(Special Issue)

Asian Research Consortium

Asian Journal of Research in Social Sciences and Humanities
Vol. 10, No. 5, May 2020 (Special Issue), pp. 10-12.

ISSN 2249-7315
A Journal Indexed in Indian Citation Index

Asian Journal of Research in Social Sciences and Humanities

www.aijsh.com

Methods for Modifying the Surface Layer before Applying Wear-Resistant Coatings

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Abstract

Comparative analysis of changes in hardness, elastic modulus and adhesion of wear-resistant coatings obtained simultaneously on substrates pre-alloyed with various elements.

Keywords: Modification, Finish Hardening of the Tool, Wear-resistant Nanocoating.

Introduction

Nitriding in plasma of a low-pressure arc discharge is a process carried out using the "PINK" plasma generator (a plasma source with an incandescent cathode) developed at the ISE SB RAS. This plasma generator can be used as an independent plasma source for finishing cleaning and activation of the surface of materials and products in inert gases before spraying, as well as for plasma assistance in the process of spraying protective and strengthening coatings. In addition, this plasma generator is successfully used for nitriding steel products in reactive gases due to bombardment with ions accelerated in the layer of spatial charge formed at the surface of bodies placed in the plasma, and which are fed a negative displacement (0 ÷ 1000 V), successfully replaces the glow discharge.

The difference between nitriding in arc discharge plasma and glow discharge is that the process is carried out on technically pure nitrogen without the introduction of hydrogen, and not in dissociated ammonia. The exception is the presence of hydrogen required in the glow discharge for reduction reactions. This is possible due to the high kinetic energy of the arc discharge ions.

Asian Journal of Research in Social Sciences and Humanities,
Vol. 10, No.5, pp. 10-12.

As the nitriding in the plasma of an arc discharge takes place at much lower pressures of the working gas compared to glow discharge, the charged particles have a large mean free path. Due to this, their kinetic energy can be regulated in a wide range from 10 to 1000 Kev. This energy is sufficient for the destruction of oxide films formed during nitriding, as well as for the activation of the treated surface. Due to this, the resulting oxides are destroyed, which leads to an acceleration of the process.

In addition to the fact that nitriding can be used as an independent processing method, it is often used to harden titanium and its alloys, as well as as an intermediate step in the processing of materials. So in the works, nitriding was used as a stage preceding the deposition of hard wear-resistant coatings such as TiN, CrN, etc. on steel substrates, pre-nitriding of which allowed to create a solid transition zone between the TiN coating and the main substrate material.

Both studies showed significant improvements in mechanical and tribological characteristics. The use of the PINK plasma generator in such experiments makes it possible to produce additional ionization of the working gas during the deposition of coatings made of nitrides of refractory metals, increase adhesion, and obtain a high-quality coating on products made of metals and dielectrics at condensation temperatures much lower than in most cases.

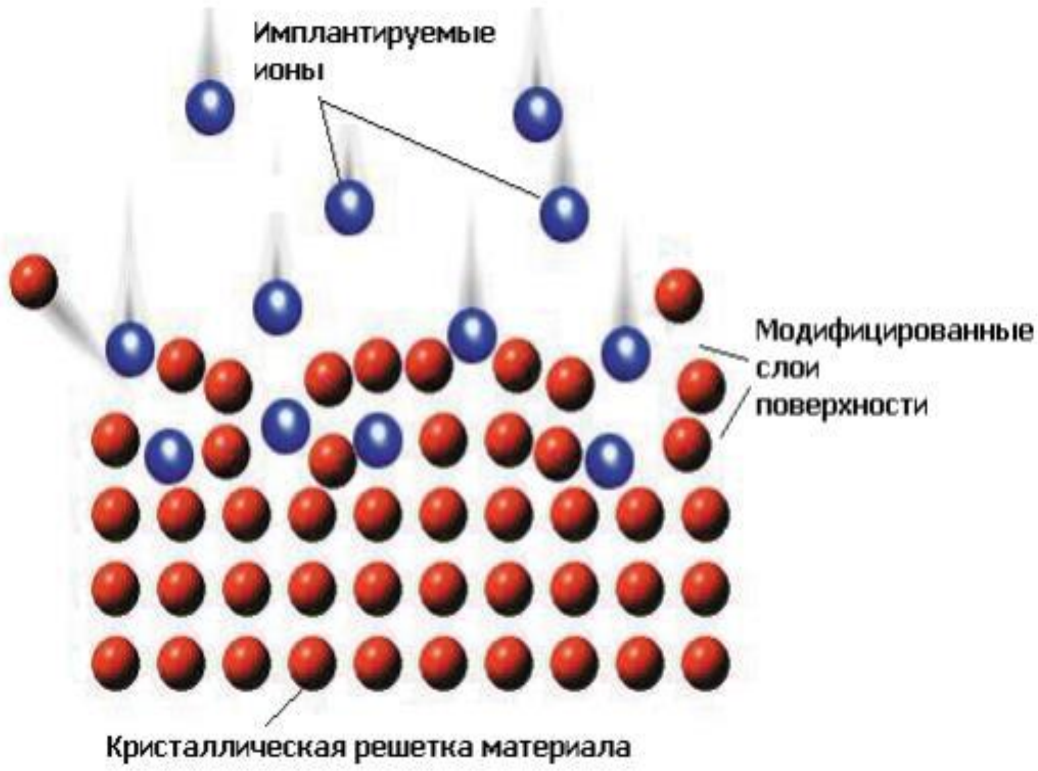

Figure 1 The Ion Implantation Process

Ion implantation the implantation process is based on doping, which involves the formation of a beam of ions of the alloying element, its acceleration and the introduction of these ions into the surface of the semiconductor plate (Fig. 1). As the path passes from the ion source to the plate surface, the ions can acquire additional energy (accelerate) or Vice versa lose some of the energy. All this is due to variable high-frequency or constant electric fields.

During ion implantation of the surface, along with the processes of sputtering, the penetration of ions into the depth of the bombarded object occurs. For metals, ion implantation is used to increase their hardness, wear resistance, corrosion resistance, etc.

Conclusion

The main advantages of the ion implantation method are: the ability to implant any impurity, any element of the Mendeleev Table; the ability to dope any material; the ability to introduce an impurity in any concentration, regardless of its solubility in the substrate material; the ability to introduce an impurity at any substrate temperature, from helium temperatures to the melting point inclusive; the ability to work with alloying substances of technical purity and even with their chemical compounds (also of any purity); the isotopic purity of the alloying ion beam (i.e. able it possible to dope only the element, but only the isotope of that element); the ease of a local alloying (with at least basic mechanical masking); the small thickness of the doped layer (less than micron), large gradients of the impurity concentration in the layer depth unattainable with traditional methods, with the inevitable diffusion blurring of boundaries; ease of control and full automatization of process; compatibility with the planar technology of microelectronics.

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