Local carbon nanotubes growth in porous anodic aluminum oxide

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Technology of growth carbon nanotube (CNT) on porous aluminum oxide membrane for cold electron emitting devices was investigated.

Porous Al_2O_3 substrate was used as template for high oriented and patterned CNT growth. Porous Al_2O_3 was formed on aluminum foil or evaporated film. Al was anodized in 0.3M oxalic acid solutions and 0.1M H_3PO_3 acid solutions to form pores with 50 and 150 nm of diameter respectively. Then Co or Ni as catalyst were deposited by electroplating or vacuum evaporation processes on the one side porous Al_2O_3 membranes. The thickness of so prepared aluminum oxide membranes (AOM) was about 30 – 40 μm.

In contrast to [1, 2], the growth of CNTs on porous Al_2O_3 substrates was performed by MWPACVD method in $CH_4 + H_2$ working gas mixture.

The first step of growing was heating the samples to the growth temperature in hydrogen plasma during 10-15 minutes. The deposition conditions were: total gas pressure about 80 Torr, gas flow – 10 liter/hour, CH_4 flow rate: 14 –16%, microwave power 400 W. Substrate temperature at the end of 10 minute growing process was about 800^0 C, as measured by optical pyrometer. After deposition, the plasma was extinguished and samples were cooled to room temperature under a flow of hydrogen.
During the deposition period the negative bias voltage about 100 V was applied to the samples holder, the bias current was about 5 mA.

It was found, that CNT growth takes place in both direction from catalyst layer – as inside membranes as well as outside it. The condition of CNT protruding through the AOM, the shape and height of CNT tips on the other side of the AOM, the effect of biasing on aligned growth CNT are investigated. In particular was found out, that under certain condition of deposition, the protruded CNT tips may have a conical shape, which is of specific interest in terms of field emission efficiency this material.

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References:

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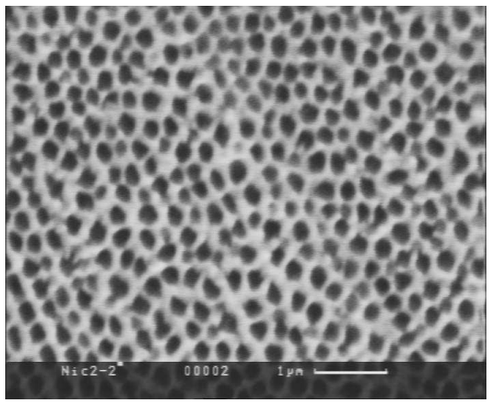

Fig.1. The view of the porous aluminum oxide membrane surface.

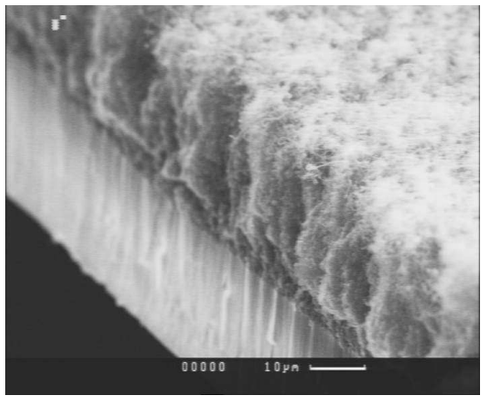

Fig.2. The disordered CNT growth on Ni covered porous aluminum oxide membrane without biasing.

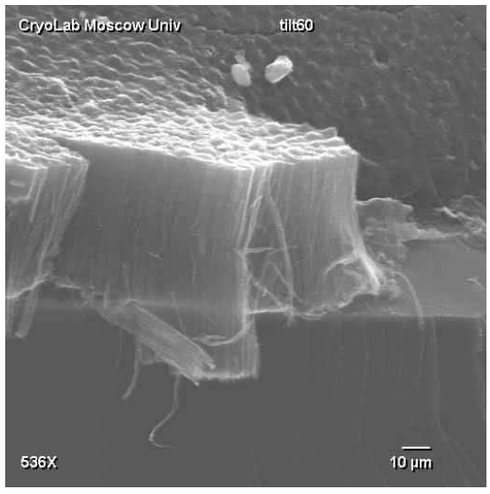

Fig.3. The aligned CNT growth with negative bias, applied to substrate holder.