Ion-plasma way of receiving strengthening heat reflecting anti-reflection coating

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Abstract. The ion-plasma deposition strengthening heat reflecting clarifying coatings is developed for plastic screens of means of individual protection. The method of magnetron sputtering are received strengthening coatings with integrated coefficient of a transmission in visible area of a range more than 96%.

1. Introduction
Acceleration of scientific and technical progress is accompanied by increase of risk of technogenic accidents at which there is an environmental pollution by highly toxic substances. Pollution of the soil, water and air causes significant economic damage. Elimination of consequences requires existence of the rescue services which employees have to be reliably protected from influence of harmful substances. The most well-tried remedies of protection at elimination of technogenic accidents are isolating suits which help with the prevention and elimination of consequences of technogenic accidents and natural cataclysms. In the isolating suits intended for work in harmful conditions, transparent plastic filters are applied.

Plastic screens made now insufficiently strong and in the conditions of hostile environment lose over time transparency. For prevention of it is necessary to put a sheeting on an external surface of plastic filters. The available means of individual protection (MIP) have a short resource of work because the filters, a part MIP, lose the properties under the influence of hostile environment. For increase in service life of protective suits production of the filters possessing a high resource of work in the conditions of aggressive environment is actual.

For hardening of plastic screens ion-plasma technologies are perspective. Plasma methods of drawing optical coverings [1-5] allow to strengthen the MIP plastic filters for work of staff of rescue services at elimination of consequences of technogenic accidents and natural cataclysms. The purpose of work is development of technology of plasma drawing strengthening heat reflecting anti-reflection coating for the MIP plastic screens.

2. Equipment and Methods
The unique UVN-70A-2 [3] stand was developed for deposition strengthening heat reflecting anti-reflection coating, with the automated complex of registration of parameters of plasma. The schematic diagram of installation of a high vacuum magnetron sputtering coating machine is given in figure 1. The following techniques and measuring equipment were applied to pilot studies of properties of the received strengthening coverings and their dependence on parameters of the abnormal smoldering category in the crossed electric and magnetic fields: measurements of spatial distribution of floating...
potential of electric field by a probe method, measurement of a magnetic field by a magnetic probe, temperature distribution by the hromel-kopelevy thermocouple, voltmeter of a direct current, ampermeter of a direct current, Hitachi 330 spectrophotometer, Phillips XL30 ESEM TMP scanning electronic microscope (SEM).

The system of pumping of the modernized vacuum UVN-70A-2 installation provides residual pressure in the vacuum camera of $6.5 \times 10^{-3}$ Pa and the subsequent operation of the magnetron with a pressure of working gas from 0.1 to 0.4 Pa. Into system of pumping enter: the pump vacuum lamellar and rotor NVR-16D, the pump vacuum diffusive N-400, a trap water-cooled. Deposition coatings is carried out by the magnetron sputtering system consisting of two identical magnetrons with replaceable cathodes therefore there is an opportunity to put difficult multilayered coverings in one running cycle. The system of gas supply includes cylinders with plasma-forming gases. Optical thickness of put layers are supervised by system of photometric control on change of intensity passing through a put coating and a transparent substrate of a ray of light.

Fig. 1 - Schematic diagram of high vacuum magnetron sputtering coating machine: 1 - vacuum camera; 2 - lateral covers; 3 - system of vacuum pumping; 4 - magnetrons; 5 - power supply; 6 - gas supply system; 7 - system of photometric control of thickness; 8 - system of rotation of substrates; 9 - processed details; 10 - heaters; 11 - observation ports; 12 - valve of start-up of air; 13 - manometrical sensor; 14 - the union of supply of cooling water; 15 - gate; 16 - high-voltage block of ionic cleaning; 17-high-voltage electrode of ionic cleaning

In the process of deposition coating the vacuum and parstially pressure of residual gases, temperature of substrates and evaporators, speed of rotation of substrates, tension on electrodes, digit current, specific capacity on a target, an induction of a magnetic field are controlled.

Key parameters of the discharge changed in the following limits: tension on the cathode $U$ changed from 375 to 600 V, category $P_p$ capacity from 0.6 to 6 KVI, distance from a magnetron l surface to a substrate from 0.1 to 0.2 m, pressure of working gas in a chamber $p$ was supported from 0.1 to 0.3 Pa, as a material of the cathode served copper, the titan and stainless steel, time of a dusting of t changed from 0.5 to 25 min., the size of an induction of a magnetic field $I_n$ changed discretely and made 0.02, 0.04 and 0.08 T, as plasma-forming gas served argon (consumption of gas $4.3 \times 10^{-4} \div 8.8 \times 10^{-7}$ kg / c) and an argon mix (consumption of gas $4.0 \times 10^{-4} \div 6.3 \times 10^{-7}$ kg/ c) with oxygen (consumption of gas $1.3 \times 10^{-4} \div 1.5 \times 10^{-7}$ kg/ c). Degree of a sparseness of a gas stream is defined by Knudsen's (Kn) number. For process of a dusting non-uniform on structure of coverings of $Kn \approx 0.1 \div 0.3$ that corresponds to a
molecular current of gas.

3. Results
Production of a coating carry out in the vacuum camera of the modernized vacuum installation UVN-70A-2. Formation on a transparent plastic product of a strengthening adhesive layer of oxide of the silicon, a heat reflecting layer of oxide of stannum and a clarifying layer of dioxide of silicon carry out magnetron sputtering in the environment of argon and oxygen. Before the room of a transparent plastic product in the vacuum camera it previously are cleared.

In the vacuum camera with a residual pressure of 2,6 10\(^{-3}\) Pa carry out an argon blousing up to the pressure of 0,2-0,3 Pa, then a transparent plastic product close the gate and light the discharge on the magnetron with a target from silicon for removal of an oxidic film from a target surface within 5 minutes of burning of the discharge then add oxygen up to the pressure of 0,1-0,3 Pa, further the gate clean and deposit on a transparent plastic substrate strengthening adhesive layer of oxide of silicon SiO\(_x\) with an optical thickness of (2,7 - 3,3)\(\lambda_0/4\), where \(\lambda_0 = 550\) nanometers. At a smaller thickness of a strengthening adhesive layer of oxide of silicon strength characteristics of a covering sharply decrease, at a bigger thickness optical properties worsen. On the end of formation on a transparent plastic substrate of a strengthening adhesive underlayer of oxide of silicon light the discharge on the magnetron with a target from stannum and on a surface of a strengthening adhesive underlayer of oxide of silicon form heat reflecting layer of oxide of stannum SnO\(_2\) with an optical thickness of (3,6 - 4,4)\(\lambda_0/4\). At a smaller thickness of a layer of oxide of tin the reflection coefficient in infrared area sharply decreases, at a bigger thickness optical properties worsen. On the end of formation of a heat reflecting layer of oxide of stannum light the discharge on the magnetron with a target from silicon and on a surface of heat reflecting oxide of stannum of a layer form clarifying layer of dioxide of SiO\(_2\) silicon with an optical thickness of (0,9 - 1,1)\(\lambda_0/4\). At thickness other than range optical properties of a coating worsen.

In fig. 2 the strengthening heat reflecting anti-reflection coating on the plastic substrate, received is schematically presented in the declared way: 1 – substrate (transparent plastic); 2 – strengthening adhesive layer of oxide of SiO\(_x\) silicon (1,5\(\leq\) x < 2,0); 3 – heat reflecting layer of oxide of SnO\(_2\) tin; 4 – anti-reflection coating of dioxide of SiO\(_2\) silicon.

In fig. 3 the range of a transmission of the strengthening heatreflecting anti-reflection coating received in the declared way, in visible area of a range is presented.

The method of magnetron sputtering are received strengthening heat reflecting protective coatings on polymeric substrates.

The coating possesses the highest 0-th group of mechanical durability on an abrasion on OST 3–1901–95 for transparent plastic products (maintains more than 3000 turns on SM-55), integrated coefficient of a transmission in visible area of a range (450-650 nanometers) more than 96% (figs. 3)
and reflection coefficient in visible area of a range (450-650 nanometers) less than 2%, reflection coefficient in infrared area of a range more than 80%. Moisture fastness of coverings corresponds to 1 group on OST 3–1901–95 (maintain influence of humidity of 98% at a temperature (98 + 2)°C within 10 days) and possess firmness in relation to chemically hostile environment.

Fig. 3 Spectral coefficient of transmission of a strengthening heat reflecting anti-reflection coating

4. Conclusion
The ion-plasma deposition techniques of multilayered functional coverings are developed for organic substrates, including strengthening heat reflecting anti-reflection coatings for transparent plastic products, for example, for screens of means of individual protection.

References
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