CFD simulation study of the gas flow balance in a vertical HVPE reactor with gas mixing block for low cost bulk GaN crystal growth

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GaN has been widely applied in various industries recent years. However, there are still several immature research fields waiting to be improved, and growth of high quality, low cost GaN substrate is one of them. We chose Halide Vapor Phase Epitaxy (HVPE) as the method to grow high quality, low cost bulk GaN crystal because of its high growth rate.

In our HVPE reactor, there are inner and outer two separately controlled gas supply lines that correlated with inner and outer two zones on the showerhead to control the gas flow balance, as shown in Fig.1. During GaN crystal growth in our reactor, part of GaCl source will react with NH_3 and become GaN crystal, and the rest GaCl will all be exhausted. In order to increase Ga yield, we need to decrease the ratio of exhausted GaCl. And to realize this, there are several problems for us to solve, such as gas mixing, showerhead nozzle configuration design, inner and outer gas flow balance optimization, and so on. In this research, we mainly focused on inner and outer gas flow balance optimization with the Virtual Reactor CFD simulator of STR group.

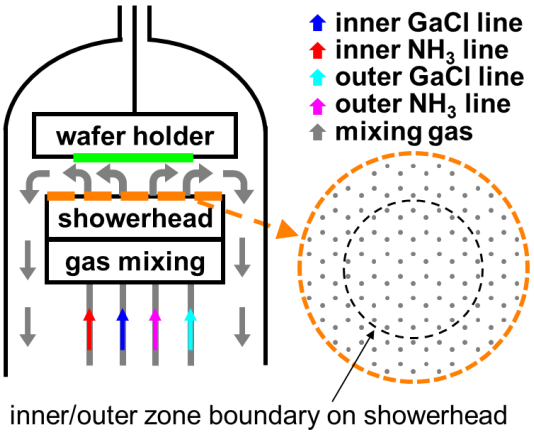

Fig.1 HVPE reactor with gas mixing block

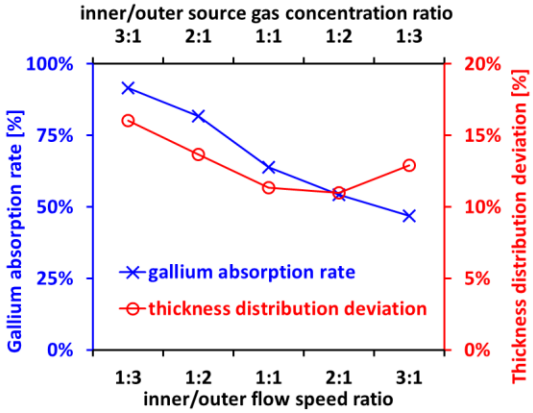

Fig.2 Influence of flow balance to Ga absorption rate and thickness uniformity

Source gas GaCl and NH_3 will mix in gas mixing block, then be pushed to wafer through showerhead. The product of velocity and source gas concentration determines mass transportation rate in this situation, and it was kept the same for both inner and outer flow while the flow speed and source gas concentration from inner and outer nozzles were changed in the simulation. The simulation result is shown in Fig.2, the Ga absorption rate is decreasing as inner flow speed increasing and inner source gas concentration ratio decreasing. And for standard deviation of thickness distribution along radius, there is an optimized point between 1:1 and 2:1 of inner/out flow speed ratio.

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