Recess Etching Process for AlGaN/GaN-HFET Devices Using In-Situ Monitoring

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Abstract:

SAMCO has developed a dry etching process for AlGaN/GaN-HFET power devices with precise control of the etching film depth. AlGaN/GaN-HFET devices are "normally on" and require a circuit to turn off the device. To avoid the turning-off of devices, "normally off" devices are preferred for power device applications. One method of making AlGaN/GaN-HFET devices "normally off" is to eliminate the 2D electron gas channel under the gate electrode. This can be achieved by recess etching (for example, etching a 25 nm AlGaN layer with less than 5 nm of the AlGaN film remaining). Precise control of the remaining AlGaN layer thickness is the most crucial factor because the remaining AlGaN layer depth determines V_g-I_d characteristics of AlGaN/GaN-HEFT devices (when V_d is constant).

Remaining AlGaN layer thickness was controlled by the etching time while carrying out very slow etching. For example, a 20 nm AlGaN layer etched for 5 minutes with a 4.0nm/min etch rate. However, the recess etching requires thickness control on the order of 1 nm and this timed etching method does not allow that. At 4.0 nm/min etch rate (= 0.07 nm/sec), a 1nm error translates to only a 15 second etching time tolerance, which is about 5% of the total etch time. Since the AlGaN etch rate can change due to byproducts in the reaction chamber, the timed etching approach is clearly not effective. This paper introduces SAMCO's development of a new, precise method for control of the remaining AlGaN layer thickness during recess etching. SAMCO's new method employs an interferometric film thickness measurement system and in-situ monitoring of the remaining AlGaN thickness.

SAMCO's RIE-200iP ICP etching system was used to etch the AlGaN layer under the gate electrode, which is illustrated in Figure 1. The AlGaN layer was 25nm thick and the etch depth was 20 nm. White light was introduced from the top of the ICP chamber during the etching and we monitored the interference pattern using interferometry (reflection from AlGaN surface and reflection from the AlGaN/GaN interface boundary). The end point of the AlGaN layer can be detected from the Time – Intensity curve of the endpoint system. Figure 2 shows the intensity of the λ = 364 nm while etching AlGaN. Additionally, an algorithm optimized by SAMCO was applied to the monitoring of the light reflection to determine the remaining depth of AlGaN. Figure 3 shows the remaining AlGaN depth while etching. The process was stopped when etching depth was believed to be 20 nm and 5 nm of AlGaN remained. An AFM analysis of the sample verified the etch depth was 20 nm.

The interferometric film thickness measurement system's outstanding performance was confirmed. SAMCO has introduced these technologies into the endpoint detection system, resulting in improved reproducibility of the AlGaN etching process. The new in-situ monitoring technology can now be applied to recess etching for power device fabrication.

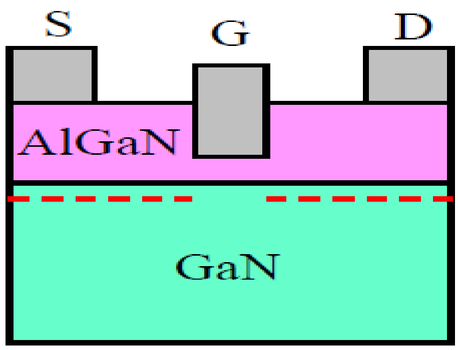

Figure 1. Structure of GaN power device. (S= Source, D= Drain, G = Gate. The dotted red line represents the two-dimensional electron gas.

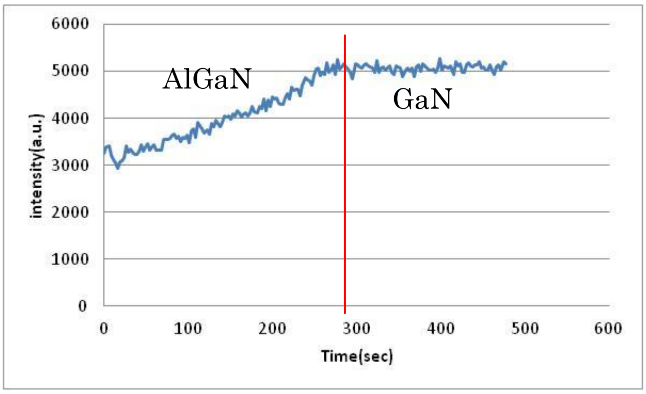

Figure 2. Intensity of the 364 nm band during the AlGaN, GaN etch. At 300 seconds, the AlGaN is etched away and the 364 nm band reflects from the absorbing GaN surface.

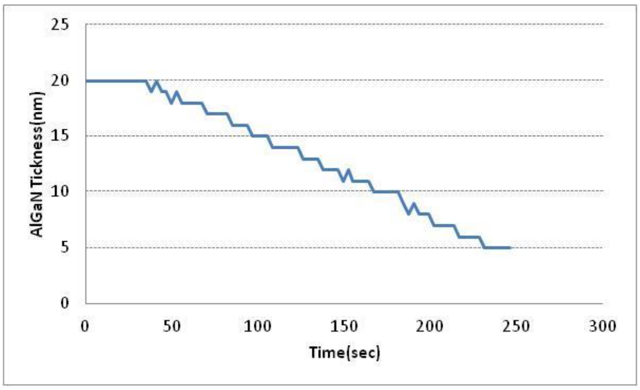

Figure 3. AlGaN thickness versus etch time calculated using the interferometric endpoint system film thickness algorithm.