Development of AlAsSb digital alloys on GaSb and InP substrates for photo-detector applications

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The III-(As, Sb) ternary or quaternary materials are commonly limited by spontaneous formation of clusters and phase separations during alloying. In particular, due to the wide miscibility band gap, growth of thick high-quality and lattice-matched AlAsSb alloy on GaSb or InP substrates is extremely challenging because of the non-unity sticking coefficient of group-V species. In this research, digital alloy growth by molecular beam epitaxy (MBE) has been adopted in preference to conventional random alloy growth because of the extra degree of control.

The AlAsSb structures are grown on epi-ready InP (001) and GaSb (001) substrates, respectively, via digital alloy growth technology by a Veeco GEN930 MBE reactor, in which both As2 and Sb2 fluxes are supplied using valved cracker cells. In order to get the precise lattice-matched AlAsSb alloy with high crystalline quality, digitally grown AlAsSb is realized by periodically alternating the As and Sb shutter to obtain the desired alloy composition. The AlAsSb epi-layers grown by digital alloy technique showed stronger photoluminescence intensity, narrower peak linewidth, and larger carrier activation energy than that grown via the random alloy technique, indicating an improved optical quality with lower density of non-radiative recombination centers for the AlAsSb digital alloy samples. In addition, a relatively long carrier lifetime was observed from the digital alloy samples, consistent with the results obtained from the photoluminescence study.

Finally, the AlAsSb epi-layers have been applied to constructed PIN and Separate Absorption and Multiplication Avalanche Photodiodes (SAM-APD) structures. The devices show optimized detection performance.

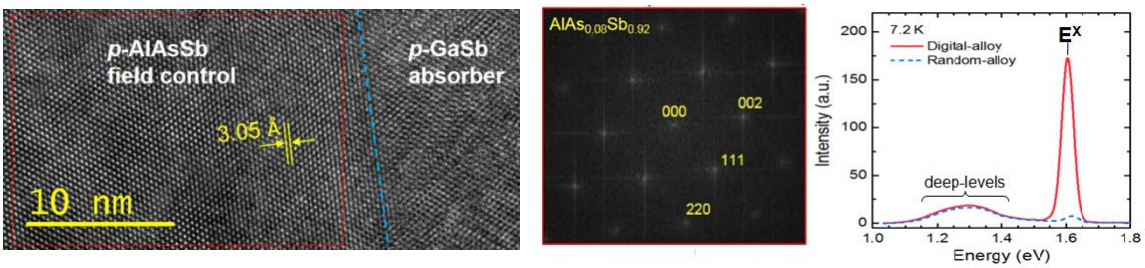

Figure (a) High-resolution cross-sectional TEM of the AlAsSb/GaSb interface and corresponding diffraction pattern of the AlAsSb digital-alloy epi-layer. (b) Low-temperature (7 K) PL emission from AlAsSb/GaSb digital-alloy epi-layer.

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