Area: Area 3 III-V Compound Semiconductor and Concentrator and Space PV Technologies

GALLIUM ARSENIDE ON SILICON WITH A LOW-TEMPERATURE BUFFER LAYER GROWN BY MIGRATION-ENHANCED EPITAXY

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Introduction

The heterogeneous integration of III-V compound semiconductor alloys on Si substrate has drawn a lot of attention. However, it is hard to obtain metamorphic GaAs epilayer on Si wafers with very low dislocation density and root mean square (RMS) roughness because of a high density of threading dislocations generated by 4.1% lattice mismatch along with 62% thermal expansion coefficient mismatch in the GaAs on Si. Previous studies have been reported various effective methods [1]. Among these, it is an effective and economic method that 2-step growth of GaAs on Si with a low-temperature grown GaAs followed by high temperature annealing and a thick GaAs under conventional growth conditions [2]. In addition, the layer-by-layer nucleation and growth is advantageous for high quality crystallinity and migration-enhanced epitaxy (MEE) is a way to meet the atomic layer growth by open the Ga and As shutters alternately [3]. MEE is conducted under low or without As background pressure and the surface migration of Ga is enhanced [4]. Consequently, the island nucleation suppresses effectively. In the study, the low-temperature grown MEE GaAs stacked with conventional MBE grown GaAs (conv-GaAs) is studied.

Experimental

A conv-GaAs layer of 2μm GaAs was deposited on the (100) Si substrate with a tilt angle of 4° toward [110] azimuth at 580 °C with different buffer layers. Sample A was deposited a 20 nm GaAs with conventional GaAs grown at 300 °C with As/Ga ratio of 2.9 followed by a 570 °C annealing. After cooling to 300 °C, a 50 nm of GaAs layer was deposited as a buffer layer using MEE and annealed at 570 °C. Sample B was synthesized with 2-step growth whose buffer layer is performed with a 70 nm 300 °C-grown GaAs followed by a 570 °C annealing. The samples were characterized by X-ray diffraction ω scan, reciprocal lattice mapping (RLM) and etch-pit density (EPD) observations.

Results and discussion

The morphologies of EPD results with and without an MEE buffer layer were shown in Figure 1. It can be observed that the GaAs film with an MEE was obtained the smooth surface. The EPD is a half less for that with an MEE layer and the corresponding results of X-ray diffraction ω scan full-width-half- maximum at GaAs (004) are 882 and 1260 s⁻¹ with and without an MEE buffer layer, respectively. In addition, the tilt angle and strain is tabulated in Table 1. The different tilt angles and relaxation ratio for Sample A and B are observed from RLM and it is suggested that the strain relaxation process may dependent on the growth of nucleation layers.

Table 1: The tilt angle and relaxation of GaAs on (A) w/ and (B) w/o an MEE grown buffer layer.

<table>
<thead>
<tr>
<th>Tilt angle to [110]</th>
<th>(−1-15)</th>
<th>115</th>
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<tbody>
<tr>
<td>#A 0.0645°</td>
<td>10% Tensile</td>
<td>8.06% Tensile</td>
</tr>
<tr>
<td>#B 0.1903°</td>
<td>100% Relaxation</td>
<td>100% Relaxation</td>
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</tbody>
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Summary

The dislocation reduction of GaAs on Si is obtained by inserting an MEE layer as a buffer layer. The dependent of relaxation level is with and without an MEE buffer layer is also observed.

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Reference