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# ***Millimetre Wave and Terahertz Sensors and Technology V***

**Neil A. Salmon  
Eddie L. Jacobs**  
*Editors*

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# Introduction

A diversity of millimetre wave and terahertz sensors and technology continues to be developed. Contributors strive to understand and satisfy end user requirements whilst offering performance improvements to the systems, subsystems and devices at lower costs, so as to meet market expectations. The understanding of signatures and the means to simulate signatures and images in passive and active systems improves each year, and this year is no exception. Below is a brief description of the topics covered in this year's conference.

## Systems

An impressive 350 GHz stand-off detection system, using 64 element superconducting transition edge sensors (TES) was demonstrated. Using a closed cycle cooler and a helium evaporation the detectors in the system operate at below 1 Kelvin. It demonstrates a compact format and high performance imagery, with a video rate NETD at well below 1 K and a spatial resolution in imagery of 2 cm at a range of 10 m.

Collaborative efforts continue between the defence end user communities and research groups to investigate sensor fusion in the recognition of IEDs. The system of this consortium combines w-band passive millimetre wave imaging and a MIMO E-band 72-79 GHz radar. The system is mounted on a vehicle and up-dates a one frame per second, combining data from IR and visible sensors to provide good receiver operational characteristics in the detection of threats.

Efforts to reduce costs and improve performance of 'walk-by' airport security screening imaging systems have been made. The consortium develops improved package and system performance of the w-band imager by designing receiver module that integrates feeds, MMIC based LNAs, and zero-biased detectors.

Innovation in sensor development is investigated by exploiting lower cost sensors using satellite LNAs at 10-12 GHz. The packaged devices offer RF and IF amplifiers, local oscillators and filters at a cost three orders of magnitude less than receivers at w-band. The system could be used as the basis for a next generation aperture synthesis imager.

The radio astronomy technology of aperture synthesis is investigated for near-field security screening. The development and use of simulation tools to examine the performance of next generation three dimensional aperture synthesis security screening portals is presented. These systems will generate images with tens of thousands of pixels.

Development of synthetic aperture radar (SAR) systems for luggage inspection at w-band is demonstrated, showing range resolution of 7 mm. The system uses low noise, medium power HEMT amplifiers and multipliers based on SiGe technology and SAR processing using back-projection algorithms. The system has a radiation bandwidth >25 GHz and a phase locked loop for stabilisation operating at a signal bandwidth of 100 MHz.

A perspective from the radio astronomy community is provided by presenting a system for measuring the cosmic background (CMB). The system is a polarimetric sensor operating at 90 GHz and 150 GHz using 1000 transition edge (TES) bolometers and 500 feedhorn-coupled polarimeters. It uses a SQUID readout operating at a temperature of 100mK with the critical temperature of the detector being 150 mK.

The characterisation of large 1.6 m aperture ka-band indoor passive millimetre wave security screening imager is presented. This identifies the phenomenon of self-emission as a limiting factor in high RF gain based passive imagers used in security screening portals. The work also quantifies millimetre wave emission from fluorescent lights which if used in the neighbourhood of a security screening system can also limit system performance. For longer periods (30s) of integration, a 200 mK sensitivity was demonstrated. Replacement amplifiers will provide a greatly improved performance, enabling this system to demonstrate portal screening phenomenology and capability at ka-band.

Perimeter surveillance at 94 GHz using change detection and 360° azimuthal scanning is presented. The system operates to a range of 500 m and radar returns are compared with templates for recognition.

## **Devices**

Biased and unbiased millimetre wave video detectors over the band 100 GHz to 400 GHz are developed, using planar GaAs (forward biased) and InGaAs (zero biased) air-bridged Schottky diodes. These devices are integrated with planar antennas and microstrip readout circuits. Radiation is focused on the planar antennas using high resistivity Si hemispherical lenses.

Efforts continue to develop yttrium-barium-copper cuprate (YBCO) (frequently used in the infrared region as a microbolometer) for the detection of millimetre and terahertz radiation. Work continues in the area of monolithic 200 mm CMOS Si wafer development which integrates bolometer focal plane arrays (having 160x160 elements) with readout electronics, in an attempt to integrate THz, IR, and visible sensors into a single focal plane array.

Silicon wafer micromachining to build titanium based 16 element microbolometer arrays coupled to micro-antennas at 300 GHz to 800 GHz is explored. The signal



bandwidth is 150 kHz and the NEP is 10 pW/root Hz. Target applications are associated with FM radars.

Hot electron bolometers are used to detect radiation generated by a parametric oscillator at 0.7 to 2.5 THz.

Theoretical studies of broadband THz emission from laser induced charge acceleration in semiconductor materials continues.

### **Phenomenology**

Improvements in the understanding of signatures are presented in these papers, where scattering of clothing at 100 GHz and 300 GHz is quantified. The principal component analysis technique is used to analyse the spectra of energetic materials as a means to aid recognition.

Scene simulation for passive millimetre wave imaging using the open-source software is demonstrated. This offers an attractive route to having a simulation capability to investigate the performance of systems in new scenarios.

Our thanks to everyone who helped make this year's meeting such a success. We look forward to another engaging conference next year in Dresden.

**Neil A. Salmon**  
**Eddie L. Jacobs**

