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Power AlGaAs Hetero-MIS Gate InP Field Effect Transistors

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This paper reports the first successful 30 GHz power performance of AlGaAs hetero-MIS gate InP FET's with good and stable DC characteristics.

For microwave and millimeter-wave power device applications, InP has been recognized as being a most attractive material because of its high electron velocity and high thermal conductivity. Previously, we have demonstrated depletion-mode InP MISFET's with MBE grown undoped $Al_xGa_{1-x}As$ layers as a gate insulator, which exhibited good and stable DC characteristics and microwave performance (45 GHz fmax for 1 μm gate devices).(1)(2) In this work, we have fabricated power InP FET's using AlGaAs hetero-MIS gate structure and evaluated their DC characteristics and microwave performance at 30 GHz.

Fabricated FET structure is shown in Fig.1. The fabrication process steps are almost the same as those, previously reported.(2) The n-type active layer was formed by Si ion-implantation into an Fe-doped semi-insulating InP substrate with implantation energy of 50 keV and dose of 3.5×10^{12} cm^{-2}. 1000 Å undoped $Al_{0.3}Ga_{0.7}As$ gate layer was grown by MBE at 500 ℃ substrate temperature. The source and drain ohmic contacts were formed with Ni/AuGe alloyed in H_2 gas at 390 ℃. The gate electrode was formed with Au/Pt/Ti by a lift-off technique. Parallelling of gate fingers by the use of SiO_2 crossover structure was employed for the present power InP FET's. The device has the gate length of 0.6-1.0 μm and the width of 420 μm (35 μm x 12 fingers).

Fabricated InP FET's exhibited good I-V characteristics with a complete pinch-off and a high transconductance of 80 mS/mm, as shown in Fig.2. The gate forward turn-on voltage was about 5 V. More than 30 V gate and drain breakdown voltages were obtained for the fabricated InP FET's.

Microwave performance was evaluated for the fabricated InP FET's at 30 GHz. For 0.6 μm gate length devices, 6.5 dB small signal power gain was obtained at 30 GHz, which, according to 6dB/oct. reduction rule, gave extrapolated cutoff frequency fmax of 64 GHz. This fmax is about twice higher than that for conventional 0.5 μm gate GaAs MESFET's. At 30 GHz, the power input-to-output relation for a 0.6 μm gate device exhibited the linear gain of 5.3 dB and the output power of about 100 mW (0.24 W/mm power density) at 1 dB gain compression point, as shown in Fig.3. Moreover, the output saturation power density of 0.5 W/mm was obtained at 30 GHz for a 1 μm gate length device.

These marked microwave performances as well as good and stable DC characteristics reveal that the developed AlGaAs hetero-MIS gate depletion-mode InP FET is very promising as a microwave and millimeter-wave power device.

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References

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(2) T. Itoh et al.;IEDM 86, Tech. Dig., p.771 (1986).

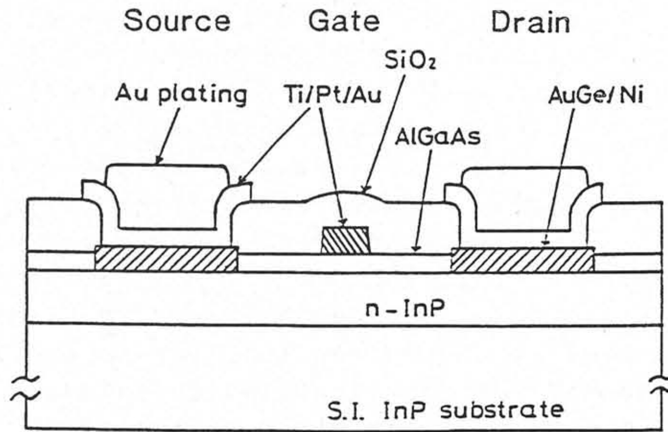

Fig.1 Fabricated FET structure

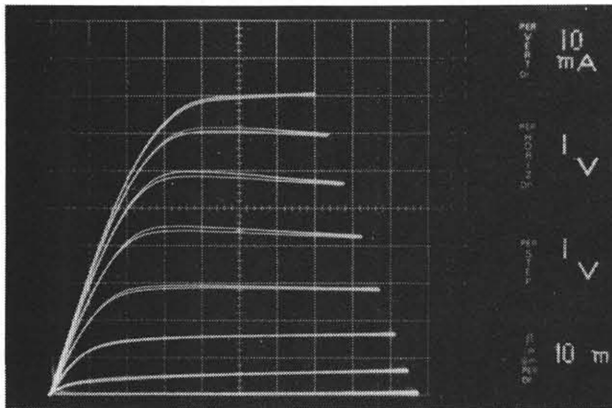

Fig.2 I-V characteristics for an InP FET with gate width of 210 μm

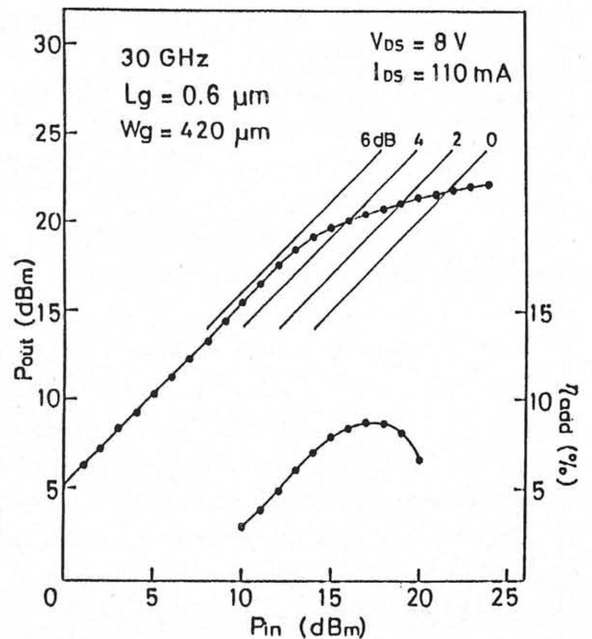

Fig.3 Output power and power-added efficiency versus input power at 30 GHz for an InP FET