Measurements of X-rays from Nanotubes and Nanorods

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INTRODUCTION

A nanostructure-based X-ray cancer treatment device does not currently exist. To demonstrate the feasibility of X-ray production, we performed several preliminary experiments recently to measure X-rays using nanotube and nanorod samples [1,2]. The X-ray production is based on electron "field emission" cold cathode principle. These experiments were carried out to demonstrate the feasibility of using novel nano-emitters as a cold cathode in the X-ray source design.

MATERIALS AND METHODS

The configuration of the experiments is shown in Fig. 1. A nanotube or nanorod sample was placed about 1 cm away from a metal target (copper or lead). An electric potential of 15,000 Volts was supplied from a converter to the nano sample and the copper target such that the field electrons are emitted from the nano sample and accelerated toward the copper target. The maximum high voltage current available by the power supply was 15 microamperes. An Amptek CdTe X-ray detector (not shown in the figure) was placed outside the window. During these experiments the pressure in the vacuum chamber was kept at about 10^{-5} Torr.

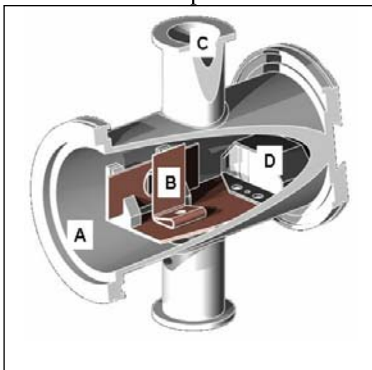

Fig. 1. Vacuum chamber (A) for measuring X-ray from a nano sample behind a metal target (B) through a window (C). A 15k volts of electric potential was supplied by a converter (D).

RESULTS

These preliminary experiments tested four nanostructure samples. The first sample was fabricated using silver paint to attach the nanotubes to a copper substrate. The target in that experiment was the lead instead of copper. The second sample was fabricated with nanotubes grown directly onto an inconel (metallic) substrate to improve electric conduction at the interface between the nanotubes and the substrate. Fig. 2 compares the measured X-ray spectra for these two samples. The significant difference in the X-ray output indicated that a good contact of the nanotubes with the metallic substrate is very important for X-ray production. To test the stability of the system, X-ray intensity was recorded as a function of time.

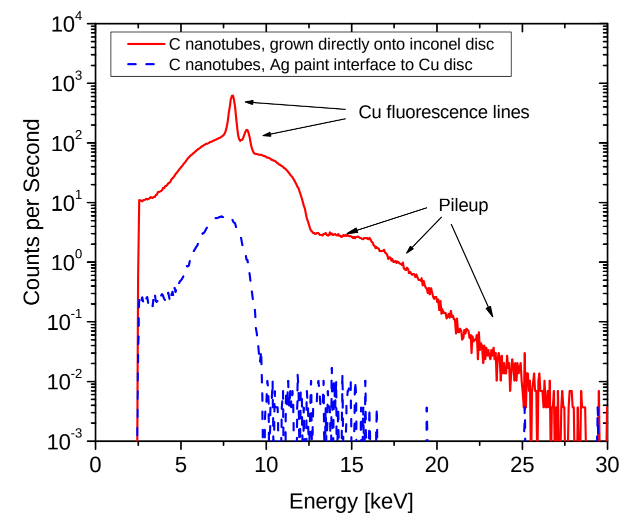

Fig. 2. X-ray spectra from two fabrication methods.

We observed about 15% fluctuation in the production rate possibly caused by voltage breakdowns (arcing and sparking) in the vacuum system—an issue needs to be addressed in the future. The third sample was a 500-nm long and 4-nm diameter carbon nanoroad sample grown on a copper disk. The X-ray spectrum measured from this sample indicated a good initial X-ray production but followed by a rapid degradation of the carbon nanoroads 1000 seconds into the operation. X-ray production experiments were also performed using tungsten nanorods which gave results similar to those of carbon nanorods. SEM images taken before and after the experiments provided evidence that the nanorods were damaged during the experiment, causing the field emission and X-ray production to halt. We believe that the failure is a result of non-uniformity of the tips and electron current was drawn from only a selective number of tips that carry a huge load.

In summary, these preliminary experiments suggest that the X-rays produced from both nanotubes and nanorods are useful for radiation treatment and imaging of cancer. They also identified key issues to be closely investigated in the future including the efficiency and stability of X-ray production.

REFERENCES

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2. Singh JP, Tang F, Karabacak T, Lu TM, Wang GQ. "Enhanced cold field emission from <100> oriented -W nanoemitters". J. Vac. Sci. Technol. B 22, 1048. 2004.