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POLARIZATION-SENSITIVE IMAGING ARRAYS

Peter P. Tong, David B. Rutledge
California Institute of Technology, Pasadena, CA 91125

Dean P. Neikirk
University of Texas, Austin, TX 78712

Peter E. Young, W.A. Peebles, and Neville C. Luhmann, Jr.
University of California, Los Angeles, CA 90024

Two different monolithic imaging arrays have been developed that image polarization as well as intensity at near-millimeter wavelengths. One array is a row of linearly polarized bow-tie antennas that lean alternately left and right. This array has measured the polarization with a precision of 7 arc-minutes, and has demonstrated diffraction-limited resolution of a 20^{o} step change in polarization. The other array is a row of circularly polarized equiangular spiral antennas, alternately spiraling clockwise and counterclockwise, that respond to left-handed and right-handed circular polarization.

POLARIZATION-SENSITIVE IMAGING

It is often useful in imaging systems to be able to measure the polarization. This can help a radar see through rain and distinguish man-made objects from natural ones, and an interferometer to measure the magnetic field in fusion plasmas. We have developed two different imaging arrays for near-millimeter waves that measure polarization and intensity simultaneously. The antennas in one of the arrays are linearly polarized bow-ties, and in the other array are circularly polarized equiangular spirals.

Imaging arrays that do not measure polarization has been reported by Neikirk et. al. [1]. Similar to them, these arrays are made as monolithic integrated circuits, with bismuth microbolometers as detectors. Power is coupled in through a lens placed on the back of the substrate. This substrate lens eliminates substrate modes and takes advantage of the fact that antennas on a substrate are more sensitive to radiation from the substrate side [2].

BOW-TIE ARRAY

Figure 1 shows the design of the linearly polarized array and a photograph of an array built for a frequency of 375 GHz, mounted in a standard DIP package. The antennas are bow-ties that lean alternately to the right and to the left. The idea is that there are in fact two sets of linearly polarized antennas, each sampling one component of the electric field. The two components are found everywhere along the array by interpolating between the samples. Once the two components are known, the polarization of a linearly polarized wave can be calculated. The sampling interval, or distance between adjacent antennas, is chosen to achieve diffraction-limited resolution. This spacing is given by $\lambda f\#$, where λ is the substrate wavelength and $f\#$ is the system f-number [3]. The array was designed by microwave modelling at 10 GHz, and fabricated in a single lithography step, by a photoresist shadowing technique. The details are given in [3].

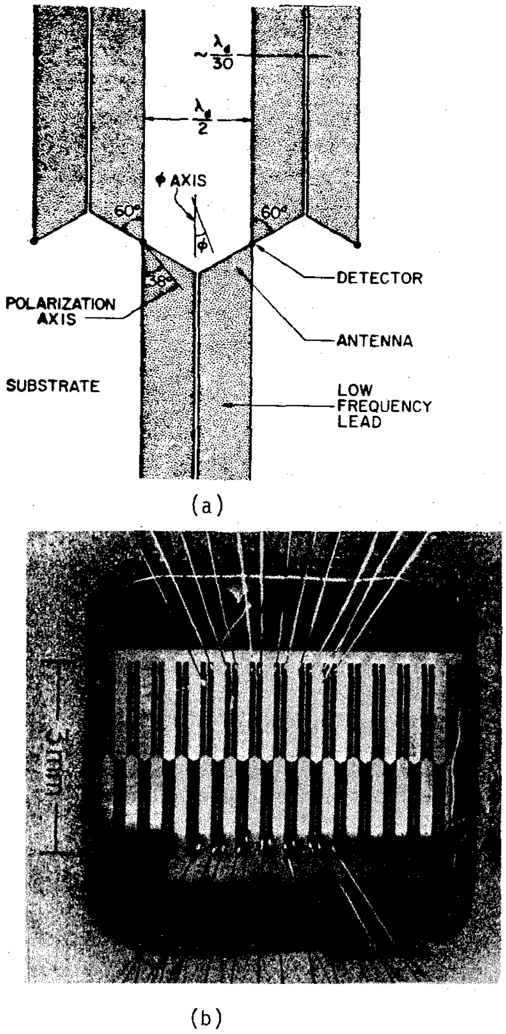

Figure 1. Linearly polarized imaging array. Design(a), and mounted in DIP package for 375 GHz(b).

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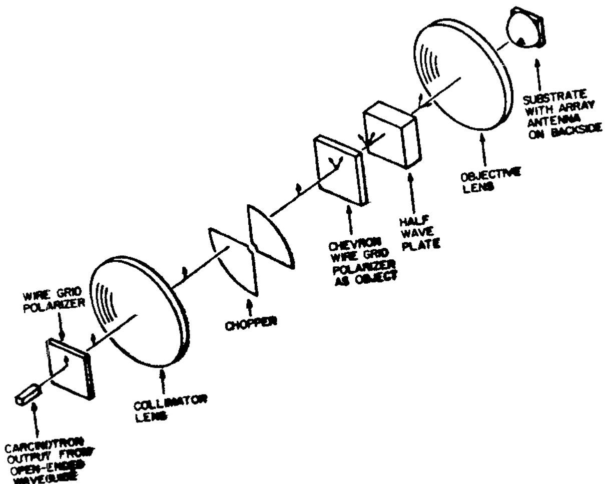
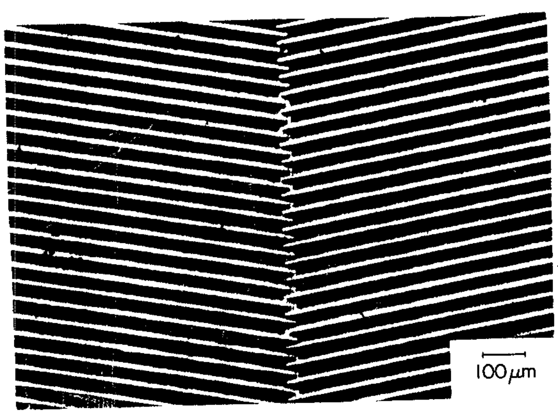
NEAR-MILLIMETER WAVE MEASUREMENTS

The precision and the resolution of the array were tested using the optical apparatus shown in Fig. 2. The first test measured how sensitivity the array was to a small change in polarization. The polarization was rotated by a half-wave plate by 2^0 and 6^0. The measured change in the polarization angles (Figure 3a) differed from the theoretical value by an average value of 7 arc minutes. Next an image was made of an aluminum chevron grid (Figure 2b), that gives a 20^0 step change in polarization. The results, shown in Fig. 3b, agree with the theoretical curve that assumes diffraction-limited optics.

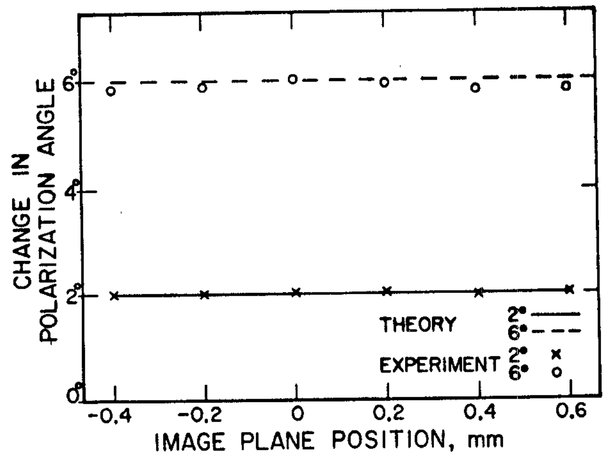


(a)

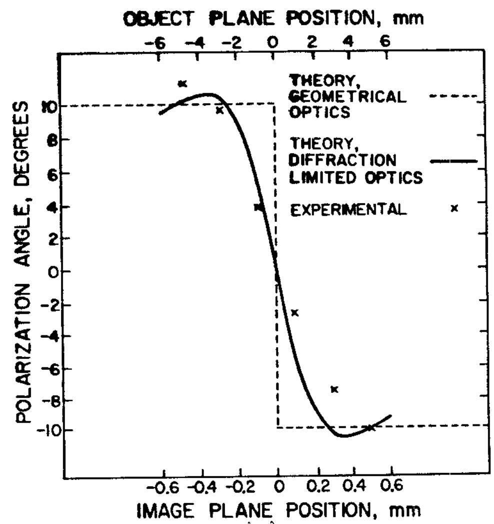


(b)

Fig. 2. Apparatus for testing the linearly polarized array. Optical set-up (a), and chevron grid for producing a 20^0 step change in polarization(b).



(a)



(b)

Fig. 3. Array response to small changes in the polarization caused by a half-wave plate (a), and to the step change in polarization produced by the chevron grid (b).

SPIRAL ARRAY

The second array consists of clockwise and counterclockwise circularly polarized equiangular spiral antennas [4]. Figure 4 shows an array designed for a frequency of 94GHz in its DIP package. The idea is similar to the linearly polarized array, that alternating circular antennas with different polarization can measure the ellipticity of the wave.

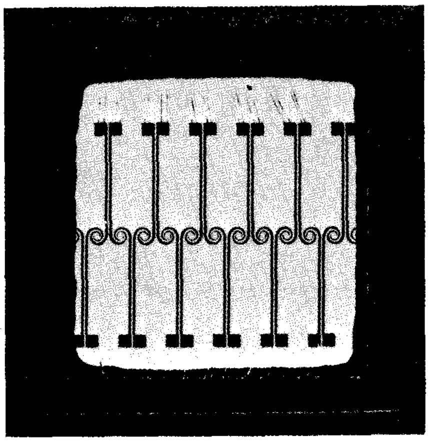


Fig. 4. Circularly polarized imaging array for 94 GHz mounted in a DIP package.

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