen-free nitriding in a glow discharge.

Operational characteristics of titanium alloys defined physical-mechanical characteristics of the surface and their phase composition, which depend on the process parameters of nitriding. Surface modification of titanium alloys were carried out by low-temperature nitriding in a glow discharge in hydrogen-free environment. The main advantage of this method lies in the absence of hydrogen embrittlement and complete environmental safety process. Application of the glow discharge can not only speed up the process by the order of the diffusion surface saturation with nitrogen, but also significantly alters the kinetics of the process and quality of the nitrided layer, in particular its physio-mechanical properties and phase composition. For research purposes, the standards from an $\alpha+\beta$ alloy Ti-Al6-Cr2-Mo2,5 (VT8) were used.

Research into the phase composition was performed by X-ray diffraction, X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES). Stratified analysis by AES was conducted by etching the surface of the samples' argon ion beam with diameters of 1.5 mm with an energy of 3000 eV and a current density of 400 mA/cm^2.

The above material shows the promise of the technology of low-temperature hydrogen-nitriding by glow discharge. This greatly expands the range of practical applications of titanium alloys. In addition, changing the technological mode allows you to manage a wide range of modified phase composition of the surface layer and as a result – to form the surface of titanium parts, taking into account the conditions of the subsequent operation.

1. Introduction

Traditionally, surface modification of titanium alloys by glow discharge nitriding was carried out at a relatively high temperature and in atmospheres containing hydrogen [1]. However, the surface layer becomes brittle, which greatly narrows the range of practical uses of the technology. When low-temperature hydrogen-free-nitriding in glow discharge (NGDs) is formed on the surface of a relatively thin layer of nitride structures and there is a relatively small depth of the diffusion zone [2]. However, due to the greater plasticity of the surface layer, new opportunities open up for the use of the modified titanium alloys in a variety of industries. This work is devoted to the results of the low-temperature NGDs to develop recommendations for further practical application.

2. Materials and methods of investigation

Research into the phase composition was performed by X-ray diffraction, X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES). Filming X-ray diffraction peaks was carried out on a DRON-3 M $\mathrm{C_O}K\alpha$ radiation scheme θ–2θ in the angular range of 30°–100° in increments of 0,05° and 2 s exposure time. With the use of X-ray diffraction, the coating thickness was also determined [3]. Stratified analysis by AES was conducted by etching the surface of the samples' argon ion beam with diameters of 1.5 mm with an energy of 3000 eV and a current density of 400 mA/cm^2. This automatic system allows for the analysis of

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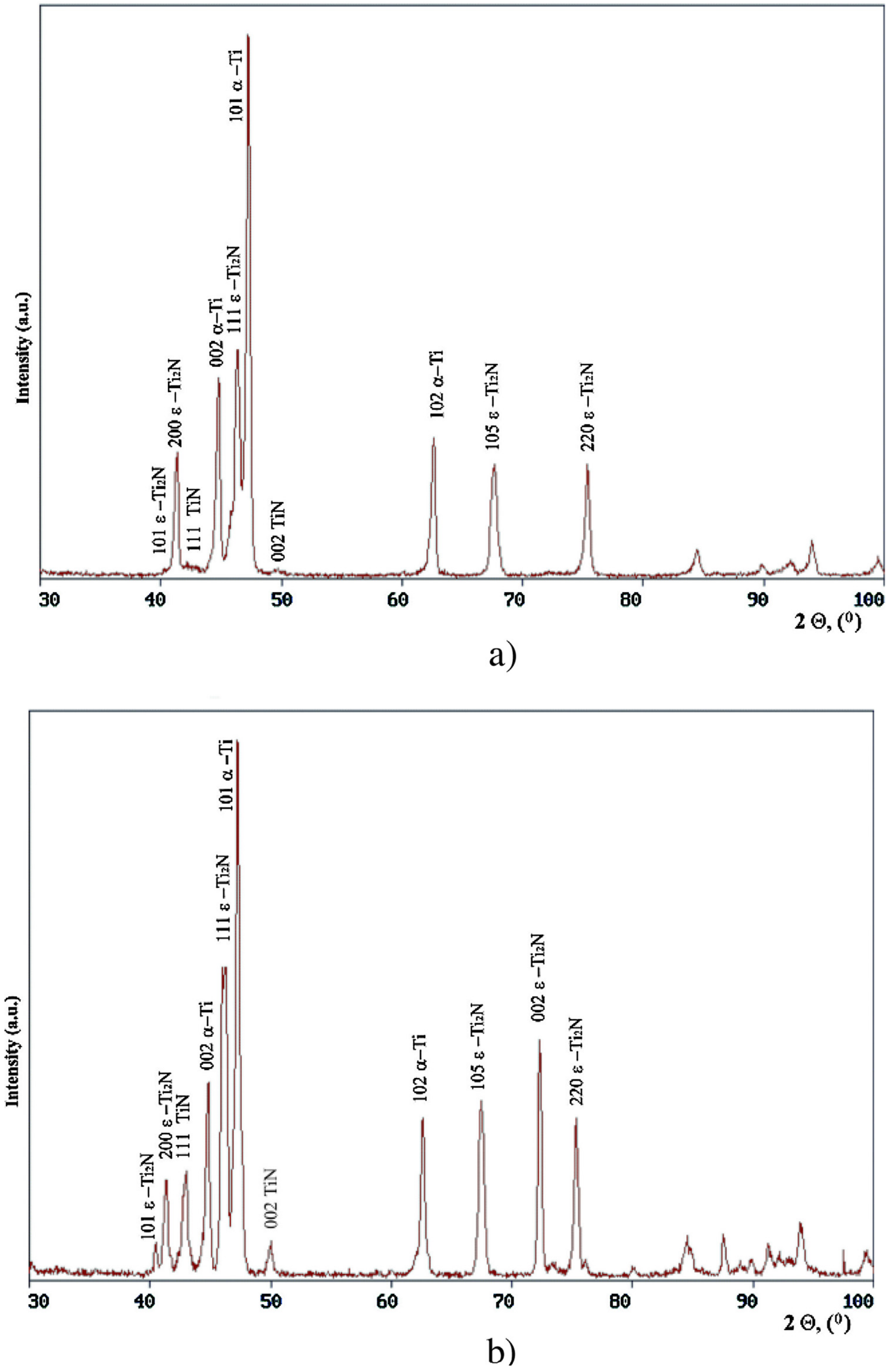

Fig. 1. Radiographs for the VT8 titanium alloy, nitrided under the №2 regime (a) and the № 1 regime (b).

layered depth no less than 0.5–1.0 nm. The studies were performed using the serial scanning electron Auger spectrometer JAMP-10S.

X-ray photoelectron spectra were obtained on the "SERIES 800 XPS" Kratos Analytical electron spectrometer using non-monochromatic X-ray emitter MgKα (1253.6 eV). Photoelectron core-level spectra were acquired using a hemispherical analyzer at a pass-energy of 50 eV with a 0.025 eV energy step. The overall resolution of the spectrometer in this operating mode was 0.95 eV measured as a full width at half maximum (FWHM) of the Ag $3d_{5/2}$ line. After subtraction of the Shirley-type background, the core-level spectra were decomposed into their components with mixed Gaussian–Lorentzian lines by a non-linear least-squares curve-fitting procedure, using the public software package XPSPEAK 4.1. The binding energies, FWHM and areas of the peaks' components were determined from the fitting results. The carbon C1s line at 284.9 eV was taken as a reference for surface-charging corrections. The peak areas and standard sensitivity factors were used to evaluate the surface composition of the samples. On the surface of the