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# High Power, High reliability p-n Junction GaAs Impatt Diodes for J-Band

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In this paper, the high power and high reliability p-n junction GaAs Impatt diodes for J-band will be discussed. GaAs Impatt diodes with hi-lo and lo-hi-lo structures are attractive because of their high efficiency and high output power operation[1,2]. However, such diodes have a serious problem concerned with the reliability due to the interdiffusion of Pt with GaAs[3]. On the contrary p-n junction GaAs Impatt diodes are thought to have high reliability, but this type of Impatt diodes have not shown yet high output power comparable to those of Schottky barrier type.

In this work, the high output power of 10 W is realized by p-n junction GaAs Impatt diodes. The $p^+$-n-$n^-$ GaAs epitaxial layers used were grown on Si doped ( 100 ) substrate wafers by a successive liquid-phase epitaxy method. The carrier profile of active layers is shown in Fig. 1. The carrier concentration and thickness of $p^+$ layer are 1 x $10^{18}$ $cm^{-3}$ and 1 μm respctively. The avalanche layer is so narrow that the carrier profile has a ideal Read structure. After forming AuGe contacts on the both sides of the GaAs wafers of 70 μm thickness, the wafers were divided into 300 μm square chips by the photolithography and scribing. The chips were mounted in standard microwave packages. The microwave performances were measured by the use of a hat type cavity.

Table 1 presents the electrical characteristics of some c.w. p-n junction GaAs Impatt diodes. An example of output power versus input power relation of the diodes with number of one to four chips is shown in Fig. 2. From this figure the power combination seems to be relatively good. The maximum output power observed was 11 W ( $\eta$ = 21.6 % ) at 5.73 GHz.

An accelerated life test was performed to evaluate the reliability of the p-n junction GaAs Impatt diodes described above. The failure criteria used in the test was 20 % shift in breakdown voltage at 1 mA. Figure 3 shows the median failure times of these diodes plotted as a function of 1/T. The activation energy obtained from Fig. 3 is 1.85 eV and the median life time of 1.5 x $10^6$ h at 200°C is deduced by the extrapolation. In case of other contacts on $p^+$ layer, (1) AuGe-Pt-$p^+$ and (2) AuGe-Pt-Mo-Pt-$p^+$, the median life time greater than $10^7$h is deduced at 200°C.

In conclusion, it is shown that the high output power more than 10 W p-n junction GaAs Impatt diodes for J-band which assure a high reliability can be realized.


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2. D. E. Iglesias, J. C. Irvin and W. C. Niehaus : " 10-W and 12-W GaAs IMPATT's ", IEEE Trans., ED-22, 4, p.200 ( April 1975 ).
3. A. K. Sinha and J. M. Poate : " Effect of alloying behavior on the electrical characterisitics of n-GaAs Schottky diodes metallized with W, Au and Pt ", Appl. Phys. Lett., 23, 12, p.666 ( Dec. 1973 ).


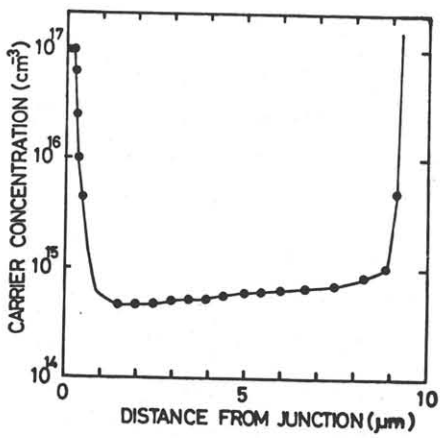


Fig.1 Carrier profile

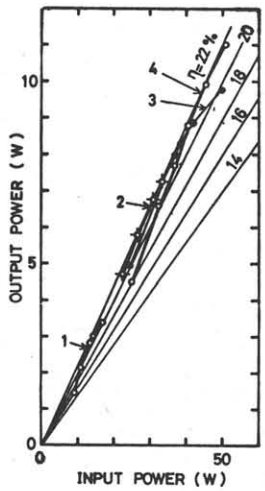


Fig.2 Power combination with one to four chips

Table 1 Electrical characteristics of c.w. p-n junction GaAs Impatt diodes

| Diode | Number of chips | $V_{op}$ (V) | $I_{op}$ ( mA ) | $P_{out}$ ( W ) | $\eta$ ( % ) | Freq. (GHz) |
|---|---|---|---|---|---|---|
| A/1 | 1 | 54 | 230 | 2.9 | 23.3 | 6.5 |
| A/2 | 2 | 70 | 530 | 8.0 | 21.6 | 6.4 |
| A/3 | 4 | 67 | 896 | 10.7 | 18.0 | 6.0 |
| B/1 | 3 | 67 | 750 | 9.8 | 19.4 | 5.8 |
| B/2 | 4 | 63 | 774 | 10.0 | 20.6 | 5.9 |
| B/3 | 4 | 60 | 854 | 11.0 | 21.6 | 5.7 |

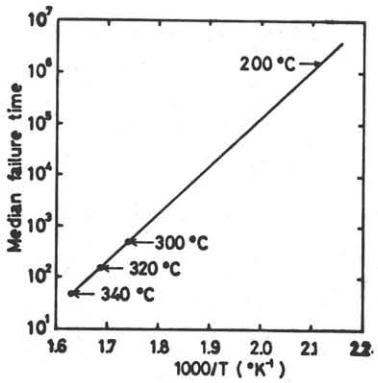


Fig.3 Median failure time as function of 1000/T