

Author(s)	Presenter	Correspond
Sourish Banerjee; University of Twente, Netherlands	X	X
Satadal Dutta; University of Twente, Netherlands		
Antonius Aarnink; University of Twente, Netherlands		
Jurriaan Schmitz; University of Twente, Netherlands		
Dirk Gravesteyn; University of Twente, Netherlands		
Alexey Kovalgin; University of Twente, Netherlands		

Abstract: (SUPPLEMENTAL DOCUMENT was submitted with the abstract)

In the field of III-V semiconductor materials, research is focused mostly on epitaxially grown films. Developing their polycrystalline counterparts (e.g., polycrystalline gallium nitride or poly-GaN) may lead to their more widespread adoption in application areas, such as in microelectronics and lighting. Unlike traditional epitaxy, atomic layer deposition (ALD) of poly-GaN films allows for less stringent growth requirements such as reduced temperatures, atomic-level thickness control and direct growth on a variety of substrates without the need of buffer layers.

The majority of reports on low temperature deposition of poly-GaN from trimethylgallium (TMG) and ammonia (NH₃) precursors mention an additional means of activation (e.g., plasma) to dissociate NH₃. This is done to increase the chemical activity of ammonia (by forming radicals) with the TMG-chemisorbed surface. However, in this work, we have used a different (radical-free) chemistry to deposit GaN films by a purely thermal route; i.e., without plasma or other radical-production means. Such a deposition approach can be beneficial, for example, in industrial-scale batch-type reactors where uniform radical delivery is a challenge.

We have utilized the strong adduct-forming chemistry of the Lewis-acid TMG and the Lewis-base NH₃ on the growth surface (Fig. 1). At the deposition temperature of 400°C the TMG-NH₃ adduct dissociates into a Ga-NH₂-Ga linkage, thereby forming the first monolayer of GaN in a self-limiting fashion. Due to the reversible nature of this adduct formation, at optimal gas-pressure conditions, alternate pulses of TMG and NH₃ with in-between purges result in the efficient film growth. This pressure-dependency of adduct formation is revealed by in-situ monitoring the growth with spectroscopic ellipsometry (SE), which shows a strong dependence of the growth per cycle (GPC) with the NH₃ partial pressure (Fig. 2). Using this approach, we obtained GPC values as high as 0,045 nm/cycle.

The efficient removal of all methyl groups of TMG during GaN deposition in the adduct-assisted mechanism is revealed from the low carbon content (1 at. %) in the films, as obtained from depth profiled X-ray photoelectron spectroscopy (Fig. 3). The cross-section scanning electron microscope (SEM) image (Fig. 4) shows a 23-nm GaN film deposited on aluminium nitride (AlN). Grazing-angle X-ray diffraction (GIXRD) spectrum (Fig. 5) reveals that the GaN film is polycrystalline and has a wurtzitic structure.

In our presentation, the purely thermal radical-free deposition of poly-GaN films will be detailed: focussing on the growth mechanism, determining the ALD window, and presenting several film properties.