Small-sized X-ray tube with the carbon nanotube field electron emitter

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The usage of field electron emitters with carbon nanotubes in vacuum electron devices instead of traditional thermoionic emitters allows to simplify the construction of the devices and to improve their characteristics. In particular it becomes possible to decrease the power supply and to diminish the turn on time.

We manufactured a prototype of an X-ray tube with the carbon nanotube field emitter and demonstrated its stable operation. The X-ray tube is a glass device 50 mm long and 16 mm in diameter. The device consists of a field electron emitter with carbon nanotubes grown on a nickel foil 5 mm in diameter, a thin semitransparent grid, placed at the distance of 300 μm from the emitter, a tungsten target (anode) and a beryllium window. This device is characterized by the anode current of 300 μA and the anode voltage of 10 kV. Carbon nanotubes have been grown by CVD method using products of thermal decomposition of polyethylene as the carbon source. Electron microscopy investigations have shown that the grown carbon layer consisted of nonoriented nanotubes 10 – 50 nm in diameter and about 10 μm long.

Long time tests of the prototype of X-ray tubes with field electron emitter were fulfilled during one month by switching the device on about 2-3 hours a day. In the course of these tests we have been measuring the value of the grid voltage V_g at which the emitter current was about $I_e \approx 500\mu A$. This current corresponded to the anode current $I_a \approx 300\mu A$. For the best sample the initial grid voltage was equal to $V_{go}=1375V$. During first 10 hours of the operation the grid voltage increased up to $V_g=1550V$, and then was stable during the next 42 hours of operation. So we observed the stable operation of the X-ray device prototype.

Elaborated X-ray tube may be used in electronics industry (integral circuits production), medical imaging, X-ray fluorescence, diffraction and spectroscopy.