Negative Refraction Demultiplexer Metamaterial for millimeter waves

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***Abstract*—In this work, by using an extraordinary transmission metamaterial prism and taking advance of its inherent dispersive behavior, the feasibility of manufacturing a multiplexer/demultiplexer at millimeter-wave is shown. Depending on the incoming beam frequency, the outgoing beam suffers a different deflection (governed by Snell's law). Since the frequency dependent index of refraction of this metamaterial can go from almost zero to -2 for the first propagation band, different negative outgoing angles can be obtained and then, diverse paths for each frequency, as the near-field experimental results confirm.**

I. Introduction

THE millimeter-wave (mm-wave) range is a promising frequency band for the future but more and more actual broad band communications and a great effort toward millimeter-wave components is needed.

In the last decade, an exotic field called metamaterial [1], [2] has shaken the foundations of the electromagnetism due to the unusual and often not naturally-available electomagnetics properties of its structures. These newly accessible electromagnetic properties make these materials an excellent platform for demonstrating unique electromagnetic phenomena and constructing novel components. However, the losses are still a big issue in these structures.

The Millimeter Wave Laboratory has overcome this problem by taking advance of the Extraordinary Transmission phenomenon [3], [4]. By just close-stacking subwavelength hole array screens, it achieved an Extraordinary Transmission Metamaterial (ETM) at mm-wave with low losses [5].

Later on, it has reported many applications for this stacked structure as polarizer or lens [6] to name a few, which proves the viability of manufacturing components with this new technology.

II. Results

The feasibility of the demultiplexing behavior of the ETM prism has been tested with the structure shown in Fig. 1. It consists of aluminum plates perforated with a double period subwavelength hole pattern and stacked with a longitudinal periodicity d_z = 1.5 mm. The near-field transmission coefficient is measured by means of a AB-Millimetre™ millimeter wave vector network analyzer in the frequency range from 45 to 110 GHz, with the same experimental set-up used for the Fresnel zone measurements [7] (see Fig. 1).

The experimental results shown in Fig. 2. corroborate the envisaged multiplexing behavior for 3 different frequencies.

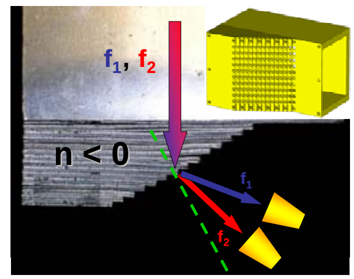

Fig 1. Details of the experimental set-up. Top view of the prototype and schematic of structure with parameters, a = 2.5 mm, d_x = 3 mm, d_y = 5 mm, and d_z = 1.5 mm. The angle of the prism is 26.6 deg.

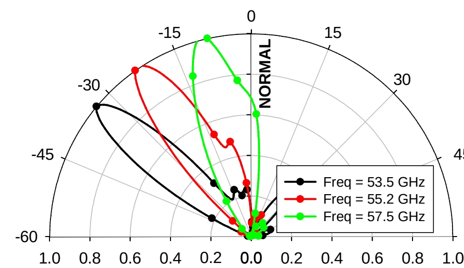

Fig 2. Normalized transmission coefficient vs. angle of refraction for 3 different frequencies.

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