OPTIMIZATION OF THE PLASMA ELECTROSTATIC FILTER USING TAGUCHI METHOD

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We investigated the flow of carbon and metal vacuum arc plasma, produced in DC discharge with superimposed high-current arc pulses, through the electrostatic filter. The dependence of the filtering efficiency and the ion current of the plasma flow on the filter current, gas pressure, distance and tilt angle of the filter blinds was determined. The plan of the experiment was developed using Taguchi method and the conditions, which guarantee maximal cleaning efficiency at maximal plasma transmission through the filter were determined.
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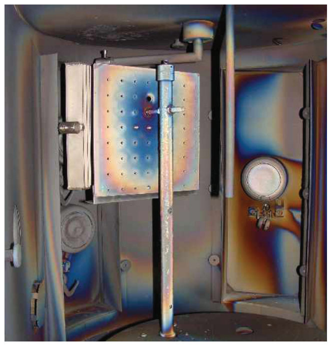
1. INTRODUCTION

One of the drawbacks of the vacuum-arc method is the presence in the plasma flow, and hence in the condensate, a significant content of the microparticles. Progressive development of the vacuum-arc method has led to new methods of deposition, one of which is DC vacuum-arc method with superimposed high-current arc pulses. Over the past decades various designs of the plasma filter to remove droplet phase from the plasma flows have been developed. The most common design is a curved filter with crossed electric and magnetic fields, providing the most complete filtering of the plasma. The use of such a construction of the filter is not always possible because of the design features of the specific vacuum-arc device. In our case, for cleaning plasma from the microdroplets, we proposed the construction of an electrostatic filter.

Three versions of the linear Venetian blind filter [1] were manufactured and investigated. Distances between the lamellae and their tilt angles were selected in each version so that there was no line of sight between the cathode and the substrate. Another structural feature of the developed constructions is the possibility to change the position of the filters. Fixings of the filters are located on two perpendicular sides, what allows to install a filter either with vertical or horizontal position of the lamellae. Moreover it is possible to apply in the experiments 1 to 3 filters with combined positions of lamellae (zigzag, twisted, etc.).

2. EXPERIMENTAL TECHNIQUES

Experiments were performed on an industrial vacuum-arc device C55CT made by the German company INOVAP GmbH for the deposition of DLC coatings. The cathodes (70 mm in diameter) were made from pure titanium and pure carbon, arc currents of I_{Ti} = 100 A, and I_C = 50 A were applied, the duration of each deposition experiment was t = 5 min. Without changing structural features of the vacuum-arc device, instead of the arc source shield and its rotary mechanism a water-cooled rotary vacuum pass was installed, which holds the electrostatic filter (Fig. 1). Three prototype filters were produced in the form of a square frame of the size of 210 × 210 mm in which the lamellae were installed at three distances between them of: 10, 15 and 20 mm.



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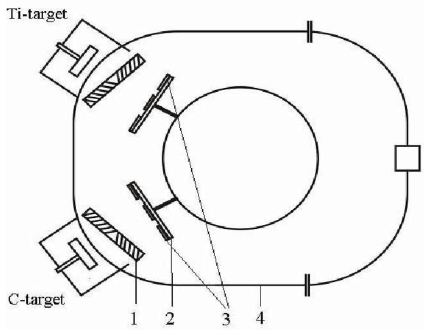

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Fig. 1. Experimental setting in the C55CT device: a) view of the chamber interior, b) pictorial scheme; 1-electrostatic filter, 2-ion current collector, 3-investigated samples, 4-vacuum chamber

The lamellae were installed in each filter so that there was no line of sight through the filter between the cathode and the substrate. The filter was fed by a separate DC source. The ion current and the efficiency of the plasma flow cleaning from the droplet phase were measured using the ion current collector of the size of 210 × 210 mm (identical as the filter size). Three investigated samples for each experiment were installed in the central horizontal zone of the surface of the ion current collector. As the substrates silicon wafers for carbon and glass plates for titanium of the size of 20×20 mm were used. During the experiment, a negative potential of (-100) V was applied to the ion current collector, and the distance between the collector surface and the cathode surface was 200 mm.

The measurement of the ion current was carried out using CIE CA60 mA clamp-meter (OBIAT Pty Ltd Australia). In the current measuring range of up to 60 A