Influence of MOCVD Growth Conditions on the Two-dimensional Electron Gas in AlGaN/GaN Heterostructures

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Key words: MOCVD, AlGaN/GaN heterostructure, 2DEG, HEMT

The low cost and availability of large-size Si substrates enabled the emergence of AlGaN based High Electron Mobility Transistors (HEMTs) on Si as a viable technology for high voltage power switching applications. Device-quality AlGaN/GaN heterostructures on 150mm silicon are demonstrated using a Veeco K465i MOCVD system. A barrier layer, 25nm $Al_{0.25}Ga_{0.75}N$, is grown over 3-μm-thick crack-free GaN layers. The 2DEG properties are determined by the quality of the AlGaN/GaN interface and improved by inserting a 1nm AlN spacer between the AlGaN/GaN layers.

The influence of MOCVD growth conditions (V/III ratio, growth temperature, and carrier gas) on the AlGaN barrier and the corresponding 2DEG performance is investigated. The surface morphology of the AlGaN is studied by AFM, and the electrical properties of the 2DEG are evaluated by Van der Pauw-Hall measurement. Figure 1 shows the morphology of AlGaN with different V/III ratios and the 2DEG properties. N_2 is used as carrier gas and the growth temp is 920 °C. A Hall mobility > 2000 cm^2/V.s and a sheet resistance < 400 Ohm/sq are observed with high V/III ratios. Figure 2 shows the effect of growth temperature and carrier gas (N_2 vs H_2) on the AlGaN morphology and 2DEG performance. The surface of AlGaN under N_2 shows a step-flow feature comparable to the surface of the underlying GaN layer, indicating the pseudomorphic growth of AlGaN with less strain relaxation for growth temperatures in the range 960 – 1010 ^oC, whereas micro-cracks begin to appear on the AlGaN surface when grown in a H_2 ambient at 1010 °C. Our results show that AlGaN barrier grown in N_2 ambient and with higher V/III ratios has better surface morphology and improved 2DEG performance (higher mobility and lower sheet resistance).

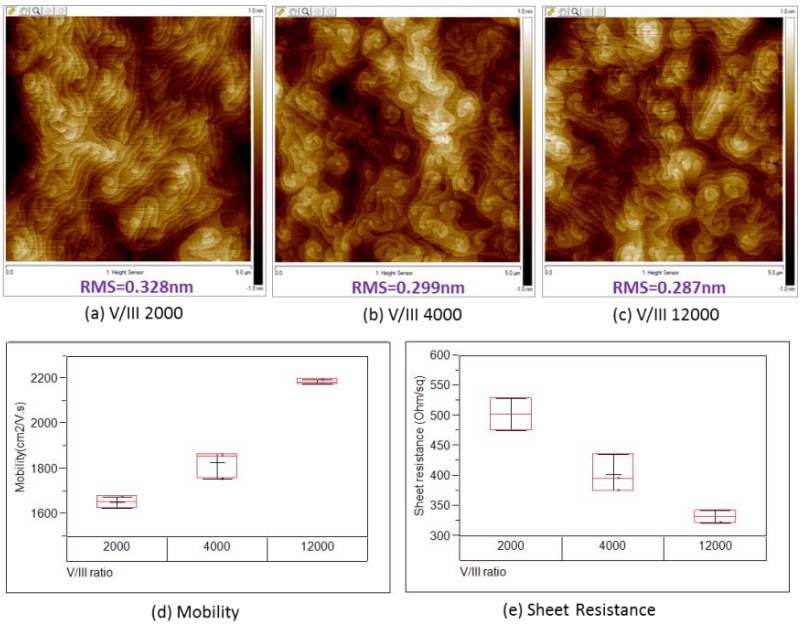

Figure 1: 5µm x 5µm AFM images and electrical properties of AlGaN/GaN heterostructures with different V/III ratio (2000, 4000, 12000) at 920 °C with N_2

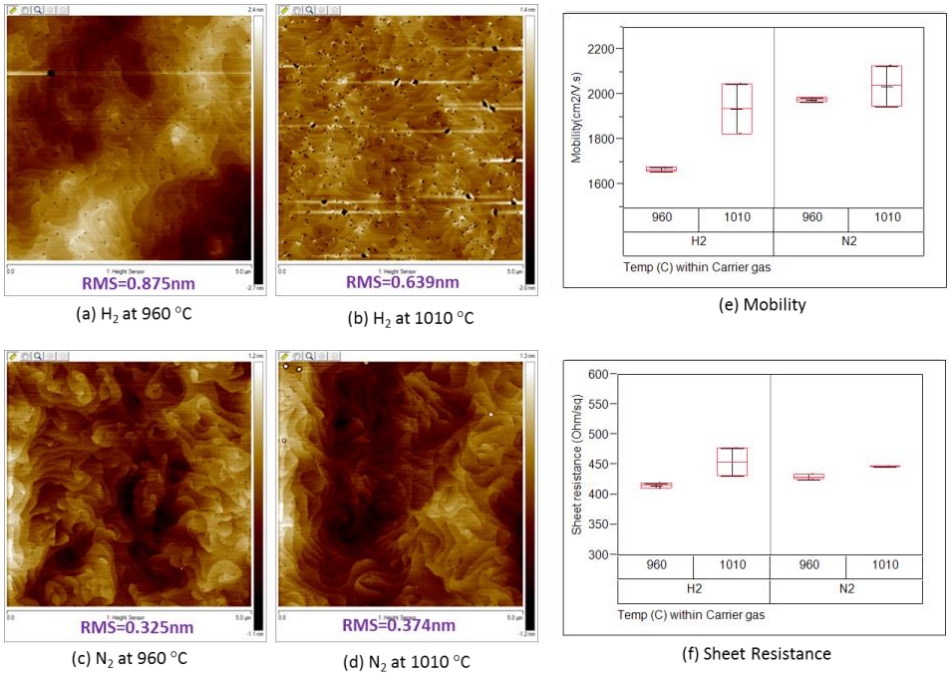

Figure 2: 5µm x 5µm AFM images and electrical properties of AlGaN/GaN heterostructures with different carrier gas (H_2, N_2) and growth temperature (960 °C, 1010 °C)