

Thinking Small

A NEW X-RAY SOURCE ARRAY USING CARBON NANOTUBES COULD REVOLUTIONIZE TOMOGRAPHIC IMAGING.

By Brett Hansen

For the past several years, researchers at the University of North Carolina at Chapel Hill have investigated the possibility of replacing the conventional X-ray tube with an array of nanotubes that remains stationary during the scan, reducing scan time and the motion blur caused by patient movement. Researchers are investigating a real-time tomosynthesis guidance system for radiation therapy, as well as a stationary digital breast tomosynthesis system using the new technology.

Conventional X-ray technology relies on a single point of an anode. For CT scans, the tube is moved using a rotating gantry and captures images from different angles to create a 3-D image. Unfortunately, as many radiologists and radiology technologists know, capturing the images can be a long process, and even the slightest patient movement can create blur.

The new array of nanotubes contained in a smaller tube — the spatially distributed multibeam field emission X-ray source (MBFEX) array — enables images to be collected by “electronically switching on and off the individual X-ray beams without any mechanical motion,” states Otto Z. Zhou, Ph.D., David Godschalk Distinguished Professor in the Department of Physics and Astronomy and the Lineberger Comprehensive Cancer Center at the University of North Carolina at Chapel Hill. The “switching on and off” occurs within one-millionth of a second.

The MBFEX technology is especially attractive for computed tomography. Because it doesn’t need to move, the MBFEX can collect images faster, minimizing motion blur. Additionally, images can be made even clearer because the X-ray exposure and data collection can be synchronized with physiological motions, which include breathing or a heartbeat, according to Zhou.

Moreover, when applied to digital breast tomosynthesis, the projection images can be collected faster and at a higher resolution than the regular rotating scanners. Instead of mechanically moving the X-ray tube, the array of X-ray beams would compile multiple images into a single 3-D image. (Many devices that use standard breast tomosynthesis, which uses a moving gantry to capture the images, are currently available only in clinical studies and are awaiting FDA approval for use in practice. As of press time, only the Hologic Selenia Dimensions 3-D system — a digital breast tomosynthesis scanner that uses a conventional X-ray tube — has received the FDA’s approval.¹)

In a 2009 paper describing the technology, the co-authors state that the nanotubes are composed of carbon microfibers.² The nanotubes offer significant advantages over conventional thermionic cathodes because they don’t need a heated filament. As a result, according to the paper, “it is much easier to place sources in close proximity. [Carbon nanotubes] may be switched on and off much faster and exhibit excellent temperature stability.”

Another application that researchers are working on is the use of the nanotubes to treat cancerous tumors with pinpoint accuracy. Additionally, high-resolution scans could be displayed during radiation treatment to more accurately attack cancerous cells while sparing healthy tissue.

Pursuing Perfection

Despite the MBFEX’s advantages over conventional X-ray technology, researchers continue to battle some obstacles. “The nanotube X-ray is brand new technology,” Zhou notes. “Many of the key components need to be developed from scratch. Making sure that all the pieces work properly and reliably is an ongoing challenge.”

One key issue that was recently overcome “after several years of intense

[research and development],” says Zhou, has been stabilizing the emitted electrons at a high voltage. After years of tweaking the configuration of the nanotubes and the X-ray tube design, the apparatus can be effectively and reliably operated at voltages up to 160 kV.³

Zhou plans to proceed to the next step, which is to carry out clinical studies of the MBFEX this summer. The research will include a reader study using breast phantoms to evaluate the performance of digital breast tomosynthesis. “We are also looking into the feasibility of utilizing the novel source technology for other imaging and radiotherapy applications,” he says.

“I think we need to see the results of the upcoming clinical trials using this technology to see how valuable it will be to imaging research,” says Mehdi Adineh, Ph.D., scientific director of the ACR’s Imaging Core Lab in Philadelphia. He adds that several related trials are currently underway at the ACR Core Lab, including the ACRIN® 4006 trial “in which we are evaluating full-field digital mammography in comparison with digital breast [tomosynthesis].”

The ACR’s research is funded by the Pennsylvania Department of Health and Zhou’s research is federally funded. Xinray Systems LLC, a joint venture of Siemens Medical Solutions and Xintek Inc., is the firm that manufactures the MBFEX sources. For more information about the technology, visit www.xinraysystems.com. //

ENDNOTES

1. Forrest, W. “FDA Approves Hologic’s 3D Digital Breast Tomosynthesis System.” Available at: <http://bit.ly/hzQYED>. Accessed Feb. 14, 2011.
2. Maltz, J.S., et al. “Fixed Gantry Tomosynthesis System for Radiation Therapy Image Guidance Based on a Multiple Source X-ray Tube with Carbon Nanotube Cathodes.” *Medical Physics* 2009;36(5):1624–1636.
3. Sprenger, F., et al. “Distributed Source X-ray Tube Technology for Tomosynthesis Imaging.” *Proceedings of SPIE* 2010;7622.