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Fabrication of Al-Pt Coating on Ni-Based Superalloys by Sputtering-Ion Beam Technique under Argon Plasma

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Abstract

Protective coatings are applied on the engineering materials to improve their physical, thermo chemical and mechanical properties. These coatings are used in various fields of industrial applications specially gas turbine blades, and in this respect, many research projects have been conducted to improve their properties. In the present study, the formation of Al-Pt (Aluminum/Platinum) alloy coatings on Nickel-based superalloys has been investigated. Sputtering ion beam technique under Argon plasma, pack cementation and subsequent heat treatment has been used to fabricate these coatings.

The main goal of this paper is to change the method for fabrication of platinum layer and investigate about effect of this variation on the morphology of coating. The results of this study confirm well with the results of other investigations, and it's related to slow diffusion of platinum through coating. This method can produce uniform coatings faster and promise to be industrial technique for the fabrication of such coatings.

Keywords:
coating, sputtering, plasma, pack cementation, aluminides, platinum

1. Introduction

In the most of turbine components failures occur through oxidation and corrosion, hence protection of these components is necessary. The use of coatings permits the separation of surface and substrate. Thus, such components have been coated with specific materials in order to improve their service lives. Some of these materials are Aluminum alloy and Aluminum intermetallic compounds, and Al-Pt compounds which the latter is known to be a very effective oxidation protection coating. These compounds have been used for the protection of superalloy turbine blades for several years, and have improved their lifetime [1-3].

Coating materials are designed to provide corrosion or oxidation protection at high temperature applications so that they are applied to high strength superalloy substrates. In this respect, some methods such as electroplating have Platinum and diffusion of Aluminum through Platinum by pack cementation is been used for the production of Al-Pt compounds commercially. In this paper, fabrication of Platinum on superalloys by Ion beam sputtering and effect of this method on the morphology of resulted platinum aluminide coatings has been investigated. For comparison of this coating method with electroplating method for fabrication of platinum layer, the same aluminum layer fabrication and diffusion process [1,4,5] applied on our research.

2. Experimental Procedures

Inconel 738 has been used as a substrate in our experiments. Substrate samples are 30 mm length, 20 mm wide and 3 mm thickness. After cleaning the substrate surface, it is fixed in the sputtering chamber.

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Pure platinum plate is used as a target pure Argon gas Ion beam has been used in this experiment. During electrical discharge, Argon gas is converted to plasma Ion beam, collide to target atoms, take them to plasma and then push them to deposit from plasma to substrate surface.

The coating parameters for sputtering were as follows: Vacuum gas pressure was 10^{-3} torr, Accelerating voltage was 28 kV, Beam current was 12 mA, Distance between target and substrate Ws 3 cm, angle between the beam and the target was 45° and time taken for sputtering was about an hour.

The specimens are coated with Platinum layer by ion beam sputtering and then coated with aluminum by pack cementation. In the pack cementation method the pack consists of Al_2O_3, Al and NH4Cl compounds. Samples coated by platinum covered in by the pack and goes to inert gas furnace in order to heat-treated. The coating was deposited using an aluminizing pack containing 20 wt% Aluminum at 900 °C, and was heat-treated for 4 h and then at 845 °C for 24 h.

The morphology of coated samples is investigated by Scanning Electron Microscopy (LEO 440i) equipped with EDS (energy dispersive spectroscopy) equipment and Jobin yvon GDS (Glow discharge spectroscopy).

3. Results and Discussion

3.1 Platinum Coating

In this study an Ion beam sputtering technique under Argon plasma was applied to deposit the Pt layer on the Nickel-based substrate. A sample has been studied by SEM, which is shown in Fig. 1. This figure shows surface morphology of the Pt layer, which has a cauliflower type appearance with a uniform and spongy surface [2]. If sample surface pretreatment was insufficient and deposition process conducted so fast the coated layer fully cracked and separated from substrate.

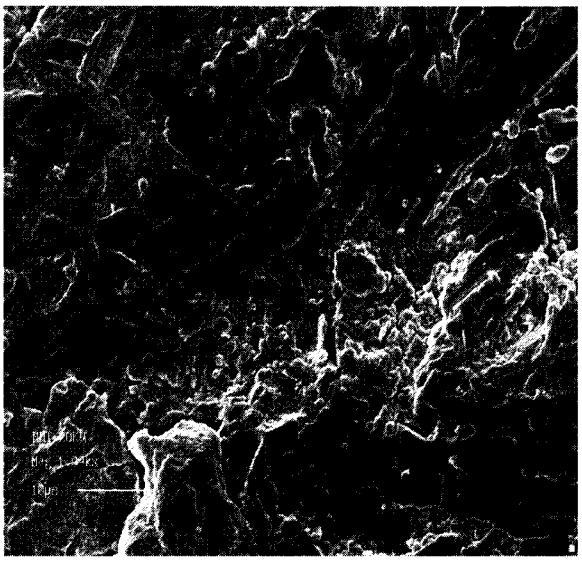

Fig. 1 Microstructure of Pt layer deposited by Ion beam sputtering on Ni-base superalloys substrate.

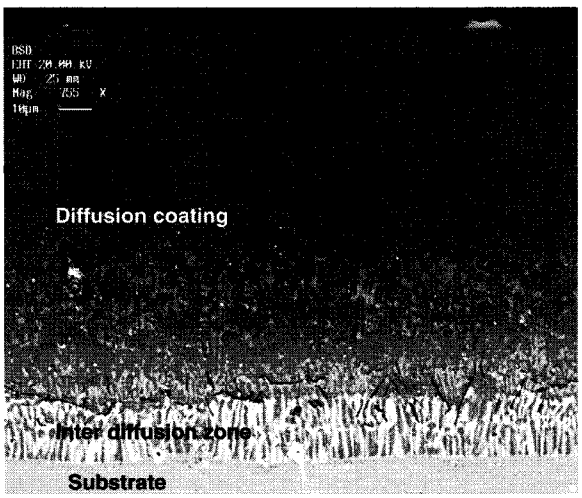

Fig. 2 Microstructure of Platinum-aluminide coatings treated by Ion beam sputtering and pack cementation.

3.2 Aluminum Coating and Diffusion Processes

In this study, the pack cementation and heat treatment method was applied for fabrication and diffusion of aluminum layer. The cross sectional microstructure of fabricated samples is shown in Fig. 2. In the Fig. 2 three areas appears: substrate, intermediate area and diffusion coating area. In the diffusion coating area the voids and two phases appear. EDS analysis exposed that these phases are mainly contain aluminum and platinum (may be as platinum aluminides) which similar to previous studies [1,3,5]. This structure fully matured after long-term heat treatment and it better characterized at Fig. 3. The inter diffusion zone has columnar like structure. EDS analysis revealed that this area contain more nickel and aluminum and according to previous results [3-5] its mainly nickel aluminde compounds.

These results confirmed by chemical composition variation of nickel, aluminum, platinum, chromium and cobalt through thickness of coating, which is been discovered by GDS. Analysis results are collected in

diagram at Fig. 4. In this diagram the variation of aluminum through platinum and substrate produced nickel aluminide and platinum aluminide coating This situation made by faster diffusion of aluminum than platinum in the coating layer. Because of the same result concentration of cobalt and nickel through thickness are also greater than platinum. Then fabrication of platinum layer by sputtering technique is not change the coating chemical morphology.

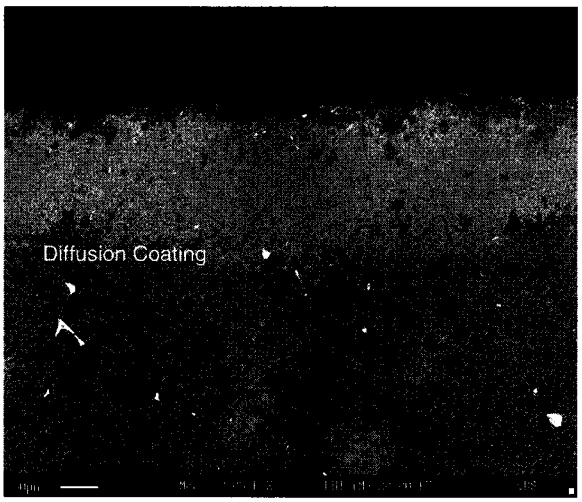

Fig. 3 Microstructure of platinum-aluminide coatings treated by Ion beam sputtering, pack cementation and final heat treatment (845 °C for 24 h).

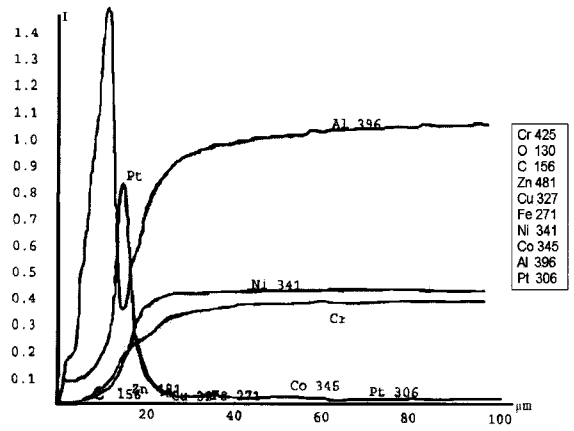

Fig. 4 Diffusion of elements through coating layer after heat-treatment by GDS.

4. Conclusion

1. Microstructure and chemical composition of Pt-Al alloy coating on Inconel 738 superalloy revealed that the application of such coatings by Ion beam sputtering is feasible.
2. The microstructure of samples discovered that they are mainly uniform, stable and adhere to surface. However, their properties can be improved by controlling some of the parameters involved.
3. Combination of SEM micrographs, EDS analysis of coating cross section and through thickness GDS analysis are very appropriate methods for fabrication of these coatings.
4. Because of slower diffusion characteristics of platinum atoms, morphology of fabricated coatings is same as the coatings produced by electroplating. But because sputtered coatings are made faster and more uniform than others, this method may improve adherence and quality of the coatings, and reduce the cost of coating process.

Acknowledgments

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Reference

[1] J.R. Nicholls, Journal of Metals **1**, 28 (2000).
[2] J.H. Sun, H.C. Jang and E. Chang, Surface and Coatings Technol. **11**, 195 (1994).
[3] P. Deb, D.H. Boone and T.F. Manley, J. Vac. Sci. Technol. **5**, 3366 (1987).
[4] P. Deb, D.H. Boone and R.J. Streiff, J. Vac. Sci. Technol. **3**, 2578 (1985).
[5] D. Vogel, L. Newman, P. Deb and D.H. Boone, Materials Science and Engineering **4**, 227 (1987).