Proceedings Paper:

Garufo, A, Sberna, P, Carluccio, G et al. (6 more authors) (2018) Leaky Lens Antenna as Optically Pumped Pulsed THz Emitter. In: 2018 43rd International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz). IRMMW-THz 2018, 09-14 Sep 2018, Nagoya, Japan. IEEE . ISBN 978-1-5386-3809-5

https://doi.org/10.1109/IRMMW-THz.2018.8509897

Leaky Lens Antenna as Optically Pumped Pulsed THz Emitter

Alessandro Garufo[1], Paolo Sberna[1], Giorgio Carluccio[1], Juan Bueno[2], Joshua R. Freeman[3], Nuria Llombart[1], Edmund H. Linfield[3], Alexander G. Davies[3] and Andrea Neto[1]
[1]Delft University of Technology, Microelectronics Department, Terahertz Sensing Group, Delft, The Netherlands
[2]SRON Netherlands Institute for Space Research, Utrecht, The Netherlands
[3]University of Leeds: School of Electronic and Electrical Engineering, Institute of Microwaves and Photonics, Leeds, United Kingdom

***Abstract*—Optically pumped pulsed THz emitters exploit the transient motion of photo-generated charge carriers in semiconductors, to produce, coupled to micro-antenna, radiated power over a wide bandwidth up to the THz frequencies. The radiation performance of the antenna greatly affects dispersion of the energy spectrum generated by the photoconductive source and if not properly designed it causes low radiated power. This work presents the design, the fabrication process, the electromagnetic and the thermal analyses of a pulsed photoconductive micro-antenna based on the leaky lens antenna concept. This device shows high radiation efficiency over a band ranging from 0.1 to 1.5 THz, thus being a suitable emitter for THz time-domain sensing system.**

I. Introduction

PHOTO-CONDUCTIVE antennas (PCAs) employ the transient motion of photo-generated charge carriers under a static biasing voltage applied in semiconductor materials to radiate power over a large bandwidth up to THz frequencies. This fact, together with their compactness and easy operation make PCAs promising for bio-chemistry, materials science and industrial time-domain THz sensing applications [1]. However, most of the antennas geometries and photo-conductive material structure, currently used in time-domain sensing (TDS) systems, suffer from narrow band emission and/or high radiation dispersion which occurs in regular lens antenna for radiating wideband signals. These issues cause poor radiation efficiency, rendering the systems slow and with low sensitivity [2].

In this work, our designed PCA (35° tapered Al slot with a square gap of 10 µm edge) is able, instead, to efficiently radiate the ultra-wide band signal generated in the photo-conductive material (LT-GaAs) thanks to the non-dispersive behavior over wide bandwidth performance provided by the leaky lens antenna [3][4] (a 2 µm LT-GaAs membrane which is kept 30 µm from the bottom surface of a Si lens, whose diameter and extension length are respectively 10 and 1.5 mm). Along with the electromagnetic analysis, the studies of the PCA heating, induced by the optical excitation, is provided, in order to assess the reliability of membrane-based PCA devices. Finally, the fabrication and characterization of a leaky lens PCA prototype are discussed.

II. Results

According to simulations, by using the equivalent circuit for pulsed PCAs in [5], when a pulsed laser (wavelength = 800 nm, pulse duration = 100 fs, pulse frequency = 80 MHz) beam (FWHM = 10 µm) with an average power of 30 mW illuminates the gap (biased with a voltage of 40 V) of our leaky slot antenna, the total power radiated from the Si lens is 146 µW. Whereas, a standard bow-tie antenna, usually used in current TDS systems, with the same geometry and optical pumping, radiates, over the same spectrum, only 94 µW. Thus, our solution allows an enhancement of the radiated power (see Fig. 1). A further advantage of the leaky lens design lies in its ultra-wideband non-dispersive behaviour, and stable phase centre [3][4], which make such antenna ideal as reflector feed in order to obtain ultra-wideband high gain THz TDS system. Higher values of the pumping laser fluence for the excitation of the leaky slot PCA (yet still within the device safety operation boundaries) provide a better impedance match between the photoconductive generator and the antenna, giving several hundreds of µW for radiated power within 0.1 and 1.5 THz. Energy spectral density and power measurements of the prototype will be presented during the conference.

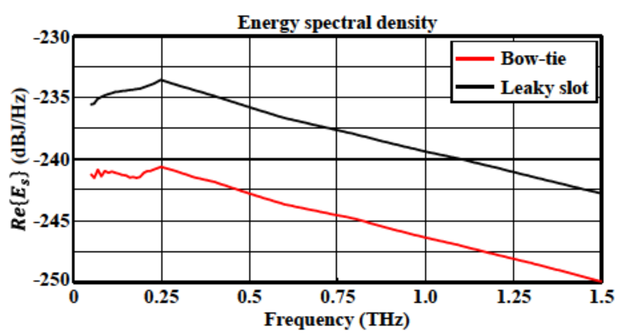

Fig. 1. Simulated energy spectral densities radiated by the lens. The red lines refer to the bow-tie antenna, whereas the black line refers to the leaky slot antenna.

References

[1]. P. U. Jepsen, D. G. Cooke, M. Koch, “Terahertz Spectroscopy and Imaging – Modern Techniques and Applications,” *Laser Photonics Reviews*, vol. 5-1, pp. 124-166, 2011.
[2]. P. H. Siegel, “THz Technology: an Overview,” *THz Sensing Technology*, World Scientific Publishing, pp. 1-44, 2003.
[3]. A. Neto, “UWB, non dispersive radiation from the planarly fed leaky lens antenna - part 1: theory and design,” IEEE Trans. Antennas Propag., vol. 58, no. 7, pp. 2238–2247, Jul. 2010.
[4]. A. Neto, S. Monni, and F. Nennie, “UWB, non dispersive radiation from the planarly fed leaky lens antenna - part II: demonstrators and measurements,” IEEE Trans. Antennas Propag., vol. 58, no. 7, pp. 2248–2258, Jul. 2010.
[5]. A. Garufo, G. Carluccio, N. Llombart, and A. Neto, “Norton equivalent circuit for pulsed photoconductive antennas – Part I: Theoretical model,” IEEE Trans. Antennas Propag., Early Access, Feb. 2018.