HVPE growth of GaN: from nanostructures to bulk substrates

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III-N semiconductors are considered as the most attractive materials for many applications such as light-emitting diodes (LED), laser diodes (LD), high electron mobility transistors (HEMT), biochemical sensors and systems for water splitting. So far III-nitride devices are mainly grown on foreign substrates, which leads to high dislocation density in structures and, thus, to degradation problems. Implementation of GaN-on-GaN technology can significantly improve device performance, which is especially important for high power applications. Here, we report on results of fabrication of GaN bulk wafers using halide vapor phase epitaxy (HVPE). Also GaN nanotubes (NT) can be synthesized by this technique exploiting non-catalytic or Au-assisted growth. As substrates, we have always used *c*-oriented Al_2O_3 with a diameter up to 3 inch. The growth was done in a vertical HVPE reactor at atmospheric pressure where the carrier gases and precursors are delivered from the bottom. For bulk GaN wafers the fabrication started with low temperature (700 °C) GaN buffer layers (LT-GaN) followed by standard growth procedure at 1000 °C. An advantage of the LT-GaN is spontaneous self-separation of bulk GaN layer from sapphire upon cooling. By this method we have fabricated 2 inch freestanding GaN wafers with thickness up to 2 mm [1]. Such wafers can be used as bulk substrates after chemical mechanical polishing. For catalytic growth of GaN NT, a thin (several nm) gold film was deposited on sapphire [2]. The NT size, shape and density can be varied using V/III ratio, temperature and substrate material. The length of the NTs was about 1 μm and the diameter was typically 200 nm. By varying the growth temperature in the range 480 °C to 520 °C, the wall thickness of the NT can be tuned from ~35 nm to ~75 nm. Non-catalytic growth of NT was achieved by spontaneously nucleation at droplets of Ga. Material was characterized using electron microscopy and optical spectroscopy methods.

1. C. Hemmingsson, G. Pozina, *J. Cryst. Growth* **366**, 61 (2013).
2. C. Hemmingsson, G. Pozina, S. Khromov S, and B. Monemar, *Nanotechnology* **22**, 085602 (2011).