The Effect of External Strain on the Conductivity of AlGaN/GaN High Electron Mobility Transistors


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AlGaN/GaN high electron mobility transistors (HEMTs) have demonstrated extremely promising results for use in broad-band power amplifiers in base station applications due to the high sheet carrier concentration, electron mobility in the two dimensional electron gas (2DEG) channel and high saturation velocity. The high electron sheet carrier concentration of nitride HEMTs is induced by piezoelectric polarization of the strained AlGaN layer and spontaneous polarization is very large in wurtzite III-nitrides. The piezoelectric polarization is five times larger than that in the AlGaAs/GaAs material systems. This suggests that nitride HEMTs are excellent candidates for pressure sensor and piezoelectric related applications.

In this work, we studied the effect of external strain on the conductivity of the sheet carrier in the 2DEG of AlGaN/GaN HEMT. The HEMT structures consisted of a 3µm thick undoped GaN buffer, 30Å thick Al0.3Ga0.7N spacer, 220Å thick Si-doped Al0.3Ga0.7N cap layer. The epi-layers were grown on sapphire substrate with by metal organic chemical vapor deposition (MOCVD). Mesa isolation was performed by Cl2/Ar Inductively Coupled Plasma etching at –90V dc self-bias and 300W of 2MHz power and a process pressure of 5mTorr. Ohmic contacts consisted of e-beam deposited Ti/Al/Pt/Au patterned by lift-off and annealed at 850ºC, 45sec under flowing N2. The devices were fabricated on half of 2” wafer and sawed into 2 mm wide stripes and wire bonded on the test feature. Figure 1 illustrates the setup for the effect of external strain on the conductivity of 2DEG channel of the nitride HEMT.

Figure 2 shows the currents between two 100 × 100 µm2 ohmic metal pads separated by 5 micron spacing versus different stress on the cantilever. The mechanical stresses (N/m2) are equal to 3(1-x/L)(t/2)(δ/L2)(5.50×107) (6894.76), where, t is thickness, L is length of beam minus overlap, x is the distance from start of beam to sensor, and δ is the deflection. Under tensile stress the direction of the piezoelectric and spontaneous polarization is parallel and anti-parallel in the case of compressively strained AlGaN layer. The effect of the gate bias voltage on the conductance of 2DEG channel under strain will be presented as well.

Figure 2 The effect of stress on the conductivity of the AlGaN/GaN HEMT (top) tensile stress (bottom) compressive stress.