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Effect of Growth Factors in Doping Concentration of MBE Grown GaAs for Tunnel Diode in Multijunction Solar Cell

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One of the critical issues in the growth of multijunction solar cell is the formation of a highly doped Esaki interband tunnel diode which interconnects unit cells of different energy band gap. Small electrical and optical losses are the requirements of such tunnel diodes [1]. To satisfy these requirements, tens of nanometer thick gallium arsenide (GaAs) can be a proper candidate due to its high carrier concentration in low energy band gap.

To obtain highly doped GaAs in molecular beam epitaxy, the temperatures of Si Knudsen cell (K-cell) for n-type GaAs and Be K-cell for p-type GaAs were controlled during GaAs epitaxial growth, and the growth rate is set to 1.75 A/s. As a result, the doping concentration of p-type and n-type GaAs increased up to 4.7×10^{19} cm^{-3} and 6.2×10^{18} cm^{-3}, respectively. However, the obtained n-type doping concentration is not sufficient to form a properly operating tunnel diode which requires a doping concentration close to 1.0×10^{19} cm^{-3} [2].

To enhance the n-type doping concentration, n-doped GaAs samples were grown with a lower growth rate ranging from 0.318 to 1.123 A/s at a Si K-cell temperature of 1,180°C. As shown in Fig. 1, the n-type doping concentration was increased to 7.7×10^{18} cm^{-3} when the growth rate was decreased to 0.318 A/s. The p-type doping concentration also increased to 4.1×10^{19} cm^{-3} with the decrease of growth rate to 0.318 A/s. Additionally, bulk resistance was also decreased in both the grown samples.

However, a transmission line measurement performed on the n-type GaAs sample grown at the rate of 0.318 A/s showed an increased specific contact resistance of 6.62×10^{-4} $\Omega \cdot cm^{-2}$. This high value of contact resistance is not suitable for forming contacts and interfaces. The increased resistance is attributed to the excessively incorporated dopant during low growth rate. Further studies need to be carried out to evaluate the effect of excess dopants on the operation of tunnel diode.

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Keywords: Tandem Solar cell, Tunnel diode, CPV

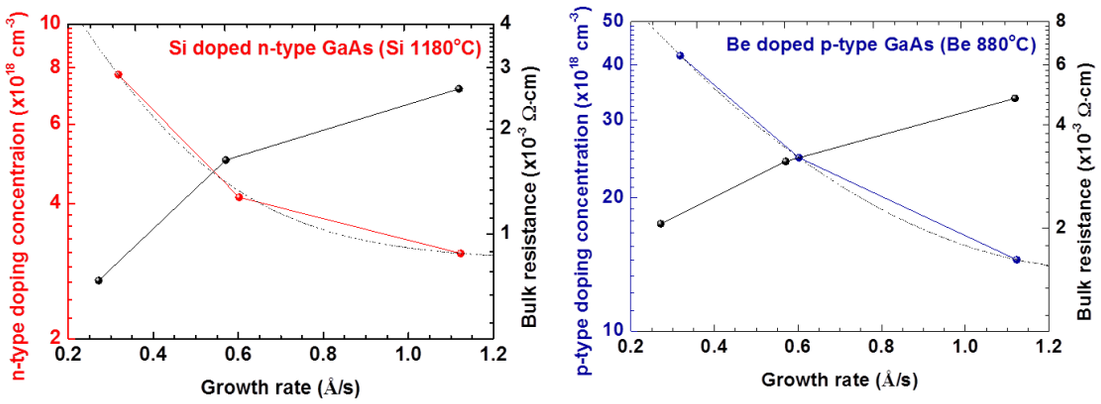

Fig. 1. N-type/p-type GaAs doping concentration and bulk resistivity with different GaAs growth rate.