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GaN Trench Etching and Sidewall Angle Control for Vertical Power Devices

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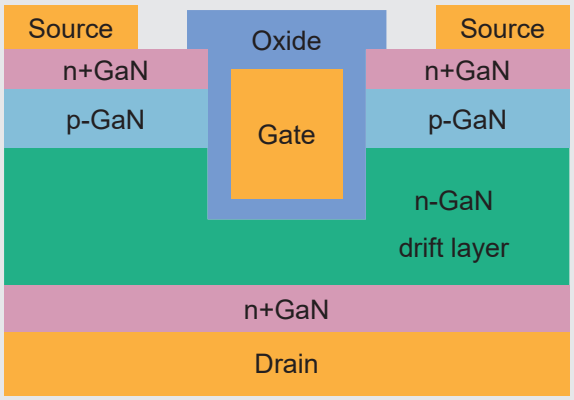
Introduction

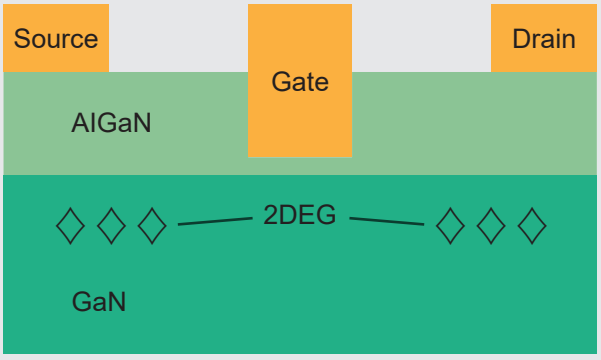
Since gallium nitride (GaN) -based semiconductors, which are widely used in short-wavelength optical devices, have excellent physical properties, they are promising as materials for electronic devices such as power devices and RF devices. Some have already been put into practical use and are already on the market. Development aimed at further increasing performance is gaining momentum year by year, and it is expected that it will be widely adopted in the field of high frequency electronic devices.

For example, it is expected that electronic devices (trench MOS, HEMT, etc.) with high withstand voltage, low ON resistance, and high channel mobility will be realized within the next few years. Figure 1 shows an example of a GaN MOSFET structure adopting a trench structure and a gate recess type GaN HEMT structure.
Samco provides ICP-RIE equipment, CVD equipment and process technology for manufacturing GaN-based light emitting devices. We also provide processes that realize trench formation, mesa formation, etc., that are 4H-SiC high-power device manufacturing processes.

In this technical report, we will introduce a process solution that contributes to the formation of trench structures and recess structures when creating GaN devices.



(a) GaN trench MOSFET structure



(b) GaN HEMT gate recess structure

Figure 1. Schematic of GaN electronic device structure.

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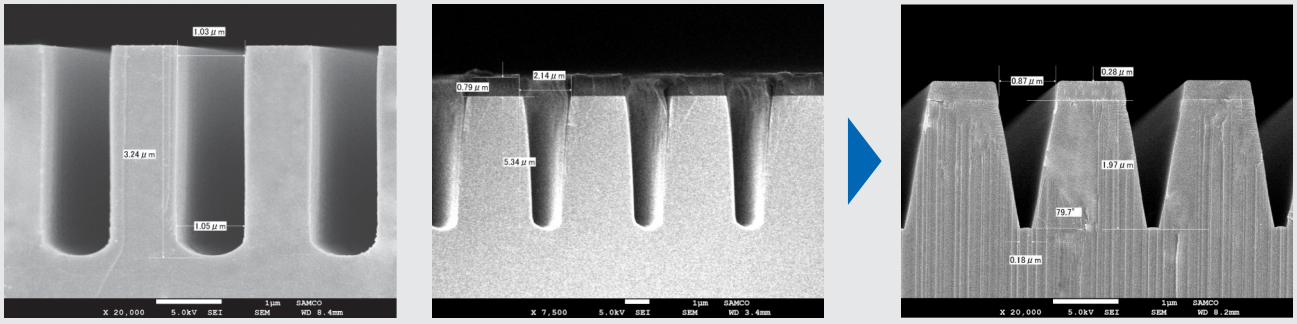
GaN Trench Etching and Sidewall Angle Control

Samco has been developing its GaN trench processing technology. As shown in Figure 2, it is possible to control the shape of trenches from vertical to forward taper machining. A sample created by epitaxially grown GaN on a sapphire substrate was used, and etching was performed with our ICP etching system RIE-400iP.

In the conventional forward taper processing, residue is deposited on the side wall, so it is necessary to remove this by post-treatment. On the other hand, the newly developed forward taper processing technology has reduced residue on the side walls and does not require post-treatment. Furthermore, one point of this process to note is that even a narrow pattern with an etching aperture width of 1 μm or less can form a forward taper of less than 80°. Using the conventional technique there are cases where the progress of etching is hindered by a narrow opening width, since the opening is filled by the accumulation of residue on the side wall. Figure 3 shows the results of successful forward taper processing by controlling the RF power ratio between ICP and Bias and balancing of the etchant gases.



(a) Vertical etch (b) Conventional forward taper etch (c) New forward taper etch

Figure 2. GaN trench etching

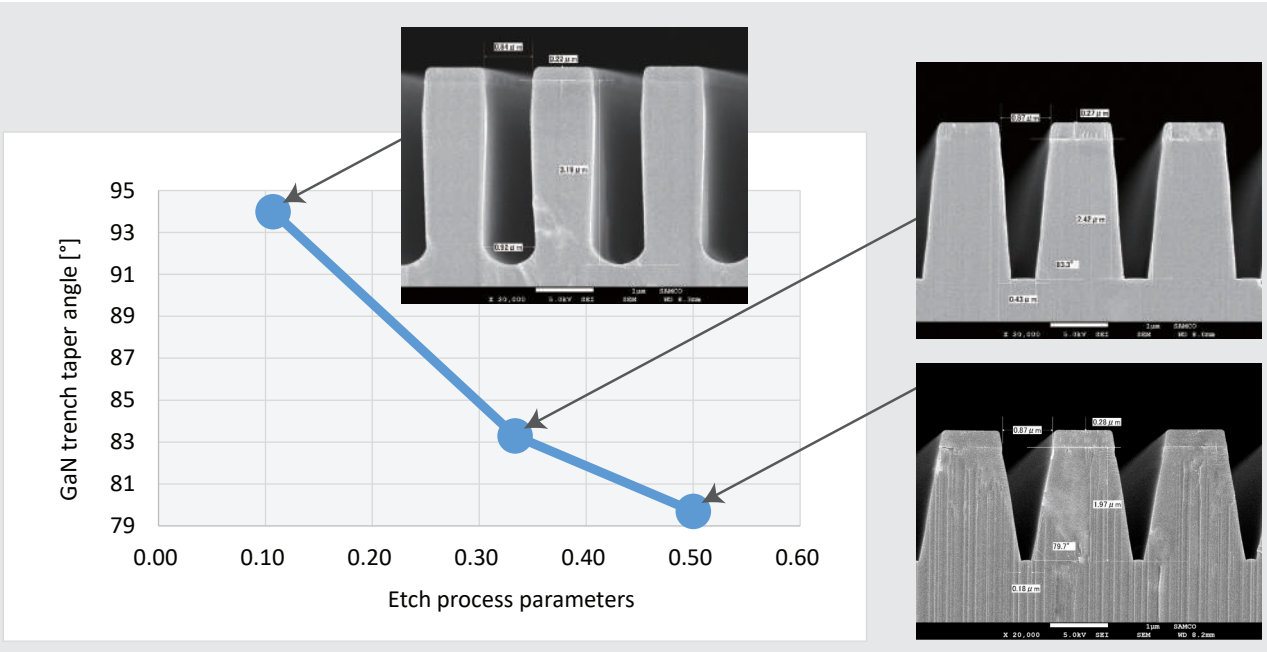


Figure 3. GaN trench sidewall angle control

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The process of forming a forward taper with this GaN trench is thought to be useful for HEMT gate recess formation. In the gate recess structure of HEMT, it is important to design the gate length and process to control the influence on the two-dimensional electron gas. Therefore, this process is applied to maintain the same opening width as when the gate is formed.

Conclusion

Samco has contributed to the manufacturing process from the GaN-LED development stage, and has responded to many customers with varying needs for etching technology for GaN-based semiconductors. In recent years, Samco has developed several process techniques such as the recess etching of GaN-HFET, high selectivity etching of GaN / AlGaN, and GaN trench etching introduced in this report.

Samco will continue to develop processes and contribute to the practical application of GaN trench MOS. Furthermore, Samco is proceeding with the development of gate oxide film formation (ALD, CVD) and metal CVD as well as etching, and intends to provide hardware and process expertise for gate formation.

References

Sarayama, Shoji. (2008). *Shinno baruku GaN tankessho no hitsuyousei to kenkyukaihatsu doukou* (Necessity and R&D Trend of True Bulk GaN Single Crystal). Kagaku Gijutsu Doukou, November 2008.

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