

Dust particles of plasma of the vacuum arch - structure and properties

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Abstract. As a part of plasma of the arc category there are electrons, ions and particles, including drop fraction. On these signs it can be carried to dust plasma. In work the analysis of okolokatodny processes is presented in the arc category in the presence of the magnetic and electric fields influencing reversible nature of movement of a cathodic spot and a plasma stream as a whole. Results of element and granulometric composition of the black powders received from plasma of the arc category at dispersion of the titan, their magnetic properties are given.

1. Introduction. It is known that the metal drops leaving the cathode, intensively evaporate and turn into plasma educations already in close proximity to a cathode [1] surface. At drop movement in a plasma stream in it there can be a convective mass transfer, the drop is under pressure streams of ions and electrons, and in certain cases there is a rotation of drops and their destruction (explosion).

The processes proceeding in a cathodic spot and dust plasma at imposing of an external magnetic field, have identical character. The particular interest represents retrograde behavior of a cathodic spot when at a certain value of an external magnetic field the cathodic spot of a vacuum arch moves in opposite to Ampere force the direction [1-4]. Let's note that change of the direction of rotation of a cathodic spot – known long ago, but the phenomenon not learned up to the end.

Interest to behavior of a cathodic spot in externally magnetic field is connected with the similar behavior of dust plasma found in a number of works in a magnetic field [5-6]. The existence reasons at a dust granule of the magnetic moment - element structure and generation of the magnetic moment by superficial loopback current of the rotating loaded particle. It is established that depending on the size of a magnetic induction magnetic properties of dust plasma are defined by various factors. In a weaker magnetic field замагничена only electronic a plasma component, in average fields (0.1–0.3 T) ions, magnetized and only in strong fields (2–3 T) magnetized dust granules. In process of increase in an induction the stop of rotation of dust plasma with the subsequent change of its direction is possible. However the reason of threshold nature of emergence of rotation, as well as in case of the return movement of a cathodic spot, remains until the end of not clear [5-6].

2. Work purpose. Research of morphology, phase, element structure and distribution by the sizes melkodispersny the powder which has settled on walls of the vacuum camera at dispersion of the titanic cathode by an arc method. In work the element and granulometric composition of the black powders received from plasma of the arc category at dispersion of the titan in the atmosphere of reactionary gases was investigated. For the purpose of clarification of influence of magnetic and



electric fields on structure and properties, melkodispersny powders received at various operating modes of cathodic knot – the potential of a substrate and current of the focusing magnetic coil changed.

3. Receiving and research technique. Dust-like particles (fig. 1,2) were besieged on walls of the vacuum camera of the NNV-6 installation in the course of ion-plasma drawing multilayered film coverings on substrates (steel 12X18H10T). Technological modes of sedimentation: arch current – 75 A, shift potential –250 V, or 0 V (the anode camera walls were). At a warming up and ionic cleaning – 500-600 V. Material of the cathode – a titanic alloy of VT1-00. As carboniferous components the acetylene given to area of the arc category of titanic plasma in the ratio with nitrogen about 4:1 was used. Pressure of a mix of nitrogen and acetylene – 0,1 – 0,05 Pas. Adjustment of supply of gases in the conditions of dynamic vacuum was made by RPG-1/1 sensors with feedback with the vacuum gage. It provided rather stable pressure (within 10-2 Pas + - 15%) in the camera during time (20 min.) all process.

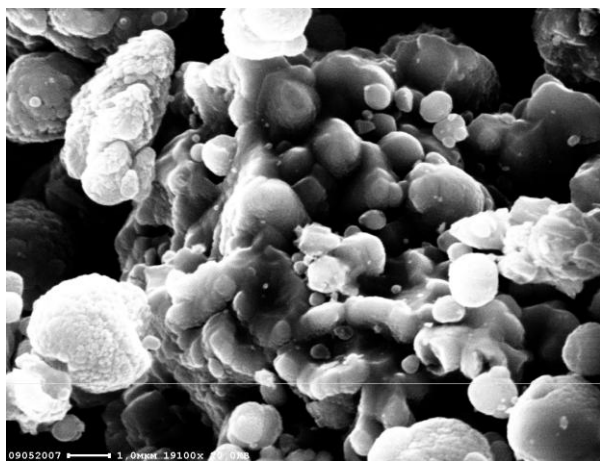


Fig. 1. Morphology of powder of magnetic fraction (x19 000)

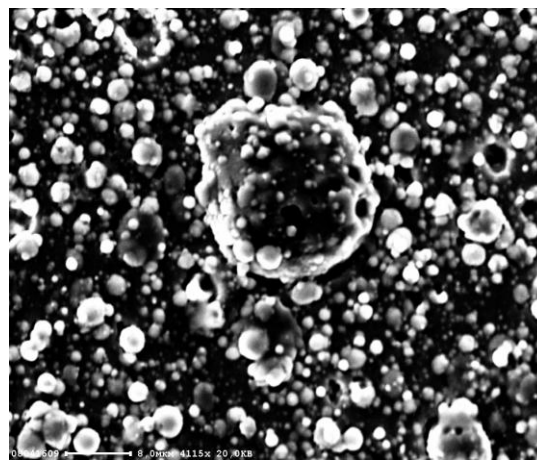


Fig. 2. Electronic microscopy of the condensed drop phase increase (x4115)

(Fraction less than 0.075 mm) extracted powder from walls of the vacuum camera the vacuum cleaner and subjected to magnetic separation in the field with intensity to 1000 E. Granulometriya of particles was made on the analyzer of the sizes of particles of Shimadzu SALD – 3101. Ranges of EPR were registered on a radio spectrometer of PS100X (frequency of 9.3 GHz). Microstructure and element structure investigated on a raster electronic microscope of LETI at an accelerating voltage of 20 kV.

4. Results. The dispersion of particles doesn't give the chance to determine by the sizes precisely magnetic properties, averaging them. It is known that for particles with small sizes jump of properties or their nonlinear dependence are characteristic at some size. The carried-out comparison of dispersion of the particles received at various operating modes of cathodic knot (interelectrode potential, current of the focusing coil) showed unequal nature of their distribution. For the particles collected from walls of the vacuum camera, distributions of type Gaussian, or described by decreasing sedate function are characteristic. The type of distribution depends, first of all from parameters of process of sedimentation. For example, the most characteristic type of distribution by the sizes of not magnetic particles for a mode with giving on a substrate of the potential of -250 V is shown in fig. 3. The sizes of the particles received at giving of potential on the submarine before magnetic separation, are in limits 5-100mkm. At sedimentation of particles without potential giving (the anode – walls of the vacuum camera) their main number is in limits of 70-130 microns.

EPR analysis - ranges showed (fig. 4) that powders are characterized by magnetic properties with various g-factors. Feature of a range of EPR of studied powders is its asymmetry. Let's note also that

with reduction of the sizes of fraction in a range of absorption there are additional lines. Magnetic separation also leads to emergence of new lines in a range of absorption by particles of the magnetic and low-magnetic fractions which aren't observed in an initial condition.

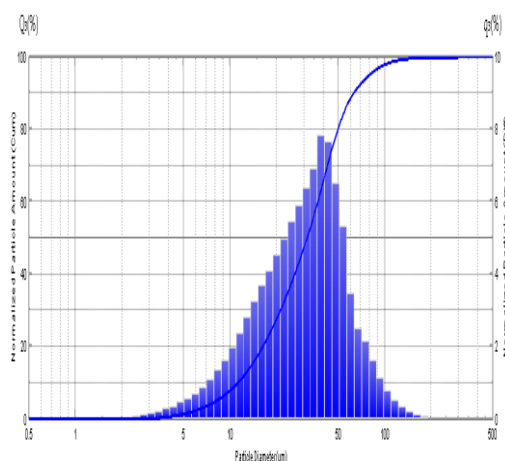


Fig. 3.распределены by the sizes of black particles (U=250 V)

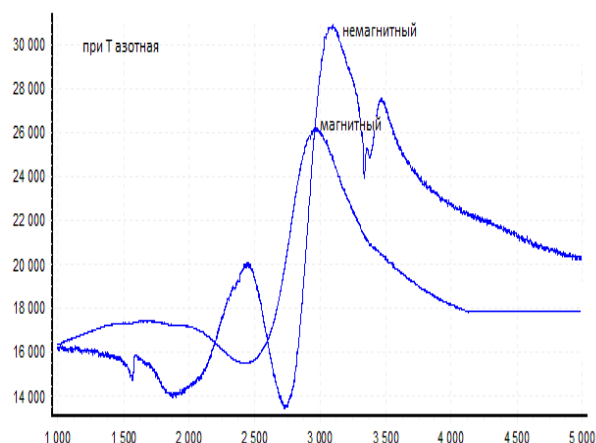


Fig. 4. EPR - ranges of powders at a nitric temperature

We considered possible mechanisms of evolution of dust plasma from a cathodic spot to its recombination on a substrate and walls of the vacuum camera in the conditions of simultaneous imposing of fields. Crystallization of a drop component of plasma and ionic streams on walls of the vacuum camera leads to education micro – and nanostructures, i.e. to manifestation of condensation of substance in wild spirits. Thus there can be structures of unknown modifications [7, 8]. In received structure from drops there are firm solutions and the "unusual" [8] crystal phases caused by nonequilibrium conditions of their receiving – with a fast speed of transition of couples liquid-crystal or steam - a crystal, with imposing E and N. Eto leads to nonequilibrium plasmochemical processes and formation of microstructures with a big free surface (see fig. 1,2).

5. Discussion and conclusions. On the basis of the conducted researches we drew a conclusion that studied melkodispersny powder can be considered as metallic structure, including in a look эндофуллеренов. The black structure can have variable element and multiphase structure (see tab. 1).

Tab. 1

Element composition of powders (with a potential of substrate of-250 V)

fraction	Element composition of powders, at. %					
	Ti	N	O	C	Fe	Cr
not magnetic	44.23	9.69	35.29	10.30	0.12	0.03
The magnetic	51.60	7.40	29.97	10.21	0.26	0.10

In condensate the reactionary gases forming difficult, even unknown hydrocarbonic connections, including with the titan are occluded. Structure germs probably are microdrops of Ti of the various sizes, arising in a cathodic spot and crystallizing then on walls of the vacuum camera in nonequilibrium conditions. The structure of powder can contain also elements of the substrate sprayed in the course of ionic cleaning. Dust particles can be divided into 2 groups. The first group - (slow) - is kept by a gasdynamic stopper and settles near the cathode and on substrates in the camera. The second - fast ions and the small drops formed in a cathodic spot at issue, create from the raised condition of nanostructure at fast (an adiabatic mode) coolings on walls of the vacuum camera. The question of mechanisms of paramagnetism of these microparticles is discussed.

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