A 384 x 288 microbolometer-based pixel camera with metamaterial absorbers for real-time terahertz imaging applications

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Abstract-INO has leveraged its expertise in the development of uncooled microbolometer detectors for infrared imaging to produce terahertz (THz) imaging systems. Optimization of the sensitivity in the THz band has been accomplished by the addition of metamaterial-based absorbers to its microbolometer focal plane arrays. With the addition of custom THz lens objectives, INO now produces the IRXCAM-THz-384 camera, capable of imaging hidden objects for applications such as non-destructive testing, non-intrusive threat detection and see-through-the-wall imaging.

THz technology has attracted a great deal of interest in recent years particularly for defense and security applications such as parcel inspection and through-camouflage vision. Uncooled microbolometer, widely used for infrared imaging for defense and more recently commercial applications are promising detectors for imaging in the THz region. INO has been actively working to optimize the performance of its uncooled microbolometer detectors for THz wavelengths. Several techniques have been investigated over the past few years such as metallic blacks, metallic absorbers, frequency selective surfaces (FSS) and antenna coupled microbolometers and has recently developed a THz camera core based on a 384 x 288 pixel 35 µm pixel pitch uncooled bolometric terahertz detector. This paper discusses two of the most successful techniques. It then provides an overview of the THz camera built around these THz-optimized detector focal plane arrays (FPAs). Lastly, THz images taken with the camera at various wavelengths are presented.

Gold black has been extensively studied at INO [1] and a deposition process of such coating has been developed. The spectroscopic measurements obtained at various deposition conditions and film thicknesses showed that there is less than 10 % in the range of 3 THz to 30 THz. Figure 1 shows SEM images of the microbolometer detector without (left) and with (center) laser trimmed gold black coating and the gold black specular reflectance (right).

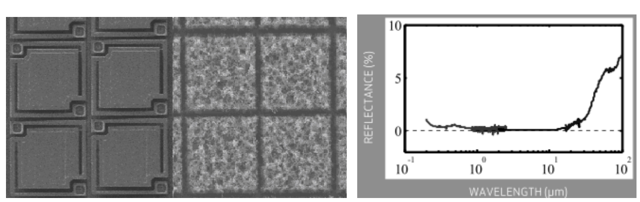

Figure 1. SEM image of 52 µm pitch microbolometer detector without and with laser trimmed gold black coating

A second method for improved absorption in the THz region has been through Frequency Selective Structures (FSS). Using a combination of inductive and capacitive FSS, it is possible to build a multilayer resonant structure [2, 3]. The resonance frequency can be adjusted by optimizing each layer impedance and pattern geometry. The structure developed was a double platform design. Figure 2 shows the ANSYS HFSS model (left) of the unit cell of microbolometer, its simulated frequency response (center) and a scanning electron microscope image of an array of 35 µm pitch pixels (right).

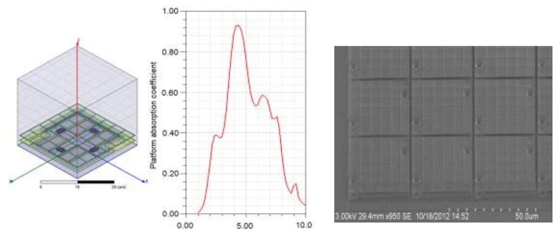

Figure 2. Structure (left) and simulated response (center) of a THz microbolometer and SEM image (right) of THz detectors

The THz-optimized FPAs are the core of the IRXCAM-THz-384 camera shown in Figure 3 with (left) and without (right) the custom THz lens barrel. The ultra-low-noise electronics core was also developed at INO and allows for a 50 Hz and 16-bit output [4].

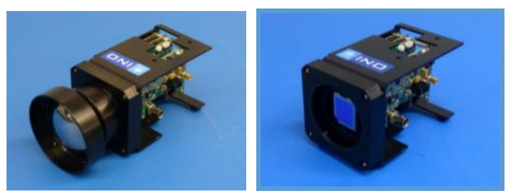

Figure 3. Photographs of the IRXCAM-THz-384 camera core with (left) and without (right) the THz lens barrel

Figure 4 presents different images taken with the IRXCAM-THz-384 camera in transmission and reflection, demonstrating the good image quality across a broad spectral range from 0.29 THz to 2.4 THz. These results demonstrate the capability of this 384 x 288 microbolometer-based pixel camera with metamaterial absorbers for real-time terahertz imaging applications.

Figure 4. Images taken with the IRXCAM-THz-384: a plastic gun in reflection (left) and a magnetic security card in transmission (center left), both at 2.4 THz; a pocket knife through a leather purse in transmission at 0.69 THz (center right) and a plastic bag filled with water inside a cardboard mailer at 0.29 THz in transmission (right)

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