Digest of Tech. Papers The 11th Conf. (1979 International) on Solid State Devices, Tokyo

B—1—6 Power GaAs MESFETs with a Graded Recess Structure

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Performance of power GaAs MESFETs was improved by adopting a graded recess structure. The highest output powers obtained are 15 W (4dB gain) at 6 GHz band and 4.3 W (3 dB gain) at 11 GHz band.

Power GaAs MESFETs with a high source to drain breakdown voltage have been realized by adopting either a highly doped (n^+) drain region[1] or an abrupt recess structure[2]. However, the investigation on the light emission from these devices revealed the existence of the high field domain at the place where the carrier concentration or the thickness of the active layer changes abruptly[2,3].

In order to overcome this problem, a new structure of the device called a graded recess structure was developed (Fig.1). The thickness of the epi-layer is increased "gradually" from the active gate region toward the source and drain electrode to avoid an anomalous field concentration and also to reduce the source resistance.

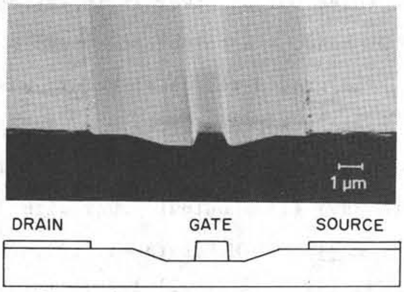

Fig.1 SEM view of a graded recessed channel

Elimination of the localized filed outside the gate region was confirmed by observing the light emission from the devices (Fig.2). In the case of the flat-type devices (Type A), the light emission which is observed at the drain ohmic contact edge is most remarkable. By adopting an abrupt recess structure (Type B), the light emitting place moves to the drain side edge of the recessed region, and the light intensity is considerably reduced, but not satisfactory enough. The light intensity of the graded recess type device (Type C) is reduced to about 1 % of that of the abrupt recess structure. This is also much weaker than the light emission from the devices with an n^+ contact region[3].

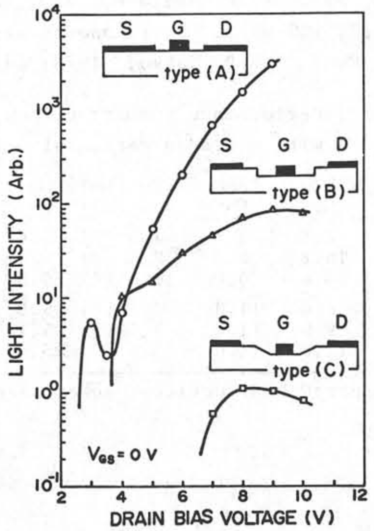

Fig.2 Structure dependence of the light emission intensity

Another feature of the graded recess power FETs is the reduced source and drain parasitic resistance. Relaxation of the anomalous field concentration brings about the reduction in the effective resistance. Furthermore, the graded recess structure device gave a higher drain breakdown voltage than the adrupt recess structure device with the same recessed region length. Therefore, the effective recessed region could be reduced without any sacrifice of the breakdown voltage.

Microwave performances of the abrupt recess and the graded recess structure devices are compared in Fig. 3. In order to eliminate the experimental error due to the matching circuit loss, small size devices with 2.8 mm gate width were measured at first. The graded recess devices gives about 1 dB higher output power (32 dB with 5 dB gain), about 0.8 dB higher linear gain (9.4 dB) and 8 % higher efficiency (38 %) than those of the abrupt recess devices. Figure 3 also shows output powers and power added efficiencies of the internally matched high power devices[4] with 33.6 mm gate width. For the abrupt recess structure device, the output power with 4 dB gain is at most 10 W. But, by adopting the graded recess structure, output power is increased about 2 dB and 15 W is obtained at 6 GHz band. At 8 GHz band, 8 W output power was obtained with 3 dB associated gain.

The graded recess structure was also applied to the X-band devices with 0.5 μm long gate[5]. The microwave performance of the graded recess structure power MESFETs are summarized in Table 1. An internally matched X-band devices with 12 mm gate width gave 4.3 W output power with 3 dB gain at 11 GHz band.

References 1) M.Fukuta et. al., IEEE Trans., MTT-24, (1976) 312. 2) T.Furutsuka et. al., IEEE Trans., ED-25, (1978) 563. 3) R.Yamamoto et.al., ibid, 567. 4) K. Honjo et. al., IEEE Trans., MTT-27, (1979) 3. 5) Y.Aono et. al., Proc. The 10th Conf. S.S.D. Tokyo, (1978) 147.

Table 1 Performance summary of power GaAs FETs with a graded recess structure

GATE WIDTH mm	FREQ. GHz	Po (Ga) W (dB)	G_ℓ dB	η_{add} %	Vds V
2.8	6.4	1.6 (5)	9.4	38	12
16.8	6.2	7.4 (4)	6.9	28	10
33.6	6.0	15.0 (4)	6.5	27	12
6.0	11.0	2.5 (4)	5.5	19	10
9.0	11.0	3.5 (3)	5.1	18	9
12.0	11.0	4.3 (3)	5.0	19	10

upper:C-band devices, lower: X-band devices

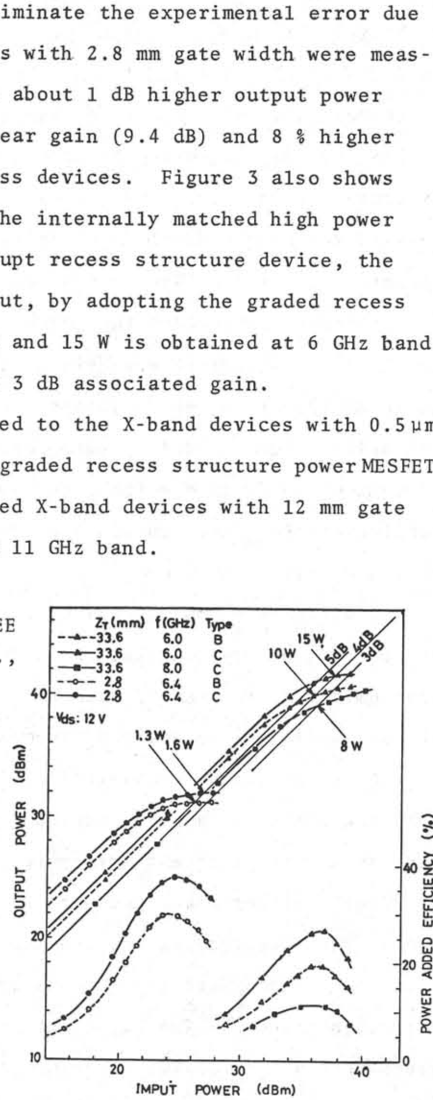

Fig.3 Output powers and power added efficiencies versus input power level for two types of devices. Type B: abrupt recess structure, Type C: graded recess structure.