Toroidal modification of carbon nanotubes

Kondrashov V.A.*, Nevolin V.K.

Moscow Institute of Electronic Technology, 124498, Zelenograd, Russia
**e-mail: kondrashovva@mail.ru*

At the moment, carbon nanotubes (CNTs) are widely known and widespread material that is used in various industries such as construction, engineering, electronics, space technologies. For their realization are used different nanotubes, multiwall and singlewall, of different length and diameter. In this paper we explore another type of carbon nanotubes, rolled into a torus shaped ring. Such nanotubes may possess unique electrical and magnetic properties, such as weakly damped ring currents which generate significant diamagnetism.

Three approaches of CNTs modification are considered: ultrasonic treatment, exposure to magnetic fields and modification by spark. All these options imply that the change will occur with carbon nanotubes which have already prepared in another process. Research of the material, obtained by these methods, is carried out by atomic-force and high-resolution scanning electron microscopy.

Ultrasonic treatment of carbon nanotubes is an oxidizing environment. Since the cavitation bubbles appear on the inhomogeneities in the bulk of liquid, the bubbles will be formed near the CNTs, which lead to their flexion, by the impact of capillary forces on CNTs due to collapsing bubble. The size of obtained CNT torus was 500-1000 nm in diameter and 10 nm thickness.

In fact the impact of the magnetic field is the same way as the first modification. Carbon nanotubes are in an oxidizing environment and are subjected to ultrasonic treatment and the impact of external rotating magnetic field. There are some publications about the application of a magnetic field for separation of carbon nanotubes, so we can suggest that CNTs will rotate in the field, as a rotor induction motor does. The size was 500 nm in diameter and 5 nm thickness.

There is the third of methods of CNTs modification. When spark discharge is going through the carbon containing gas and catalyst particles (Fe, Ni, Co), carbon nanotubes are growing. Such catalyst particles will rotate in an electromagnetic field of the discharge, thus the growth of ring shaped nanotubes will start. The size of the CNT torus was 200 nm in diameter and 12 nm thickness.

There is the possibility to combine these methods to increase the quantity of the material. Thus it is proposed to produce a spark discharge (28 kV, 190 Hz) in a carbon-containing dielectric liquid (2-propanol) with a solution of carbon nanotubes. Due to discharge it will be observed the effect of cavitation which is mixing of CNTs in solution. The discharge will evaporate and ionize a liquid, releasing free carbon which will create a reducing environment. Due to the discharge CNT will be activated for twisting by the spark field and/or external magnetic field, which will lead to the folding and stitching the ends of carbon nanotubes by free carbon. Expected size will near 80 nm in diameter and 3 nm.

Thus, we have developed three approaches to obtain toroidal carbon nanotubes and have shown how to combine these methods at one process.