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A Ultra Broadband SPST GaAs PIN Diode Switch with 30 dB Isolation and 1.0 dB Insertion Loss

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Abstract

In the recent progress of MMICs technology, MMIC control devices such as switches and phase shifters are widely used in microwave and millimeter-wave communication systems [1]. In these systems, MMIC switches are required to have high isolation as well as low insertion loss. The MMIC using the GaAs PIN diode is required for the millimeter-wave communication systems [1].

In this paper, the GaAs PIN diode was designed by using a de-embedded method [2]. By analyzing the Ron and Coff, the parameter of the structure for the diode was determined. A SPST GaAs PIN diode switch has demonstrated.

Figure 1 shows the cross-sectional view of the GaAs PIN diode. The equivalent circuit for the GaAs PIN diode is shown in Fig. 2. Here, Ron, Con, Roff and Coff are intrinsic resistances and capacitances under on- and off-state, respectively. Ls is the parasitic inductance introduced by air bridge, Lvia is via hole inductance, and Rs is parasitic resistance. The equivalent circuit model shown in Fig. 2 takes into account the parasitic elements such as Ls, Lvia and Rs. All equivalent circuit parameters were obtained by using a de-embedded method [2]. Table 1 lists the equivalent circuit parameters. Figure 3 shows the characteristics of Rs and Coff versus the space A are shown in Fig. 1, where the thickness of i-GaAs layer is 2 μ m, the forward bias current is 10 mA and the reverse bias voltage is -10V. Coff is independent of the space A. However, Rs decreases with the narrowing of the space A. This fact shows that the resistance due to the diffusion current depends on the space A. To reduce the loss of GaAs PIN diode in high-frequency region, reduction of the parasitic resistance determined by diffusion current is most important. We determined the space A of 5 μ m shown in Fig. 3.

Figure 4 shows the circuit configuration of the SPST switch. To obtain higher isolation characteristics, two shunted diodes were cascaded. Figure 5 shows the chip photograph of the SPST switch. The electrode diameter of the GaAs PIN diode is 40 μ m. The thickness of semi-insulating GaAs substrate is 100 μ m. The SPST switch was measured by using on-wafer RF probing systems. DC bias voltages applied to switch were supplied with bias Tee. Forward bias current of each diode is 10 mA and reverse bias voltage is -10 V. Figure 6 shows the frequency characteristics of SPST switch at measured input power level of -10 dBm. It has been exhibited that insertion loss of 1.0 dB and isolation of 30 dB were obtained in 10 GHz to 50 GHz.

In conclusion, the broadband SPST GaAs PIN diode switch has been demonstrated. By analyzing the equivalent circuit parameters of the diode, the diode structure has been determined. By using the developed diode, a SPST switch has exhibited that the insertion loss of 1.0 dB and the isolation of 30 dB were obtained in 10 GHz to 50 GHz.

References

[1] D.Teeter,R.Wohlert,B.Cole,G.Jackson,E.Tong,P.Saledas,M.Adlerstein,M.Schindler, and S.Shanfield, "Ka-band GaAs HBT PIN diode switches and phase shifters, " *1994 IEEE MTT-S International Microwave Symposium Digest*, 451-454.

[2] H.Takasu, "Ka-band SPDT MMIC switch using low loss GaAs PIN diode, " *IEICE Trans. C-I*, vol.J82-C-I, no.9, pp.554-560, Sept. 1999 (in Japanese).

Table 1 Equivalent circuit parameters of PIN diode.

Ls (nH)	Lvia (nH)	Ron (Ω)	Roff (kΩ)	Cj (pF)	Coff (pF)
0.06	0.045	0.3	200	0.08	0.068.

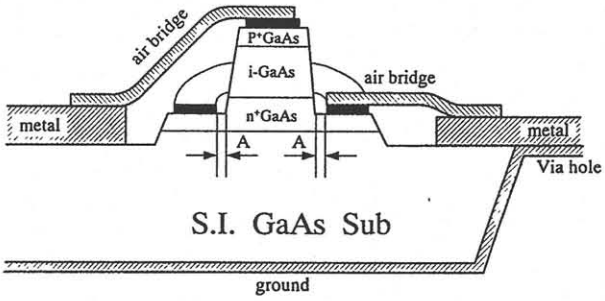

Fig. 1 Cross-sectional view of GaAs PIN diode.

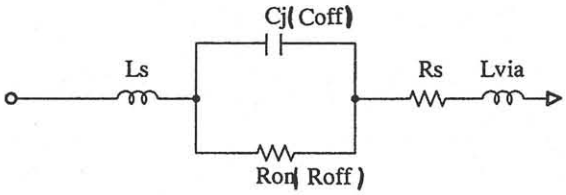

Fig. 2 Equivalent circuit model of diode.

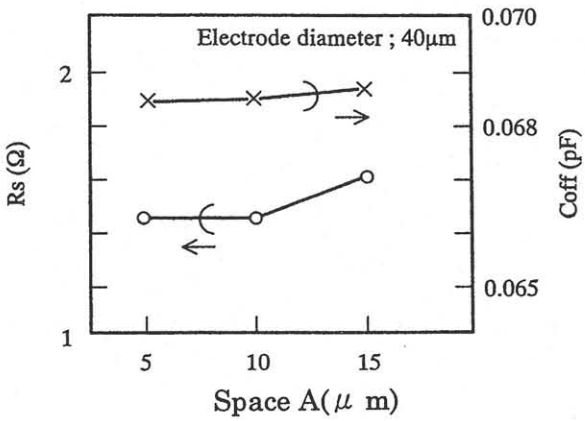

Fig. 3 Characteristics of Ron and Coff versus space A.

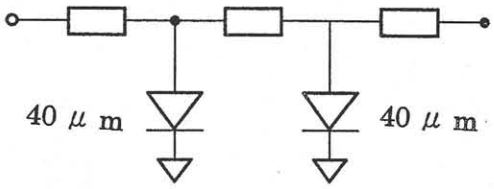

Fig. 4 Circuit configuration of SPST switch.

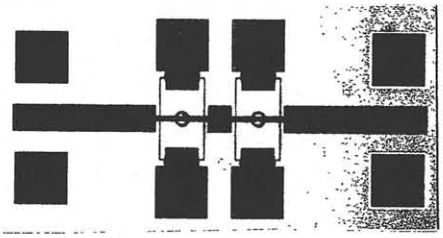

Fig. 5 Photograph of SPST switch.

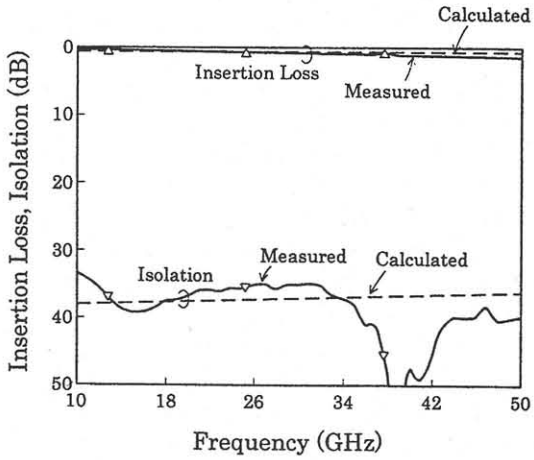

Fig. 6 Frequency characteristics of SPST switch