Preliminary studies on halide vapor phase epitaxy of AlGaN alloy on GaN substrates

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Most of the nitride-based optoelectronic and electronic devices are built on foreign substrates (sapphire, silicon, silicon carbide) covered with a thin (few hundred nanometers to a few micrometers) layer of a nitride semiconductor (i.e. GaN, AlGaN etc.). Such substrates are called templates. Currently, there is a focus on replacing the foreign substrates with native GaN or AlN substrates. This is especially visible in terms of high-power and high-frequency transistors as well as deep-UV light emitting diodes (LEDs) and laser diodes (LD). Such devices require a native substrate with a very high structural quality. As mentioned, the growth process of bulk AlGaN or free-standing bulk AlGaN crystal has not been demonstrated to date. AlN is successfully crystallized by physical vapor transport (PVT) process [1]. It is grown at temperatures on the order of 2400°C in atmospheric pressure of nitrogen (N_2). This technology cannot, however, be applied for AlGaN growth due to completely different thermodynamic properties of AlN and GaN. Namely, AlN is thermodynamically stable at high temperatures in N_2 pressure of 1 bar. Meanwhile, thermodynamical decomposition of GaN occurs at 800°C in the same gas conditions [2]. As the temperature increases, the equilibrium partial pressure of N_2 in GaN system also increases. Therefore, in order to grow GaN at high temperatures (>800°C), high N_2 pressure is required.

In the halide vapor phase epitaxy (HVPE) (at atmospheric pressure) NH_3 is used in place of nitrogen. NH_3 ensures a thermodynamic stability of GaN at temperatures around 1000°C. These temperatures are too low for an effective AlN crystallization process but they are sufficient for crystallization of AlGaN [3].

In this paper preliminary results related to the crystallization of AlGaN alloy with an aluminum (Al) content of up to 5% atm will be presented. Ammonothermal GaN substrates will be used as seeds [4]. The most important problems concerning nucleation in the gas phase, the effect of mismatching lattice constants, and composition homogeneity of the obtained layers will be discussed. The influence of growth parameters such as pressure, temperature and V/III ratio will be presented. The crystallization results will be compared with the results of simulations of reagent flows, their distribution and supersaturation calculations. The effect of substrate misorientation on the morphology and incorporation of Al will be discussed.

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