Gaseous Thermionic Vacuum Arc (G-TVA) – a new method for carbon film deposition from evaporating liquids or gases

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The aim of this paper is to present the characterization of the carbon thin film deposited by Gaseous Thermionic Vacuum Arc, an extension of TVA (Thermionic Vacuum Arc) input materials from solid samples to gases and liquids for carbon thin film deposition. The shape of the discharge produced in gas using the newly proposed G-TVA technology is similar with those obtained in the case of TVA in the metal vapors.Characterization of the obtained DLC thin films has been made by Transmission Electron Microscop (TEM) with a magnification of 1,4 M and and resolution of 1,4 Å. Other techniques used were Grain Size Distribution and Selected Area Diffraction (SAED). Also, XPS spectra were performed.

1. Introduction

The extension of Thermionic Vacuum Arc technology to coatings using gases or evaporable liquids instead of solid materials is of great interest. This new type of discharge - Gaseous Thermionic Vacuum Arc (G-TVA) consists of a heated thermionic cathode (as in the case of TVA) while the anode is a disk type sintered powder piece tightly bounded to a stainless steel tubing connected adequately to the gas supply bottle.

A peculiarity of the G-TVA discharge is the critical value of the interelectrodic distance. Indeed, for small distances between electrodes, a cold cathode discharge can ignite. For distance higher than this critical distance we will have a real G-TVA discharge because only if the cathode is heated the discharge can ignite. In this case, the G-TVA discharge is sustained by the thermoelectron emission current from the cathode. The shape of the discharge produced in gas using the newly proposed G-TVA technology is similar with those obtained in the case of TVA in the metal vapors. Extended researches are necessary to compare all parameters of the two mentioned discharges. Also, we obtained carbon film deposited on glass samples mounted at different distances away from the G-TVA anode.

2. Experimental arrangement

This new type of discharge - Gaseous Thermionic Vacuum Arc (G-TVA) consists of a heated thermionic cathode (as in the case of TVA) while the anode is a disk type sintered powder piece tightly bounded to a stainless steel tubing connected adequately to the gas supply bottle.(Fig. 1)

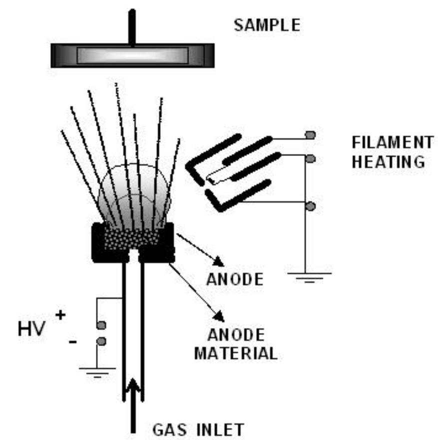

Fig. 1. Schematic configuration of the electrodes in the case of G-TVA

The anode consists from a stainless-steel pieces with a diameter of 16-25 mm, provided with a tubing necessary to connect this anode to an out vacuum chamber gas sources. Inside of the hole of the stainless steel piece is mounted a disk of sintered metal powder with an average size of 100 µm.

A leak valve is used to select the gas inlet flow and a manometer the pressure of the gas before entering in vacuum chamber. Due to the use of a sintered powder piece in construction of the anode, the coming gas flux to the anode is dispersed by the sintered powder. In this way the full surface of the anode is participating to the sustain of the uniform distributed plasma an anode surface.

In order to localize the arc discharge just around the electrodes, we established like in the case of TVA, a strong gradient of the gas from anode surface away. If the vacuum vessel is pumped down with a high speed and the gas flux through the sintered filter is low, we can limit the presence of the gas needed to ignite and sustain the discharge just around the electrodes. That means that a high enough pressure is maintained part around the anode fall, where the Paschen conditions for plasma ignition are fulfilled. A gradient pressure of two times of magnitude for the gas has been obtained (fig. 2) Away from to the anode the gas pressure as well as the gas residual gas density is low enough to avoid the plasma expansion.

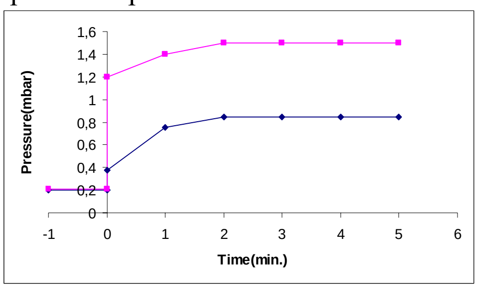

Fig.2. Time evolution of the pressure at the inlet of gases at the order of 1.2 torr.

I_{arc}(mA)	U_{arc} (V)	$I_{filament}$(A)	Interelectrodic distance (mm)
350	1600	25	5

Table I. Working conditions from the GTVA discharge

A peculiarity of the G-TVA discharge is the critical value of the interelectrodic distance. Indeed, for small distance, a cold cathode discharge can ignite.

For distance higher than this critical distance we will have a real G-TVA discharge because only if the cathode is heated the discharge can ignite. In this case, the G-TVA discharge is sustained by the thermoelectron emission current from the cathode. Further researches are necessary to establish all plasma parameters controlling G-TVA ignition and operation.

3. Results and discussion

We tested the ignition and the operation of the gaseous TVA diffusing through the sintered powder anode, a flux of CH_4 (sintering powder size: 0.006-0.009 clG, porosity 30 %)., at different anode sample distances (Table II), and the XPS (X-ray photoelectron spectrometry), showed a very interesting feature for all the samples.

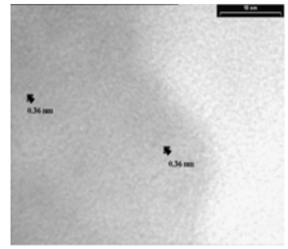

Fig 3 GTVA1-3 film TEM imagine Fig 4 Fringes of graphite planes

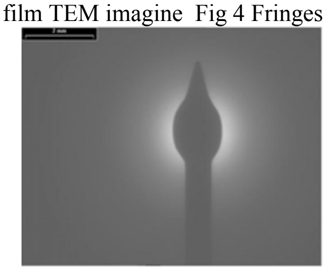

Fig.5. SAED image on GTVA

The obtained thin The obtained thin films are very smooth, with roughness under 5 nm, compact, with high adherence and well nanostructured.(Fig. 3)

Characterization of the obtained DLC thin films has been made by Transmission Electron Microscope (TEM) with a magnification of 1,4 M and resolution of 1,4 Å. (Fig. 4) Other techniques used were a Grain Size Distribution and Selected Area Diffraction (SAED). (Fig.5)

4. Conclusion

The shape of the discharge produced in gas using the newly proposed G-TVA technology is similar with those obtained in the case of TVA in the metal vapors. Extended researches are necessary to compare all parameters of the two mentioned discharges. Also, we obtained carbon film deposited on glass samples mounted at different distances away from the G-TVA anode. Obtained results confirm our initial hypothesis that G-TVA might be an useful tool for high quality thin film depositions.

5. References

[1] G.Musa, I.Mustata, V.Ciupina, R.Vladoiu, G.Prodan, E.Vasile, H.Ehrich, *Diamond and Related Materials*, 13, (2004),1398.

[2] T.Akan, N.Ekem, S.Pat, R.Vladoiu, and G.Musa, *Journal of Optoelectronics and Advanced Materials*, 7, (2005), 2489.

[3] G. Musa, H. Ehrich, M. Mausbac, *J Vac Sci and Techn*., A12, 2887-2895 (1994).

[4] G.Musa, I. Mustata, A.Popescu, H.Ehrich, J.Schumann, *Thin Solid Films*, 333, 95-102(1998).

[5] G.Musa, C. Surdu Bob, C.P.Lungu, V.Ciupina, R. Vladoiu, J.Optoel. Adv M, 4, (2007)