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Inductively Coupled $BCl_3/Cl_2/Ar$ Plasma Etching of High Al Content AlGaN

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III-nitride materials are researched extensively for high power electronics as well as for UV and visible optoelectronics. One of the many attractive qualities of III-nitride materials is their chemical stability. However, this quality can make material processing and device fabrication challenging. Though significant research has been carried out on processing III-nitride materials, comparatively few studies on high aluminum content AlGaN have been reported.

Al and Ga chlorides are volatile, making the gas chemistries of BCl_3 and Cl_2 attractive for use in dry etching. However, obtaining a smooth surface of AlGaN with a dry etch can be difficult due to two compounding effects: $AlCl_x$ has a lower volatility than $GaCl_x$ and the bond energy of Ga-N is lower than that of Al-N. This exploratory work aims to document some of the etch characteristics during inductively coupled plasma reactive ion etching (ICP-RIE) of high aluminum content AlGaN with a $BCl_3/Cl_2/Ar$ plasma. Etch rate and surface morphology were investigated for $Al_{0.85}Ga_{0.15}N$. Etch rate lends insight into chemical tendencies of AlGaN alloys, while surface morphology is of interest in structures requiring subsequent processing steps such as gate recessing.

Our results show that lowering rf bias and increasing ICP power leads to smoother surfaces while maintaining an attractive etch rate. Also, the ratio of BCl_3 to Cl_2 significantly affects the surface roughness. In addition, we show significant improvement of surface roughness, even under sub-optimal etch conditions, by implementing a 1min BCl_3/Ar plasma pre-treatment dry etch step prior to introducing Cl_2 to the main etch using a $BCl_3/Cl_2/Ar$ plasma.

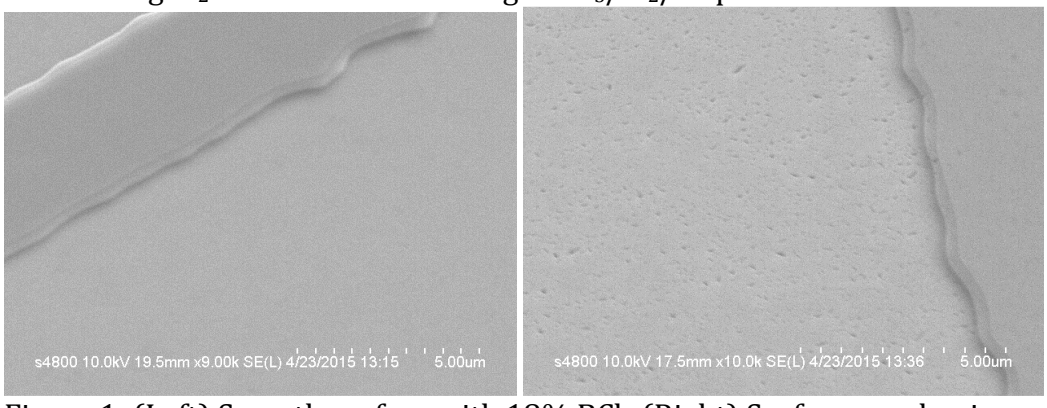

Figure 1: (Left) Smooth surface with 18% BCl_3 (Right) Surface roughening and pitting present with an increase of BCl_3 to 29%.

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