The whole picture: T-rays excite the

Mysterious envelopes containing anthrax, concealed weapons, secure communications, the CIA…

These could all be ingredients in the latest Tom Clancy spy thriller. Instead, each of these is connected to new research at the University of Adelaide that could potentially lead to major improvements in security worldwide.

The research is aimed at better understanding the properties and uses of T-rays.

While most people have heard of X-rays, T-rays are relatively unknown to the public. Like X-rays, T-rays are a form of radiation—the 'T' in T-rays comes from 'terahertz', which is the frequency of the radiation. X-rays, microwaves and infra-red, all various forms of radiation, are found at different frequencies.

Unlike X-rays, T-rays are safe to the human body and offer many opportunities for developments in medical science and security, among other fields.

Research into T-rays at Bell Laboratories in the United States sparked the interest of Associate Professor Derek Abbott in the University of Adelaide's School of Electrical & Electronic Engineering. He was the first in Australia to start looking seriously into T-rays.

"I first got inspired to look into T-rays around 1995 or 96, and then I started seriously studying them in 1997," he said. "In 97 I started applying for grants to get a program going, and eventually I won the first large ARC (Australian Research Council) grant in Australia on T-rays in 1999."

That initial success was followed in 2004, when Dr Sam Mickan and Dr Abbott won two major grants from the ARC—a Discovery grant of $800,000 for fundamental research into T-rays, and an infrastructural grant worth $1.35 million to establish the world's first laser-based T-ray user facility, headed by Dr Mickan.

In a relatively short space of time, the potential of T-ray research and the expertise in this field at Adelaide had been recognised by the ARC.

imagination

Photograph Drew Lenman

Why T-rays?

Unlike X-rays, T-rays are not invasive—they can only penetrate the human body by a couple of centimetres at most. Because T-rays do not damage biological tissue, it is possible for them to be used in many different ways—such as detecting skin cancer and other tumours that are close to the surface of the skin, or examining samples of DNA to search for evidence of genetic disease.

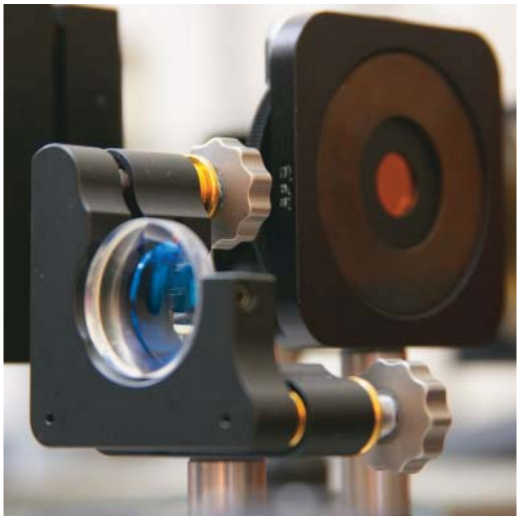
T-rays can identify different molecules, but they don't offer much detail at the individual atomic bond level. This is a good thing, according to Dr Abbott.

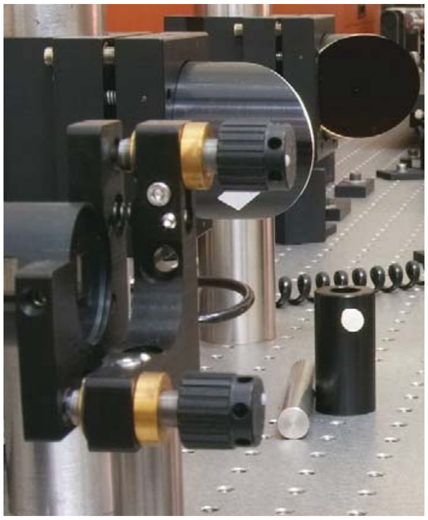
"The beautiful thing about T-rays is that they give you information about the character of the whole molecule.

"In a sense it's less detail, not more. If you're driving along in your car, you don't want to look through a magnifying glass, you'll see too much detail, all the little bits and pebbles on the road. You don't need to see at that level of detail because you'll crash the car; you actually want to take a step back and look at the whole picture. That's what T-rays are doing for us at the molecular level."

There are limitations: T-rays are blocked by metal, for example. And, because they can't penetrate the human body by more than a couple of centimetres, they will never replace the more harmful X-rays for security scans at airports, or medical imaging for diagnosis of broken bones.

"On the other hand, T-rays are much better than X-rays for imaging surface soft tissue, so you can see T-rays as complementing X-rays rather than replacing them," Dr Abbott said.





Security Applications

T-rays are useful for identifying biological and chemical material, which may make them invaluable for countering biological and chemical terrorism.

"One of the important security applications for T-rays will be their ability to look inside packages to test for chemicals without having to open the package—the classic example being the 'anthrax envelope'," said Dr Abbott.

Referring to the packages received by prominent individuals and organisations across the US following the terrorist attacks of September 11, 2001, the 'anthrax envelope' sparked widespread fear right around the world, including Australia.

In a test, one of Dr Abbott's PhD students, Brad Ferguson, used T-rays to detect bacterial spores inside a sealed envelope. He set about investigating whether T-rays would detect the difference between the spores and other powders, such as salt, baking soda, flour, sugar, and Chinese five spice.

"The T-ray image showed that you can clearly distinguish between all the different powders in the envelope," Dr Abbott said.

"Brad Ferguson's work, in being able to differentiate between the bacterial spores and other material, is a very important step forward."

Dr Abbott said T-rays would likely become valuable to security in many ways.

Because T-rays can detect different gases with great sensitivity, they could be used for monitoring a building or even an aeroplane cockpit for harmful emissions. This has application not just in terrorism prevention, but also in monitoring for accidental gas emissions.

T-rays could also be used at secure checkpoints, such as border crossings and airports, to scan people for concealed weapons.

"The low terahertz frequency range is where you can look through clothes and see what people are hiding," Dr Abbott said.

"The ethical aspect of looking under people's clothes isn't an issue, because

Photographs Voon Siong Wong

you're not able to see anything apart from an outline of the person's body shape and an outline of the weapon.

"Even as the technique improves and the image gets more distinct, you can easily do some signal processing on it to 'fuzz out the naughty bits'."

Another key security application of T-rays is the possibility of using them for communications.

"It would only be used for short distances because it can't travel through the atmosphere for very long distances, but that's okay because you could use it as part of a wireless communications network in a building," Dr Abbott said.

"It would be a lot harder to eavesdrop on from outside the building than traditional frequencies that are used at the moment, because the signal wouldn't travel through the walls that well. So for secure wireless local area networks, that would be something of interest—and, of course, terahertz frequencies will give you greatly increased bandwidth."

Cloak and Dagger

Dr Abbott had suspected for many years that T-rays would become important to security across a range of fields, but even he was surprised when he was actively approached by someone from the CIA (Central Intelligence Agency) in the United States.

"I was in Santa Fe at the time and I was approached by a guy from the CIA there. He asked me if it was possible to photocopy a book without opening it, using T-rays.

"I said to him, 'Look, if you gave me $30 million, in principle I think we could do it.' But it was going to take a lot of money and a lot of effort. And I asked him, 'Why do you want to photocopy books while they're shut anyway? What's the point?' And he said, 'Sorry, I can't tell you that.'

"Theoretically, yes you could do that using T-rays, but it would be a huge problem to solve. I think I underquoted him by saying it would cost $30 million."

There's no doubt that T-rays are beginning to spark the imagination, not just in the real world but also in Hollywood. T-rays have hit popular culture, with the characters of the spy thriller TV show *Alias* using as-yet-undeveloped terahertz technology on a regular basis.

"They're ahead of what the actual developments are, which is great," Dr Abbott said, "much as a show like *Star Trek* was ahead of the game with personal communicators, which are now a reality."

The reality for Dr Abbott and his colleagues is that T-rays research is an exciting field, with many potential benefits.

"I think this will become a very strong area within the University because of its multi-disciplinary implications," he said.

"It will bring people in the molecular sciences together with engineers, and physical scientists, chemists, chemical engineers, electrical engineers, biologists… it will bring many people together, and I think some very interesting work will come out of that."

For example, one of Dr Abbott's former PhD students, Dr Sam Mickan, is blazing the trail in T-ray biomolecular fingerprinting and T-ray detection of liquids.

Dr Mickan's liquid techniques are creating much interest and have recently sparked a collaboration with Dr Chris Colby in the School of Chemical Engineering in the area of chemical detection in the wine industry.

"The technology that allows us to create and study T-rays has come along in leaps and bounds since we first started this work. It's a very good time for us," Dr Abbott said. ■

Story **David Ellis**