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# Characteristics of Linearly Tapered Slot Antenna With CPW Feed on High Resistivity Silicon

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## SUMMARY

A linearly tapered slot antenna (LTSA) has been fabricated on a high resistivity silicon substrate and tested at C-Band frequencies. The LTSA is electromagnetically coupled to a coplanar waveguide (CPW) feed. In this paper, the measured radiation patterns, gain and return loss are presented and discussed.

## INTRODUCTION

Linearly tapered slot antennas (LTSA's) have many exceptional features such as narrow beamwidth, high element gain, wide bandwidth and small transverse spacing between elements in an array. These features make them attractive in satellite communication antennas (ref. 1). Previously reported LTSA antennas are fabricated on low dielectric constant RT-5880 Duroid substrate (refs. 2 to 4). This paper describes the design and performance of a LTSA constructed on a high resistivity silicon substrate. By choosing a silicon substrate with sufficiently high resistivity it is possible to make the dielectric attenuation constant of the microwave transmission line for the feed network approach that of GaAs (ref. 5). Compared to designs presented earlier, the new design has smaller dimensions because of the higher dielectric constant of silicon. In addition, the use of silicon provides for the potential of integration with silicon MMIC's and digital control circuits. Lastly, when compared with GaAs, silicon wafers are available in much larger diameters and at lower cost thus facilitating integration of active devices, antenna and control circuits on a single wafer.

## ANTENNA DESIGN AND FABRICATION

The antenna and the feed network are fabricated on a single 5000 to 10,000  $\Omega$ -cm silicon wafer. The thickness of the wafer is 0.381 mm with  $\epsilon_r = 11.7$ . The thickness of the gold metalization is about 2.5  $\mu\text{m}$  which is about three times the skin depth at the center frequency  $f_0$  of 6 GHz. This substrate has an effective thickness ratio (ref. 1) of 0.02 which is within the optimum range for high gain and low side lobes. Figure 1 shows a feed with electromagnetic coupling between a grounded CPW (GCPW) and slotline which are on opposite sides of a silicon wafer (ref. 6). At the GCPW input port,  $Z_0$  is 50  $\Omega$  while close to the transition to the slotline  $Z_0$  is 60  $\Omega$ . The  $Z_0$  of the slotline is 70  $\Omega$ . The distances  $L_s$  and  $L_m$  are  $\sim \lambda_{g(\text{slotline})}/4$  and  $\lambda_{g(\text{microstrip})}/4$ , respectively at  $f_0$ . The LTSA is formed by gradually flaring the width of the slotline by an angle  $2\alpha$ . When  $2\alpha$  is close to 11 degrees a symmetric beam width is achieved for an antenna on Duroid (ref. 1). A symmetric beam results in high aperture efficiency if used for illuminating a reflector. The width  $H$  of the antenna is

arbitrarily chosen as  $0.3 \lambda_{g(\text{slotline})}$ . The length  $L$  of the antenna as determined by  $\alpha$  and  $H$  which is  $1.5 \lambda_{g(\text{slotline})}$ . Figure 2 shows a picture of the fabricated antenna.

## ANTENNA PERFORMANCE AND DISCUSSIONS

The measured return loss ( $S_{11}$ ) at the coaxial input port of the feed network is shown in figure 3. The return loss is observed to be better than  $-10$  dB (2:1 VSWR) over a frequency range extending from 6 to 8 GHz. Although, the antenna has been designed at 6 GHz, the best return loss occurs at about 7 GHz. This could be due to double side processing of the wafer which might have inadvertently offset the feed resulting in a shorter stub length. Typical measured E- and H-plane radiation patterns are shown in figure 4. The patterns are found to have good characteristics. The measured gain of the antenna is 5, 7, and 9 dB at 5, 7, and 9.4 GHz, respectively. Lastly, optimization of the LTSA on silicon has not been carried out and better performance might be expected with improvements.

## CONCLUSIONS

The design and performance characteristics of a LTSA fabricated on high resistivity silicon wafer is presented. The LTSA exhibits good impedance match and radiation patterns.

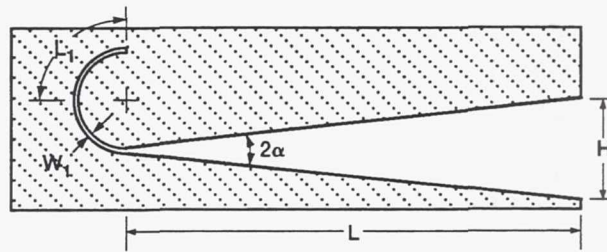
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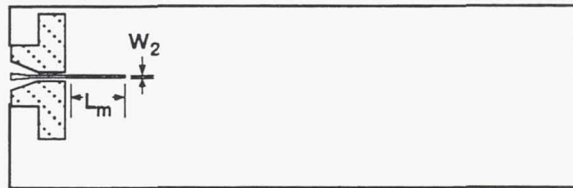
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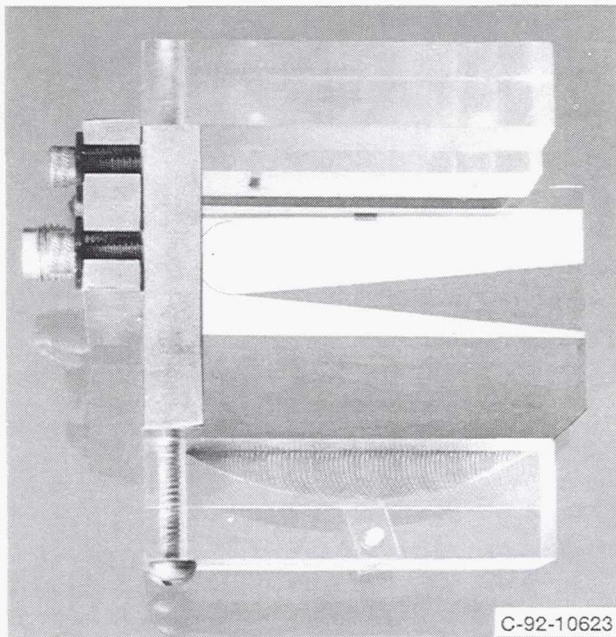


(a) Front side metalization.

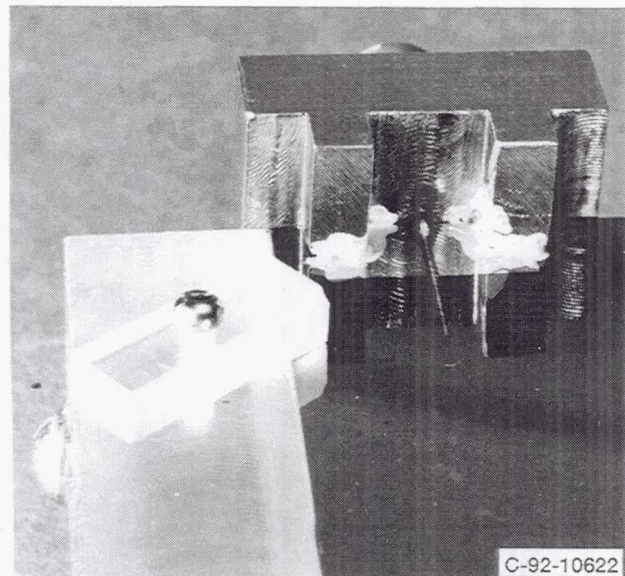


(b) Back side metalization.

Figure 1.—Schematic of the linearly tapered slot antenna.  
 $W_s = 0.16$  mm,  $W_m = 0.15$  mm.



(a) Linearly Tapered Slot Antenna (LTSA) on silicon.



(b) Coplanar Waveguide Feed (CPW) for Linearly Tapered Slot Antenna on silicon.

Figure 2.—Photograph of the antenna.

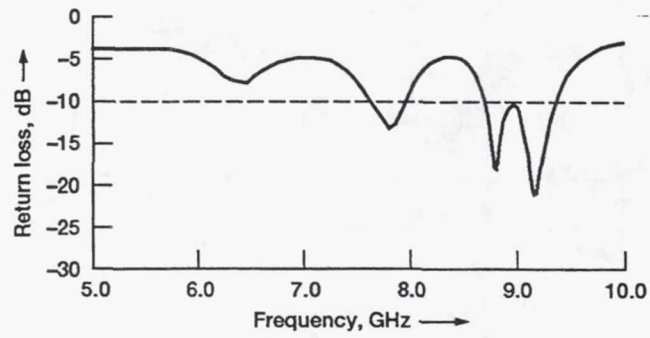


Figure 3.—Measured return loss ( $S_{11}$ ) at the coaxial input port.

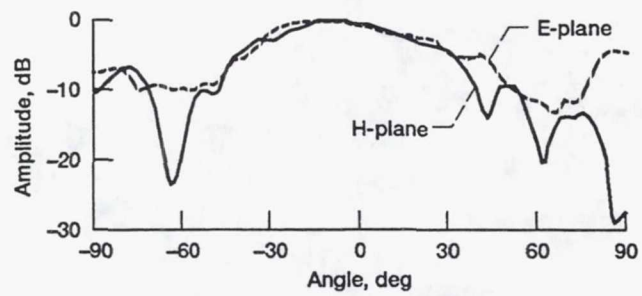


Figure 4.—Measured radiation pattern of the LTSA at 7 GHz.

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