Wide Field of View Lens-Based Focusing System for Security Imagers at THz frequencies

Llombart Juan, N.; Gandini, E.; Tamminen, A.; Luukanen, A.

DOI
10.1109/IRMMW-THz.2016.7758592

Publication date
2016

Document Version
Accepted author manuscript

Published in
41st International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz

Citation (APA)
Llombart Juan, N., Gandini, E., Tamminen, A., & Luukanen, A. (2016). Wide Field of View Lens-Based Focusing System for Security Imagers at THz frequencies. In *41st International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz* (pp. 1-1). IEEE. https://doi.org/10.1109/IRMMW-THz.2016.7758592

Wide Field of View Lens-Based Focusing System for Security Imagers at THz frequencies

Nuria Llombart[1], Erio Gandini[1] , Aleksi Tamminen, Artuu Luukanen

[1] Technical University of Delft, The Netherlands
[2] Asqella, Finland

***Abstract*—The aim of the European project CONSORTIS is the development of a walk-by imaging system for concealed object detections working at submillimeter-wave frequencies. This imager will allow to image a full body at two frequency bands with high sensitivity (<1K) and large frame rate (10Hz). The imager relies on a large focal plane array with about 10k detectors operating at both bands coupled a common optical system. This contribution describes the optimization of the quasi-optical system for this imager. The proposed architecture is based on a novel flipped dual-lens design with a scan loss of less than 3dBs for both bands. This scan loss corresponds to resolution loss of only a factor 1.4 at the e**

I. Introduction

In the European project CONSORTIS [1], an active and a passive systems in the frequency range 200 to 600 GHz will be used simultaneously to achieve high probability of detection. This contribution the design and implementation of the quasi-optical system used in the CONSROTIS passive imager. The passive imager relies on Focal Plane Array (FPA) of about 10.000 Kinetic inductance detectors (KIDs) developed in [2]. This type of detectors can be coupled to a single read-out line, decreasing significantly the complexity of the FPA architecture.

The required FoV for security applications is to scan a full body person [3]. The CONSORTIS passive imager will rely on a configuration which combines multiple receivers and mechanical scanning. Only a few half power beam widths (HPBW) need to be mechanically scanned since FPA has a nearly Nyquist sampling scheme. The final image will be composed of approximately 125000 pixels. The optical system will operate at frequency bands located at 250 and 500 GHz. The security scenario requires 200 beams with a 0.26deg angular bandwidth corresponding to an angular FoV of 45deg. The required angular FoV in CONSORTIS is significantly larger than previous system security scanner operated at submillimeter wavelengths.

II. Results

The proposed architecture of the optical system is based on a novel flipped dual-lens design as shown in Fig.1a. The aperture stop of the system corresponds to the top lens. Since the aperture stop is placed on the top lens, its diameter, Dt, and imaging range, Rf , define the resolution at the center of the FoV. The diameter of the bottom lens, Db, was oversized (flipped design) in order to optimize the lens surface profile differently for detectors at the center and edge of the FPA. This can be seen in Fig. 1 where the rays associated with the edge of the FPA hit approximately half of the lens surface. This configuration allows high order polynomials instead of canonical curves (such as spheres or hyperbolas) in the lens surfaces definition with the objective to reduce the phase aberrations associated to different scanning points. The lens thickness was also optimized in order to reduce absorption losses in the dielectric.

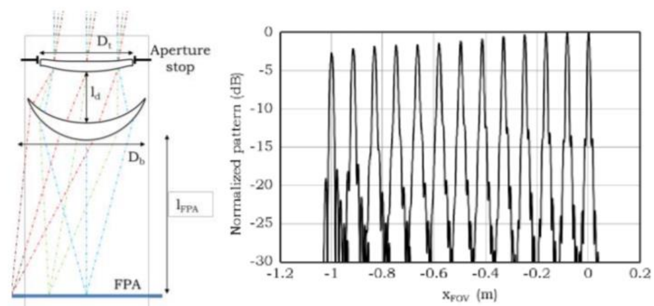

Fig. 1. Flipped dual-lens design: (a) geometry, (b) simulated beams at 500GHz

The optimized flipped dual-lens system was simulated by using GRASP [4] when illuminated uniformly by a feed in the FPA. The required linear scan is ±50 and ±100 HPBW at 250 and 500 GHz, respectively. The radiation patterns from broadside to the edge of the FOV are shown in Fig. 1b at the two design frequencies. A few patterns only are plotted in order to show the beam quality over the considered scanning range. The angular HPBWs at the center of the FOV are approximately 0.6º and 0.3º at 250 and 500 GHz, respectively. The patterns at the edge of the FOV show a slightly larger main lobe than the one at broadside. The HPBW is enlarged by only a factor 1.4 with respect to the broadside beam. The scan loss is 3.2 and 2.8 dB at 250 and 500 GHz, respectively. The material used for the lenses is TOPAS which introduces an additional 1dB loss due to reflections at the air-dielectric interfaces and ab absorption loss of 0.7 and 2 dB at 250 and 500 GHz, respectively. The FoV and performance achieved with this optical system are well above the current state of the art. The system now is under fabrication and will be measured in the coming months.

References

[1] http://consortis.eu. [2] J. Hassel, A. V. Timofeev, V. Vesterinen, H. Sipola, P. Helist, M. Aikio, A. Myr, L. Grnberg, and A. Luukanen, “Bolometric kinetic inductance detector technology for submillimeter radiometric imaging,” SPIE, 2016. [3] A. Luukanen, et. al. Proc. SPIE 8362, 836209, 2012 [4] TICRA, GRASP, version 9.8.01, 2012.