A New Type of Optoelectronic Millimeter-wave Finline Switches

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ABSTRACT

A new type of millimeter-wave finline switches constructed on telfon substrates is proposed, which can be easily fabricated and mounted. The experiment results are reported, which show 1.6 dB insertion loss and 23.4 dB on/off ratio have been reached. Because of its good compatibility with the conventional finline structures, it may have a wild application field, especially in the hybrid integrated millimeter-wave circuits.

INTRODUCTION

There has been continued and increasing interest over the past years in the controls of microwave and millimeter-wave devices and circuits with optical signals. These controls offer several attractive advantages, such as nearly perfect isolation between controlling and controlled signals, fast switching time, and the ability to handle high power, etc.[1]. Most of them are based on the photoconductive effect of semiconductors. As the complex dielectric constant of the semiconductor in a microwave device or circuit is modified by optically induced electron-hole plasma, the function of the device or circuit is changed. Several optically controlled devices have been realized: switches, phase shifters, and modulators, which were based on either a stripline, or coplanar waveguide, or dielectric waveguide[2][3][4].

The optoelectronic finline switch was first investigated by Platte, et al. In their experiment, the insertion loss was about 6 dB, and on/off ratio, around 4 dB [5]. Unde, et at. have made considerable improvement for this switch, and demonstrated that the insertion loss between 1 and 2 dB and on/off ratio up to 40 dB had been achieved[6][7].

Both Platte and Unde constructed the finlines on the semiconductor wafers. Because these materials are brittle, great care has to be paid in fabrication and mounting these finlines. Moreover, a low insertion loss of these finlines is more difficult to be realized because, as a general thing, the $\tan\delta$ of the semiconductors is larger, and the dielectric constant , higher than those of the dielectrics. It may be necessary to constructed the optoelectronic finline structures on a semicondutor substrate for the monolith integrated circuits. When this control device is used in the hybrid integrated circuits, it is easier to used a dielectric substrate since the difficulties stated above, and the dimensional limitation of the semiconductor substrates can be avoided . In addition, the application field of the optoelectronic finline switches on a dielectic substrate may be wild because of its good compatibility with the conventional finlines devices and circuits. In this paper, a new optoelectronic millimeter-wave switch, using a finline on a telfon substrate, is proposed. The primary experimental results are reported, which show that 1.6 dB insertion loss and 23 dB on/off ratio have been reached.

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EXPERIMENT SET UP AND RESULTS

The finlines are constructed on telfon substrates, which is shown in Fig.1. The finline tapers are designed by the taper synthesis method [8], and a piece of semiconductors sheet, such as Si, or GaAs, or InP, is stamped in the center of the finline. It is important to choose an appropriate shape and thickness for a certain type of semiconductor patches, so that a lower insertion loss and larger on/off ratio can be obtained.

The experiment set up is shown in Fig. 2. An example waveform in our experiment is given in Fig. 3. An appropriate power level is chosen by adjusting the standard attenuator. When a laser pulse illuminating the device under test(DUT), a large amount of electron-hole pairs are created, and a great deal of microwave power transmitted though the finline, is reflected, then the output of the detector reach the valley of the waveform. The light induced electron-hole pairs recombine after the laser pulse having passed. Then most of the microwave power can be transferred and the output of the detector recovers from the valley to the high level. After the waveform being stored, and the laser pulse being removed from the DUT, the output voltage, which then is a horizontal line, can be adjusted to the bottom of the waveform by changing the standard attenuator. The on/off ratio can be obtained by subtracting the initial value from the final one of the attenuator.

The experiments have been done on this new type of finlines with Si, GaAs, and InP patches, and the results with a Si patch and 0.2 mm slot width of the finline are listed in Table 1. From it we can see that 1.6 dB insertion loss and 23.4 dB on/off ratio have been reached. The on/off ratio in [7], when the slot width w=0.2 mm, are around 25 dB. So the on/off ratios of the optoelectronic finline switches on the telfon and on the semiconductor substrates are in the same order. On the other hand, the difficulties and the limitation, mentioned above, may be overcome by the former.

CONCLUSION

A new type of optoelectronic finline switches has been proposed, and its on/off ratio and insertion loss have reached an attractive level. Its lower insertion loss is expected for a better design. When several semiconductor patches are stamped on the finline with the optimum distance separations, a larger on/off ratio is possible. We can see, from the experiment results listed in Table 1, that the new structure with two isolators, may be used as an optically controlled attenuator. It is very important that the new switches have good compatibility with the conventional finline, which is an important structure for the hybrid integrated millimeter-wave circuits. Because the technology for the finlines on the dielectric substrates is nearing its maturity, its applications are extensive, and different types of semiconductors may be used in the new switches, the application field of the new switches is expected to be wild. From the point of the practical usage, a great number of investigations need to be made, which are being carried on in our lab.

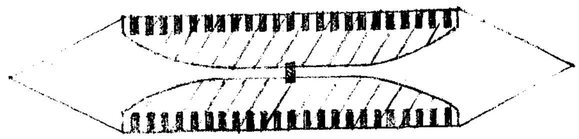

Fig.1 Finline-on-telfon substrate with a semiconductor patch

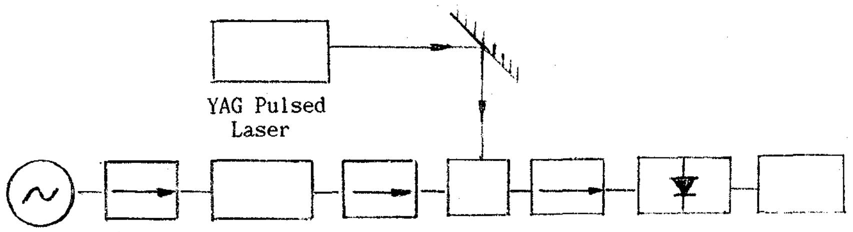

Fig. 2 Experimental set up

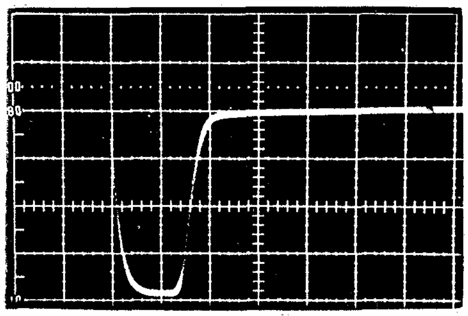

Fig.3 Output waveform from the detector

Table 1

Reduced Optical Power (P/Po)	1	$8.77*10^{-2}$	$4.47*10^{-2}$	$3.40*10^{-2}$	$2.98*10^{-2}$	0
Microwave Insertion Loss(dB)	25.0	17.0	12.5	10.9	3.5	1.6
On/off Ratio (dB)	23.4	15.4	10.9	9.3	2.9	

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