Dielectric Rod Waveguide Antenna Array Element for Millimeter Waves

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INTRODUCTION

Dielectric rod waveguide antennas of rectangular cross section are of increasing interest at millimeter wave frequencies. Such antennas have relatively low cost, low losses, a broadband input match and a high packing potential. The radiation pattern of the dielectric rod waveguide antenna can be also almost frequency independent. Thus it is an interesting candidate to be used as an antenna array element. In this paper the suitability of Sapphire rod waveguides as antenna array elements is studied with simulations and prototype measurements.

DRW ARRAYS

In general an antenna array enables a larger gain and narrower beam than a single antenna element. By changing the element spacing and increasing the number of elements a wide variety of radiation patterns can be created. However, it has to be remembered that the larger the number of elements, the more complex will be the element feeding network. Another way to create different radiation patterns is to change the signal phase between the antenna elements.

Earlier, dielectric rod waveguide antennas have been studied as optimized feed elements for focal plane arrays [1]. Dielectric rods were made of polyethylene (ε_r = 2.3) and they were fed by slotlines as the metal waveguide feeding requires a horn structure with low permittivity rods. Using a horn feed would require too much space and would lead to large element spacing. In the case of the higher permittivity DRW a horn feed is not required [2] and thus valuable space is saved. Fig. 1a) illustrates a 2 x 2 DRW antenna array fed by regular metal waveguides.

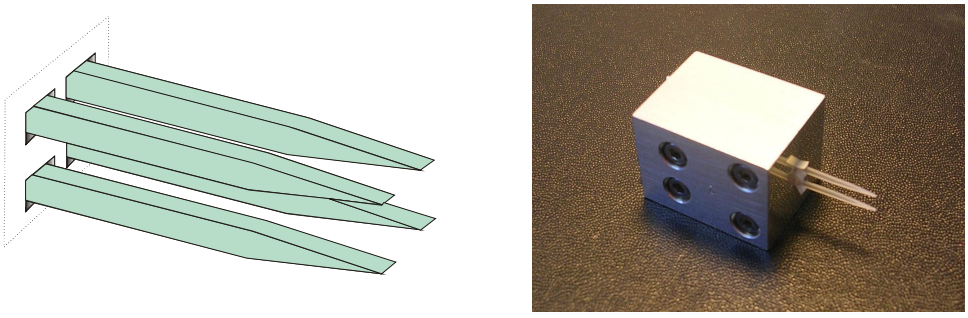

Figure 1: a) Illustration of a 2 x 2 DRW antenna array fed by regular metal waveguides, b) a two element prototype.

TWO ELEMENT ARRAY PROTOTYPE

HFSS™ was used to simulate vertically placed two-element DRW array with different element spacing. It was decided to manufacture a prototype array with element spacing of one wavelength and to use Sapphire ($\varepsilon_{r,z}$ = 11.56, $\varepsilon_{r,\rho}$=9.39) rods. The cross-section of the rod is 0.5x1.0 mm^2 and it has 6 mm long horizontal tapers in both ends. With spacing of one wavelength the main beam is about 60° and sidelobes are about 8 dB lower.

One challenge in the DRW antenna arrays is the difficulty to design an efficient feed system with the high packing density. In [1] a metal waveguide feed and a slotline feed were considered. It was decided to use a metal waveguide splitter as a feed element for two element prototype. Matching of the splitter was improved with a matching post [3]. Thin teflon sheets were used to attach the rods in the middle of the metal waveguides.

Antenna radiation pattern was measured both in E and H plane, by using the millimeter network analyzer and rotating the antenna. Measurement results are compared with the simulations made with HFSS. Fig. 2 a) presents the measured and simulated E plane radiation pattern. The main beam is about 60° and the pattern corresponds well with the simulation. Fig. 2 b) shows the simulated patterns of 2x2 element array in both E and H plane. It can be noticed that the main beam shapes nearly coincide in both planes.

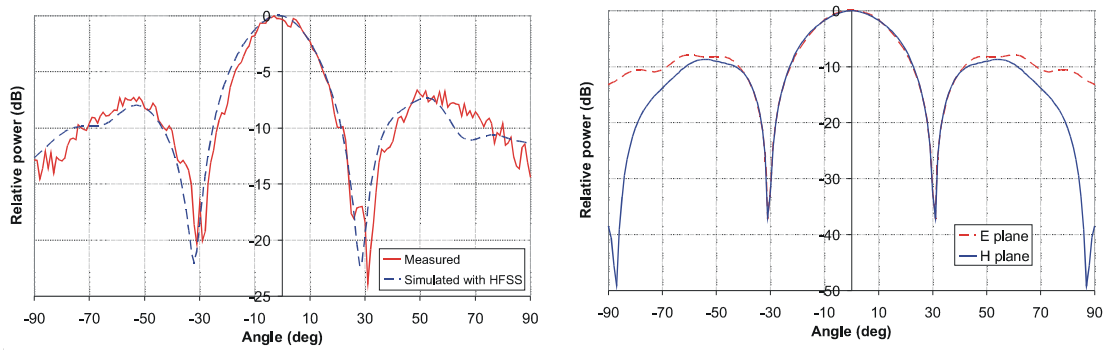

Figure 2: a) Measured E plane radiation pattern of the prototype, b) simulated patterns of the 2x2 DRW element array

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