Digest of Tech. Papers The 6th Conf. on Solid State Devices, Tokyo, Sep. 1974

A4-2

Microwave Oscillation with GaAs FET

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GaAs Schottky-barrier gate FET is a new type of microwave transistor with potential high frequency performance. The advantage in low noise amplification has been confirmed in single gate structure and multifunction operation realized with dual-gate structure.[1] In this paper, another promising operation of GaAs FET is reported, that is high efficiency microwave oscillation. Device design guidelines will be discussed for improving the oscillator performance.

It may be suspected that the bulk negative differential conductivity inherent to GaAs would cause instability even in FET structure. To clarify the problem, we have carried out two-dimensional dynamic simulation of junction gate GaAs FET. The analysis has showed that short transit time and reforming of channel boundary due to RF voltage suppress the formation and/or transit of Gunn domains. Therefore GaAs FET operates as a stable linear device during oscillation.

The oscillation output power Pmax can be estimated from a pentode-type static characteristics as

$$P_{max} \propto V_{dss} \cdot I_{dss} \qquad (1)$$

where Idss stands for the saturation drain current and Vdss for drain-source voltage required for current saturation. Equation (1) shows the larger current carrying capability is advantageous for oscillation output power.

GaAs FET's were fabricated using a conventional planar structure with a gate 1.5 μm long and 300 μm wide. Various samples of different saturated current were prepared to test eq. (1). The device was mounted in a specially designed low loss ceramic disk package and showed typically maximum frequency of oscillation of 50 GHz. An oscillator circuit (see Fig.1) was designed using small signal S-parameters of GaAs FET and was constructed on an alumina substrate with a simple feedback loop added for oscillation.

An example of oscillation spectrum is shown in Fig.2. Half width is less than 50 KHz which is comparable to or better than Gunn diodes. The oscillation frequency is determined by circuit, being insensitive to the device. Oscillation output power varies proportionally to product Vdss·Idss as Fig.3, which agrees with the expectation of eq. (1). Oscillation efficency is also a function of drain saturation current as in Fig.4. The best data in this preliminary experiment has been 21% efficiency and 80 mW in power, both at the oscil-

lation frequency of 10.5 GHz. These data will be improved easily by optimizing the device structure.

Above mentioned results and oscillation mechanisms suggest advantages of GaAs FET oscillator ; (1) higher efficiency than Gunn diodes, (2) lower bias voltage than IMPATT diodes, (3) quieter oscillation than diode oscillators, (4) freedom of circuit design, and (5) frequency stability against temperature variation.

These features will open a wide application field and promising future for GaAs FET oscillations. GaAs FET is a candidate to satisfy,in a single device, various requirements, e.g. efficiency, power,and noise,raised against a solid state microwave oscillator.

1) S.Asai et al., Proc. 5th Conf. on Solid-State Devices (Tokyo,1973) p.442

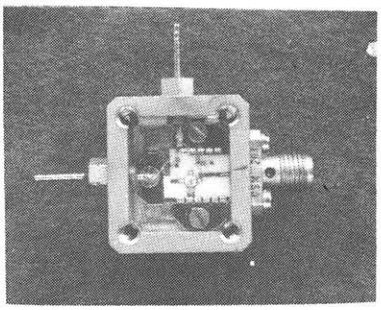

Fig.1 Oscillator Circuit

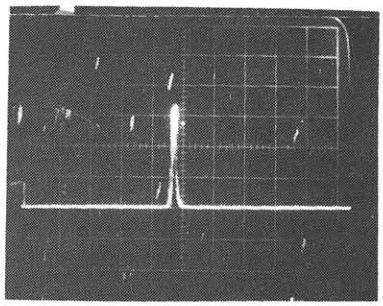

Fig.2 Oscillation Spectrum
(f=10.5GHz, Hori.:500KHz/div)

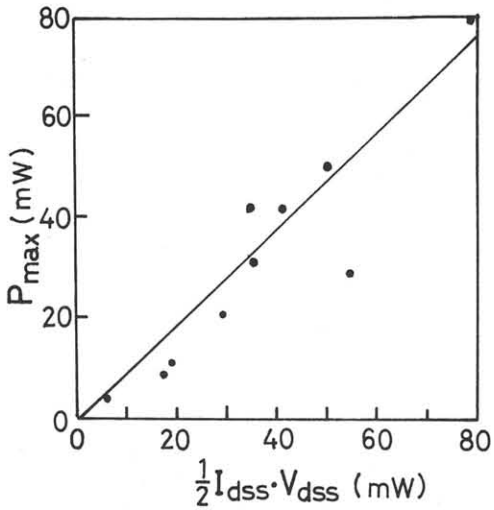

Fig.3 Output Power

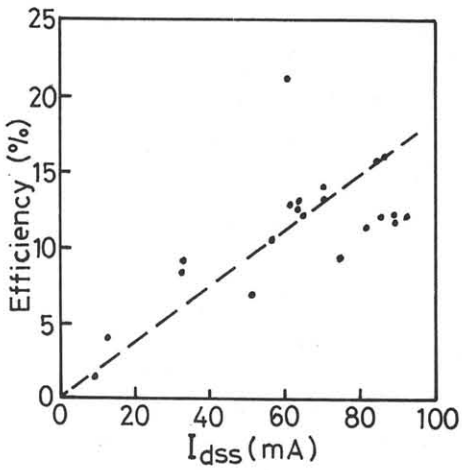

Fig.4 Oscillation Efficiency