CW GUNN DIODES IN COMPOSITE STRUCTURE

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It is a way of obtaining a higher output power to operate microwave generators in parallel combinations. It was already reported(1)(2) that several watts of output were obtained with impatt diodes in parallel and series combinations. While, such the attempt at Gunn diodes in CW operation is not seen yet, except for a case of 300 mW output in X-band with a cascaded Gunn oscillator(3). The present report is related to experimental results of Gunn diodes in composite structure.

Three types of Gunn diodes herein used are fabricated in mesa structures with epitaxially grown n-type GaAs crystals. The resistivities and dimensions of active layers of individual Gunn diodes are shown in Table 1. The carrier mobility of each crystal is about 5,000 $cm^2/V \cdot sec$. The diodes are mounted upside down onto a copper stud of a package shown in Fig. 1, while, the sides of substrate are bonded to gold ribbon as illustrated in Fig. 2.

Table I

Type	(ohm-cm)	Dimension (μ)	R_L(ohm)
I	2.0	180 x 180 x 9	5.5
II	0.4	140 x 140 x 9	1.7
III	0.35	110 x 110 x 9	2.5

The thermal resistance of type I single mounted diode is about 25 deg/W. As, in a composite structure, diodes are separated by more than 1.2 mm apart from each other, the thermal resistance between two adjacent diodes is estimated at less than 2.5 deg/W. The respective diode used for the composite structures is, when singly mounted, able to be DC biased more than 15 V which corresponds to more than three times of the Gunn threshold voltage. The maximum output powers are obtained when 10 to 15 V is applied. The package capacitance and the lead ribbon inductance are about 0.7 pF and 0.4 $m\mu H$ respectively from measurements on singly mounted diodes. X-band waveguide system is used for the microwave characteristic measurements. The composite

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diodes are mounted in a waveguide type cavity whose a/b is 6 to reduce the impedance.

The maximum output power and efficiency of each diode against the reciprocal of low field resistance are illustrated in Fig. 3 and 4 respectively in which the ordinals of curves represent the numbers of diodes in parallel combinations. From the results, it is obviously found that the decrease of efficiency and output power limitation are caused by increasing numbers of diodes, namely, resulting the reduction of the diode impedance.

In general, there are two typical modes in bulk microwave diode oscillation, the Gunn mode and the LSA mode. The Gunn mode operation can be obtained at a low impedance circuit condition, namely a constant voltage condition, though a certain level of RF amplitude is necessary for the parallel diodes to synchronize each other. While, the LSA mode operation requires a high RF voltage amplitude.

The diodes of type I seem to operate in rather LSA mode than Gunn mode because of its carrier concentration and its saturation characteristic of DC current, meanwhile other types of diodes oscillate in Gunn mode. This may explain the fact that the efficiency of type I decreases at a value of $1/R_L$ smaller than those of other types. The type II diodes give the highest power operation at the lowest impedance. The difference between the type II and III may be due to that of respective carrier concentrations and hence the thermal condition.

Fig. 5 shows the bias dependency of DC current, output power, oscillation frequency of the type II of single and double mounted diodes. And Fig. 6 shows the tuning characteristic of type II diodes with use of a cavity short plunger. In the double mounted diode, the maximum output power of 450 mW at an efficiency of 2.9 % is obtained at the bias level of 11 V. The lower the diode impedance is, the more severe the matching condition becomes. In the experiment, the imput power of more than 20 watts can be obtained in case of four diodes in parallel combination of type I.

It is concluded that the circuit impedance condition is the most important factor in order to get more powerful Gunn diodes in parallel combination.

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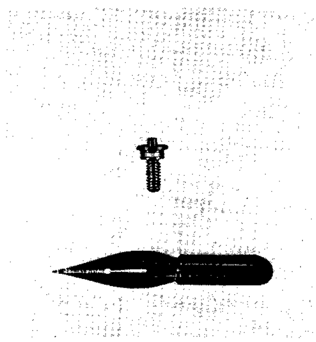

Fig. 1. A package for Gunn diodes.

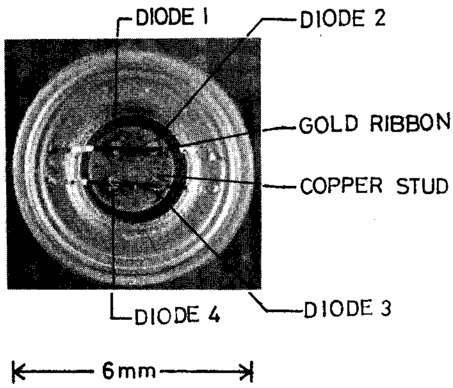

Fig. 2. Gunn diodes connected in parallel combination mounted on a stud of a package.

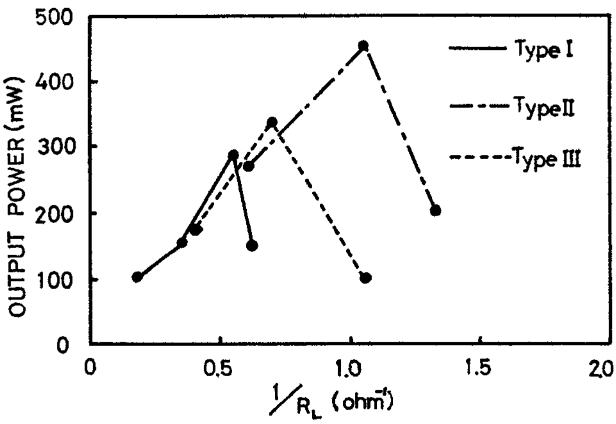

Fig. 3. Output power vs. inverse of low field resistance. The number of diodes are indicated at each point.

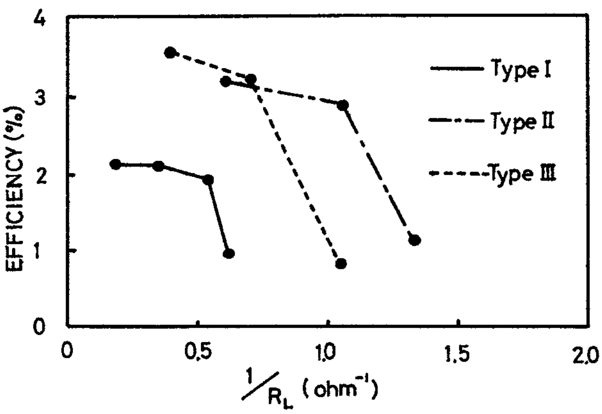

Fig. 4. Efficiency vs. inverse of low field resistance. The number of diodes are indicated at each point.

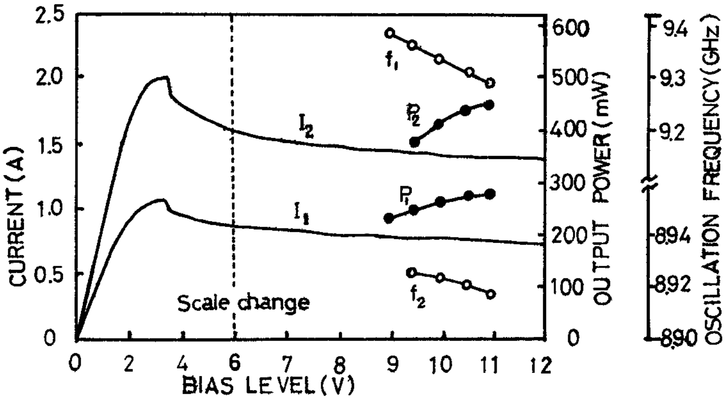

Fig. 5. Bias dependency of currents, output powers and oscillation frequencies. Each suffix number represents the number of diodes.

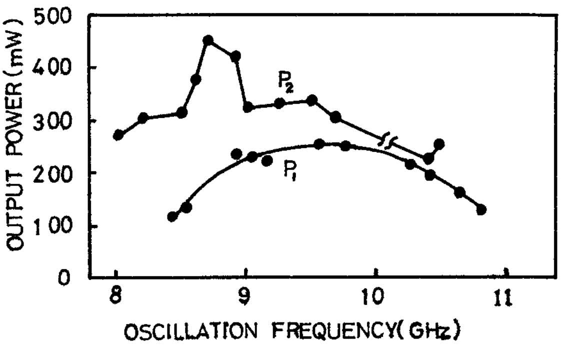

Fig. 6. Tuning characteristics: output power vs. oscillation frequency. Each suffix number represents the number of diodes.