

NEW TECHNIQUE OF FIELD EMISSION CATHODES PREPARATION BY LOW TEMPERATURE DEPOSITION FROM ETHANOL VAPOR

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Introduction

Process of chemical vapor deposition (CVD) is one of the most effective methods for preparation of flat emission cathodes. This method allows to produce different carbon structures on the cathode substrate. Depending on conditions of deposition, derivable carbon surface can be diamond-like films [1], amorphous graphite [2], various carbon constitutions, including carbon nanotubes [3]. Investigation results of field emission properties produced cathodes have shown this is a promising technology for production Field Emission Display (FED).

Majority of CVD technology require high temperature, making it impossible to use vacuum glass, as a substrate. Therefore one of the goals in research of production efficient flat emission cathodes is development of a low temperature synthesis technique.

Field emission cathodes described in this paper were produced by means of low temperature chemical vapor deposition method of carbon nanotubes from ethanol vapor. The substrate temperature during the deposition was 500 °C. This paper summarizes research results of prepared field emission cathodes.

Experiment

Low temperature chemical vapor deposition from ethanol was used for production of the samples. Selective deposition of carbon nanotubes took place under low temperature due to pyrolysis of ethanol vapor. Heating of substrate and pyrolysis of reagent vapor was done by a graphite heater, which was placed inside reactionary space. The temperature of heater was varied in the range 1300 – 2200 °C. The substrate temperature was about 500 °C. Further description of this technology can be found in paper [4].

The substrate was usual 1.1 mm glass with sputtered aluminium layer. Ni was used as a catalyst. For optimization of cathode surface topography, three types of samples were prepared,

with different catalyst distribution on the substrate. Catalyst layer in the first sample was uniform sputtered Ni layer. In the second and the third samples, the catalyst sputtering was produced through screens with 1 mm и 50 µm holes correspondingly. The distance between holes compared with the twice island diameter. The total area of each cathode sample was about 0.5 cm².

Prepared cathode samples were tested in a diode structure. The glass plate with sputtered ITO layer was used as an anode. The distance between anode and cathode was setting by glass spacers and equals 200 µm. During the experiment the pressure of residual gas in the vacuum chamber was less than 3×10^{-7} Torr.

The special measuring bench was used for the investigation of cathodes field emission properties. This equipment allow to measure emission current from 0 to 1 mA with step 0.3 µA, voltage from 0 to 10 kV with step 2.3 V. Error of measurements does not exceed 1%.

Field emission cathodes were examined in the long duration mode for 10 hours under fixed value of current 50 µA. The test objective was in stabilization of the emission current value by means of the high-voltage power supply. During the experiment measurements of voltage, supplied on equipment, and emission were performed every second.

Results and discussion

Current voltage characteristic of examined samples before and after 10 hours of long duration test are shown on Figures 1 and 2 respectively.

From diagrams on the Fig. 2 it is obviously, that the least threshold voltage (voltage needed for emission current is 1 µA) is 650 V for the sample with islands of nanotubes with diameter 50 µm. For the second and third samples the threshold voltage is higher 1100 V. This difference in the value voltage can be explained by the more optimal topography of surface the third cathode. The developed structure allows getting the additional amplification of the electrical field on

edges of islands.

On Fig. 3 the graphs of the voltage-time dependencies are given for each of the samples. From this figure it is obviously that the samples with 50 μm islands subjected to degradation not observed with other samples.

Calculation of the current density, collected from samples, has shown that the current density of third type of samples is highest. The degradation of the cathode with islands of nanotubes with diameter 50 μm can be explained by the higher current on the emission centers.

Conclusions

Our experiment has demonstrated the possibility of the carbon nanotubes synthesis by low temperature (substrate temperature was 500°C) vapor deposition method from the ethanol vapor. Field emission samples were produced with different catalyst distribution on the substrate surface.

The field emission properties investigation has revealed that the cathodes with islands of nanotubes with diameter 50 μm have the best emission characteristics.

The results of cathodes stability investigation presented, that under current density, collected from cathode, less than 80 $\mu\text{A}/\text{cm}^2$, the tested cathodes are subjected unsubstantial changes of emission properties.

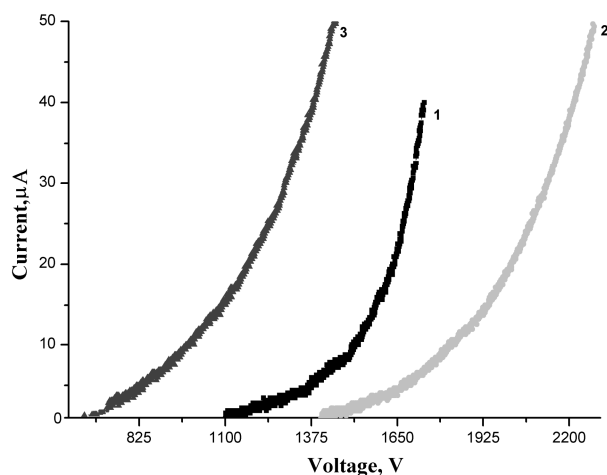


Fig. 1. Current voltage characteristic before long duration test: 1 – sample with uniform layer of CNT, 2 – sample with islands of nanotubes with diameter 1 mm, 3 – sample with islands of nanotubes with diameter 50 μm

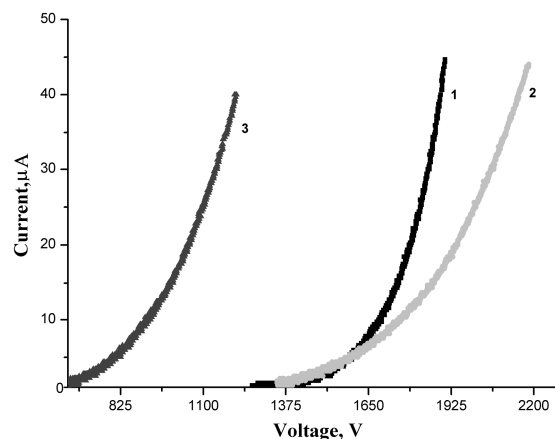


Fig. 2. Current voltage characteristic after long duration test: 1 – sample with uniform layer of CNT, 2 – sample with islands of nanotubes with diameter 1 mm, 3 – sample with islands of nanotubes with diameter 50 μm

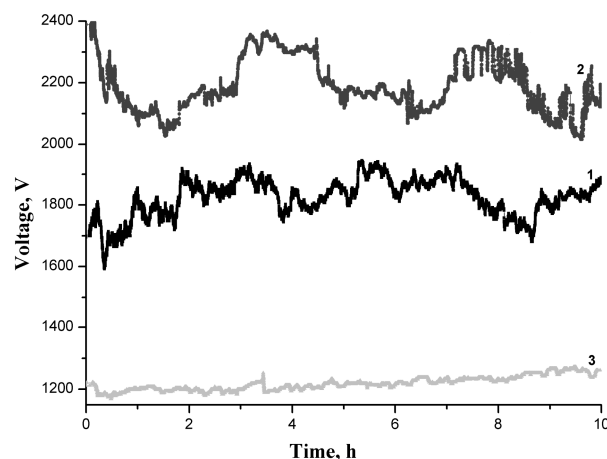


Fig. 3. Voltage time dependencies.

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