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Selective Growth of GaAs by Reduced Pressure MOCVD Using TMG and TEG

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On the selective growth of GaAs by MOCVD, some works have been reported. In these reports, TMG:($Ga(CH_3)_3$) was used as a Ga source. When the growth was done under an atomospheric pressure, the selectivity was not so good and polycrystalline GaAs was deposited on a mask. The deposition on a mask near the window region depended on the mask material. It was also reported that the polycrystalline GaAs showed a high resistivity. On the other hand, good selectivity was observed when the growth was done under a reduced pressure of around 10 Torr.

We have studied the selective growth using two kinds of Ga sources, TMG and TEG:($Ga(C_2H_5)_3$) and three kinds of mask materials, SiO_2, SiN and W by a reduced pressure MOCVD system operating at 100 Torr, and have found that the selectivity has been completely different between these materials.

When TMG was used and each mask pattern was relatively small (less than 200 x 200 µm), the selctivity was complete and any deposition was not observed on a mask. the growth rate of GaAs on a window region showed a strong dependence on the mask pattern and the ratio of the window area to the masked area.

In case of TEG, on the contrary, we did not observe any selectivity. Single crystalline GaAs was grown on a window region, and a polycrystalline layer was deposited on a mask as shown in Fig. 1. The growth rate of the GaAs on a window region showed a fairly high temperature dependence. The deposition rate of the polycrystalline layer was not so affected by the substrate temperature. Figure 2 shows the temperature dependence of the growth rate of the single crystalline GaAs normalized by the deposition rate of the polycrystalline GaAs. At about 570 °C, the growth rate of the single crystalline GaAs and the deposition rate of polycrystalline GaAs were nearly the same. These facts indicate that the planar surface is formed on a masked substrate, even when mesa structures are formed on a substrate. A polycrystalline layer showed a resistivity of 10^4 - 10^5 Ω·cm at the Se doping level of 1 x $10^{18}cm^{-3}$ as shown in Fig. 3. This resistivity is sufficiently high for the device isolation. When the doping level was much increased, the resistivity decreased to 10Ω·cm. A single crystalline layer did not show an electron density of more than 5 x 10^{18} cm^{-3}. Se may be incorporated much more in the polycrystalline layer.

The difference in the selectivity between the source materials is thought to be due to the difference in the easiness of the decomposition of these materials. TEG may almost decompose to Ga atom near the substrate surface and the mobility of Ga atom may be very low on the surface. Therefore, GaAs is deposited even on a mask. On the other hand, TMG may not completely decompose when TMG reaches the wafer surface, especially when the growth is done under a reduced pressure. The mobility of such species on the wafer surface may be high and they may move to a window region or fly away from the wafer.

The selective growth by TMG or TEG makes it possible to realize some new types of device structures. GaAs MESFETs with a low source resistance and weak short channel effects have been already fabricated using the selectively grown n^+ GaAs with the good selectivity of TMG. Buried heterostructure laser diodes of a planar structure will be able to be fabricated with the planar growth by TEG. A good current confinement will be easily achieved by high resistive polycrystalline GaAs and an insulator mask with a simple process and a sigle growth run. The selective growth using TMG or TEG will be a very useful technique for many other devices.

References

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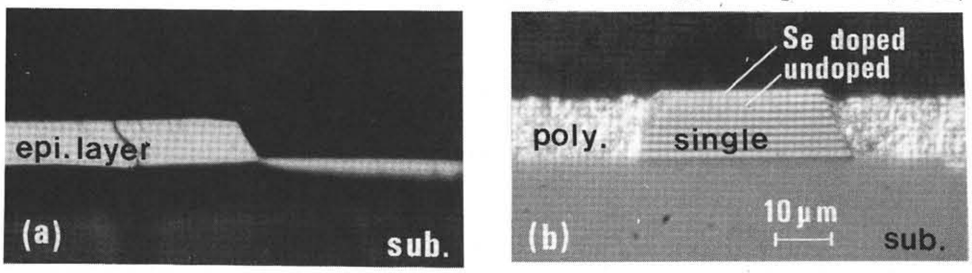

Fig. 1 The cross-sectional views of the grown layer using (a) TMG and (b) TEG.

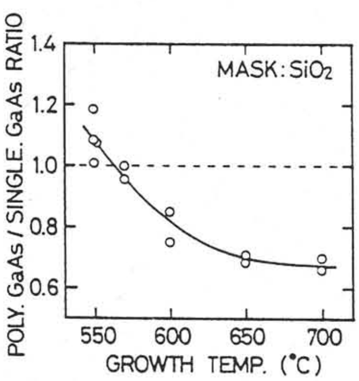

Fig. 2 The temperature dependence of the growth rate of the single crystalline GaAs normalized by that of the polycrystalline GaAs.

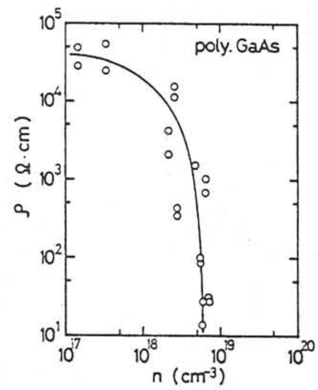

Fig. 3 The resietivity of polycrystalline GaAs as a function of the doping level in single crystalline GaAs.