Extended Abstracts of the 18th (1986 International) Conference on Solid State Devices and Materials, Tokyo, 1986, pp. 743-744 **C-7-7 (LN)**

Atomic Layer Epitaxy of Uniform GaAs on 3-inch Substrate in Low Pressure MOCVD System

K.Mori, A.Ogura, M.Yoshida and H.Terao
Fundamental Research Laboratories, NEC Corporation
Miyazaki 4-chome, Miyamae, Kawasaki, Kanagawa 213

The atomic layer epitaxy (ALE) of compound semiconductors, in which process the substrate is exposed alternately to gas sources of compound semiconductor components, has been expected to be applied to low temperature growth, selective growth and uniform multi-layer epitaxy with abrupt interface. In the ALE growth of GaAs in both MOMBE[1)] and hydride VPE[2)] systems, low temperature growth and selective growth were realized. This presentation reports the abruptness of a GaAs-AlAs heterostructure and the thickness uniformity of a GaAs layer on a 3-inch GaAs substrate, grown by the metalorganic (MO-) ALE process in a low pressure MOCVD system.

A horizontal low pressure MOCVD system[3)] was used for the MO-ALE process. The total pressure in a reactor was 100 Torr and the total flow rate of H_2 was 9 standard-l/min. One cycle in the ALE process consists of the AsH_3 purge by H_2 flow, the supply of an MO source (trimethylgallium(TMG) or trimethylaluminum(TMA)) in H_2 flow, the MO purge by H_2 flow, and the supply of AsH_3 in H_2 flow. The substrate was not rotated during ALE.

Figure 1 shows a transmission electron microscope (TEM) lattice image of GaAs-AlAs multi-heterostructure on GaAs (100) substrate. Each layer was grown at 500 ^oC with 20 cycles. In each cycle, TMG with 0.010 Torr or TMA with 0.011 Torr flowed for 3 sec, and AsH_3 flowed with 0.044 Torr for 8 sec. It can be said that the heterointerface is abrupt, at less than 2 monolayers. The TEM lattice image also shows layer thicknesses. Darker regions of GaAs layers are 20 monolayer thick. However, each AlAs layer consists of 17 monolayers with 20 cycle ALE growth. It is concluded that GaAs and AlAs were grown under the conditions for a monolayer growth and 85 % monolayer growth, respectively.

The MO-ALE process was applied to GaAs growth on a 3-inch 2^o off (100) GaAs wafer. AsH_3 flowed with 0.11 Torr for 4 sec. The MO-ALE growth was conducted at 500 ^oC with 1484 cycles and the MOCVD growth was conducted at 700 ^oC for 10 min without any substrate rotation. Both GaAs layers were sandwiched between $Al_{0.3}Ga_{0.7}As$ layers grown by MOCVD with the substrate rotation. The variation in thickness for both GaAs layers along the gas flow direction, measured in an optical microscope after 2^{o} angle lapping and selective etching, is shown in Fig.2. The thickness of MO-ALE GaAs layer is constant within the measurement accuracy, from the front edge to the downstream end, while the thickness of MOCVD GaAs layer decreases by a half in the same range. Although thicknesses of MO-ALE layers are dependent on growth temperature,[4] the MO-ALE process seems to be free of reactant consumption effect and/or non-uniformity in the diffusion boundary layer, which are problems in conventional MOCVD processes.

In summary, MO-ALE was carried out using TMG, TMA, and AsH_3 in a horizontal low pressure MOCVD system. The abruptness of GaAs-AlAs heterointerfaces was demonstrated and the excellent thickness uniformity for GaAs grown on a 3-inch substrate was achieved.

References

1) J.Nishizawa,H.Abe and T.Kurabayashi:J.Electrochem.Soc.132(1985)1197.
2) A.Usui and H.Sunakawa:Jpn.J.Appl.Phys.25(1986)L212.
3) A.Okamoto,H.Terao and T.Kamejima:Jpn.J.Appl.Phys.25(1986)238.
4) N.Kobayashi,T.Makimoto and Y.Horikoshi:Jpn.J.Appl.Phys.24(1985)L962.

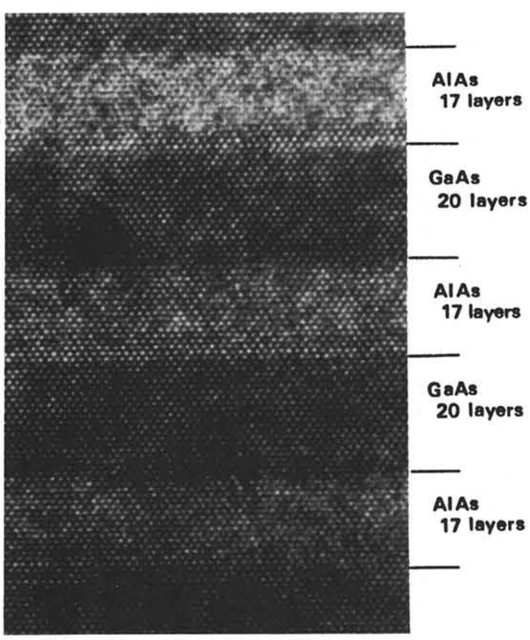

Fig.1 TEM lattice image for a GaAs-AlAs multi-heterostructure.

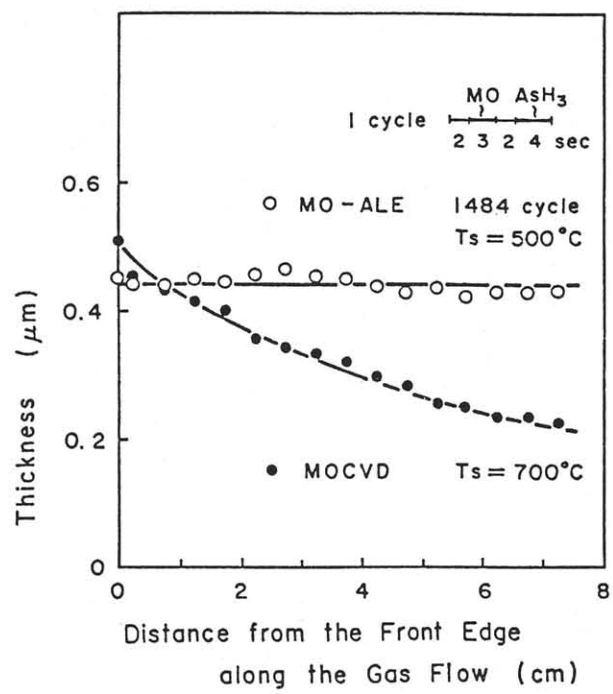

Fig.2 Variation in thicknesses for MO-ALE and MOCVD GaAs layers on 3-inch substrate along the gas flow direction.