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Improved Performance of AlGaN/GaN HEMTs Using N_2/NH_3 Pretreatment before Passivation

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Abstract : Owing to the high breakdown field, high saturation drift velocity, 2DEG with high density and mobility and so on, AlGaN/GaN HEMTs have been widely used in high-frequency and high-power applications. To acquire a higher power often means higher breakdown voltage and higher drain current. Surface leakage current is usually the key issue affecting the breakdown voltage and power performance. In this work, we have performed in-situ N_2/NH_3 pretreatment before the passivation to suppress the surface leakage and achieve device performance enhancement. The AlGaN/GaN HEMT used in this work was grown on a 3-in. SiC substrate, whose epitaxial structure consists of a 3.5-nm GaN cap layer, a 25-nm $Al_{0.25}GaN$ barrier layer, a 1-nm AlN layer, a 400-nm i-GaN layer and a buffer layer. In order to analyze the mechanism for the N-based pretreatment, the details are measured by XPS analysis. It is found that the intensity of Ga-O bonds is decreasing and the intensity of Ga-N bonds is increasing, which means with the supplement of N, the dangling bonds on the surface are indeed reduced with the forming of Ga-N bonds, reducing the surface states. The surface states have a great influence on the leakage current, and improved surface states represent a better off-state of the device. After the N-based pretreatment, the breakdown voltage of the device with L_s=6 μm increased from 93V to 170V, which increased by 82.8%. Moreover, for HEMTs with L_s of 6-μm, we can obtain a peak output power (Pout) of 12.79W/mm, power added efficiency (PAE) of 49.84% and a linear gain of 20.2 dB at 60V under 3.6GHz. Comparing the result with the reference 6-μm device, Pout is increased by 16.5%. Meanwhile, PAE and the linear gain also have a slight increase. The experimental results indicate that using N_2/NH_3 pretreatment before passivation is an attractive approach to achieving power performance enhancement.

Keywords : AlGaN/GaN HEMT, N-based pretreatment, output power, passivation
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