Optically Driven CPW Fed Slot Antennas and Arrays for Wireless Communications

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ABSTRACT

This paper presents a comparison of three different types of CPW fed slot antennas integrated with a photodetector. The antennas are driven by optical power converted into microwave power using the photodetector which is directly attached to the antennas without the use of any amplifying devices. The operating frequency of these antennas is around 18.5GHz. This paper presents the approach for matching a photodetector to a single element or to an array of elements. Measured data and simulations for various antenna/photodetector configurations are compared and discussed.

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I. INTRODUCTION

The need for more bandwidth and capacity in wireless systems is the main culprit for the great interest in the development of wireless communications systems operating in higher and higher frequencies. The integration of fiber optics systems with RF components is a promising solution, as well as a cost effective way to increase bandwidth and overall system efficiency [1]. Although, fiber optics offer a lot of benefits (light weight, immunity to signal interference, great bandwidth), they cannot radiate a lot of power. Even the most modern fibers simply cannot transfer as much power as a typical coaxial cable. The idea behind this work is to minimize the losses due to mismatch between the Optics and the RF components and to maximize the gain of the transmitting/receiving antenna [2].

Figure 1 depicts an SEM image of a side-illuminated waveguide photodetector (WGPD) that is used to convert the RF-modulated optical power into a microwave signal. The WGPD is a standard p-i-n device. Flexibility in the design of WGPD including optical coupling, optical absorption, transit time and capacitance provides the needed versatility to optimize the device design for a given application. The photodetector is fed by an optical fiber.

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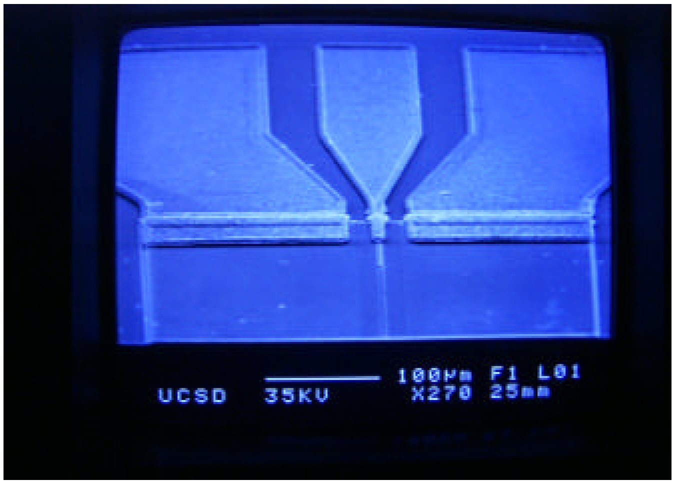


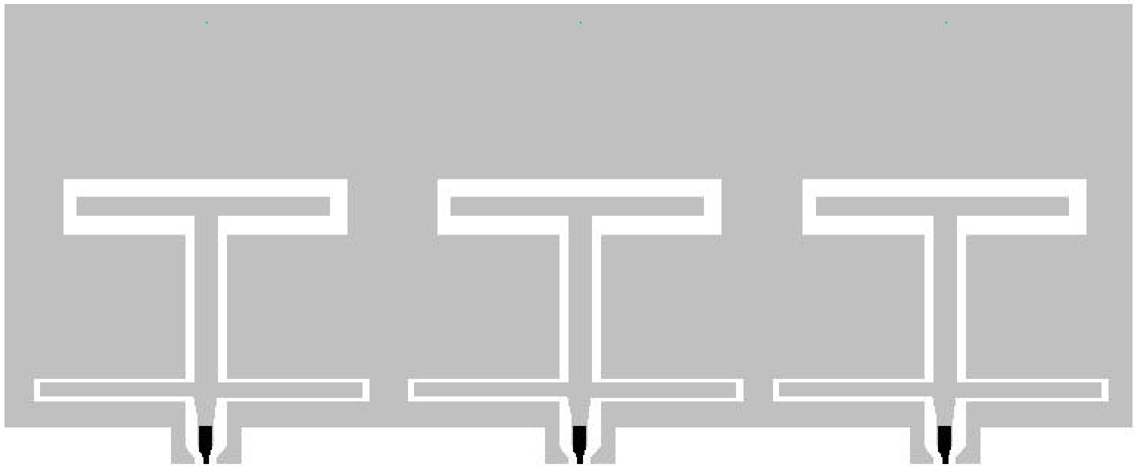
Figure 1. SEM image of the fabricated WGPD showing the CPW electrodes

II. ANTENNA CONFIGURATIONS

The layouts of the three antennas configurations studied in this paper are shown in Figure 2. In all three designs, the length of the slot was 4500 µm, the slot width 100 µm, while the gap was 160µm for the CPW and 25µm for the rest of the antennas [3]. The antennas are placed on top of a 500 µm BeO substrate with e_r= 6.7 and dissipation factor around 0.004 at 18 GHz . All three antennas have a double open-end shunt stub to give the input impedance of 20 +j50Ohms (around 18.5GHz), which is the complex conjugate of the photodetector impedance. The dimensions of the double open-end shunt stub is 7300 µm in length and 100µm in width. For the array, the three elements were placed at 6000µm distance of separation. The black part of the layout represents the photodetector, while the top of all structures is considered as an infinite ground plane.

(a) (b)

Figure 2:(a) Single element antenna, (b) three element antenna



(c)

Figure 2 (c). An array of three single element antennas

The table below contains, data for the three antenna configurations. One can see that the configuration in 2 (c) yields the best gain but it also requires three inputs, which correspond to three fibers feeding three different photodetectors. Configuration 2 (b), on the other hand, gives more gain than the single element and it still only requires one photodetector as its input. All configurations are easy to match to the photodetector and they all provide very good bandwidth.

Figure 3 shows the S11 parameters for two of the antenna configurations, mainly, the antennas in Figure 2(b) and 2 (c). The S11 parameter for the antenna in Figure 1 (c) is the same as that of Figure 2 (c) and thus it has been omitted from the figure.

	Optimum operational Frequency	Antenna Efficiency	Linear Gain	Linear Directivity	Linear Maximum	3dB Beam Width
One element antenna	19 GHz	99.3688%	3.70249dBi	3.72999dBi	At (175, 270) deg	(43.6, 121.3) deg
Three element antenna	18.6 GHz	95.922%	4.19581dBi	4.41741dBi	At (140, 100) deg	(56.2, 114.45) deg
Three element array	19 GHz	99.6943%	7.44899dBi	7.46228dBi	At (175, 270) deg	(43.6, 81.9) deg

Table 1: Simulation results of the three designs [4]

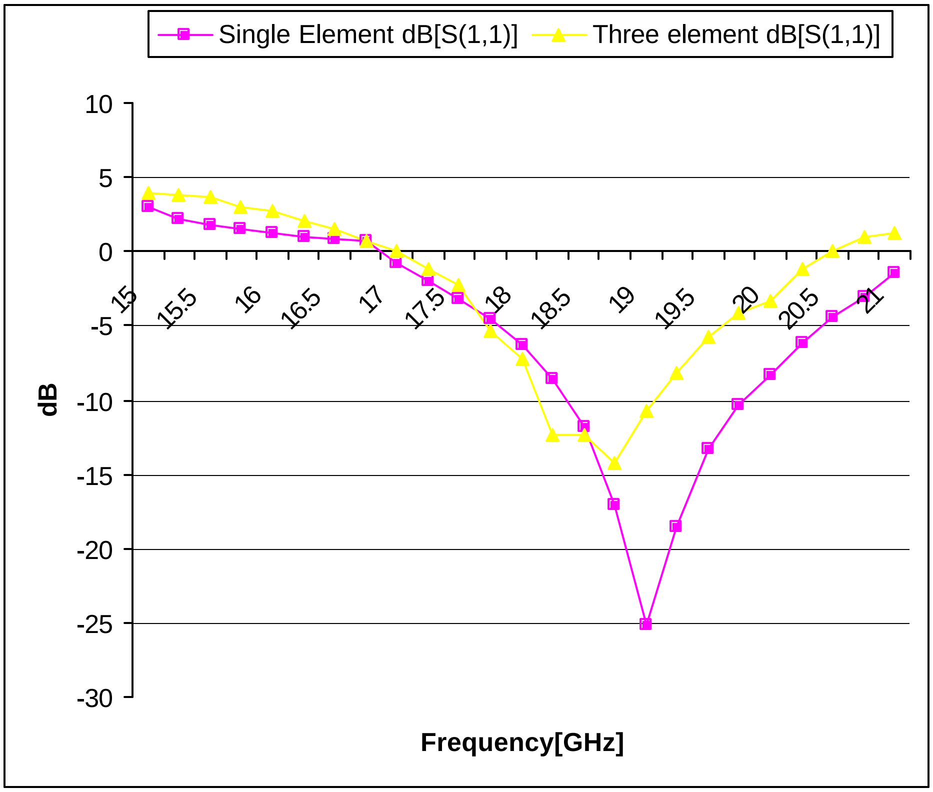


Figure 3. S11 parameters for antennas in Figures 2 (b) and 2(c)

III. CONCLUSIONS

A new RF/Photonic interface that consists of an antenna and a waveguide photodetector was presented and analyzed. Three different CPW-fed slot antenna configurations were chosen as the radiating elements fed directly from the waveguide photodetector, which converts the RF-modulated optical power into electrical signal at microwave frequencies. This new RF/photonic antenna, with the appropriate space-time processing and coding, can yield a new smart antenna for high capacity wireless communications.

IV. REFERENCES

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