

Strain Calculations from Hall Measurements in Undoped Al_{0.25}Ga_{0.75}N/GaN HEMT Structures

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Abstract. The transport properties of undoped Al_{0.25}Ga_{0.75}N/GaN HEMT structures grown by MOCVD were investigated in a temperature range of 20 K-350 K. With Quantitative Mobility Spectrum Analysis (QMSA) method; it was found that, all conduction in undoped Al_{0.25}Ga_{0.75}N/GaN HEMT structures belong to the two dimensional electron gas (2DEG). With the acceptance of Hall sheet carrier density is the total polarization induced charge density, strains of 2DEG interfaces were calculated. Calculated strain values are in good agreement with the literature. Effects of the growth parameters of the nucleation layers of samples on the mobility and density of the 2DEG are listed.

Keywords: AlGaN/GaN, HEMT, 2DEG, QMSA, Strain.

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Because of heat and radiation resistant high power microwave frequency capabilities, AlGaN/GaN HEMTs are superior on Si or GaAs based devices [1]. For a better localized 2DEG at the AlGaN/GaN interface, the composition transition at the interface must be sudden and the interface must be horizontally smooth. It is very well known that [2-3] the interface roughness has an important effect on 2DEG properties, such as the mobility and carrier density. If strain relaxation process occurs, this leads more roughness at the interface [4], so lower 2DEG must be expected. In this work, non-existence parallel conduction in undoped Al_{0.25}Ga_{0.75}N/GaN HEMTs are showed with QMSA method. Because of all transport is done at interface and the samples are undoped, hall carrier density is accepted as polarization induced carrier density ($n_s = \sigma(x)/e$). The in-plane and growth axis strains are calculated from this polarization induced carrier density.

According to Ambacher et al. [3], the amount of polarization induced carrier can be calculated using:

$$|\sigma(x)| = |P_{PE}(Al_xGa_{1-x}N) + P_{SP}(Al_xGa_{1-x}N) - P_{SP}(GaN)|, \quad (1)$$

where spontaneous polarization and piezoelectric polarization are defined as;

$$P_{SP}(Al_xGa_{1-x}N) = (-0.052x - 0.029) \text{ C/m}^2, \quad (2)$$

$$P_{PE}(Al_xGa_{1-x}N) = 2\epsilon_x \left\{ e_{31}(x) - e_{33}(x) \frac{C_{13}(x)}{C_{33}(x)} \right\} \text{ C/m}^2, \quad (3)$$

and an in-plane strain can be written from Eq. (3) as:

$$\epsilon_x = \frac{P_{PE}(Al_xGa_{1-x}N)}{2 \left\{ e_{31}(x) - e_{33}(x) \frac{C_{13}(x)}{C_{33}(x)} \right\}}. \quad (4)$$

The growth-axis strain (ϵ_z) is related with the in-plane strain (ϵ_x) in α GaN is $\epsilon_z = -2(C_{13}/C_{33})\epsilon_x$. Results are compatible with surface investigations.

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