160-190 GHz Monolithic Low Noise Amplifiers

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ABSTRACT

This paper presents the results of two 160-190 GHz monolithic low noise amplifiers (LNAs) fabricated with 0.07-μm pseudomorphic (PM) InAlAs/InGaAs/InP HEMT technology using a reactive ion etch (RIE) via hole process. A peak small signal gain of 9 dB was measured at 188 GHz for the first LNA with a 3-dB bandwidth from 164 to 192 GHz while the second LNA has achieved over 6-dB gain from 142 to 180 GHz. The same design (second LNA) was also fabricated with 0.08-μm gate and a wet etch process, showing a small signal gain of 6 dB with noise figure 6 dB. All the measurement results were obtained via on-wafer probing. The LNA noise measurement at 170 GHz is also the first attempt at this frequency.

INTRODUCTION

Millimeter-wave (MMW) LNA's are very important components for smart munitions, passive imaging and radiometer applications. The PM HEMT devices with both GaAs and InP materials have demonstrated high gain and low noise capability at W-band (75-110 GHz) and D-band (110-170 GHz) frequencies for hybrid integrated circuits [1]-[2]. High gain, low noise amplifiers have been successfully developed up to 160 GHz [3]-[6], [10]-[14]. For the frequency range above 120 GHz, InP-based HEMTs are superior to GaAs-based HEMT's for amplification due to the higher electron peak drift velocity in the InP based HEMT devices. The MMIC LNA's fabricated with the InP HEMT MMIC process have also achieved high gain and low noise figure performance at lower frequencies. Examples include a Q-band (44.5 GHz) two-stage balanced LNA exhibiting 2.2-dB noise figure (NF) with 20-dB associated gain [7], and a W-band four-stage balanced amplifier with a small signal gain of 23 dB from 75 to 110 GHz [8]. A two-stage cryogenically cooled W-band LNA also exhibited 0.7-dB NF at 95 GHz with 12-dB associated gain [9]. The motivation of this work is to demonstrate the feasibility of MMIC LNAs with better performance at higher frequency via the improvement of device and process technology.

This paper describes the design, fabrication, and testing of two 160-190 monolithic two-stage balanced amplifiers. Compared with the previously reported InP HEMT MMIC LNAs [5]-[9], [11], [14] fabricated with 0.1-μm InAlAs/InGaAs/InP PM HEMT technology, this work has the following new features in MMIC technology: (1) 0.07-μm gate-length HEMT for higher f_T

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FIGURE CAPTIONS

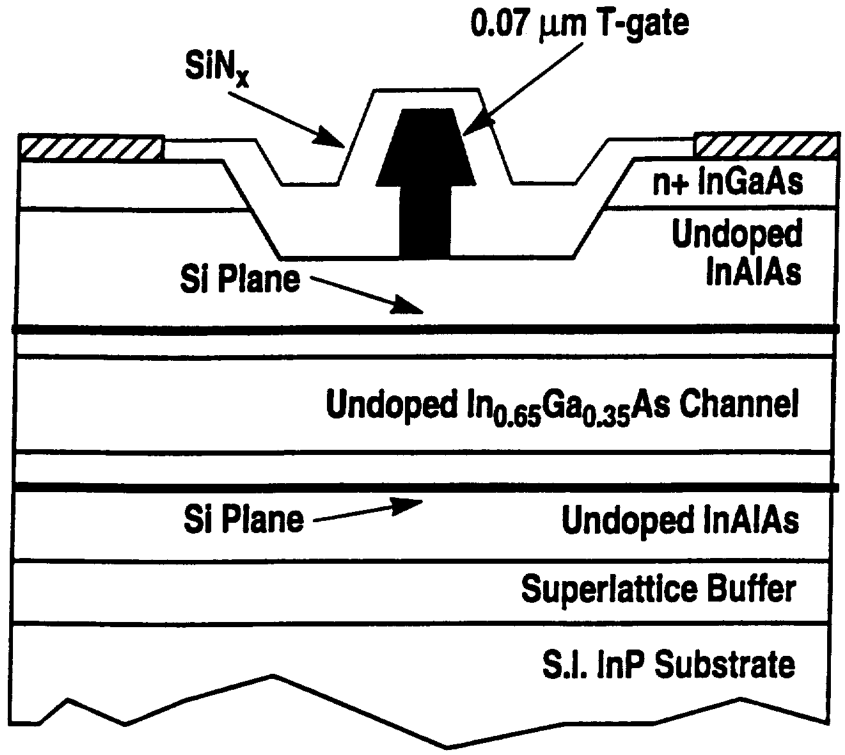
Fig. 1. InGaAs/InAlAs/InP PM HEMT device layer structure.

Fig. 2. (a). Chip layout of the InP-based HENT LNA (ALH250C) with 9 dB gain peak at 168 and 188 GHz.

(b). Chip layout of the InP-based HEMT LNA (ALH252C) with gain greater than 6 dB from 142 to 180 GHz.

Fig. 3. Block diagram of the 140-220 GHz network analyzer test set.

Fig. 4. Measured small signal gain of (a) first, (b) second, MMIC LNA vs. frequency. The bias conditions are Vd = 1.25~1.4 V with Id = 32.8 mA for the first LNA and Vd = 1.31~1.41 V with Id = 42.8 mA for the second one.



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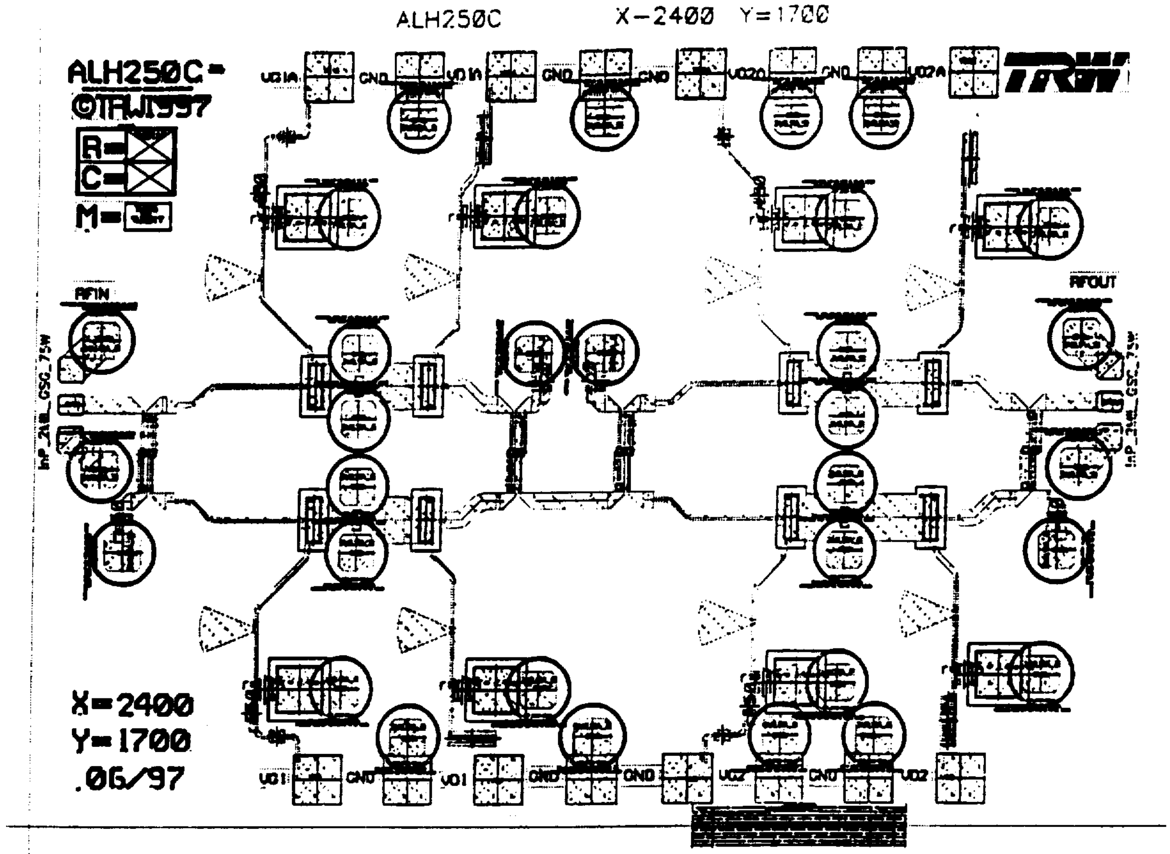


Fig. 2. (a). Chip layout of the InP-based HENT LNA (ALH250C) with 9 dB gain peak at 168 and 188 GHz.

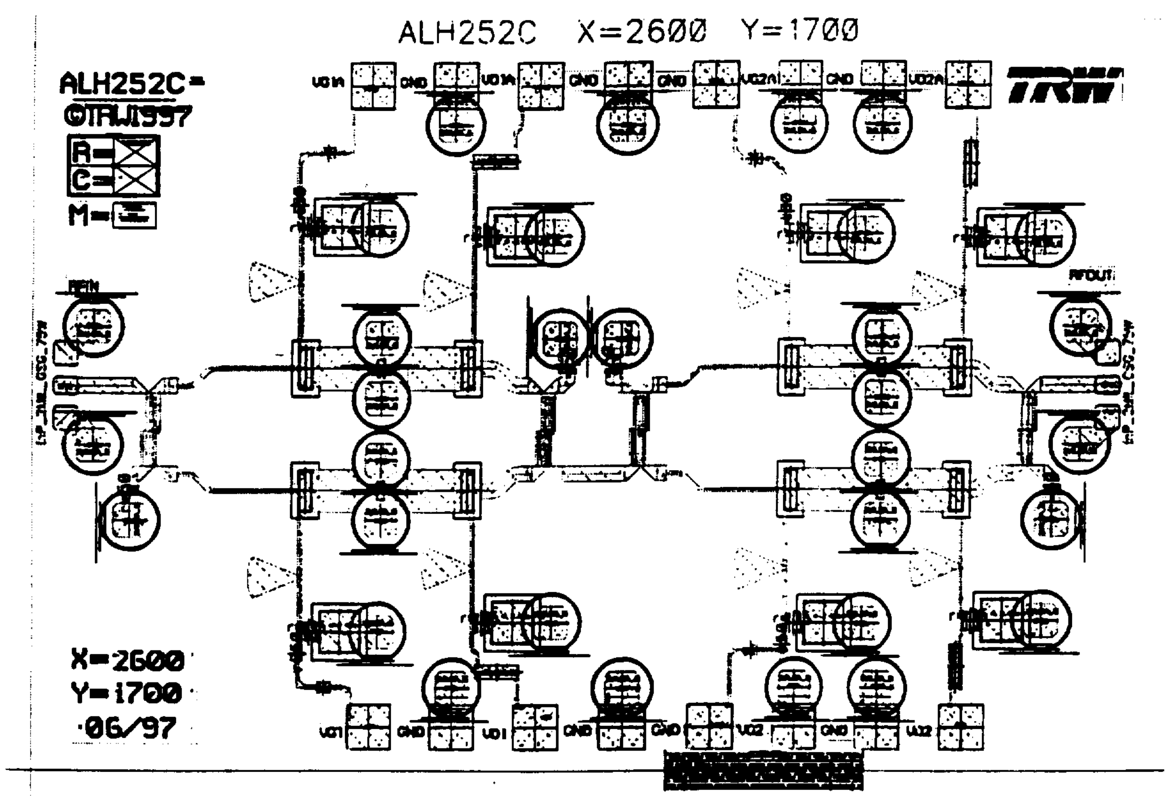
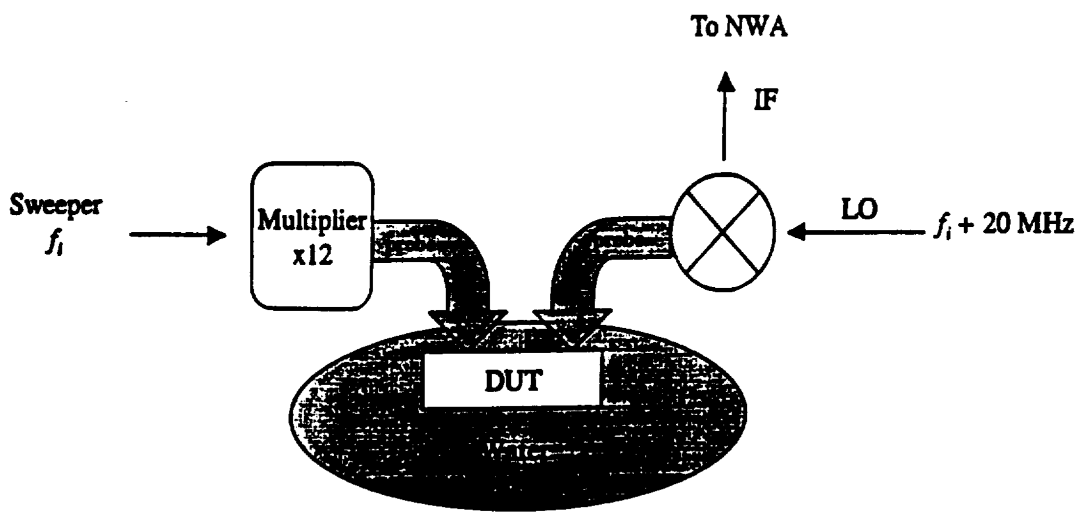


Figure 2(b). Chip layout of the InP-based HEMT LNA (ALH252C) with gain greater than 6 dB from 142 to 180 GHz.



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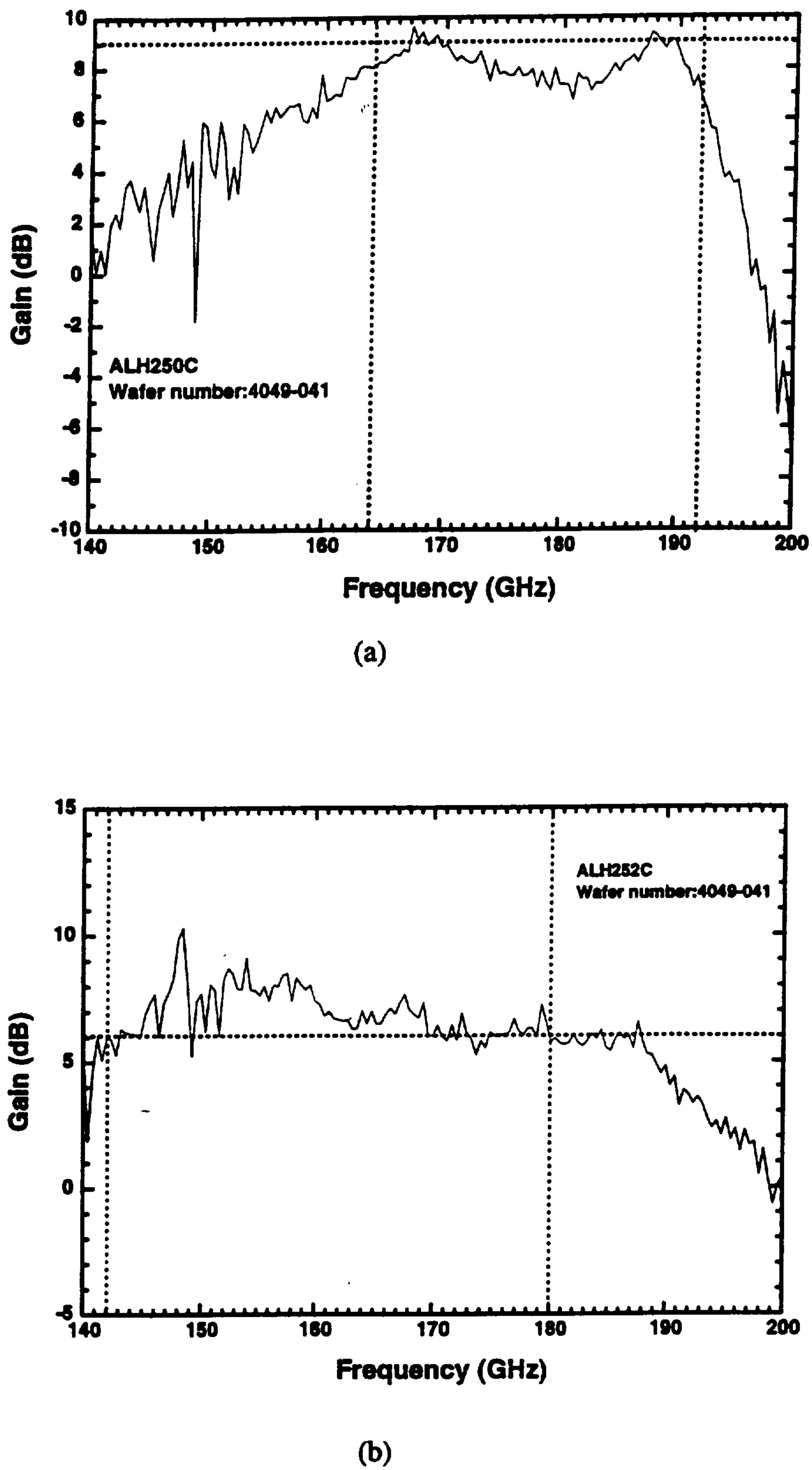

(a)

(b)

Fig. 4. Measured small signal gain of (a) first, (b) second, MMIC LNA vs. frequency. The bias conditions are Vd = 1.25~1.4 V with Id = 32.8 mA for the first LNA and Vd = 1.31~1.41 V with Id = 42.8 mA for the second one.