***Abstract* - Gallium-nitride (GaN) high electron mobility transistors (HEMTs) with step aluminum mole fraction or doping concentration in the barrier is reported. The barrier layer is divided into two Source Side (SS) and Drain Side (DS) parts with the same lengths and thicknesses, but with different aluminum mole fraction or doping levels. Average of the aluminum mole fraction or doping concentration in the barrier is equal to those in the conventional structure. Changes that happen in the maximum lateral electric field, breakdown voltage, maximum DC trans-conductance (gm), drain current, gate-source capacitance, cut off frequency and DC output conductance (go) as a function of different source side (NSS) and drain side (NDS) barrier doping levels or different aluminum mole fractions at source side (XSS) and drain side (XDS) are studied in details. Simulation results illustrate that a smaller NDS compared to NSS improves the breakdown voltage. On the other hand, decreasing NSS, reduces the gate-source capacitance and DC output conductance. With varying NSS and NDS, the DC trans-conductance has a nonlinear variation. Also, proposed structures with smaller XSS than XDS reduces the maximum lateral electric field and then improve the breakdown voltage and go.**