APPLICATION OF COATINGS ON INNER SURFACES OF METALLIC AND DIELECTRIC PIPES WITH THE USE OF HF -PLASMA SOURCE

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In a present activity the experimental results on application of metallic coating onto inner parts of various tools are presented. Plasma was generated by means of HF- source with low external magnetic field. The main characteristics of coatings dependent on operating conditions were investigated.

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INTRODUCTION

Ion-plasma deposition methods are widely used for strengthening of cutting tools and machinery parts. Methods based on arc and magnetron plasma sources have attracted considerable attention due to possibility of application of multi-layer and composite coatings [1,2]. Some difficulties can arise during application of coatings onto inner surfaces of tools, especially on tools having irregular geometry. In [3] there was proposed a method in which arc-plasma source and HF - field applied to the sample were used for the deposition of coatings. Utilization of HF - field allowed application of coatings onto dielectric materials. At present a number of experiments are focused on application of HF plasma sources for the deposition of coating on inner parts of tools that allowed to produce films without formation of droplets. For instance, plasma immersion ion implantation (PIII) methods are among them [4]. In the present activity the experimental surfaces of metallic and dielectric pipes with the use of HF plasma source are presented. At the basis of this method lies the dispersion of the cathode material with high energy ions of argon (Ar+) during creation of HF plasma in the weak magnetic field of up to 150 Gauss.

EXPERIMENTAL

The experimental scheme of the device used is shown in Fig.1. It consists of a vacuum chamber (1), which was evacuated to 10^{-5} Torr with the following working gas inlet with a required pressure of 10^{-2} Torr.

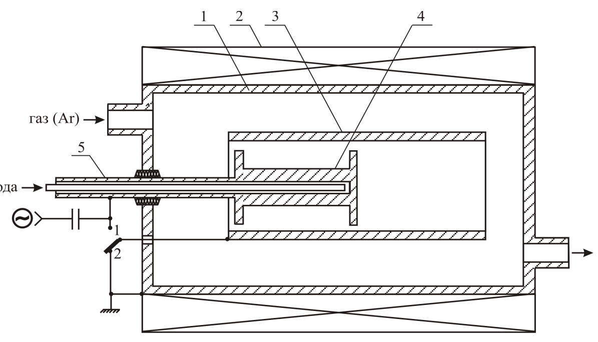


Fig.1. Scheme of the experimental device: 1 –chamber, 2 – focusing coil, 3 – substrate (metallic tube),4 – cathode (Al, Cu, Ti, stainless steel), 5 – cooled moving electrode

A cooled cylindrical cathode (4) with reflective elements placed on its ends made of different materials (Al, Cu, Ti, and stainless steel) served as a metallic plasma source. The cathode was supplied with a mechanism for longitudal displacement and fixed in a cylindrical pipe (3), made of stainless steels or titanium. External magnetic field was created with the help of magnetic coils (2). The presence of external magnetic field in such a device ensured drift and oscillatory motion of electrons and allowed to generate plasma within 10^{-1} – 10^{-4} Torr range of pressures.

Deposition was carried out onto glass and metallic samples placed inside a cylindrical pipe. For our first experiments we used a combined cooper and aluminum cathode.

Before the application of the coatings the samples were cleaned with HF- plasma so that HF-voltage was applied to cylindrical pipe during 5-10 minutes. The HF generator was operated at ≤ 3 kW and the frequency was 1-15 MHz. As it follows from the dependence of the dispersion of materials on the energy of ions Ar+ that in our case took place the effective dispersion of the cathode material (Cu, Al, stainless steel, Ti). Measured with the help of the thermocouple, the cathode temperature did not exceed 350ºC. Therefore, the flow of atoms was caused not by evaporation, but due to dispersion of the electrode material.

Fig.2 shows the measured temperatures of the central (sputtered) electrode and the internal cylinder as well as the cooling-down time after switching-off HF-voltage.

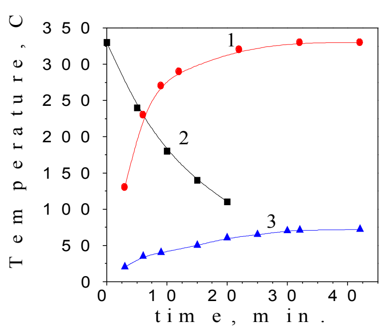


Fig.2. Time-temperature characteristics of the cooper target and the substrate: 1-heating of the cooper target during deposition (without target cooling) $P=3\cdot10^{-3}$ Torr $U=-1000$ V, 2 – cooling-down of the cooper target after deposition of coating, 3 – substrate heating during deposition of cooper $P=3\cdot10^{-3}$ Torr, $U=-1000$ V

The dependence of the coating thickness on the length of the glass plates placed inside a cylindrical pipe during operation with the cooper cathode is depicted in Fig.3.

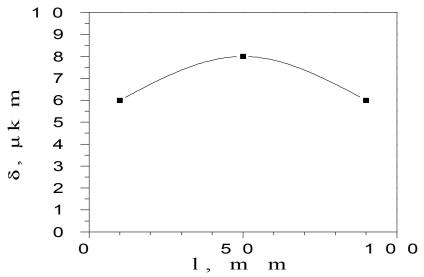
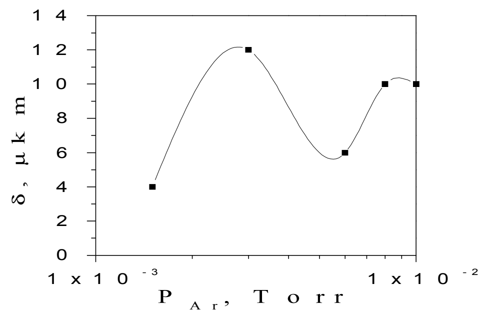


Fig.3. The changing of the coating thickness (Cu) on an inner surface of a cylinder within the limits of the target length (l)(target length 100 mm, cylinder diameter D = 45 mm)

Fig.4. shows the dependence of the coating thickness on the pressure. It is shown that the maximum thicknesses of the copper coating on glass plates correspond to two values of pressures. At low pressure takes place a more intense dispersion of the central electrode. The second maximum of the coating thickness at larger pressures may be connected with an increase of plasma density due to such a method of its creation.



3.

Fig.4. Dependence of the coating thickness on the Ar pressure D = 45 mm; P_{Ar}= 1,33 Pa; E_{CM}=-1000 V (target potential); deposition time 1,5 h

It should be noted that at low working gas pressure take place a decrease of the coating growth rate in some cases leading to a full stopping of deposition. This may happen not only due to the dispersion of the central electrode by a working gas flow but also because of dispersion of the inner surface of external cylinder and tools placed on it. The dependence of the growth rate of the coating of glass samples on the distance to the central electrode is shown in Fig.5. As it is seen from this figure the growth rate decreases with increasing the distance from the central electrode. The glass tubes coated inside wall by stainless steel is shown in Fig.6.

A number of experiments were carried out on dispersing of high-cutting steels with their following deposition onto samples made of titanium and glass. The obtained coatings were droplet-free, possessed good adhesion properties and were reproducible. Some glass samples coated with high-cutting steel had good adhesion and homogeneity. In most cases the pryout force of the coatings comprised 1.5 - 2.4 kg/mm^2. The similar adhesion properties were also observed for titanium samples coated with high-cutting steel.

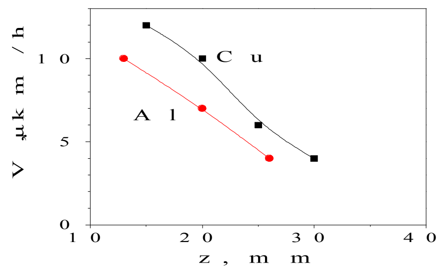


Fig.5. The dependence of the growth rate on the distance target-substrate z =R-r:
■ – Cu, $P_{Ar}=2\bullet10^{-2}$ Torr; E_{cm} = -1000 V
● – Al (alloy), $P_{Ar}=4\bullet10^{-3}$ Torr; E_{cm}= -700 V
R –radius of the inner surface of cylinder (Ti-substrate)
r – target radius (7,5 mm)

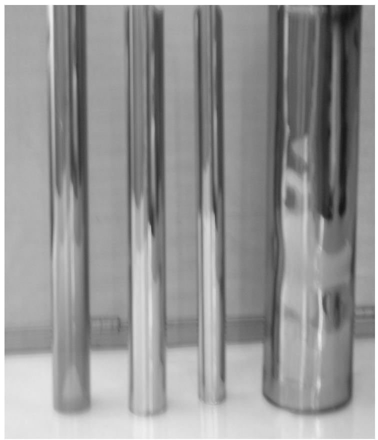


Fig.6. The glass tubes coated inside wall by stainless steel

CONCLUSIONS

1. There was developed a plasma-vacuum source on the base of HF-generator for the deposition of coatings onto inner parts of pipes.
2. Droplets-free coatings with good adhesion were obtained using dispersion of various materials (Cu,Al, Ti) and HF-generator.
2. The discharge parameters were optimized to obtain deposition rates compared with PVD.

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НАНЕСЕНИЕ ПОКРЫТИЙ НА ВНУТРЕННИЕ ПОВЕРХНОСТИ МЕТАЛЛИЧЕСКИХ И ДИЭЛЕКТРИЧЕСКИХ ТРУБ С ПРИМЕНЕНИЕМ ВЫСОКОЧАСТОТНОГО ПЛАЗМЕННОГО ИСТОЧНИКА

В.В. Гасилин, Ю.Н.Незовибатько, Г.С. Поклипач, В.С. Таран, О.М. Швец

Представлены результаты нанесения металлических покрытий на внутренние поверхности металлических и диэлектрических труб. Металлическая плазма создавалась при помощи высокочастотного источника с малым внешним магнитным полем. Исследованы основные характеристики покрытий в зависимости от условий оперируемого процесса.

НАНЕСЕННЯ ПОКРИТТЯ НА ВНУТРІШНІ ПОВЕРХНІ МЕТАЛЕВИХ І ДІЕЛЕКТРИЧНИХ ТРУБ З ВИКОРИСТАННЯМ ВИСОКОЧАСТОТНОГО ПЛАЗМОВОГО ДЖЕРЕЛА

В.В. Гасілін, Ю.М. Незавибатько, Г.С. Поклiпач, В.С. Таран, О.М. Швець.

Надані результати металевого нанесення покриття на внутрішні поверхні металевих і діелектричних труб. Металева плазма створювалась за допомогою високочастотного джерела з малим зовнішнім магнітним полем. Досліджені основні характеристики покриття в залежності від умов оперуємого процесу.