nature news

Published online 28 July 2009 | Nature | doi:10.1038/news.2009.744

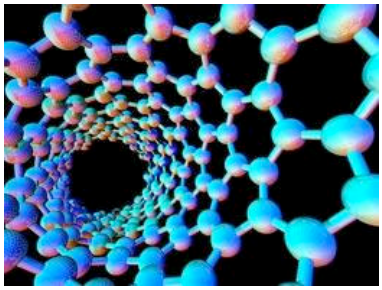
News

Nanotubes sharpen X-ray vision

Mini X-ray tubes could revolutionize radiotherapy — and airport baggage scanners.

Zeeya Merali

It's taken more than a century, but X-rays are finally getting a shake-up. A new way of generating them uses carbon nanotubes and could allow real-time three-dimensional scanning.



Carbon nanotubes can be used to generate X-rays.

Pasieka / Science Photo Library

"If you look at current imaging technology, technically very little has changed since Wilhelm Röntgen discovered X-rays more than 100 years ago," says materials scientist Otto Zhou at the University of North Carolina (UNC) in Chapel Hill.

Zhou and his colleagues first came up with their novel alternative to conventional imaging devices when the existing X-ray machine in their nanotechnology lab broke down. "It didn't take long to show that nanotubes could generate X-rays in principle," says Zhou. "What has taken time is turning this idea into a viable technology."

In conventional X-ray systems, electrons are released from a heated tungsten filament and accelerated down a tube until they strike a metal target, creating X-rays. Because the X-rays are fired from a single source, 3D imaging, such as computed tomography (CT) scanning, is particularly cumbersome. "If you want images taken from 360° around the body, you need to rotate this system around the patient," says Zhou.

"It didn't take long to show that nanotubes could generate X-rays in principle. What has taken time is turning this idea into a viable technology."

Otto Zhou
University of North Carolina

Zhou's 3D scanner, by contrast, uses a series of nanotubes instead of tungsten filament. Each nanotube emits electrons when a voltage is applied, through a quantum effect called field emission: the electric field becomes concentrated around the nanotube's tip, amplifying the field's effect and making it relatively easy to generate electrons.[1]

What makes such a system suitable for real-time 3D scanning, however, is the speed at which individual nanotubes can be switched on or off. This can be done within microseconds by applying or removing this voltage. Zhou's device has many nanotubes positioned around the subject in a 3D array. They are activated in sequence, generating a ripple of X-rays that sweeps around the body, he says. "Electronic switching can create a scanning beam without requiring any mechanical motion of the apparatus," he says.

Faster imaging

This scanning technology is fast enough to provide real-time 3D imaging, which will help improve tumour targeting in radiotherapy treatments, says team member and medical physicist Sha Chang, also at UNC.

"Current radiotherapy methods do their best to deliver radiation to tumours, but if the patient moves, it can miss the target," says Chang. "But imaging with nanotube X-rays while the patient is actually undergoing treatment will minimize damage to tissue surrounding the tumour." Chang presented the work on the 3D scanner at this week's meeting of the American Association of Physicists in Medicine in Anaheim, California, and will begin clinical tests in the summer.

The team has already shown that high-speed nanotube imaging also reduces the blurring that can be caused by breathing or heartbeats, says Chang. They have tested a single-beam nanotube device on mice[2] and successfully produced sharp images by triggering successive X-ray releases in time with the animals' heartbeats and breaths. "Much research on cancer is done using mice, and they have faster heart and breathing rates than humans, making it hard to use conventional X-rays," says Chang.

Peter Schardt, a medical imaging expert at electronics company Siemens, in Erlangen, Germany, admires the group's work and says that it could help cut down the amount of radiation given to patients. "At the moment, because of the problem of blurring in 3D scans, radiographers need to take many images that they later discard," he says. "With this new technique they won't need to take these extra images."

The technology will also be practical to implement, Schardt says. "The nanotubes will cost more than conventional X-ray tubes, but it's a trade-off because there will be great savings in the mechanical costs currently required for CT scanners," he says. "In two or three years we could be seeing carbon-nanotube scanners that cost about the same amount as today's CT scanners, but have a much higher resolution and lower maintenance costs."

Other benefits will extend beyond hospital walls, says George Zarur, science adviser to the US Department of Homeland Security in Washington DC. He believes the technique could speed up airport baggage checks. "I think this will revolutionize the CT industry," Zarur says.

References

1. Cao, G. *et al. Phys. Med. Biol.* 54, 2323– 2340 (2009).
2. Cao, G. *et al. Proc. SPIE* 7258, 72585Q (2009).

Comments

Reader comments are usually moderated after posting. If you find something offensive or inappropriate, you can speed this process by clicking 'Report this comment' (or, if that doesn't work for you, email webadmin@nature.com). For more controversial topics, we reserve the right to moderate before comments are published.

Add your own comment

You can be as critical or controversial as you like, but please don't get personal or offensive, and do keep it brief. Remember this is for feedback and discussion - not for publishing papers, press releases or advertisements, for example. If you ramble on in an annoying way too often, we may remove your posting privileges.

You need to be registered with Nature to leave a comment. Please log in or register as a new user. You will be re-directed back to this page.

Log in / register

Nature ISSN 0028-0836 EISSN 1476-4687