EFFECT OF THE NATURE OF THE REACTOR WALL MATERIAL ON MORPHOLOGY AND STRUCTURE OF PRODUCTS RESULTED FROM ARC GRAPHITE SPUTTERING

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Introduction

In spite of the great attention that scientists give to the processes occurring in the reactor for fullerene synthesis [1-23], many problems have not been solved yet.

Every experimental work, called to answer one or another question, induces more questions than gives answers.

The investigation presented is brought about by the consideration of some processes occurring in the gas phase and on the surface of the solid being in the reaction zone.

Experiments performed are called to answer the question about the effect that the nature of solid has on the structure and morphology of products formed on its surface.

Experimental

The work presented seeks to verify the hypothesis about the influence that the nature of substrate exerts on the structure and morphology of the nanostructural carbon layer formed.

The arc vacuum plasmo-chemical apparatus was used in the experiment. The reactor diameter was 1500 mm. The cores from MPG-7 graphite were used as a source for carbon vapor. The cores were 800 mm in length and had 9x9 mm cross-section. Graphite was evaporated under He pressure about 0.5 at and at the following arc parameters: current of 180 A and voltage of 26 V.

The temperature of the external reactor wall was kept constant (about 25-30 ^{o}C) due to the temperature-controlling water-cooled jacket. As the anode was consumed, the cathode was moved along the reactor axis.

The special, inserted inside the reactor, cage was designed (Fig.1) to resolve the problem posed. 9 specimens of foils from different metals (Ti, Fe, Cu, Al, W, manganin, stainless steel, Ni, Mo) were radially fixed in this cage. The graphite evaporated core was equidistant from all the specimens. This provided equal experimental conditions for all 9 specimens studied.

The core was evaporated for 3 h. Then the cage was removed from the reactor. The layers formed on the specimen surface were studied using TEM and SEM.

Electron-microscopic investigations were performed on the T-90 electron scanning microscope and the electron transmission microscope.

Results and discussion

In the course of synthesis the out-growth called deposit forms on the permanent electrode. It consists of multi-wall carbon nanotubes and some amount of graphitized mass. This product forms from charged particles which move under action of the electromagnetic field formed by electrodes at the temperature above 2000 ^{o}C (Fig.1). As deposit grows and remains conductor, its structure forms in such a way that its ohmic resistance remains minimum.

In the course of the arc graphite evaporation the gase phase with T>2000K breaks loose from the arc zone at the velocity about 20-25 m/c and reaches the reactor wall for $3.5 \cdot 10^{-3}$c. Within this time a number of reactions may occur: firstly, this is formation of fullerenes and onions; when the gase phase contains catalyst, the single-wall carbon nanotubes and other nanostructures may form.

When the vapor phase reaches the wall, nanostructures like tubes may also grow in the carbon layer.

Microscopic investigations revealed that layers on different metals differ by both the surface morphology and by their structure in the layer depth (Fig.2a,b,c). The sponge layer forms on the Fe specimen. The slightly marked double-stage layer (vapor and some particles go through the upper sponge layer and thicken in the second one) is observed on copper. The brightly marked two-ply layer forms on the surface of the Ti specimen. In this case vapor and particles also go through the upper sponge layer, thicken in the second one and form monolith. The processes underlying this effect require further investigations. Fig.2 shows morphology of the surface of the layers formed.

Nanostructural investigations of the synthesis products which are part of the layer formed were performed using transmission electron microscopy. It was revealed that besides different carbon nanoclusters of indefinite form, layers contained nanotubes.

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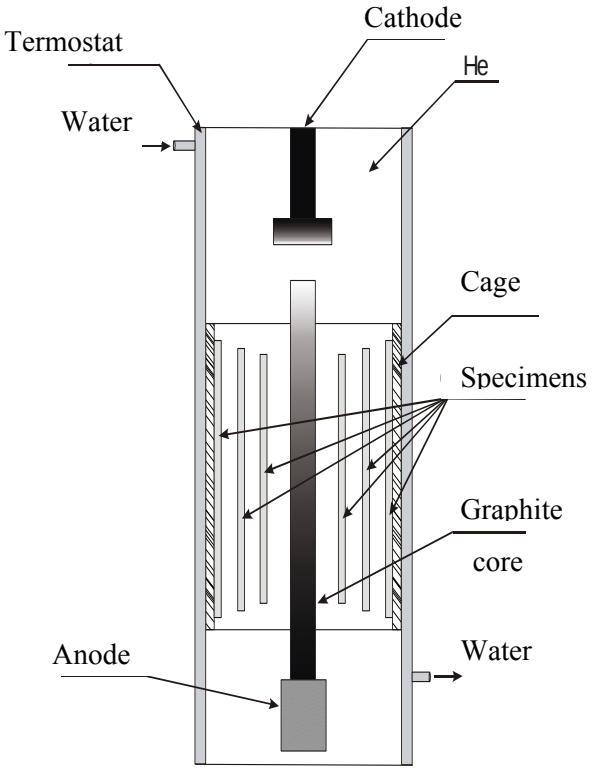

Fig. 1

Within each specimen tubes show equal geometric structure, but they may differ by size. However, in each metal the layer contains tubes with the individual structure inherent only the tubes formed only on this metal (Fig.3 a,b,c). Their structure strongly differ from that usually observed in the stainless steel reactors after synthesis of these materials (Fig.3, b).

Conclusions

In the course of the work it has been found that the nature of the substrate metal affects both morphology of the nanostructural carbon layer formed and the form and the structure of the carbon nanotubes which are part of these layers.

Apparently, being over the metal surface, vapors of substrate metals have a special effect on carbon vapor.

All mentioned above require further additional investigations.

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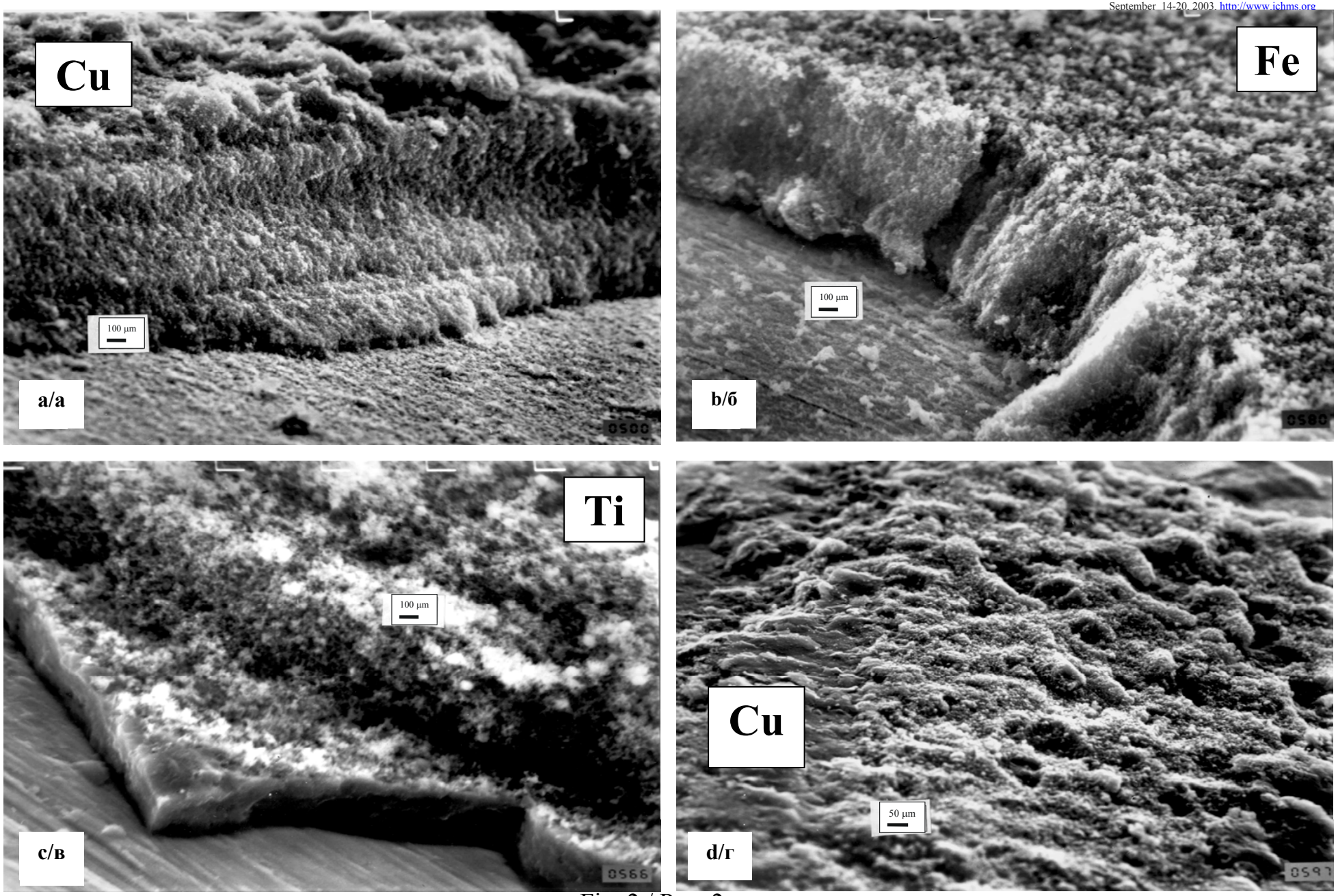

Fig. 2 / Рис. 2

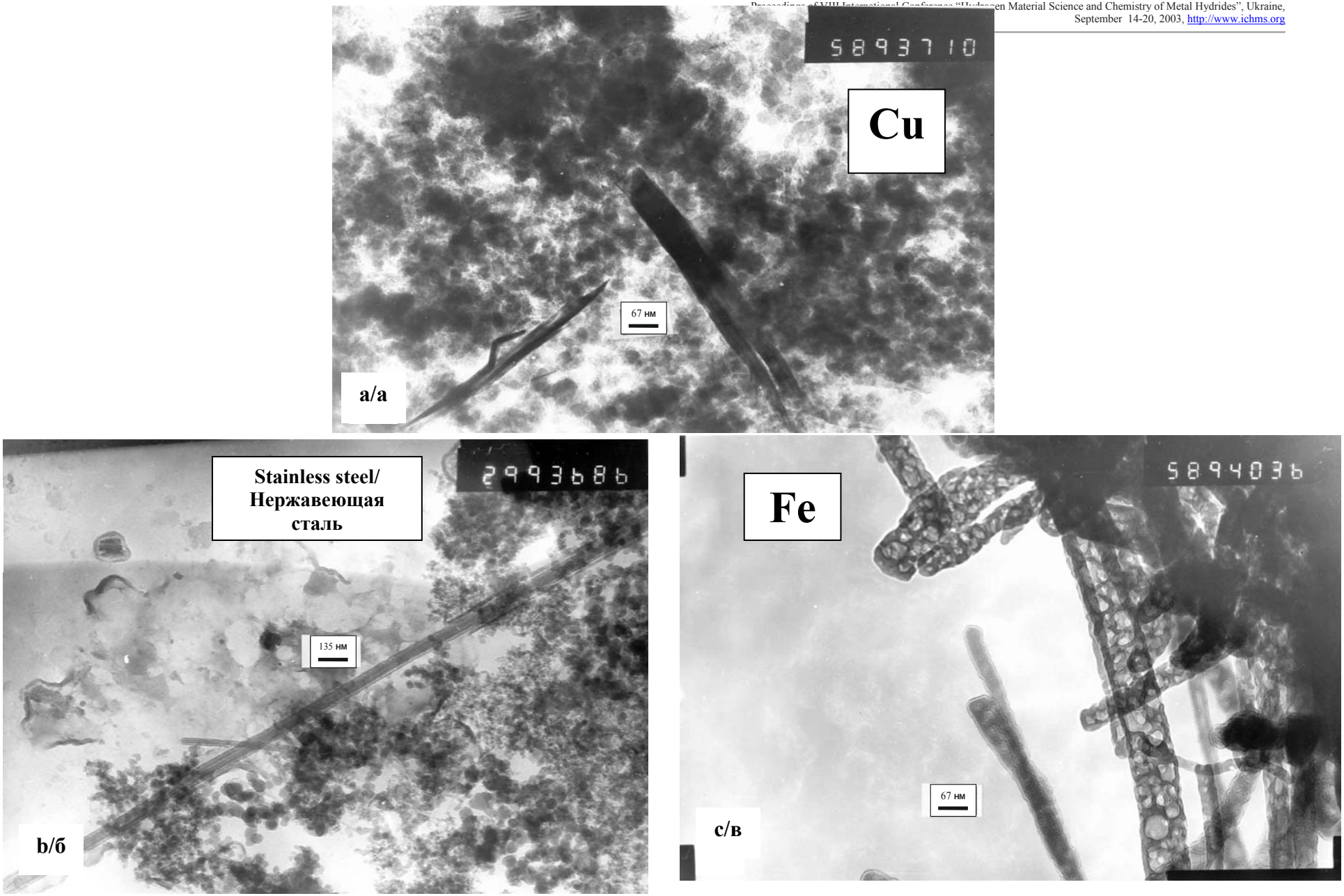
Cu
67 нм
a/a
Stainless steel/
Нержавеющая
сталь
135 нм
b/б
Fe
67 нм
c/в

Fig. 3 / Рис. 3