THE PROCEDURE OF THIN FULLERENE FILMS DEPOSITION ON ZIRCONIUM SUBSTRATES

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Introduction

The problem of a rise of strength characteristics for thermal fuel elements (heat emitting elements or tvel in Russian) covers is serious enough. This raises the question of preparing carbides on their surface having regard to phase transitions in zirconium matrix, and production of multiphase defensive film seems to be realistic.

The results of the technology development of fullerene films preparing on zirconium substrate by electrochemical method are given in this paper.

Results and discussion

Thin films are deposited on zirconium substrates by electrochemical method from solutions of fullerenes in hydrocarbon solvents, particularly, in toluene. For this purpose two electrodes cell with the working volume up to 40 ml was used. Constant-current source allowed to vary potentials difference between electrodes in the range from 1 to 2000V and current strength - from 0 to 1mA. Electric conductance of fullerene solution in toluene (TF solution) was provided by ethanol introduction in solution. Volume relation between toluene and ethanol was 6:1.

Fullerenes used for solutions preparing were extracted from soot produced by the arc-discharge method, and consisted of fullerites C_{60} (base),C_{70} and minor amounts of high order fullerites. According to XRD data initial fullerite had FCC lattice. Concentration of fullerenes in a solution corresponded to 2,8 mg/ml.

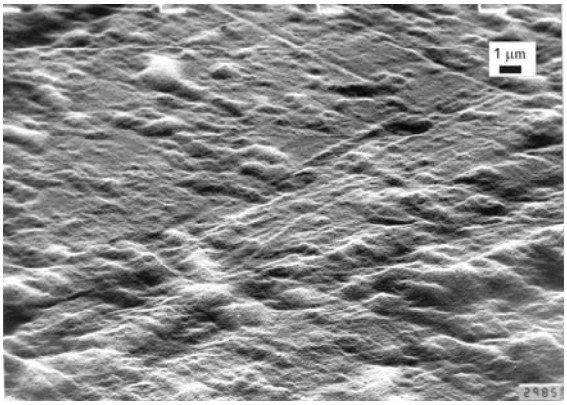
Nickel was used as electrode material. Working area of electrodes was 10x10 mm^2. The distance between electrodes was fixed and equal to 5 mm.

Zirconium substrates of sizes about 3x8 mm^2 sizes were mounted on one of the Ni electrodes, scilicet on Ni-anode. Zirconium substrates themselves had the shape of a cylinder which was cut along its axis. Before an experiment zirconium substrates and Ni electrodes were polished mechanically and degreased. Solution of fullerenes in toluene was filtered before work using filter paper.

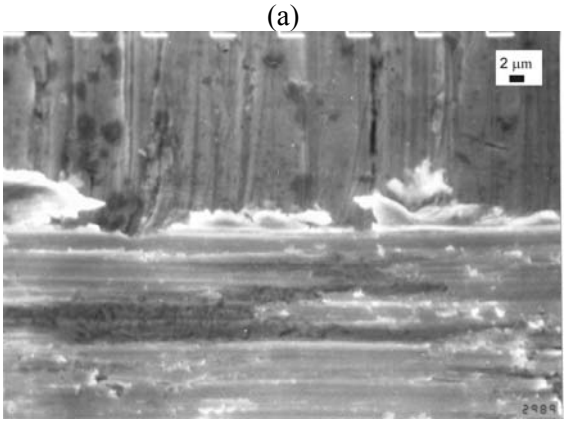
Electrodeposition of thin fullerene films on zirconium substrates was carried out under constant potential difference between electrodes and various electric current density. Depth of films could be changed due to the varying regimes of fullerene electrodeposition on zirconium substrates.

Regimes of thin fullerene films electrodeposition on zirconium substrates for four samples are given below:

1) U = 600 V, I_0 = 0,41 mA, I_f = 0,15 mA, ΔI = 0,26 mA, Δt = 40 min. The solution is fresh-prepared, 8 experiments, Zr-substrate was mounted by aluminum foil on the Ni-anode. Zr-substrate was not washed by ethanol after an experiment (Fig.1).



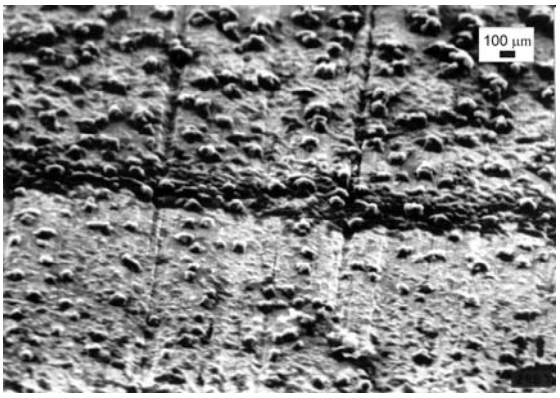
(a)



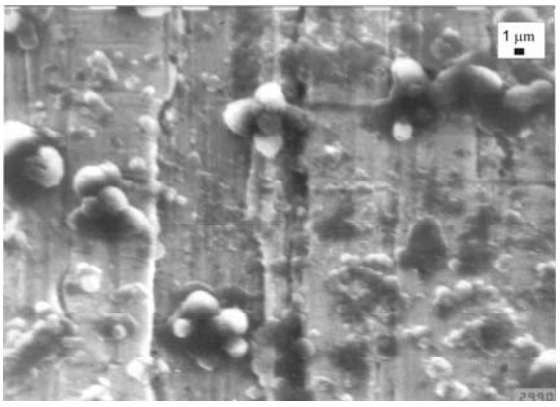
(b)

Fig.1. Fullerene films produced by technology "1": a) overall view; b) trace of mechanical action.

2) U = 1000 V, I_0 = 0,58 mA, I_f = 0,22 mA, ΔI = 0,36 mA, Δt = 30 min. The solution is fresh-prepared, 9 experiments, Zr-substrate was mounted by aluminum foil on Ni-anode analogously to the first sample. Zr-substrate was not washed by ethanol after an experiment (Fig.2).



(a)



(b)

Fig.2. Fullerene films produced by technology "2": a) overall view; b) fullerite crystals.

3) The solution was taken from the first experiment and was filtered. U = 1000 V, I_0 = 0,44 mA, I_f = 0,21 mA, ΔI = 0,23 mA, Δt = 25 min. The sample was washed by ethanol after the experiment (Fig.3).

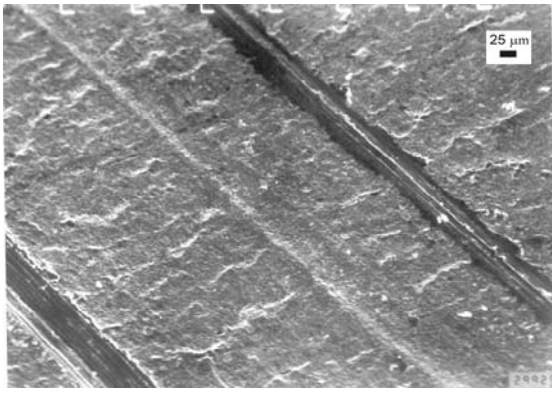


Fig.3. Fullerene films produced by technology "3" (trace of mechanical action).

4) The solution was taken from the second experiment and was filtered. U = 800 V, I_0 = 0,35 mA, I_f = 0,21 mA, ΔI = 0,14 mA, Δt = 45 min. Film was formed on both sides. The film was washed in ethanol (Fig.4).

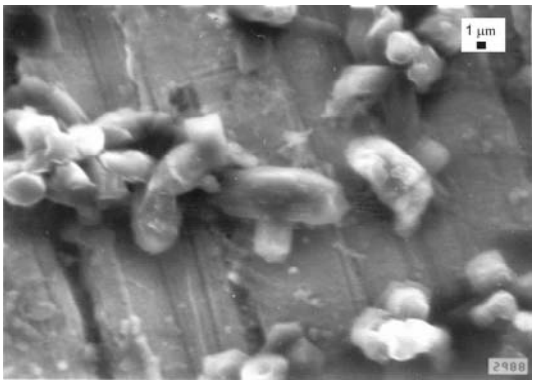


Fig.4. Fullerene films produced by technology "4" (fullerite crystals).

The first and the third regimes of fullerene films deposition on zirconium substrate are optimal, as can be seen from Figs. 1-4. Under these conditions fullerite is distributed at the surface as thin film with good adhesion, and this film is not broken off during mechanical action, the large-scale crystals of fullerite, shown in Figures 2,b and 4, are absent.

Conclusions

The regimes of thin homogeneous fullerene films deposition on zirconium substrate by the electrochemical method have been tested.

Acknowledgement

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