## Advanced MOVPE Technology for III-V Compound Semiconductor Thin Film Growth

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The precise control of the stoichiometry, thickness, and interface structure of III-V compound semiconductor thin films is an essential aspect in developing high performance OEIC devices.

We are examining the optimization of gas-switching sequence to control the As-P substitution on the hetero-interface that is a major issue during InGaP/GaAs growth in MOVPE[1]. In this study, we examined the gas-switching sequence of InGaP growth on GaAs. The adsorption/desorption behavior of TBAs and TMGa on GaAs at 660°C was examined by kinetic ellipsometry. The dielectric properties obtained by ellipsometry from GaAs surface show different level by the surface reconstruction and adsorption/desorption of group-V materials. The time dependent signal change at 2.4eV in ellipsometry are used to determine the best gas switching sequence. The ellipsometric signal of GaAs surface keeps same level for several seconds after cutting the supply of TBAs. This suggests that excess amount of As adsorbed on GaAs surface during the growth and it is hard to be removed. The excess amount of As may degrade the abrupt interface of InGaP/GaAs, so we tried to terminate it by supplying TMGa. When TMGa was supplied to GaAs surface, just after the cut off of TBAs supply, no signal change was observed. After 0.6 second, the signal level began to change, and after 3.0 second, the signal level went to different stage. This suggests that 0.6 second of TMGa introduction is enough for As termination.

On the other hand, introduction of TBP on GaAs surface caused a significant signal change in ellipsometry within a second. This is due to the formation of GaP layer on top of GaAs. The diffusion of P into GaAs is quite fast, so it should be suppressed by forming InGaP layer at the beginning of interface formation. This means TBP and the mixture of TMIn and TMGa should be introduced to the MOVPE chamber at the same time, while normal sequence has some leading period of TBP before group-III gas introduction. According to these observations made by kinetic ellipsometry, we had established novel gas-switching sequence to fabricate abrupt InGaP/GaAs interface as shown in fig.1. The effect of novel gas-switching sequence on the improvement of hetero interface structure was evaluated by high-resolution X-ray diffraction. The electronic properties of the hetero interface was examined by CV measurement technique

We also performed a 3-dimensional CFD(Computational Fluid Dynamics) simulation of InGaAsP MOVPE[2] in a horizontal reactor by using commercial code, FLUENT™. The chemical model of growth is defined simply, with only 8 reactions of 11 chemical species, considering convenience of practical use in the field like reactor design and process optimization. In this model, four reactions of them are precursor decomposition reaction and the others are reactions on the surface. We have examined the growth rate and composition profile in our horizontal reactor to evaluate the validity of the model. The growth rate first increases progressively as the Ga and In precursors are diffusing and reacting from the upper inlet to the susceptor area, and then decreases because of the precursors and intermediate species depletion. The model showed considerable agreement with minor modification onto kinetic parameters. Some additional work on growth model may have to be done to make the model have much higher similarity with growth in various kinds of reactors. The revised model may be useful in future R&D work for complicated planetary type reactor systems.

**References**

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[2] O. Feron, Y. Feurprier, Y. Shimogaki, M. Sugiyama, W. Asawamethapant, N. Futakuchi, and Y. Nakano, *Appl. Surf. Sci.*, **159-160**, 318-327 (2000).

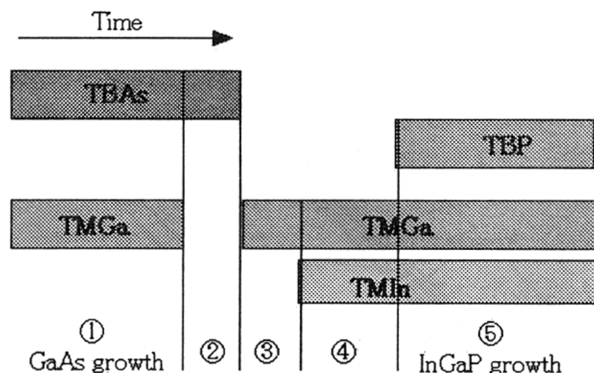


Fig.1 The best sequence for abrupt InGap/GaAs interface.