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THE PLASMA-ASSISTED TiAlC SPECTRAL EMISSION SIGNAL CONTROLLING SYNTHESIS PROCESS

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INTRODUCTION

In the realm of practical applications of surface engineering, Methods of PA PVD plasma synthesis are counted among the most advanced. The most popular coating materials, exhibiting high wear resistance, are those constituted by phases such as CrN, TiN, TiCN, TiAlN and TiC. These are characterized by high hardness, low coefficient of friction and, in many cases, high corrosion resistance.

Research carried out at IMP has proven the possibility of formation of TiAlC – type coatings through plasma-chemical reactions taking place between ions and titanium particles, generated by a titanium electrode with metallo-organic substrates containing aluminium. Obtaining of coatings of complex composition of the TiAlN, TiCrN type calls for the application of specially designed segment electrodes, powder metallurgy or alloy, which act as the source of the metallic element. The amount of the metallic component entering the composition of the layer is limited and determined mainly by the composition of the metallic electrode.

The utilization of metalloorganic precursors in the PA PVD-arc method in order to obtain coatings of high hardness and resistant to oxidation at elevated temperatures is an original idea.

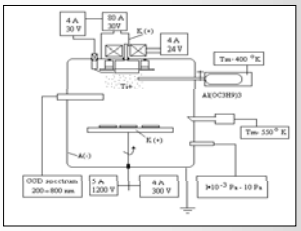
SYNTHESIS OF TiAlC

The synthesis of TiAlC coatings was carried out in plasma generated from low pressure arc discharge (80 A) on a titanium electrode of 65 mm diameter. Trimethyloaluminium was metered directly onto the surface of the titanium cathode. The pressure was maintained at the level of $5*10^{-2}$ [Pa].

Specimens of Armco iron and H13 grade steel were exposed to a plasma flux on a rotating stage, parallel to the surface of the titanium electrode, at a distance of 250 mm.

RESEARCH STAND

The research stand on which the experiments were carried out was a technological cell used for PA PVD-Arc processing, equipped with a source of low pressure, direct current arc discharge, a metering device for a metallo-organic medium and a Solar spectrographic measurement system. A diagram of the PA PVD-Arc technological cell and the design of the Solar spectrometer are shown in Fig. 1.



PA PVD-Arc technological cell

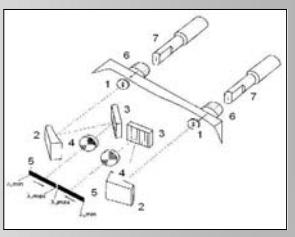


Diagram of Solar spectrometer

1 – entrance slits, 2- collimating mirrors, 3- diffraction gratings, 4- camera lences, 5 – focal planes of spectrographs, 6 – fiber optic holders, 7 – fiber optics

SPECTROGRAPHIC ANALYSIS OF REFERENCE PLASMA, GENERATED ON Ti AND Al

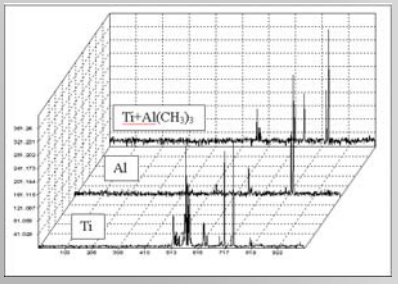
Spectral analysis of plasma formed by ions of titanium and Al $(CH_3)_3$ metered into that environment was preceded by investigations of plasma generated in conditions of low pressure (0.003 Pa) at Ti and Al electrodes.

The aim of these investigation was the distinction of characteristic spectrum lines fro titanium and aluminium that are recorded in the configured research system.

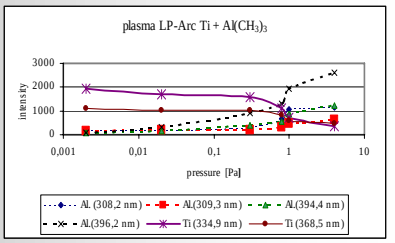
The recorded spectra of the plasma of Ti and Al ions contain a series of signals of varying intensity.

CONCLUSION

- There is a possibility of an approximate analysis of phenomena occurring in it, in particular of the process of generation of ions and excited particles.
- The high resolution of the analysis (2 nm) allows the distinction of spectral lines of the metallic elements analysed, i.e. Ti and Al, as well as bands of molecular and non-metallic components within the range of 200 – 900 nm.
- The spectrographic investigations of the plasma show that the composition of the plasma undergoes a change with the rise of pressure of reactive gases introduced into the zone of the arc discharge.
- With a rise of pressure a change is effected in the energy of plasma constituents.
- From the point of view of coating synthesis these may be undesirable processes because they may lead to a synthesis of stable molecules within the plasma.
- The proportions of metallic and non-metallic particles in the obtained phases depend on the concentration of metallo-organic components in the composition of the gaseous atmosphere introduced into the titanium plasma zone.



Compilation of spectrographic signals from titanium, aluminium plasma ions and from the plasma of $Ti+Al(CH_3)_3$



Variation of intensity of spectral lines from titanium and aluminium, depending on the pressure of the reactive atmosphere

The spectral signal from the $Ti+Al(CH_3)_3$ plasma contain ionic lines from titanium and excited aluminium, recorded earlier while recording the reference plasma of Ti and Al.

The intensity of the signal from the aluminium line varies, depending on the intensity of Trimethyloaluminium in the plasma.

The analysis of obtained spectrographic signals from the $Ti+Al(CH_3)_3$ plasma allows the statement that in a plasma formed from particles excited and ionized,

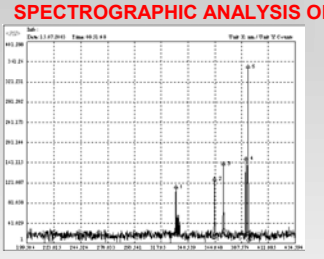
The qualitative analysis carried out shows that the intensity of the particular spectral lines of titanium and aluminium varies with the pressure of the reactive atmosphere.

SPECTROGRAPHIC ANALYSIS OF PLASMA OF LOW PRESSURE ARC DISCHARGE

Spectrographic diagnosis of the plasma spectrum enables the continuous monitoring of processes taking place in the plasma environment.

The analysis of spectral signals from the plasma allows the monitoring of physico-chemical processes taking place on the electrode surface, in the plasma space and on the substrate being coated.

SPECTROGRAPHIC ANALYSIS OF PLASMA GENERATED IN $Ti+Al(CH_3)_3$



Record of emission from spectrum of ions of plasma generated from $Ti+Al(CH_3)_3$

Peak number	Wave lenght [nm]	Intensity
1	333,801	113,000
2	368,457	129,000
3	375,782	159,000
4	394,094	170,000
5	395,817	353,000

Wavelengths and intensities of emitted signals

Acknowledgement: Research work funded from budget of the Minister of Scientific Research and Information, and carried out as part of Long Term Programme, entitled: "Perfection of Systems of Innovation Development in Production and Utilization for the Period of 2004-2008"

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