MMIC by 120nm InAlAs/InGaAs Metamorphic HEMT를 이용한 77 GHz 전력 증폭기 제작

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77 GHz Power Amplifier MMIC by 120nm InAlAs/InGaAs Metamorphic HEMT

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Abstract

In this paper, 77 GHz CPW power amplifier MMIC, which are consisted of a 2 stage driver stage and a power stage employing 8x50um gate width, have been successfully developed by using 120nm $In_{0.4}AlAs/In_{0.35}GaAs$ Metamorphic high electron mobility transistors (MHEMTs). The devices show an extrinsic transconductance g_m of 660 mS/mm, a maximum drain current of 700 mA/mm, and a gate drain breakdown voltage of -8.5 V. A cut-off frequency (f_T) of 172 GHz and a maximum oscillation frequency (f_{max}) of over 300 GHz are achieved. The fabricated PA exhibited high power gain of 20dB only with 3 stages. The output power is measured to be 12.5 dBm.

I. Introduction

Because of their superior propagation characteristics, the most commonly used frequencies in W-band transceiver systems are 77 GHz and 94 GHz. Recently, the 77 GHz automotive car radars are becoming more popular. The metamorphic HEMT (MHEMT) with the indium contents of channel and barrier in the range of 40 % could be potentially used in transceiver circuits fabricated on the same wafer due to its low noise and high power performance[1]-[3]. In this work, 77 GHz power amplifier (PA) MMIC, which are consisted of a drive stage and power stage, have been successfully demonstrated by using 120 nm $In_{0.4}AlAs/In_{0.35}GaAs$ MHEMTs. Thanks to the high gain of MHEMT devices, the PA exhibited shows power gain of 20dB only with 3 stages. The output power is measured to be 12.5 dBm, which is comparable to the PAs using GaAs pHEMT devices.

II. Device and MMIC

$In_{0.4}AlAs/In_{0.35}GaAs$ MHEMTs layers were grown by MBE on GaAs substrate. This structure achieved the sheet carrier density of 3.7×10^{12} cm^{-2} and the electron mobility of 7,650$cm^2/V\text{-}s$ at 300 K. The devices were isolated by MESA formation by wet chemical etching ($H_3PO_4/H_2O_2/H_2O$). The ohmic metal of Ge/Au/Ni/Au were evaporated, followed by a rapid thermal annealing at 300 °C. The ohmic contact resistance was as small as 0.09 Ω-mm. 120 nm T-gates were defined by e-beam lithography using a trilayer ZEP/PMGI/ZEP and selective gate recess etching was employed with a solution of succinic acid, ammonia, and hydrogen peroxide. Prior to gate metal deposition, devices were exposed to Ar plasma using RIE machine in order to remove the native oxide layer and the gate metal of

Ti/Pt/Au was evaporated [4]. Finally, devices were passivated by using a remote PECVD Si_3N_4 of 1200 Å. For the passive device process, we use thin film resistor of NiCr 550 Å with 20 Ω / ☐ and MIM capacitors of Si_3N_4 600 Å with 1000 pF/mm^2.

The devices showed the unity current gain frequency f_T of 172 GHz extrapolated from the current gain (H_{21}) and maximum oscillation frequency f_{max} of over 300 GHz extrapolated from the maximum available gain (MAG) at a drain voltage V_{DS} of 1.2 V and a gate voltage V_{GS} of -0.4 V [Fig.1].

77GHz power amplifier (PA) is one of the most important components in transmitters. We developed a monolithic 77GHz power amplifier using 120nm MHEMT. The coupled line has been employed to guarantee low frequency stability. The power stage uses MHEMT with 8x50um gate width while the driver stage uses only 2x50um. The fabricated PA shows a small signal gain of 20dB and an output power of 12.5dBm at 77GHz.

IV. Conclusion

In summary, 77 GHz PA MMICs have been successfully developed by using 120 nm $In_{0.4}AlAs/In_{0.35}GaAs$ MHEMTs. A f_T and f_{max} were obtained 172 GHz and over 300 GHz, respectively. The PA MMIC exhibited small signal gain of 20dB and output power of 12.5dBm. These performances could be useful to low-cost and small size components for 77 GHz automotive radar.

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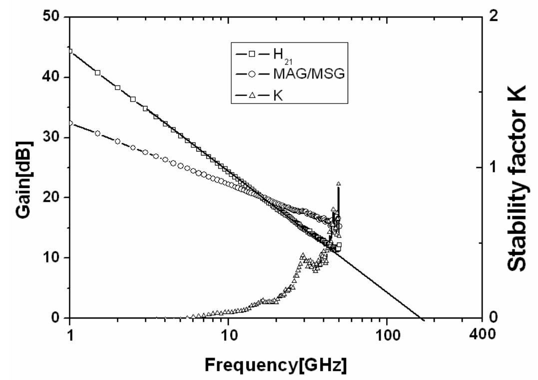

Fig 1. RF performance of 120nm MHEMT

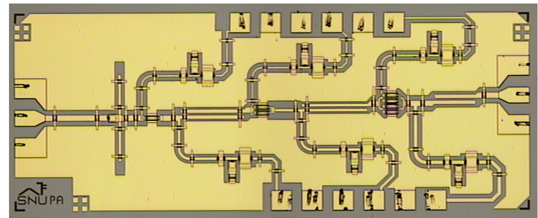

Fig 2. Photograph of 77GHz PA MMIC

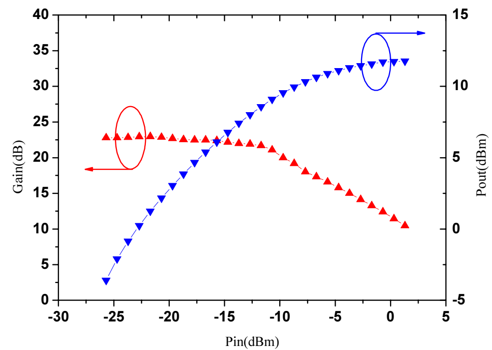

Fig 3. The measured power performance of 77 GHz PA MMIC

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