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—— Short Notes

$Ga_{1-x}Al_xAs_{1-y}P_y$ 均一組成的液相成長

An Uniformly Compositional $Ga_{1-x}Al_xAs_{1-y}P_y$ Layer Grown on GaAs by Liquid Phase Epitaxy

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Abstract —— Aluminum and Phosphorus are distributed uniformly in $Ga_{1-x}Al_xAs_{1-y}P_y$ epitaxial layer grown on GaAs substrate by Temperature Difference Method [4].

Small lattice mismatch in GaAs-$Ga_{1-x}Al_xAs$ interface caused by the different thermal expansion of GaAs and AlAs shortens the life time of GaAs lasers. $Ga_{1-x}Al_xAs_{1-y}P_y$ which incorporates with small amount of phosphorus in $Ga_{1-x}Al_xAs$ was used to compensate the lattice stress in GaAs-$Ga_{1-x}Al_xAs_{1-y}P_y$ heterojunction to improve the life time of lasers. The liquid phase epitaxial method used to grow GaAs-$Ga_{1-x}Al_xAs_{1-y}P_y$ heterojunction lasers was first done by Nelson [1]. The characteristic of Nelson method is maintaining source-seed near-equibilium during growth with a slow cooling rate. Because of the larger segregation of Al and P in Ga melt and the change of segregation coefficient caused by the continuous temperature cooling, it is difficult to grow $Ga_{1-x}Al_xAs_{1-y}P_y$ epitaxial layer on GaAs with an uniform composition of Al and P. This limits the ability to precisely lattice-match throughout the various layers of GaAs-$Ga_{1-x}Al_xAs_{1-y}P_y$ heterojunction [2,3].

In order to achieve the perfect lattice match in GaAs-$Ga_{1-x}Al_xAs_{1-y}P_y$ heterojunction, it needs to keep an uniform composition in epitaxial layer. A method called TDM (Temperature Difference Method) [4] is used in this experiment to improve the perporties of the epitaxial layer. Fig. 1, shows the apparatus of LPE system.

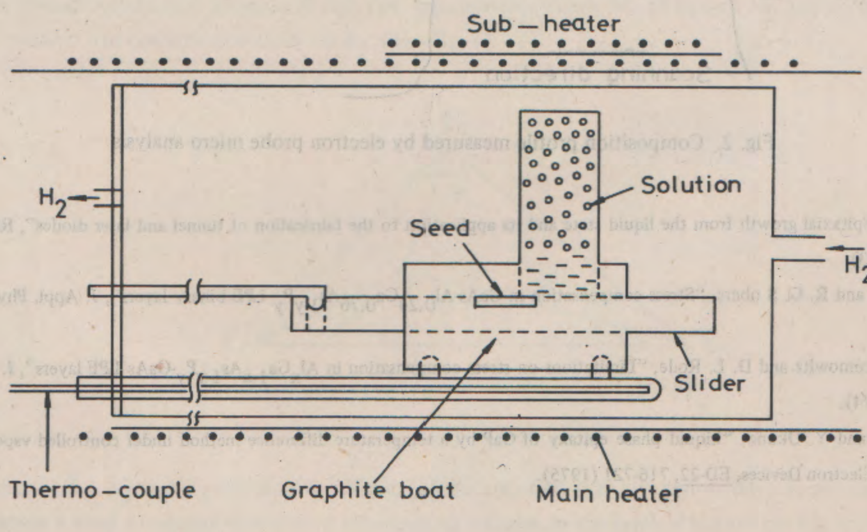

Fig. 1. Apparatus for Temperature difference method LPE.

The vertical portion of the graphite boat contains the Ga-rich melt and GaAs, GaP, Al in an amount to just saturate in Ga melt at 880°C. The boat was maintained at 900°C for 4 hours in a palladium-purified hydrogen ambient to allow complete dissolution of the melt. Then, the melt was cooled to 800°C, and at this temperature it was super-saturated and a large amount of $Ga_{1-x}Al_xAs_{1-y}P_y$ platelet as a source was formed on the surface of the melt. (100) oriented GaAs substrate was used as a seed. The melt was kept about 10°C hotter than the seed with an extra heater. The seed temperature was kept constant at 800°C during the whole growth and this constant growth temperature maintained the segregation coefficient to be constant. After growth, the layer composition profile determined by using EPMA (Electroprobe Micro-analysis) is shown in Fig. 2. As mentioned above, since the melt was super-saturated with the Al and P, the quick depletion of the Al and P in the melt due to their high segregations was overcome. The segregation coefficients were also kept constant. The Al and P were uniformly distributed in the epitaxial layer even the layer was thick. It is expected that by adjusting the composition of the Al and P, this uniformly compositional $Ga_{1-x}Al_xAs_{1-y}P_y$ layer can improve the lattice match in GaAs-$Ga_{1-x}Al_xAs_{1-y}P_y$ heterojunction and thus produce better double heterojunction lasers.

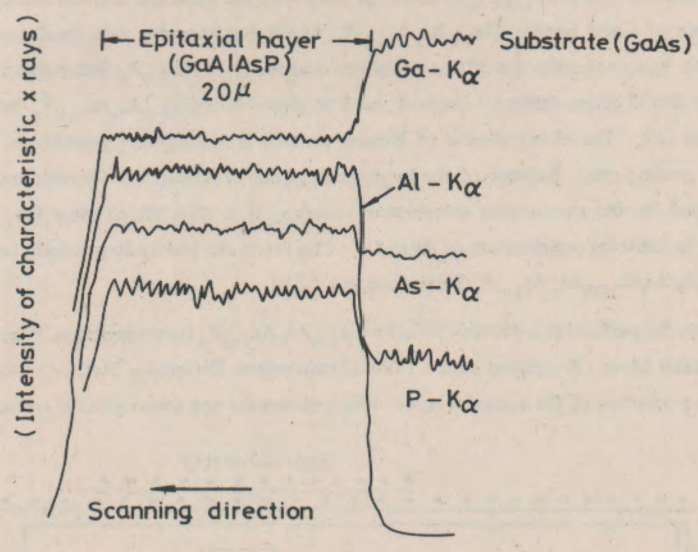

Fig. 2. Composition profile measured by electron probe micro analysis

References

1. H. Nelson, "Epitaxial growth from the liquid state and its application to the fabrication of tunnel and laser diodes", RCA Rev. 24, 603-615 (1963).

2. R. L. Brown and R. G. S obers, "Stress compensation in GaAs-$Al_{0.24}Ga_{0.76}As_{1-y}P_y$ LPE binary layers", J. Appl. Phys., 45, 4735 (1974).

3. Martin A. Afromowitz and D. L. Rode, "Limitations on stress compensation in $Al_xGa_{1-x}As_{1-y}P_y$-GaAs LPE layers", J. Appl. Phys., 45, 4738 (1974).

4. J. Nishizawa and Y. Okuno, "Liquid phase epitaxy of GaP by a temperature difference method under controlled vapor pressure", IEEE Trans. Electron Devices, ED-22, 716-721 (1975).