[I~12]

Influence of CCl_4 on GaAs surface morphology during the AP-MOCVD GaAs growth

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For nano-scale structure fabrications, growth of self-assembled quantum wire and superlattices using macro-steps on vicinal surfaces have attracted of considerable interests because ex-situ patterning in nano-scale can cause inherent damages at heterointerface. Recently, step bunching phenomena occurred on various types of GaAs substrates such as slightly tilted, vicinal (100), and (111)B surfaces during GaAs growth by MOCVD has been observed and discussed [1,2]. In those studies, the terrace width and step heights were measured, and their dependencies on intrinsic growth parameters such as growth temperature, growth rate, arsine pressure were investigated. Dependency on extrinsic growth parameter has not been studied so far. Kim *et al.* [3] investigating selective epitaxy of GaAs on patterned GaAs substrates have reported remarkable increase of GaAs lateral growth rate toward [011] direction in the presence of CCl_4 during MOCVD growth on patterned GaAs substrates. In contrast, the vertical growth ratio was relatively insensitive to the CCl_4 flow rate.

(100) semi-insulating GaAs substrates, slightly tilted (0.03° toward <111>), 3° off toward [011], and [0-11] were employed for MOCVD GaAs epitaxial growth. The GaAs substrates were degreased in organic solvents and etched in a H_2SO_4:H_2O_2:H_2O (5:1:1) solution for 2 minutes before loading into vertical quartz reactor. Trimethylgallium (TMG) and arsine (AsH_3) were used as gas sources. After high temperature annealing at 850°C under AsH3 ambient for 10 minutes, GaAs buffer layers were grown at 650°C with the CCl_4 supply of 0, 0.03, 0.05, 0.1, 0.15, 0.2 sccm, respectively. Surface morphology of GaAs was examined by an atomic force microscopy (AFM).

Figure 1(a) showed the AFM image of GaAs surface without CCl_4 grown on slightly tilted GaAs substrates. Average step heights were measured approximately 3Å and average terrace widths were about 500nm. The image indicated that flat surface was observed and therefore, step flow growth mode was maintained during the epitaxial growth. As the CCl_4 supply rate increased, step heights and terrace widths of GaAs epitaxial layers increased. Figure 1(b) showed that AFM image of GaAs surface with CCl_4 of 0.2 sccm. Drastic morphological change in GaAs surface was observed and macro-steps formed. Some step heights and terrace widths were increased to ~9Å, and ~2μm, respectively. GaAs epitaxial layers under similar growth conditions were grown on substrates tilted by 3° off toward [011], and [0-11]. Steps of several nanometers in height were formed, but the

morphology was more regular than those of GaAs grown on slightly tilted substrates. CCl_4 have played an important role in resulting enhancement of incorporation rate of Ga adatoms to step edges and morphological change in GaAs surface. The possible formation of macro-steps could be utilized for a template of in-situ formation of quantum wire/dot fabrication.

References

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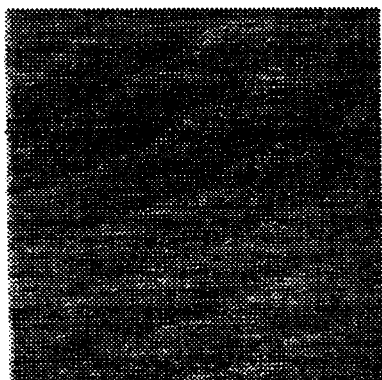
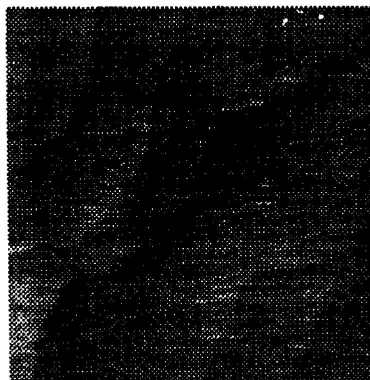


1μm

Fig. 1(a) AFM image of GaAs surface morphology grown on slightly tilted substrates revealing the maintenance of step flow growth mode.



4μm

Fig. 1(b) AFM image of GaAs surface morphology with CCl_4 supply rate of 0.2 sccm revealing drastic morphological change.