



# In situ Characterisation of Nitride Structures in Real Time

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## Introduction:

Optical monitoring techniques offer MOCVD its most practical means of in-situ monitoring of the growth. However, even optical techniques require good optical access which does not degrade during growth due to deposition on to the access windows. As the technology moves towards production, kits become larger and have more wafers which then travel past the monitoring port faster. This then imposes the need for the rapid acquisition of data.

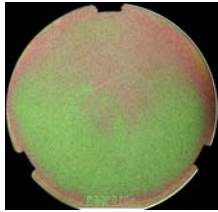
Ideally any in-situ monitoring system will be able to sample all wafers and also several points across each wafer to provide non-destructive information on the growth rate, its uniformity and the abruptness of growth features. Additionally in the case of GaN materials all of this information has to be obtained from wafers at over 1000°C without disturbing the gas flow or thermal environment.

Here we report on the in-situ optical analysis of GaN/AlGaIn HFET structures. It will be shown that this data correlates well with the in-situ monitoring data, therefore offering the reality of in-situ characterisation when used in conjunction with a real time analysis package such as **R-Fit LIVE**. Furthermore, this information can be used to fine tune the growth recipe to give highly reproducible layer thicknesses in real time.

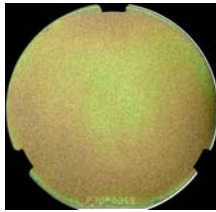
## Experimental:

The HFET structures were epitaxially grown on sapphire in a Thomas Swan close coupled showerhead reactor on 2" wafers. Epitaxial structures were deposited at temperatures between 1000 and 1100°C with a standard rotation speed of 100rpm. Reflectance interferograms were recorded using an ORS (Optical Reference Systems) Ltd **EpiEYE** single wavelength monitor operating at 670nm. A 3x2" arrangement of wafers in the reactor was used and reflectance interferograms were recorded at up to 7 points across each of up to 3 wafers during a growth run. The reflectance data was analysed using the ORS Ltd **R-Fit v4.0** package. The data can be used to provide real time information on growth rate across the wafer allowing comparison of wafer to wafer uniformity in a single run and run to run reproducibility. After growth, the wafers were subsequently characterised for morphology, microstructure, wafer uniformity by optical interferometry using a **Large Area Imaging System (LAIS)** from ORS Ltd. and electrical resistivity by Leighton measurements. Post growth analysis of many interferograms using **R-Fit v4** has given a fit for the refractive index of this material to be  $2.436 + i0.0$ . The **LAIS** operates in both reflectance and transmittance modes of operation, depending on what parameters of the sample you wish to access, and in these experiments uniformity measurements were made in transmission mode throughout. A transition in the colour profile in the **LAIS** from green to pink represents approximately 40nm of material.

## Results and Discussion:

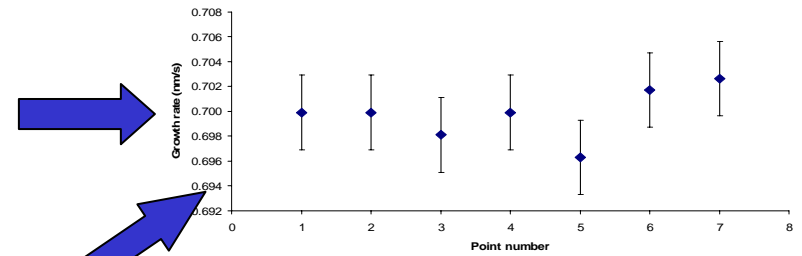
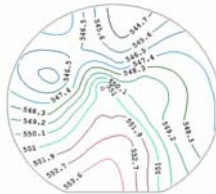


Poor wafer uniformity.



Excellent wafer uniformity.

Statistical Summary	
Number of Test Points	55
Average Value	549.6
Maximum Value	555.0
Minimum Value	543.6
Sample Spread(%)	2.11
Std Dev Value	2.7
Wafer Uniformity Value(%)	0.49



The growth rate measured across the wafer from leading to trailing edge and equal points in between, shows the same high level of uniformity

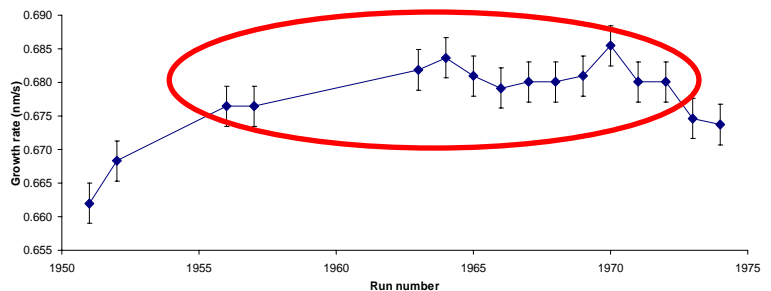
The electrical resistivity map also demonstrates excellent uniformity for this wafer, with only 0.49% variation across the sampled region.

### 1. Uniformity measured In-situ

Growth rate at the centre of a wafer in a series of runs of the same recipe, through a single growth "campaign". The region in red is where the material was in specification.

*In-situ growth rate analysis can be used to monitor when the reactor environment has sufficiently "seasoned" to produce pass-standard wafers, and when the reactor performance is starting to degrade as a further cleaning becomes necessary.*

### 2. Reactor maintenance



## Conclusions:

- in-situ wafer profiling of the growth rate demonstrates an excellent correlation with post growth optical and electrical characterisation techniques. This offers the opportunity for in-situ characterisation of material provided the recording instrument is sufficiently fast and flexible enough to capture several points across a wafer per sweep beneath the optical port.
- Monitoring the growth rate in-situ provides the ability for the fine-tuning of layer deposition times in order to produce wafers that are in-specification.
- Growth rate monitoring provides an additional metric to determine the number of runs that may be required in order to condition the reactor to the required substrate temperature/reactor thermal environment in order to produce the best quality material. This information is not available by monitoring the reactor and/or substrate temperature alone.