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Transmission Electron Microscopy Study of the Influence of Catalyst Deposition Techniques on the State of Catalytic Nanoparticles and Carbon Nanotubes

I.I. Khodos[(1)*], Yu.A. Kasumov[(1)], V.T. Volkov[(1)], V.N. Matveev[(1)]

(1) Institute of Microelectronics Technology, RAS, 142432, Chernogolovka, Moscow region, Russia, e-mail: khodos@iptm.ru

* Corresponding author.

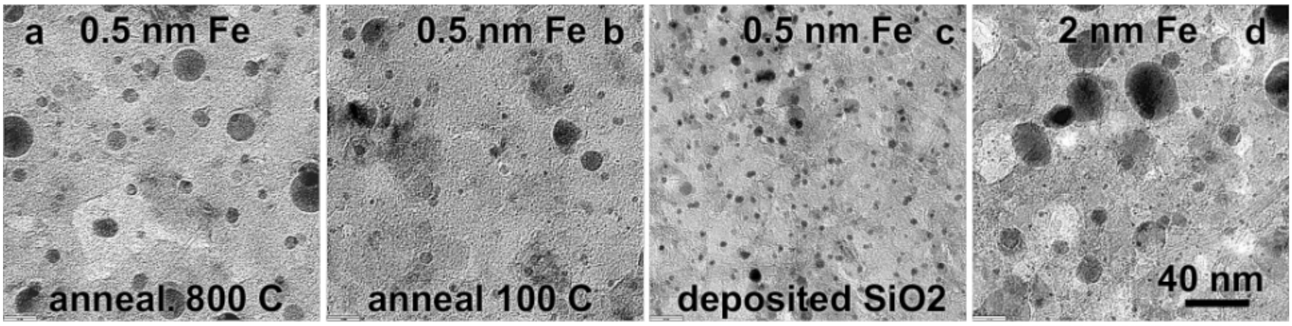
Abstract – Carbon nanotubes have been synthesized by a single burst chemical vapor deposition technique [1] on thin SiO_2 membranes transparent for direct transmission electron microscopy (TEM) observation. Various techniques were employed for catalyst preparation. The influence of these techniques on the size and the state of the catalytic nanoparticles and carbon nanostructures synthesized over these particles is studied by TEM.

It is known that diameter of nanotube depends on diameter of a catalytic particle on which this nanotube has grown [2]. By means of various methods of deposition and processing of the catalytic particles (for example, annealing) it is possible to vary their diameter distribution.

The catalyst (Fe) and a metal intermediate layer (10 nm thick Al film [3]) were deposited on SiO_2 membranes produced by thermal oxidation of silicon, or deposition of SiO_2 layer on a NaCl crystal (subsequently dissolved) by electron beam evaporation. Catalyst deposition has been executed in two ways: electron beam evaporation and rf-sputtering. The islanded catalytic Fe film of 0.5 nm and 2 nm in thickness was deposited. After the catalyst deposition samples were annealed in the vacuum furnace at the temperatures of 100^oC and 800^oC. Growth of nanotubes was carried by a method of single injection of acetylene [1] at pressure of 2.5 mbar at temperature 950^oC.

Observations revealed that such parameters as catalytic particle size, and density, carbon nanotube type and diameter, and even amorphous carbon coating of nanotubes and nanoparticles depend on catalyst deposition technique.

As a result of comparison of the obtained data it has been established that the narrowest diameter distribution of catalytic particles (fig.1), and, accordingly, nanotube diameters is observed in case of deposition of 0.5 nm Fe/Al bilayer using electron beam evaporation onto membranes from deposited SiO_2 and the subsequent annealing at 100^oC.



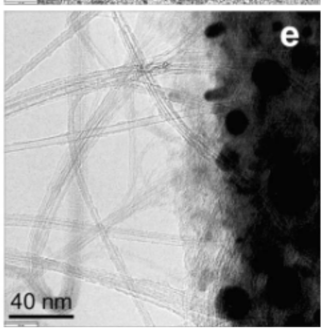


Figure 1: TEM image of Fe particles on alumina over thin SiO_2 membranes after synthesis of carbon nanotubes, **a)** 0.5 nm Fe film on a membrane from thermally grown SiO_2, annealing before synthesis at 800 C; **b)** 0.5 nm Fe, thermally grown SiO_2, annealing at 100 C; **c)** 0.5 nm Fe on a membrane from SiO_2 deposited by electron beam evaporation, annealing at 100 C; **d)** 2 nm Fe, deposited SiO_2, annealing at 100 C; **e)** single-walled carbon nanotubes synthesized on a sample **(d)**.

References

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