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A High Performance InP HEMT with Saw-Toothed Source and Drain *

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Abstract: Millimeter-wave transistor technology is very important for MMIC design and fabrication. An InP HEMT with saw-toothed source and drain is described. The pattern distortion due to the proximity effect of lithography is avoided. High yield InP HEMT with good DC and RF performances is obtained. The device transconductance is 1050mS/mm, threshold voltage is -1.0V, and current gain cut off frequency is 120GHz.

Key words: InP; HEMT; MMIC
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1 Introduction

High yield HEMT's fabrication technology is very important for MMIC application[1]. For millimeter wave HEMTs, reduction of source and drain spacing is one of the most effective methods to improve their performance[2]. But this increases technology difficulty. When the space between the source and drain reaches 2μm or less, the proximity effect of lithography will be serious. In this case, after source and drain lithography, actual space between the source and drain will become less than that desired. This is a hidden trouble in the following process, because it can result in a short of the gate metal to the source or drain.

In this paper, we present a special saw-toothed source and drain design for an InP based HEMT, as well as a good result of keeping source and drain pattern size after lithography and metalizition. Using this method we have achieved more than 80% yield for an InP HEMT with 2μm source drain space.

2 Design and experiment

Based on common HEMT structures, the source and drain patterns are specially designed. A transistor with saw-toothed source and drain is shown in Fig.1. The space between the source and drain is 2μm, the gate length is 0.12μm, and the gate width is 42μm. The adjacent edges of the source and drain are saw-tooth shapes. They consist of 11 small rectangles for each side; the size of every small rectangle is 1μm × 2μm and the distance between adjacent rectangles is 2μm. These little saw-tooth shaped rectangles are connected with a big rectangle of 5μm × 42μm, and form the

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whole source or drain area.

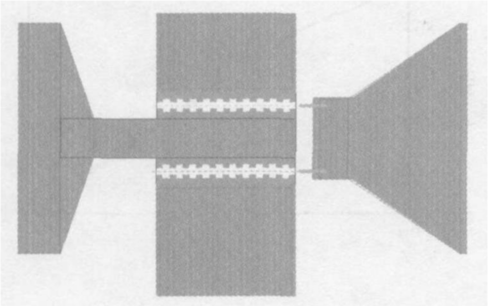

Fig. 1 A part of InP HEMT layout with saw-toothed source and drain

The HEMT's epitaxial layers were grown on 50mm semi-insulating (100) InP substrate by molecular beam epitaxy (MBE)[3]. From bottom to top, the layers consist of a 250nm InAlAs buffer, 15nm $In_{0.53}Ga_{0.47}As$ channel, 3nm $In_{0.52}Al_{0.48}As$ spacer, Si planar doping layer ($5 \times 10^{12}cm^{-2}$), 10nm $In_{0.52}Al_{0.48}As$ barrier, 5nm InP etch-stop layer, and 20nm n^+ $In_{0.53}Ga_{0.47}As$ cap layer.

After lithography for the source and drain, Au/Ge/Ni/Au ohmic contact metals were evaporated and lifted-off, and alloyed for 10min in nitrogen at 295 ℃. A T-shaped TiPtAu gate was fabricated with PMMA/PMGI/PMMA triple-layer resist system. E-beam lithography and a standard lift-off technique were used[4,5].

3 Result and discussion

Usually lithography conditions and development time must be controlled very stringently. By this new source and drain design, patterns are not too sensitive to technology parameters. Source and drain areas do not remarkably expand in case of over-development, as shown in Fig. 2.

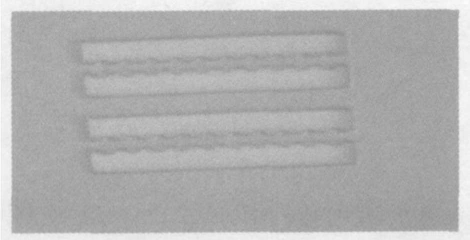

Fig. 2 Photo of saw-toothed source and drain after development

Figure 3 shows the source and drain patterns with usual structure after development. Spacing between the source and drain becomes more narrow due to proximity effect.

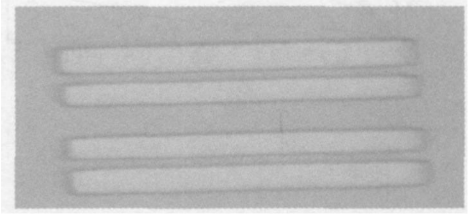

Fig. 3 Photo of source and drain with usual structure after development

4 Device performance

Based on these technologies, we have developed an InP based HEMT with good DC and RF performances. The transistor f_T is 120GHz and the G_m is 1050mS/mm.

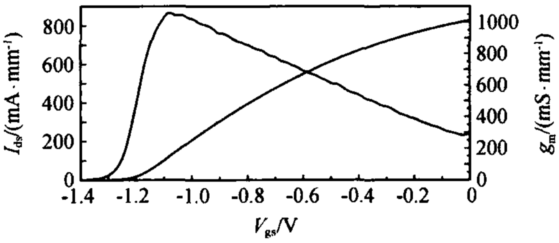

Fig. 4 G_m and I_{ds} versus V_{gs}

5 Conclusion

Using these saw-toothed source and drain patterns space less than 2μm is easy to achieve. This will be useful for high performance HEMT devices and IC design and fabrications. As a result, we get an InP HEMT with 0.2μm gate length and 2μm source drain spacing. The device transconductance is 1050mS/mm, threshold voltage is -1.0V, and current gain cut off frequency is more than 120GHz. These HEMTs have 16dB gain at 40GHz. Device fabrication yield is over 80% by an on-wafer test.

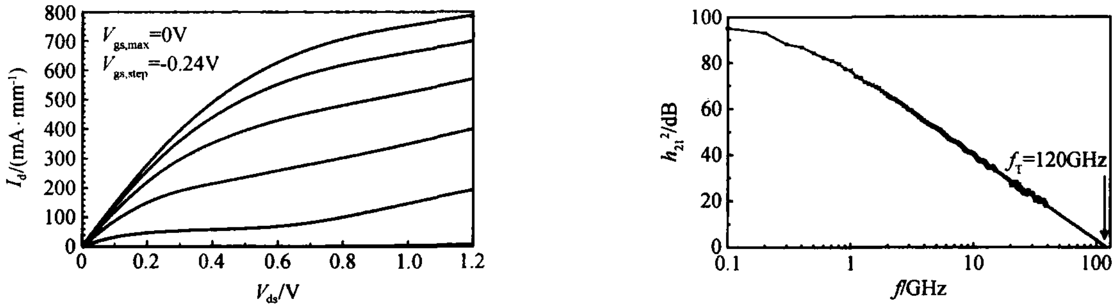

Fig. 5 DC and RF performance

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锯齿型源漏结构的新型 InP 基 HEMT 器件*

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摘要: 毫米波晶体管的制作技术是微波电路设计和制造的基础. 从优化器件结构的角度, 提出了一种锯齿型源漏的新型 InP 基 HEMT 器件. 实验证明, 采用这种结构可以减少光刻过程中临近效应的影响, 改善源漏的图形形貌, 提高器件制做的成品率. 获得了具有良好直流和微波特性的晶体管, 其跨导达到 1050mS/mm, 阈值电压为 -1.0V, 截止频率达到 120GHz.

关键词: InP; HEMT; 微波单片集成电路

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