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High f_{max} 0.1 ㎛ Γ-gate InGaAs/InAlAs/GaAs Metamorphic HEMT

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1. Introduction

It is well known that InP-based HEMT's have better device performances than GaAs-based PHEMT's [1,2]. However InP-based wafers are not only more expansive but also more brittle than GaAs-based ones. GaAs-based metarmorphic HEMT's (MHEMT's) were fabricated by growing epitaxial layer on GaAs substrate, renders convenience to device fabrication because an application of the processes used to GaAs PHEMT's is possible, and offers the high frequencies and the gain characteristics. In this paper, we report excellent RF performance of 0.1 ㎛ MHEMT's fabricated in standard MINT processes [3,4]. And, in order to enhance etch uniformity in gate recess etch process, we employed descum process which removes the remnant PR of E-beam gate pattern by using O_2 plasma.

2. MHEMT's fabrications and characteristics

GaAs-based wafers for MHEMT's were grown by MBE. An epitaxial structure grown on S.I. GaAs is shown in Fig. 1. A 1 ㎛-thick buffer layer with increasing In mole fraction from 0 to 50 % is grown on a S.I. GaAs substrate, and a 400 nm-thick InAlAs buffer is necessary to protect impurities from a S.I. GaAs substrate. An electron density with double δ-dopes and mobility of the grown MHEMT's epitaxial structure at room temperature are 3.44×10^{12} / cm^2 and 9710 cm^2 / V·sec, respectively.

In this paper, MHEMT's with an unit gate width of 70 ㎛ and 2 gates(70 × 2 ㎛ HEMT's) were fabricated by MINT standard processes such as mesa, ohmic contacts, Γ-shaped gate patterning, PR descum, wet selective gate recess [5], gate contacts, and Si_3N_4 passivation.

The fabricated 0.1 ㎛ MHEMT's were characterized by measuring DC, RF performances. From DC measurements, current density of MHEMT's is 714 mA / mm, Maximum gm of 914 mS / mm is shown in Fig. 2.

RF characteristics were measured by HP 8510C VNA(vector network analyzer) system, S_{21} gain of 8.6 dB at 50 GHz was obtained as shown in Fig. 3. f_T and f_{max} are 154 GHz and 454 GHz, respectively, from Fig. 4.

3. Conclusion

In this paper, 0.1 ㎛ Γ-gates with 70 × 2 ㎛ MHEMT's were fabricated using a DH(double heterostructure) epitaxial structure, and such MHEMT's were characterized through the DC and RF measurements. A channel current density and g_m were 714 mA / mm and 914 mS / mm, respectively. And, from RF measurements, f_T and f_{max} were 154 GHz and 454 GHz, respectively. f_{max} from the fabricated 0.1 ㎛ Γ-gate MHEMT's is one of the best reported thus far.

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$In_{0.53}Ga_{0.47}As$	6 x 10^{18}/㎠	15nm
$In_{0.52}Al_{0.48}As$	undoped	15nm
δ-doping	4.5x10^{12}/㎠	
$In_{0.52}Al_{0.48}As$	undoped	3nm
$In_{0.53}Ga_{0.47}As$	undoped	23nm
$In_{0.52}Al_{0.48}As$	undoped	4nm
δ-doping	1.3x10^{12}/㎠	
$In_{0.52}Al_{0.48}As$	undoped	400nm
$In_xAl_{1-x}As$ (x = 0~0.5)	undoped	1000nm
S.I. GaAs substrate		

Figure 1. MHEMT's epitaxial structure.

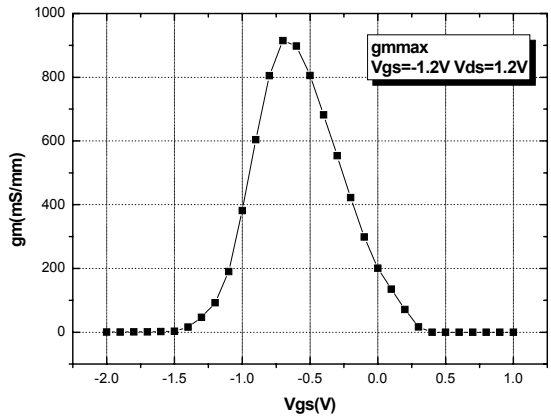

Figure 2. MHEMT's gm characteristic.

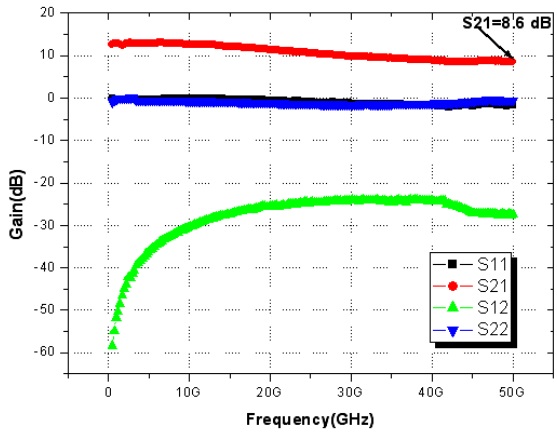

Figure 3. MHEMT's S_{21} gain characteristic.

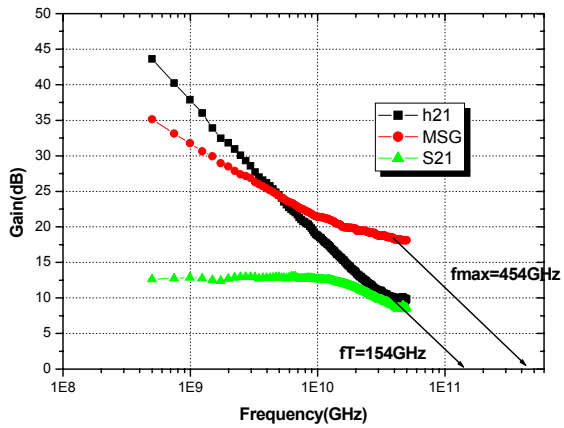

Figure 4. MHEMT's RF characteristics.