Investigation of Temperature Effects on GaN MOS Capacitors and Field-Effect Transistors

by

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ABSTRACT

We have performed an extensive study on the temperature effects on electrical characteristics of GaN MOS capacitors and MOS Channel-HEMTs (MOSC-HEMTs). The capacitance-voltage technique was used to characterize the pyroelectric polarization effects on capacitors and the current-voltage measurements were employed to extract threshold voltage, subthreshold swing and field-effect mobility on MOSC-HEMTs. From the flatband voltage shift, we have extracted pyroelectric voltage coefficient (P_v) of 7.4×10^4 V/m-K and 8.5×10^4 V/m-K for devices on sapphire and bulk GaN substrates respectively. The discrepancies between the experimental P_v values and the theoretical values calculated using the piezoelectric constants given by F. Bernardini are attributed a mismatch in lattice constants and thermal expansion coefficients between the GaN epilayer and the underlying substrates. The temperature dependence of threshold voltage on all three types of GaN samples is more complex than the flatband voltage variation for capacitors. From subthreshold swing, we have found that the interface charge (Q_{it}) decreases with increasing temperature, which has the same effect as polarization charges on threshold voltage shift. The field-effect mobility is very insensitive to the temperature below 150°C, then changes more rapidly ($T^{-1.59}$ for sapphire substrate and $T^{-0.86}$ for Si substrate) from 150°C to 250°C, which indicates that it is surface scattering limited or caused by reducing interface traps at low temperatures and phonon scattering limited at higher temperatures.