Investigation of InP epitaxial films on GaAs Substrate grown by Chloride Vapor Phase Epitaxy

S.Sawada, S.Matsukawa*, T.Iwasaki, Y.Miura and M.Yokogawa

Semiconductor Division, *R & D Group Analytical Characterization Center, Sumitomo Electric Industries, Ltd.

1-1-1, Koya-kita, Itami, Hyogo, 664-0016, Japan

E-mail: sawada-shigeru@sei.co.jp, iwasaki-takashi@sei.co.jp, miura-yoshiki@sei.co.jp

Abstract

InP epitaxial films on GaAs substrate are grown by Chloride Vapor Phase Epitaxy. Good surface morphology is successfully obtained at first. According to the observation by TEM, cross-section of InP films shows that dislocations arose from GaAs substrate and InP film boundary gradually disappears toward top surface of InP layer. This report shows the possibility of larger and less-fragile substrate for InP high-speed devices such as InP HEMTs and HBTs.

Introduction

The demand of devices for 40G D-WDM system continues to grow in the market. The high-speed devices over 40G bit require InP based devices instead of GaAs based devices. In order to commercialize InP based devices, there are some problems as follows;

1. Commercialized InP substrate is smaller size (3inch) at present. (4-inch is still under development [1].) However the process for GaAs based devices already became 4-6 inch.
2. InP wafer is more fragile than GaAs.

To solve these problems, metamorphic HEMTs devices are researched by MBE or MOVPE. However the epitaxial layers including Phosphorus does not be made by MBE and InP-on-GaAs substrates do not be grown by MOVPE. This study chooses the Chloride VPE method for InP-on-GaAs substrates with InP buffer layer grown at the low temperature [2].

Experiment

The Chloride VPE method has much faster growth rate (~10 μm/h) to grow a thick epi-layer easily and its purity of epi-layer is the best method of another epi-growth method i.e. MBE, MOVPE. The epi-structure and time chart of this study are shown in fig. 1. At first InP(~0.5 μm) buffer layer is grown at the lower temperature, and InP(~2 μm) film is grown at the higher temperature serially. The obtained InP layers have been characterized by transmission electron microscope (TEM), optical microscope and flatness tester.

Results and Discussions

The good surface morphology is observed (see fig. 2.). Wafer flatness is around 3 μm as same as an ordinary GaAs substrate. Cross-section of InP films by TEM is shown in fig.3. Dislocations arose from GaAs substrate and InP film boundary gradually disappear toward InP surface. Electron diffraction patterns of each InP films are shown in fig. 4. The pattern of the first InP buffer layer grown at the lower temperature consists of diffraction spots for the GaAs substrate and other spots for InP film. However the pattern of second InP film grown at the higher temperature consists of only diffraction spots for InP. It shows that crystal characterization of top InP layer is good. Lower temperature InP buffer film takes the most important role to obtain the good InP layer on GaAs.

Lower temperature InP buffer has many kinds of lattice parameters. As shown in fig.4, lower temperature InP buffer takes a role as bridge of different lattice mismatch from GaAs layer to InP layer. That is the key to make a good surface condition InP on GaAs.

Conclusion

The good surface morphology wafer of InP-On-GaAs by Chloride VPE is successfully obtained at first. InP layer grown at the lower temperature that has many kinds of lattice parameters takes the important role to obtain good InP layer. These wafers have the possibility of larger and less-fragile substrate for InP over 40GHz devices such as InP HEMTs and HBTs.

References

[1] Y.Hosokawa, Y.Yabuhara, R.Nakai and K.Fujita ,Proceedings of the 10th Int'l. Conf. on InP and Related Materials, 34(1998)

[2] Y. Miura N.Takahashi A.Koukitu H.Seki :Jpn.. J. Appl. Phys. Vol.35 (1996)

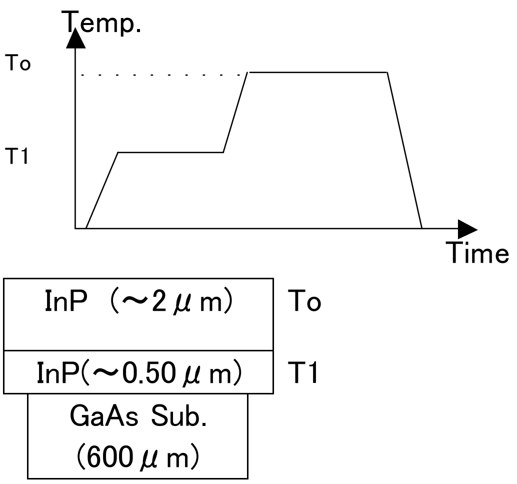
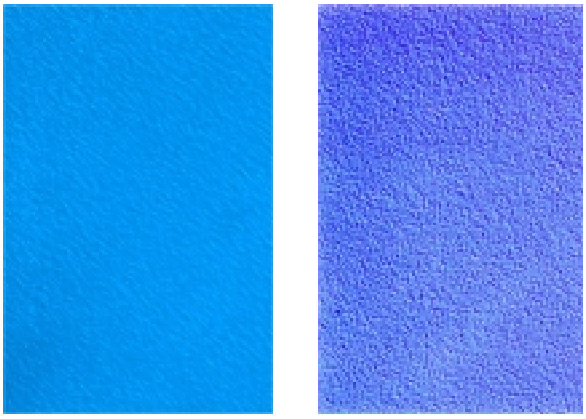
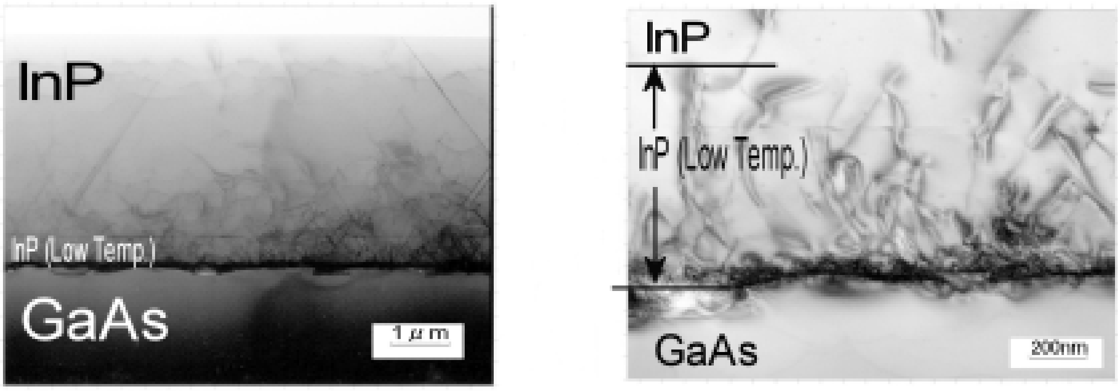


Fig.1. Epi-structure and time chart



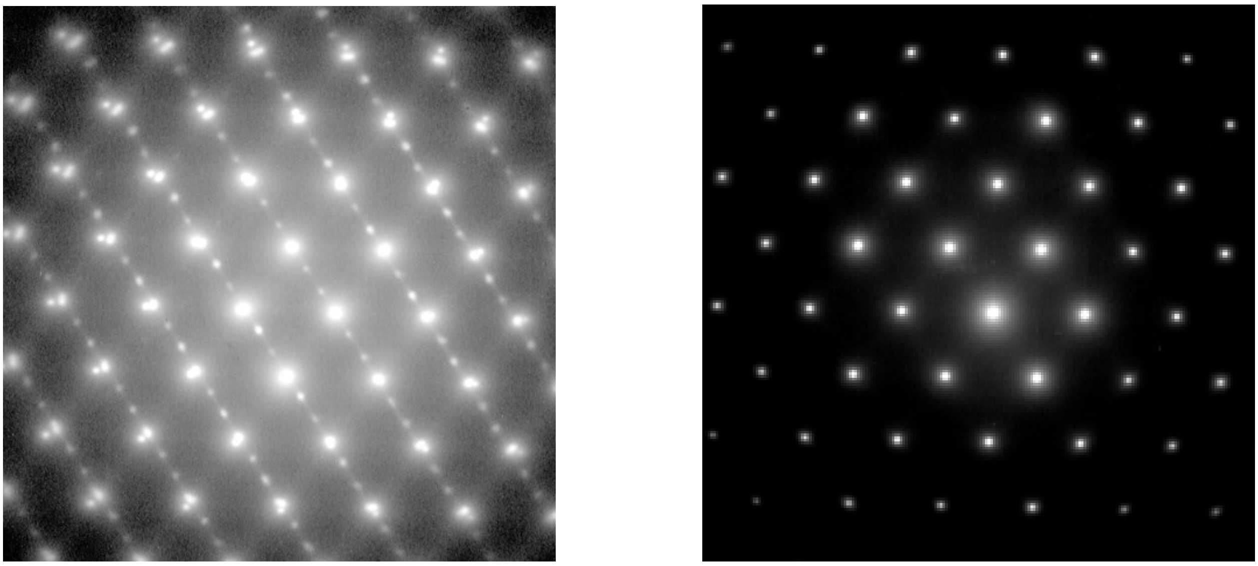
(a)InP on InP (b) InP on GaAs

Fig. 2. Surface morphology



(a) Whole InP films (b) GaAs and InP boundary

Fig. 3. Cross section of epi-layer by TEM



(a) Lower temperature InP buffer (b) Top of InP layer

Fig. 4. Electron diffraction pattern