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Finite Width Coplanar Waveguide Patch Antenna With Vertical Fed Through Interconnect

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FINITE WIDTH COPLANAR WAVEGUIDE PATCH ANTENNA WITH VERTICAL FED THROUGH INTERCONNECT

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Abstract

The paper presents the design, fabrication and characterization of a finite width coplanar waveguide (FCPW) patch antenna and a FCPW-to-FCPW vertical interconnect. The experimental results demonstrate the antenna and interconnect performance. A scheme to integrate an eight element FCPW patch array with MMIC phase shifters and amplifiers using vertical interconnects is described. The antenna module has potential applications in an advanced satellite to ground transmit phased array at K-Band.

I. INTRODUCTION:

A Finite Width Coplanar Waveguide (FCPW) on a dielectric substrate consists of a center strip conductor separated from finite ground planes by narrow slots on either sides [1] as shown in Fig. 1. The substrate thickness, the strip width, the slot width and the ground plane width are denoted as D, S, W and G respectively. The FCPW has all the advantages of conventional CPW [2] and in addition the finite ground planes suppress, the propagation of spurious substrate modes. The spurious substrate modes at high frequencies can degrade the electrical performance of an array antenna. In the past several authors [3], [4] have investigated conventional CPW patch antennas at 4.3 GHz and 8.5 GHz respectively fabricated on a low dielectric constant substrate, ε_r = 2.2. This paper discusses first, the design, fabrication and experimental characterization of a FCPW patch antenna with an integrated feed at K-Band. The width of the CPW ground planes are arbitrarily taken as twice the center strip conductor width which results in a very compact feed design. The entire circuit is fabricated on a low temperature co-firing ceramic tape (Ferro Corp.), ε_r = 5.9. The higher dielectric constant of the substrate material helps to reduce the size of the patch which results in a compact array. The conductor pattern is deposited using gold paste and low cost screen printing technique. Second, the measured performance of a FCPW-to-FCPW vertical fed through interconnect is presented. Lastly, the vertical integration of an eight element FCPW patch array with a system level integrated circuit (SLIC) module consisting of MMIC phase shifters and amplifiers is described. The resulting tile subarray has potential applications in an advanced satellite to ground transmit phased array.

II. INTEGRATED FCPW PATCH ANTENNA:

a.) Construction:

A schematic illustrating the integrated FCPW patch antenna is shown in Fig. 1. The antenna is constructed by widening the center strip conductor of the FCPW to form a rectangular patch. The lowest order of resonance for the patch occurs when the mean slot length summation a-thru-i is one guide wavelength $\lambda_{g(slot)}$. At resonance the electric field lines are as shown in Fig. 1. The antenna radiates with a polarization parallel to the side c-d or f-g.

b.) Measured Characteristics:

The input impedance of the antenna is determined using THRU-REFLECT-LINE on-wafer calibration standards, a pair of G-S-G microwave probes, HP8510C ANA and NIST De-embedding software [5]. The TRL standards are also fabricated on the same substrate as the antenna using the screen printing process. The experimentally de-embedded input impedance at the reference plane P-Q is shown in Fig. 2. The antenna resonates at about 19.95 GHz. The measured E-and H-Plane radiation patterns, gain and the cross-polarization level will be discussed at the conference.

III. FCPW-to-FCPW VERTICAL INTERCONNECT:

A schematic illustrating two back-to-back FCPW-to-FCPW vertical interconnect with a short length of FCPW in between is shown in Fig. 3. The via has a diameter of about 0.01 inch. The rest of the dimensions are same as in Fig. 1. The measured return loss and insertion loss are shown in Fig. 4. These measurements show that, the insertion loss and return loss per interconnect is about 0.3 dB and -30 dB respectively.

IV. INTEGRATION OF ANTENNA OVERLAY WITH SLIC MODULE:

The SLIC module is being developed by Lockheed Martin under a contract from NASA Lewis Research Center. The module consists of four dual channel MMICs with supporting circuitry. Each of the dual channels consists of a 3-bit phase shifter, an analog attenuator and amplitude calibration and control elements. In addition, the module also has a photonic link to bring the 20 GHz RF signals and digital control signals. A second link returns module status to the controller. Fig. 5 schematically illustrates the integration of the antenna overlay with the SLIC module. The results of the overlay characterization will be presented at the conference.

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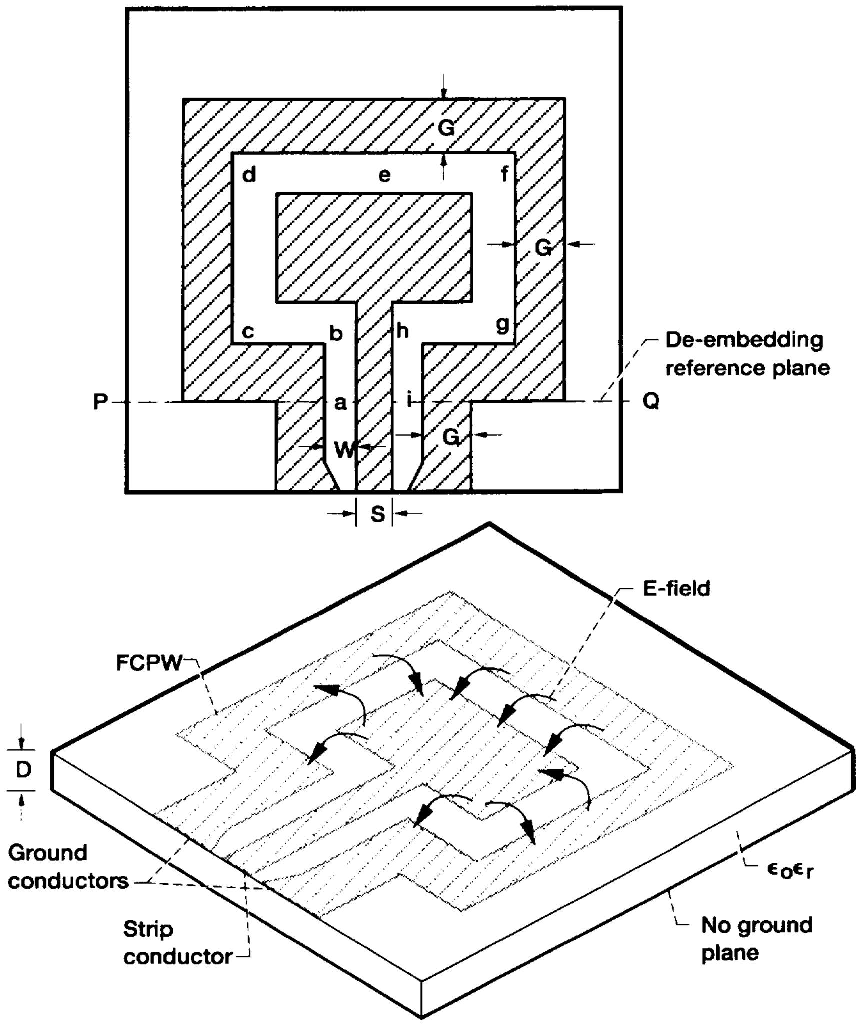

Figure 1.—Schematic of FCPW patch antenna. ϵ_r = 5.9, D = 0.01125 in., S = 0.012 in., W = 0.004 in. and G = 0.024 in.

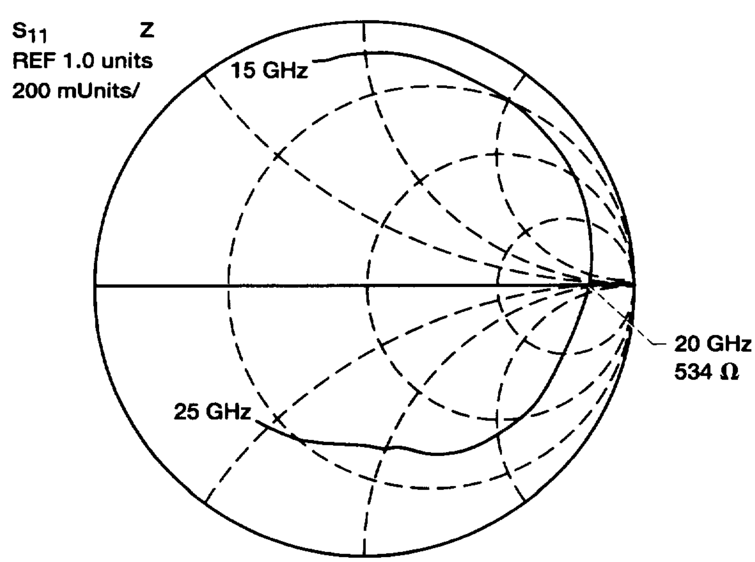

Figure 2.—Measured input impedance of the antenna.

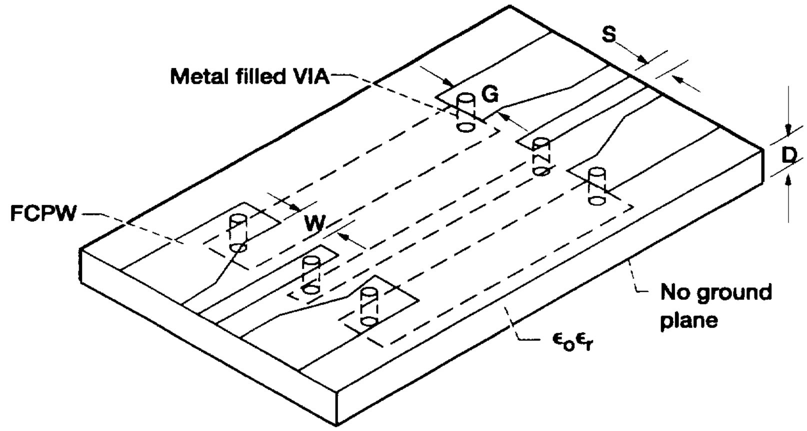

Figure 3.—Schematic of two back-to-back FCPW-to-FCPW vertical interconnect. D = 0.01125 inch, ϵ_r = 5.9.

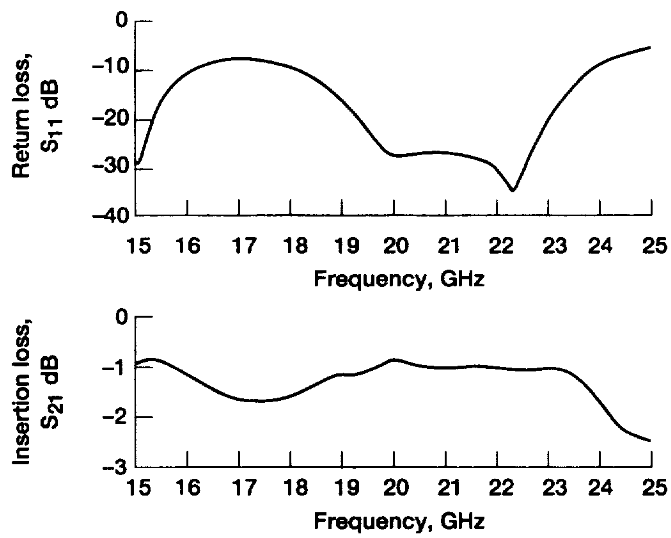

Figure 4.—Measured return loss and insertion loss of the interconnect.

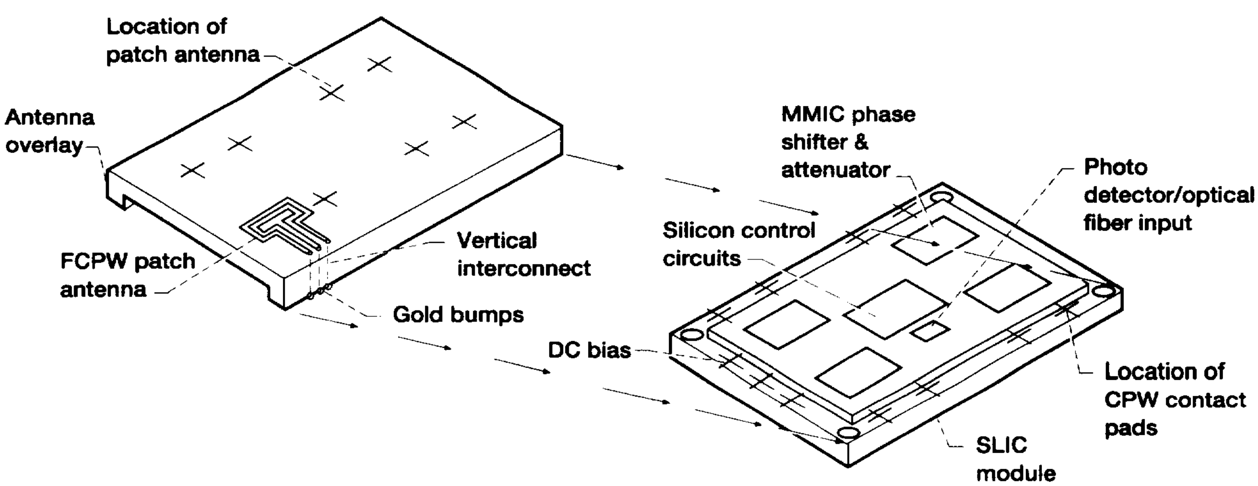

Figure 5.—Schematic of the SLIC module with the antenna overlay.

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13. ABSTRACT ***(Maximum 200 words)***

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