A Comparison of Deep Level Effects on the DC Characteristics of $In_xGa_{1-x}P/In_{0.20}Ga_{0.80}As/GaAs$ and $Al_{0.24}Ga_{0.76}As/In_{0.20}Ga_{0.80}As/GaAs$ High Electron Mobility Transistors Grown by Solid Source MBE

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Abstract

Deep Level Transient Spectroscopy (DLTS) has been used to characterise the deep levels in $In_xGa_{1-x}P/In_{0.20}Ga_{0.80}As/GaAs$ ($0.40 \leq x \leq 0.48$) pseudomorphic high electron mobility transistor (pHEMT) grown by solid source molecular beam epitaxy (SSMBE) using a valved phosphorus cracker cell. Three different pHEMT devices were investigated, namely; one with single InGaP barrier layer, double InGaP barrier layers and strained InGaP barrier layer. Only one electron trap in the InGaP barrier layer was detected in each of the devices. The activation energy of the electron trap is 0.39eV for the single barrier layer device, 0.40eV for the double barrier layer device and 0.57eV for the strained barrier layer device. The trap concentration is $7.22x10^{18}cm^{-3}$, $2.38x10^{20}cm^{-3}$ and $5.02x10^{20}cm^{-3}$ for these devices, respectively. The current-voltage (I-V) characteristics and transconductance of the devices were measured at 300K, 77K and 30K. The drain saturation current of the devices becomes smaller due to the carriers being captured by the defects, and the transconductance becomes higher due to an increase in carrier mobility in the channel as the temperature was lowered from 300 to 30K. All devices did not show any collapse in the I-V characteristic or persistent photoconductivity (PPC) at low temperature, suggesting that the trap in the InGaP layer does not have DX centre-like characteristic. A comparison was made with $Al_{0.24}Ga_{0.76}As/In_{0.20}Ga_{0.80}As/GaAs$ pHEMTs grown by SSMBE. Only one electron trap with activation energy of 0.49 eV was detected in the $Al_{0.24}Ga_{0.76}As$ layer of the $Al_{0.24}Ga_{0.76}As/In_{0.20}Ga_{0.80}As/GaAs$ pHEMT. The trap concentration is $1.72 \times 10^{20}cm^{-3}$. Drain current collapse at temperature below 77K at low drain bias and persistent photoconductivity effect was evident in the $Al_{0.24}Ga_{0.76}As/In_{0.20}Ga_{0.80}As/GaAs$ pHEMT, clearly indicating the presence of DX centers in the $Al_{0.24}Ga_{0.76}As$ layers.

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