

Chlorine-Based ICP Etching for Improving the Luminance Efficiency in Nitride LEDs

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Abstract:

In order to improve the luminance efficiency of gallium nitride LEDs epitaxially grown on sapphire, crystal quality improvement, internal quantum efficiency improvements through device structure changes, and external quantum efficiency improvements through light extraction innovation, are required. Patterning of the sapphire surface (PSS) is one way of achieving the above improvements. Figure 1 is an example of a cone-shaped PSS. A smooth, “step free” and “notch free” etching result was obtained.

The PSS etching carried out in our research was performed on SAMCO’s RIE-330iPC system fitted with SAMCO’s internally developed SSTC^[1] coil. Importantly, the photoresist underwent processing to allow increased heat resistance. This processing step eliminated the need to use a specially designed ESC for direct cooling of the wafers. Based on a Cl₂ chemistry, the use of additive gases allowed control of the cone shape, critical dimensions and height. High-speed etching along with excellent cone profiles have been obtained. Standard etching rates are ~100nm/min.

Furthermore, we studied etching of the LED layers in order to achieve improvements in external quantum efficiency. First, the GaN LED structure was grown on a PSS using MOCVD. Then, the LED layer was etched using an ICP etcher for device isolation. Quantum efficiency was found to improve several percent through the use of reverse-taper etching. A SEM image is shown in Figure 2 confirming the reverse-taper and PSS structure.

We are continuing to work on the improvement of GaN LED external quantum efficiency using our ICP etching processes. Going forward we are looking for further improvements through finer patterning of the PSS and also a concave-convex nano-patterning of the GaN surface.

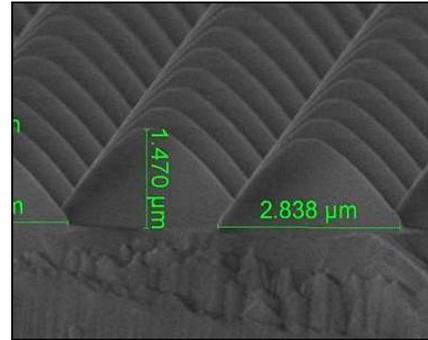


Figure 1. Chlorine-based ICP etching for cone shaped structure on a sapphire substrate.

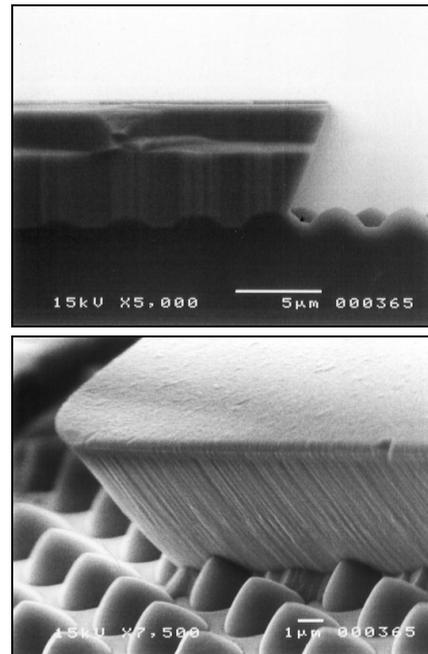


Figure 2. Chlorine-based ICP etching of a reverse-taper structure for GaN.

Reference:

[1]S.Nakagami ,H.Nakano,T.Tatsuta, M.Sawai and O.Tsuji: 18th International Symposium on Plasma Chemistry, 32P-72, August 26-31(2007), Kyoto University, Japan