Enhanced electron mobility in InSb/Ga0.22In0.78Sb composite channel HEMT structure

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GaInSb channel HEMT structure with strained-stepped buffer has simultaneously realized higher electron mobility (μ) and sheet electron density (NS) since the tensile-strained upper buffer has allowed the In content in channel to be increased keeping larger conduction band discontinuity [1]. In this work, InSb/Ga0.22In0.78Sb composite channel HEMT structure in which InSb channel is inserted into Ga0.22In0.78Sb channel is investigated in order to further enhance μ.

The schematic of HEMT structure, shown in inset of Fig. 1, was grown on SI-GaAs(100) substrate by MBE. The InSb thickness (dInSb) ranges from 0 to 4 nm (within critical thickness). Hall effect measurement and AFM were performed to evaluate μ and Ns, and threading-dislocation density (DTD).

Fig. 1 shows the dependence of μ and NS on dInSb at RT and 77 K. The μ at RT increases at dInSb = 1, 2 nm and then decreases drastically at 4 nm, where the increase in DTD is also observed. The increase in μ becomes even larger at 77 K. Meanwhile, NS is almost constant with dInSb. The maximum μ at RT is 14,500 cm2/Vs with NS = 2.55×1012 cm-2 at 1 nm. The increased μ can be attributed to the decreased average electron effective mass in channel due to the insertion of InSb. The increased DTD at 4 nm indicates the dislocation generation within critical thickness [2], which leads to the decrease in μ.

In conclusion, the InSb/Ga0.22In0.78Sb composite channel HEMT structure is effective in further enhancing μ.