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Experimental Validation of an MKID Coupled Dual Polarized Leaky Lens Antenna

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***Abstract*—This contribution presents the design and sub-mm wave measurements of a wideband dual polarized leaky lens antenna coupled to kinetic inductance detector (KIDs) to be specifically used for tightly spaced focal plane arrays. The antenna is planar and composed by two crossed slots, fed by two orthogonal coplanar waveguide (CPW) lines. In transmission, the crossed CPW lines are fed differentially in order to couple the radiation into the slots. The slot antenna feeds a dielectric lens to achieve directive patterns. The main goal of this work is to show the measurement results of the patterns and efficiency, and compare this antenna with its singly polarized version. The measured received power from an incoherent source is increased by a factor of 2 compared to a single-polarized version of the antenna.**

I. Introduction

The next generation sub-mm wave imaging systems requires wide-band and dual-polarized antennas to increase the imaging speed. The instruments used for space science and radio-astronomy are mostly based on antenna arrays located on the focal plane of a large reflector. The aperture efficiency of the feed antennas becomes critical for the overall system performance for instruments that require tightly spaced focal plane arrays (FPAs) for full sampling of the focal field since it relates to the spill over from the reflector [1]. Recently, by improving the radiation characteristics of the single polarized leaky slot antenna presented in [2], a dual-polarized leaky lens antenna with an aperture efficiency that is larger than 60% within a bandwidth of 1:2.5 has been presented [3]. The lens antenna design specifically aims at tightly spaced focal plane arrays in sub-mm band. The leaky wave antenna is coupled to a KID resonator [4] to absorb the incoming power, and the work provides a highly efficient and a wide-band antenna solution with planar feeding lines. The design has been compared with widely studied antennas in the literature (double slot antenna [5], horn antennas [6] etc.), and its superior performance in terms of its operational bandwidth and the antenna aperture efficiency has been reported in [3].

This work is an extended version of the study presented by some of the authors in [3]. The aim of the work is to provide sub-mm measurements of the dual-polarized leaky lens antenna and to show that the received power from an incoherent source can be doubled by using the dual-polarized leaky lens antenna compared to the single polarized version of the antenna.

II. Antenna Geometry

The geometrical design parameters of the lens antenna are highlighted in Fig. 1. The proposed design aims at a frequency band from 1.4 THz to 2.8 THz for SAFARI-like scenario [7].

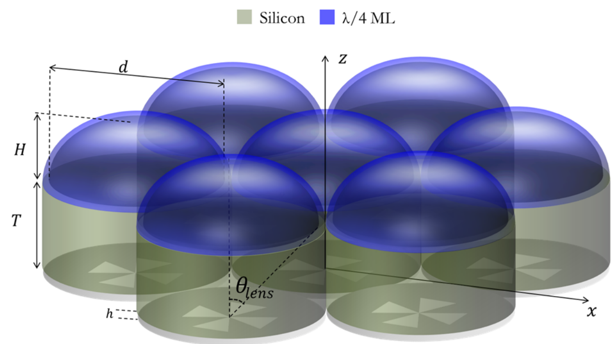

Fig. 1. The schematic of the proposed hexagonally oriented dual-polarized leaky lens antenna array.

In this scenario, a tightly packed lens antenna array is located on the focal plane of a reflector with a large $f_{\#}$, typically larger than 10 [7]. The lens antennas are separated with a distance of $d = 0.5\,\lambda_0\,f_{\#}$ to achieve full focal plane sampling [1]. Here λ_0 is the free-space wavelength at the central frequency and $f_{\#}$ is the f-number of the reflector. The dimensions of the lens antenna are reported in Table I. We are using a lens truncation angle $\theta_{lens} \approx 46.3^0$ to satisfy tight feed sampling with providing high lens antenna aperture efficiency.

Table I. Geometrical design parameters of the lens

$\boldsymbol{d}$	$\mathbf{1.55}\ \boldsymbol{mm}$
$\boldsymbol{T}$	$0.736\ mm$
$\boldsymbol{H}$	$0.442\ mm$
$\boldsymbol{h}$	$3\ um$
$\boldsymbol{\theta_{lens}}$	46.3^0

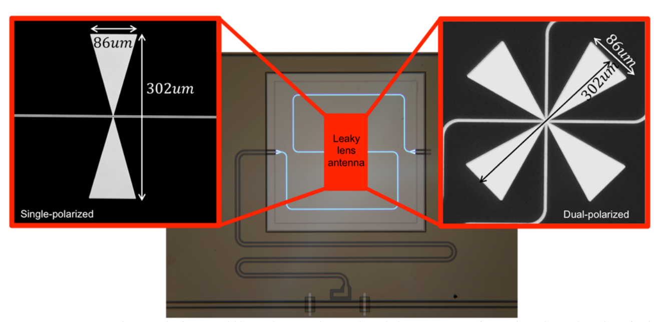

Fig. 2. Back and front illuminated optical images of a single pixel of the leaky lens antenna coupled to a KID. Left is the single polarized leaky slot and right is dual polarized leaky slot.

Both the single and dual polarized leaky lens antennas have been fabricated. The incoming radiation captured by the antenna is coupled to the CPW lines (that are crossed in the center of the slots), where the power is absorbed. The dimensions of the antennas are exactly the same (See Fig. 2). According to our measurements, the fractional power ratio between the powers received by the detector with the dual polarized leaky lens antenna and by the detector with the single polarized version of the lens antenna is $\frac{P_r^{Dual-pol\,leaky}}{P_r^{single-pol\,leaky}} \approx 2$. This showed that the proposed antenna recieves double power from an incoherent source.

The radiation patterns inside the lens have been simulated with CST MWS [8], and reported to be quite similar within the band, as expected [9]. The beam patterns of the dual-pol leaky have been measured at 1.55 THz by means of scanning a hot source along the x-y plane which is perpendicular to the optical axis of the cryostat (see Fig. 3a). We measured the beams without using a polarizer in the measurement setup. The measured 2D beam pattern and the comparison between the simulated and the measured beams in E and H-planes are highlighted in Fig. 3b and c, respectively. The simulated beams has been obtained from the CST simulations in reception. Each simulation in Rx has been launched for a plane wave excitation with different discrete oblique incidence angle ($\theta_{inc} = \pm\ 2.5^0, 5^0, 7.5^0, 10^0$). As can be seen from Fig. 3, we have a quite good agreement between the simulated and measured beams at 1.55 THz.

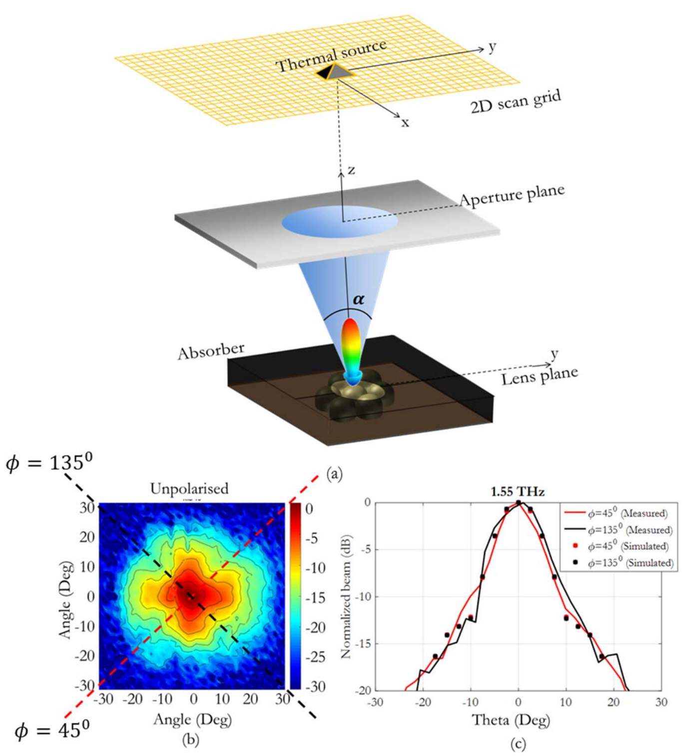

Fig. 3. (a) Schematic diagram of the beam pattern setup. (b) The measured 2D beam pattern. (c) Comparison between the simulated beams obtained from the CST simulations in reception and measured beams in E and H-planes.

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