Cleaning of a surface of details in plasma of the volume category between solid and liquid electrodes

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Abstract. Plasma electrothermal installation with the liquid cathode is developed. Cleaning modes from a surface of products are investigated and fulfilled.

1. Introduction

One of the main technological operations at production and restoration of worn-out details in mechanical engineering is operation of cleaning of a surface. The operation of cleaning of the surface of semiconductors should be carried out in instrument making and electronics. Cleaning [1; 2, 3, 4] defines quality and reliability of operation of the unit, increases its operational properties, and for marketable appearance.

2. Experimental plasma electrothermal installation with a liquid electrode for cleaning from the surface of products

Experimental plasma electrothermal installation is developed for optimization of process of cleaning with a liquid electrode [5; 6; 7; 8] (fig. 1). The bathtub is made of copper plates and has a cooling shirt. It is filled with researches electrolytes of necessary concentration. The bathtub is connected to one of power supply plugs. The top solid electrode joins other plug of a source. This electrode is established on the coordinate device, allowing to regulate interelectrode distances and on X, Y coordinates. As electrolyte were used NaCl, CuSO₄, NH₄NO₃.

Experimental installation is intended for research of an electric discharge in the range of the parameters Up =0,3 – 3000V, currents of I=0,01÷200 A, j =0,1 - 25 A/cm², interelectrode distances l = 0,1 – 100 mm. The cooling system of installation serves for electrolyte cooling. It comes from the high-level water supply system, and supply of electrolyte is carried out from a special tank.

Current passing through an electrolytic cell, in which the surface of anode is much less than at the cathode. At a small tension current passing in volume of solution is described by the Ohm law, and processes on electrodes is described by the Faraday's laws. The increase in tension leads to an electrolyte warming up mainly in an attached to anode zone as in it almost all resistance of an electrolytic cell is concentrated.

Transitions from one mode of passing of current to another happen through achievement of critical values of tension. For formation of a continuous steam-gas cover (fig. 2), at least unstable, it is necessary to provide allocation in an attached to anode zone of energy, sufficient for electrolyte boiling up in some volume.

For formation of a steam-gas cover it is necessary to heat the attached to anode layer of solution to a boiling point [9].
Voltamper characteristics of a cell are written down by means of the two-coordinate recorder PDP-4-002 when giving tension increasing on the linear law with a constant speed in the range from 1 to 30 V /s. Voltamper characteristics are presented in fig. 3. The received dependences were, as a rule, linear. In solutions of high concentration resistance of a cell is almost constantly in all range of tension (curves 1 and 2 in fig. 3).

Main contents and result of work

The received voltamper characteristics and calculations allow to develop plasma electrothermal installation for cleaning from the surface of products.

We offer process of cleaning of the surface of semiconductors, non-ferrous metals and steels by means of the plasma electrothermal installation (fig. 4), burning between the liquid cathode – 20 ÷ 25% - water solution NaCl and the solid anode shipped in it - a cleared product, methods of removal of agnails and fair processing.
Fig. 4. The block diagram of plasma electrothermal installation with a liquid electrode
1 - voltage stabilizer; 2 - interelectrode gap monitoring system; 3 - monitoring system of parameters of electrolyte; 4 - monitoring system of electric parameters of the category; 5 - exhaust ventilation; 6 - pump of pumping of electrolyte; 7 - the filter for purification of electrolyte; 8 - capacity with electrolyte; 9 - the pump of supply of electrolyte in an electrolytic bathtub; 10 - electrolytic bathtub; 11 - processed detail; 12 - the coordinating device; 13 - rectifier block; 14 transformer; 15 - tension regulator; 16 - detail fastening; 17 – counter of amount of electricity.

In this case at \( U > U_k \) where \( U_k \) - cathodic power failure, burns the high-voltage category in formed on the electrolyte surface to the steam-gas environment. This category consists of a set of microcategories in the colloidal environment with porous capillary structure. Our supervision showed that these microcategories clear the surface of semiconductors for 20-30 sec. (fig. 5), non-ferrous metals, such as copper, brass, bronze, aluminum during 30-40 sec.

Fig. 5. Cleaning of the surface of the semiconductor (germaniye, increase - x 180), time of processing \( T = 25 \) sec.
   a) - the raw surface;
   b) - the processed surface.

Fig. 6. Quality of surfaces after processing by category plasma with a liquid electrode. Pressure \( P = 10^5 \) Pa, electrolyte temperature =300K.

The most high-quality cleaning of surfaces is carried out if in NaCl solution are added the boric or lemon acids reducing a overalcalinity of electrolyte. It is especially important that size \( \text{pH} \) influences not only on the anode density of current \( j_a \), but also on the parameter \( R_s \) of a roughness of the surface.

Addition of sodium nitrate serve as inhibitor of corrosion and after processing the cleared surface becomes resistant. Category tension (\( \approx 120 \) V) practically does not influence on parameters of quality of the surface and the speed of cleaning of a detail. Density of anode current influences both on quality of processing and on processing duration. For example, for 20 sec. of processing of a detail current with a density of 1 A/cm\(^2\) with a depth of immersion of \( h = 0.5 \times 10^{-3} \), we received a roughness of the surface of the 8th class. The increase of current density to 3 A/cm\(^2\) (at duration of time of processing 15sec) allowed to improve quality of cleaning of the surface still. The surface roughness in accordance with GOST 2789 - 73 corresponded to a class 9-10 [10]. The further increase in density of current or processing time practically does not influence on the class of a roughness of the surface. Temperature of electrolyte influences on quality of the processed surface. Our researches showed that with increase in temperature of electrolyte productivity decreases. Therefore we cooled electrolyte by means of flowing tap water. In (fig. 6) there are results of researches of dependence of the \( R_s \) parameter of quality of the processed surfaces of details from copper M1 (a curve 1 are given at \( U = 120V \) and time of processing \( t = 40 \) sec) and steel chrome moly (25XHBA) (a curve 2, magnetowire steel, \( U = 90V, \ t = 60 \) sec.) at processing by the category with a liquid electrode.
(electrolyte 300K temperature) depending on current density in a solid electrode. It is visible that at increase in density of current more than 3÷4 A/cm² noticeable improvement of quality of surfaces it is not observed.

Methods of cleaning and fair processing raise a roughness class to 8÷10 [11], and diamond processing [12], polishing by paste, electrochemical processing [13] allow to reach the class of a roughness 13÷14. These methods not always are reliable, they are characterized by the low productivity, labor input and unevenness dross on edges, i.e. process of formation of geometrical characteristics of the surface is unhandy process.

3. Conclusion

The issue mechanism of conductivity of a steam-gas attached anode cover allows to explain the following experimental data and regularities:

- cleaning is reached only in solutions with rather high specific conductivity (over 0,05 Ohm⁻¹ . cm⁻¹) as the blanket of electrolyte has to contain necessary number of the ions providing an excess charge.
- limit temperature of cleaning (~ 800°C), excluding thermal reflex of steel products is connected with limited issue ability of boiling solution.
- experimentally observed sedimentation of components of solution on the surface of the anode is connected with issue in a steam-gas cover of ions of both signs with prevalence of the negative. Out of solution the interaction of ions of opposite signs will not be weakened any more by hydration that will lead to crystallization of nonvolatile components of solution. The crystallized connections will go to the atmosphere together with couples, will collect on the walls of a working chamber or will sink on the anode by a continuous layer.

4. References

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