MMIC-COMPATIBLE 55 mW InP AND GaAs 30 - 40 GHz FIELD CONTROLLED TE-OSCILLATORS

K. Lübke, H. Scheiber, D. Grützmacher*, C. Diskus and H. Thim

Institut für Mikroelektronik, Universität Linz, A-4040 Linz/Austria
* Institut für Halbleitertechnik, Technische Hochschule Aachen, D-5100 Aachen/West Germany

ABSTRACT

55 mW 34 GHz InP, 56 mW 29 GHz GaAs and 39 mW 37 GHz GaAs lateral MMIC-compatible transferred electron oscillators with MESFET injection contacts have been fabricated exhibiting 2.9%, 5.3% and 4.9% efficiencies, respectively. CW power levels are somewhat lower (30 mW). The achieved power levels are the highest ever obtained with lateral TEOs and FET-oscillators.

INTRODUCTION

Continuous progress in the development of millimeter wave monolithic integrated receivers has stimulated the search for a planar source for local oscillator applications. The two successfully applied approaches are the GaAs FET oscillator /1/ /2/ /3/ and planar transferred electron oscillators /4/ /5/. FET oscillators are high efficiency devices (30% at 35 GHz) but suffer from transit-time effects ($1/f^2$ limitation) and circuit matching difficulties. Transferred electron oscillators exhibit lower efficiencies but require simpler loading circuits as they are two-terminal devices and are easier to manufacture as submicrometer dimensions are not needed. TEOs are also known for their superior noise performance.

The purpose of this paper is to report new results obtained with planar InP and GaAs transferred-electron oscillators having a MESFET cathode contact. In this device the electron injection is controlled by a negatively biased Schottky gate preventing travelling domains ("Gunn oscillations") from forming. Instead, a stationary high field domain forms in the gate-drain region which exhibits a frequency-independent negative resistance. The device is thus not subject to the usual transit-time ($1/f^2$) limitation conventional TEOs and FETs are suffering from. This makes this kind of device particularly well suited for the 50 - 100 GHz range. So far the fabricated devices have been tested only up to 40 GHz. The power levels obtained are higher than those produced by GaAs-FET oscillators /1/ and those obtained with "notched" InP TEOs /4/. The advantage of the MESFET-cathode TED or so-called "FECTED" (field effect controlled TED) is that the injection current can be adjusted continuously by the gate bias voltage /6/.

DEVICE STRUCTURE

Fig. 1 shows a cross sectional view of the device. It consists of a 0.9 μm thick MOCVD-grown active n-layer ($n=5x10^{16}cm^{-3}$), a Schottky drain contact, an ohmic source contact, a 0.5 μm long Schottky gate with an integrated 10 pF capacitor to source. The device width is 400 μm.

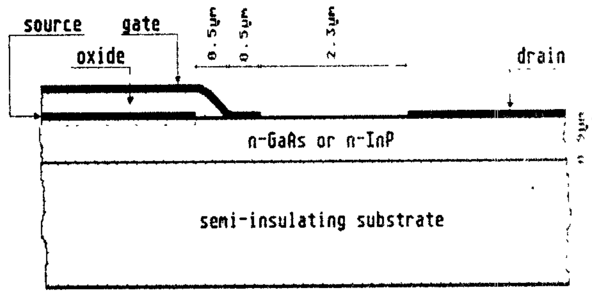

Fig. 1: Cross sectional view of the FECTED

EXPERIMENTAL RESULTS

Both, the InP and the GaAs devices have been tested in microstrip circuits shown in Fig. 2. There are two identical stub terminated 3λ/8 long

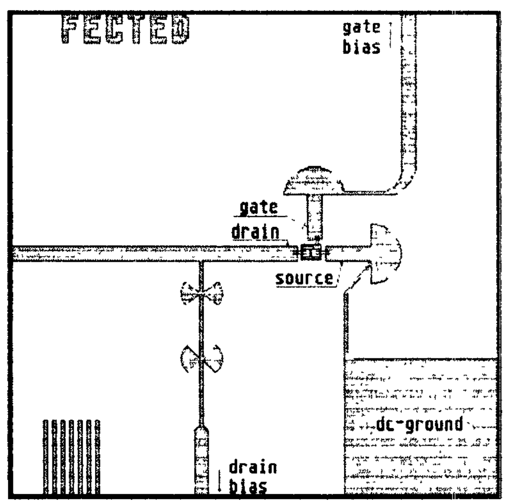

Fig. 2: Microstrip circuit configuration of a 37 GHz FECTED

CH2725-0/89/0000-0729$01.00 © 1989 IEEE

50Ω transmission lines providing capacitive impedances to both source and gate contacts. They compensate the various bonding wire inductances at upper Ka-band frequencies with a resonance at 37 GHz thereby producing a maximum reflection gain at that frequency. Amplification over almost 10 GHz has been measured with a GaAs FECTED mounted in this circuit as is shown in Fig. 3. A negative gate bias voltage of about -6V was applied to the device.

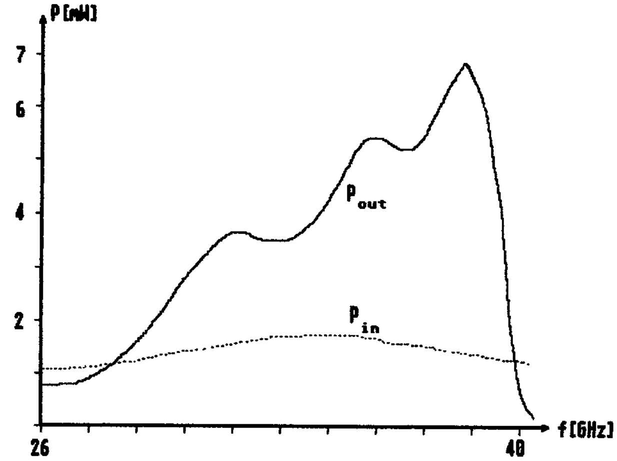

Fig. 3: Output and input power versus frequency of a FECTED reflection type amplifier

In order to produce free running oscillations a dielectric resonator had to be placed near the drain contact. The best oscillatory results have been summarized in the table shown below. These data have been recorded using pulsed drain bias voltages in order to avoid possible burn out.

Material	Drain Bias Pulse Width	V_{DS}(V)	V_{GS}(V)	I(A)	eff.%	P(mW)	f(GHz)
GaAs	1µs	7.0	-5.0	0.15	5.3	56	28.4
GaAs	1µs	6.1	-7.9	0.13	4.9	39	37.4
InP	1µs	11.3	-4.3	0.17	2.9	55	34.4
GaAs	60µs	6.7	-8.35	0.15	2.9	29.5	29.8
GaAs	60µs	5.4	-9.1	0.144	3.8	29.8	37.3

Other devices with lower power levels have been operated CW. The data shown in the table are devided into short and long pulses-results. The output power levels obtained with long pulses are generally lower due to the high operating device temperature. This temperature level is believed to be close to that occurring in CW operated devices as the power output remained unchanged when increasing the duty cycle from 10% to 40%. The results reported here exceed previously reported GaAs data by about 30 to 50% /7/.

Fig. 4 shows the spectral characteristic of a free running 8 mW CW operated FECTED oscillator.

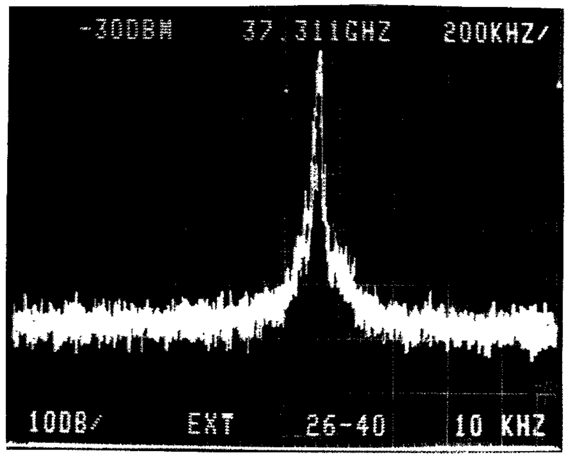

Fig. 4: Spectrum of an 8 mW FECTED oscillator

SUMMARY

We have demonstrated that planar GaAs and InP FECTED oscillators are attractive MMIC compatible candidates for local oscillator applications at Ka-band and possibly at higher frequencies as they are not transit-time limited as conventional TEOs and FETs are. At 29 and 34 GHz the highest output power levels ever obtained with lateral TEOs and FET oscillators and at 37 GHz the highest lateral TEO output power have been produced.

ACKNOWLEDGEMENTS

This work was supported in part by the Austrian Fonds zur Foerderung der wissenschaftlichen Forschung and by the US Army through its European Research Office. The authors would like to thank G. Hofmann, J. Katzenmayer and G. Roitmayr for fabrication of the devices and H. Lettenmayr for characterization of the epitaxial layers.

REFERENCES

/1/ Tserng,H.Q. and Kim,B.: "Q-band GaAs MESFET oscillator with 30% efficiency", Electr. Letters, 1988, 24, pp. 83-84

/2/ Tserng,H.Q. and Kim,B.: "A 115 GHz monolithic GaAs FET oscillator", IEEE GaAs IC Symp. Digest, 1985, pp. 11-12

/3/ Dow,G.S., Sensiper,D. and Schellenberg,J.M.: "Highly stable 35 GHz GaAs FET oscillators", 1986, IEEE MTT-S Digest, pp. 589-591

/4/ Binari,S.C., Neidert,R.E. and Meissner,K.E.: "Monolithic and descrete mm-wave InP lateral transferred-electron oscillators", 1988, IEEE MTT-S Digest, pp. 683-686

/5/ Scheiber,H., Lübke,K., Diskus,C. and Thim,H.: "A planar 10 mW 30 GHz MIC compatible GaAs MESFET-like oscillator", Inst. Phys. Conf. Ser. No. 91, 1988, pp. 817-820

/6/ Kuch,R., Lübke,K., Stangl,G., Lindner,G. and Thim,H.: "A planar Gunn diode with an injection limiting FET cathode contact", Inst. Phys. Conf. Ser. No. 63, 1982, pp. 293-297

/7/ Scheiber,H., Lübke,K., Diskus,C. and Thim,H.: "An IC-compatible 45 mW Ka-band GaAs TEO", Electr. Lett. 1989, 25, p. 223