

Potential Applications Of Nanotechnology In Radiation Oncology

Otto Zhou, S Chang, Y Cheng, J Zhang
University of North Carolina at Chapel Hill
Chapel Hill, NC, US

Lay language version of paper WE-C20A-3
Wednesday, August 13, 2003, 10:20 AM
45th Annual AAPM Meeting, San Diego

Since the development of the first x-ray imaging devices more than 100 years ago, the basic technology of X-ray production has changed very little. X-ray-producing electrons are generated by heating a metallic filament to more than 1500 degrees Celsius, and the electrons are "boiled off" of the hot filament, much like vapor from boiling water. The electrons are then accelerated by a high electric field and bombard a heavy metal target to produce X-rays. These electron sources are slow in response time, high in energy consumption, and limited in lifetime.

Early in 2002 we demonstrated for the first time that carbon nanotubes (CNT), a new form of carbon discovered only a decade ago, can generate electrons at room temperature that produce diagnostic quality and intensity X-rays (Figure 1). CNTs are very strong tubular structures formed from a single layer of carbon atoms rolled into a tube billionth of a meter in diameter (Figure 2). The nanotubes behave like tiny electron guns and operate at few volts, rather than the thousands required for conventional x-ray sources. CNTs also have other unique properties that include extremely high mechanical strength, high thermal conductivity, and excellent chemical and thermal stability.



Figure 1 X-ray image of a humanoid hand by the CNT x-ray tube. The image was taken using XV film at 40keV and 3.4mAs.

Our breakthrough publication on CNT electron nanotubes X-ray imaging in the July 8 *Applied Physics Letters** was listed as one of the top physics research works in 2002 by the American Physical Society. The head of the research group, Dr. Otto Zhou, explained to the media, "what we offer here in terms of electron source is a fundamentally new device. This idea has been around for a long time, but no one has been able to come up with a cathode that will give you the kind of performance you need to take images." In addition to the room-temperature electron emission CNT has also other important that are especially attractive for radiology and radiation oncology. The potential advantages of the future CNT X-ray devices are fast response time, programmable x-ray intensity, programmable spatial distribution (Figure 3), ultra-fine focal spot, rapid pulsation

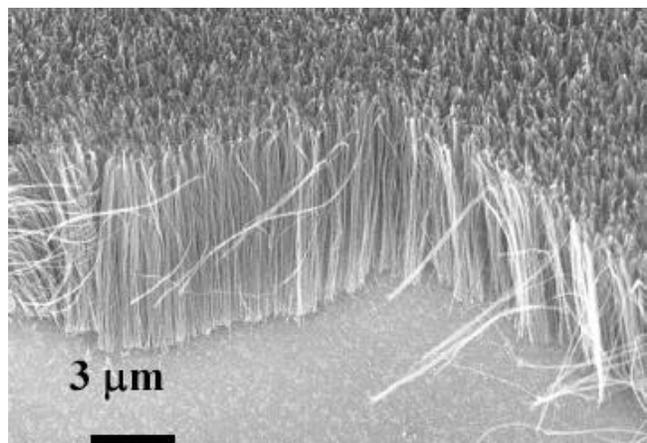


Figure 2 Microscopic image of carbon nanotubes.

capacity, long lifetime, low energy consumption, miniaturization, and low cost. We will discuss several potential applications of CNTs in radiotherapy including a kV x-ray source in an accelerator head for a diagnostic portal and coherence tomography imaging. In addition to the CNT-based X-ray tubes, the research group has also developed microwave amplifiers using CNT electron sources, gas discharge tubes, and a carbon nanotube field emission coating.

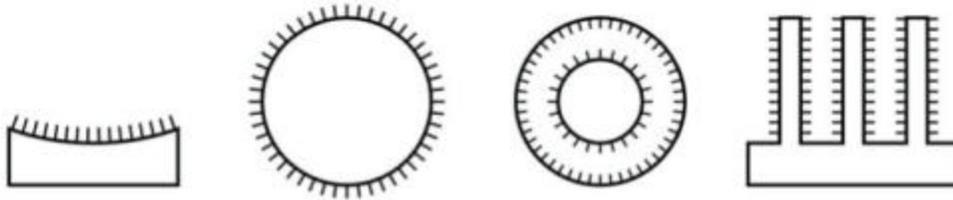


Figure 3 Examples of potential shapes of CNT electron field emitters.

*Journal Reference:

Yue D.Z., Qui Q., Cheng Y, Zhang J., Shimoda H., Chang S., Lu J. P., Zhou O, "Generation of continuous and pulsed diagnostic imaging x-ray radiation using a carbon-nanotube-based field-emission cathode" *Applied Phys. Review Lett* 81(2):355-357 (2002)