Ion source surface processing based on glow discharge in supersonic cross gas flow control

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Abstract. Surface treatment by glow discharge in a transverse gas flow provides a number of advantages over magnetron discharge. Sputtering target at lower pressures, which increases the purity of the deposited material. In addition, more uniform erosion of target and thickness of deposited coating. However is necessary to develop glow discharge control system in cross flow working gas, which allow to obtain products with desired characteristics.

1. Relevance
Requirements to quality indicators ion-plasma treatment of surfaces, such as sufficient adhesion, porosity, uniformity, cleanliness, chemical composition and thickness of the resulting layer, no defects on detail surface, mechanical properties, etc. with the development of technology increases.

To achieve desired purity and chemical composition necessary to reduce pressure in the chamber. This reduce concentration of working gas inclusions on the treated surface. For example, during the movement of target material in the vapor phase, impurities existing in the atmosphere of the chamber deposited with target material.

However, reducing chamber pressure reduces efficiency of glow discharge necessary for formation of ions, because increases voltage, with weak growth of current this leads to an unjustified waste of electricity, heat up the electrodes and, most importantly, overheating treated surface, which is unacceptable. And at pressures below 10-2 Torr discharge stops to burn.

There is fundamentally new solution to this problem [1, 2]. It is creation of zones with different concentrations of neutral particles in electrode gap. For example, in cathode area to create a high vacuum with a minimum concentration of neutral particles, which can provide a pumping system, and anode area to provide comparatively high concentration of neutral particles necessary for glow discharge implementation. Electrons in a region with a high concentration of neutral particles may experience tens collisions with neutral particles, while material processing at vacuum provided by pumping system. To satisfy this condition is necessary to create a continuous flow of the working gas particles in part of electrode gap and at the same time maintain vacuum in the discharge chamber lower than 0.5 Pa. To achieve this separation zones in the electrode gap may allow a continuous flow of gas. One type is the continuous stream of supersonic flow. Density of the gas pumped through the work area should provide more than a dozen of electron collisions with neutral particles, which will maintain glow discharge, providing chamber pressure below 0.5 Pa.

2. Results
This requires research possibility of technological parameters regulating in vacuum technology complex (VTC) (Table 1) [3]. Developed control system should ensure that the process parameters would automatically make better decisions based on information about the process. Reaching the stable quality of finished product, its cost is reduced and there is a possibility of its mass implementation. Analysis of technological surface treatment processes showed that control of process parameters and analysis of systems working capacity is difficult due to the of ultrafast processes in high-energy technology complex [1, 2]. Maintaining the stability of the process variables is possible due to system response in a short time. To do this, is necessary to identify the process parameters influencing the quality parameters of products, as well as equipment parameters influencing process parameters and bind them into a single technological complex (Figure 1).

Table 1 - Values of factors of units instability VTC, affecting quality of treatment.

| VTC units                  | Parameters                        | Factors affecting the stability of parameters                                                                 | Accuracy parameters |
|----------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|
| Cathode                   | Power                             | Voltage, current density                                                                                     | ±5%                 |
|                           | Density of plasma flow            | Electrode gap, sprayed material composition                                                                 | ±5%                 |
| Plasma distribution       | Permittivity                      | Composition of gas environment.                                                                            | ±2%                 |
| environment               |                                   |                                                                                                               |                     |
| Detail                    | Coefficient of thermal energy of the plasma conversion | Thermal material parameters.                                                                              | ±3%                 |
|                           | Dimensions and weight characteristics | Weight, shape, initial temperature of the surface.                                                            | ±0.5%               |
| Movement gears            | Movement speed, electromechanical drive characteristics | Supply voltage, moment of inertia                                                                          | ±5%                 |
| Control system            | Performance characteristics of units transfer functions | Accuracy approximation method                                                                            | ±3%                 |
|                           | System specifications             | Microprocessor bit depth, speed                                                                            | ±0.1%               |

Overall picture of the influence of factors of instability automatic control system (ACS) units of VTC on its parameters, based on the analysis of experimental results and patent information studies, is shown in Table 1 [3]. It should be considered as an aggregate structure of VTC units as a complex system, involved in surface treatment.

The main criterion for evaluating the quality and stability of process parameters serves uniform reflectance coating applied over the entire area of detail that speaks of uniformity (optical characteristics), desired thickness of coating and its chemical composition.

Optimal way of ASC VTC building, leading to stabilization of process quality indicators, is to stabilize the set value sensor readings [4], in this case, the reflection coefficient. Correlation between the parameters of VTK, process parameters and quality indicators is shown in Figure 1.

Therefore, the main task is to develop methods for measuring reflection coefficient and its stabilization by controlling parameters of units VTC.

To realize coating process with given parameters is necessary to make monitoring and control VTC parameters in real-time flow of process.
In these conditions is actual, on the one hand, calculation of optimal process parameters change, and on the other - development and research of ACS process [4] plasma spraying, based on the implementation of the combined control by introducing feedback informative process parameters [3], which will provide more efficient use of VTC.

3. Conclusion

Study of carried out by sputtering metals on material show the instability of the quality indicators of the process. Essential value in these play VTC parameters.

The main criterion for evaluating the quality of process parameter serves reflection coefficient of treated material. However, complexity of temperature measurement is related to screening zone of plasma torch interaction, to measure temperature of the plasma brightness, spectral pyrometer with polarization filtering used.

References

[1] A I Saifutdinov, B A Timerkaev, and B R Zalyaliev 2014 Control of glow discharge parameters using transverse supersonic gas flow - numerical experiment Journal of Physics: Conference Series 567 0120313

[2] B A Timerkaev, B R Zalyaliev 2014 Glow Discharge in a Transverse Supersonic Gas Flow at Low Pressures. High Temperature 52 No 4 pp 471–74

[3] D I Israphilov 2007 Management of A Plasma Technological Complex for Heat Treatment Ofparts with Specified Strength Characteristics

[4] I Sh Abdullin 2013 Analysis of the automatic control system of vacuum-sputter technology complex for consumer industry Vestnik KGTU No 24 pp 160-62.