FURTHER READING
http://astro.temple.edu/~skong

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'Boosting terahertz radiation in THz-TDS using a continuous-wave laser', C. Ryu and S.G. Kong

Terahertz sensing receives a boost with a cost-effective way to increase the radiation power in terahertz spectroscopy

a turn-up for terahertz*

A technique to increase the power of the source in a terahertz time-domain spectrometer has been demonstrated by researchers at Temple University in the US. By mixing a low-cost continuous-wave laser with a femtosecond (fs) pump laser beam, C. Ryu and S. G. Kong increased the power of the terahertz radiation; a result which could enable future terahertz spectrometers to be cost-effective yet powerful enough for real-world remote sensing applications.

Sensitive sensing

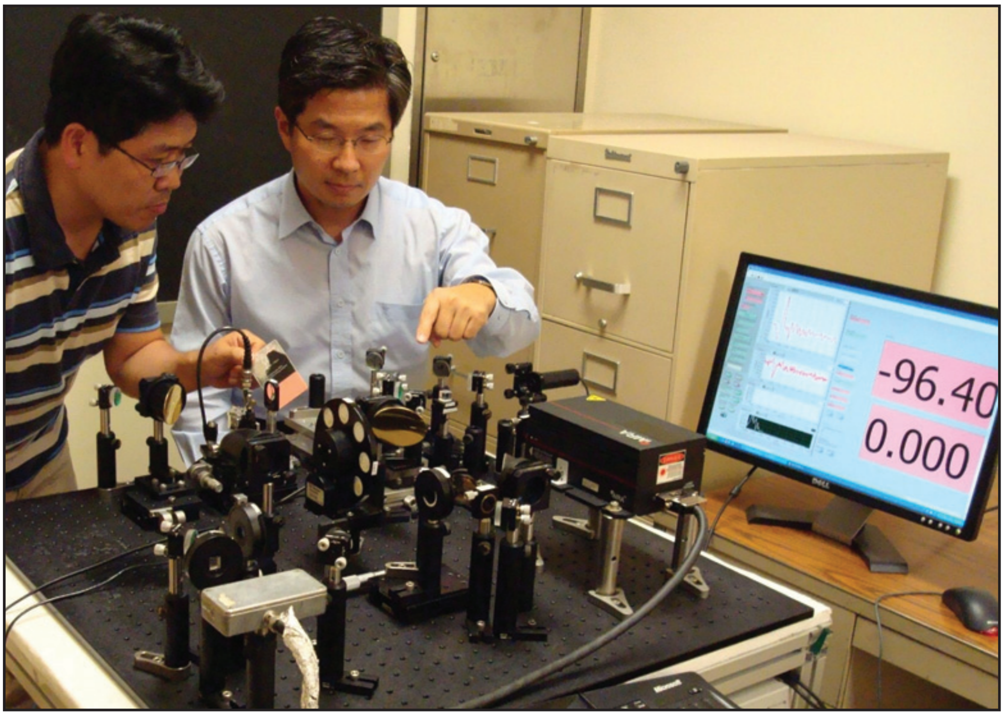
Terahertz (THz) spectroscopy uses short pulses of THz radiation over the wavelength range of 1000 – 100 μm (300 GHz – 3 THz) to probe properties such as the wavelength dependence of a material's complex refractive index. THz radiation is sensitive to the sample material's effect on the phase as well as the amplitude, which provides more information than conventional Fourier spectroscopy that is only sensitive to the amplitude.

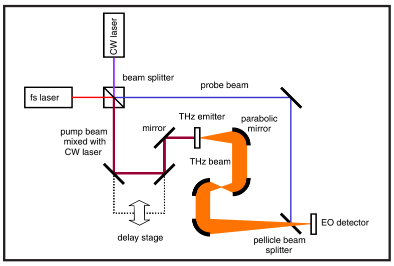
THz waves easily penetrate most nonpolar dielectric materials, such as paper, clothing and wood panels, and THz spectroscopy has demonstrated great potential in detecting explosives or weapons, illegal narcotic substances and biological agents concealed in dielectric barrier materials. In addition, THz radiation is safe for biological tissues since its low photon energy (one million times weaker than X-rays) does not cause any harmful ionisation effects.

A high price to pay

Commercially available THz spectrometers often employ an ultrashort pulsed laser at a near-infrared centre wavelength and a semiconductor based detection system to produce wideband radiation at 0.05 – 4 THz. The application of near-infrared laser pulses of duration less than 100 fs to a semiconductor optical switching device generates a THz wave pulse flashing for only a few picoseconds. Since the pulse width of the fs laser is very short and its repetition rate is typically below a few MHz, beams produced by this technique do not exceed a few microwatts.

THz spectroscopy is not yet used in real-world applications, due in part to technical challenges, such as the strong attenuation of THz radiation by water molecules in the atmosphere, which significantly limits the sensing range of current spectrometers. Higher power THz radiation would give a higher signal-to-noise ratio as well as an increase in the sensing range, but a fs laser source costs several tens of thousands of dollars, and the price increases in proportion to the power as well.





ABOVE: C. Ryu and S. G. Kong from Temple University are investigating ways to increase the terahertz radiation of a terahertz time-domain spectrometer to detect low-density explosive traces **RIGHT:** A CW laser is mixed with a femtosecond (fs) pump laser beam to increase the terahertz radiation power of the terahertz time-domain spectrometer

Powering up

The researchers at Temple University have been developing techniques to increase the sensing range of THz spectroscopy for remote inspection in humid open-air environments. By mixing a 15 mW continuous-wave (CW) laser with a fs pump laser beam in a terahertz time-domain spectrometer, they found that they could increase the power of the THz radiation by 17%. From their results they predict that the power will be doubled if a CW laser beam of 120 mW is used and, with the CW laser costing just a few hundred dollars, their simple configuration could be an inexpensive solution to higher-power THz generation. They are currently testing different beam mixing configurations and combinations of laser sources and THz emitter structures to produce an even higher gain in power.

Developing powerful THz radiation sources and sensitive detectors is essential to enable THz spectroscopic techniques to be deployed in real-world applications such as detecting low-density explosive traces from a distance. The researchers are also investigating another cost-effective way of increasing the sensing range of THz spectrometers: THz signal restoration to recover degraded THz radiation from atmospheric attenuation. With a combination of these techniques, they would like to achieve the detection and characterisation of materials from a distance of more than 30 metres, and see THz spectroscopy fulfil its potential in practical remote sensing applications.