CCS-MOCVD Reactor
Gallium Nitride

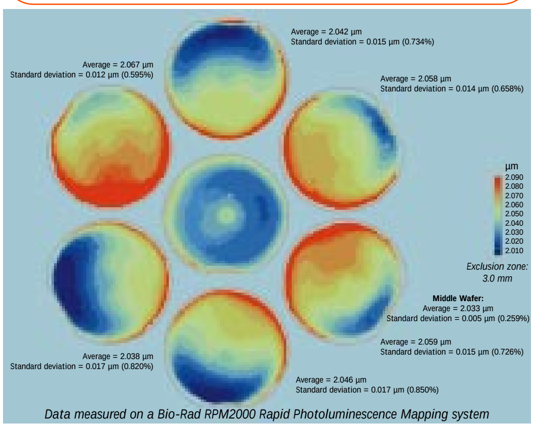
Introduction

Thomas Swan's range of vertical, MOCVD reactors are based upon the close coupled showerhead (CCS)* concept recognised as a robust route to uniformity and scaleability. CCS technology was initially developed for the growth of InP and GaAs based materials and is used by Thomas Swan in its current range of multi-wafer MOCVD reactors. Successful implementation of this technology has provided a wide range of susceptor-substrate options applicable to both R&D and high volume production for both InP and GaAs materials with a maximum density of 19x2".

The Close Coupled Showerhead and GaN - A unique combination

Recognition of the inherent strengths of the CCS technology by Thomas Swan and its customers led to the development of a CCS reactor specifically for the growth of the III-nitride materials. Given the enormous interest and potential for device applications based on GaN materials this represented a natural evolution of the CCS reactor. The growth of device quality GaN based materials places rigorous and severe requirements on the performance of the MOCVD reactor, and it is necessary to address issues such as reagent pre-reaction, high growth temperature, ambient gas switching, and ammonia compatibility. This necessitated changes in both the gas control system and the reactor chamber design which have now resulted in MOCVD system that is perfectly matched to the needs of these materials. The CCS reactor reproducibly delivers layer thickness uniformities of the highest order (standard deviation of <1% for GaN over all 7x2" wafers) in combination with the capability to grow high indium (≤40%) and aluminium (≤30%) content alloys.

GaN thickness uniformity.
Close coupled showerhead multi-wafer reactor



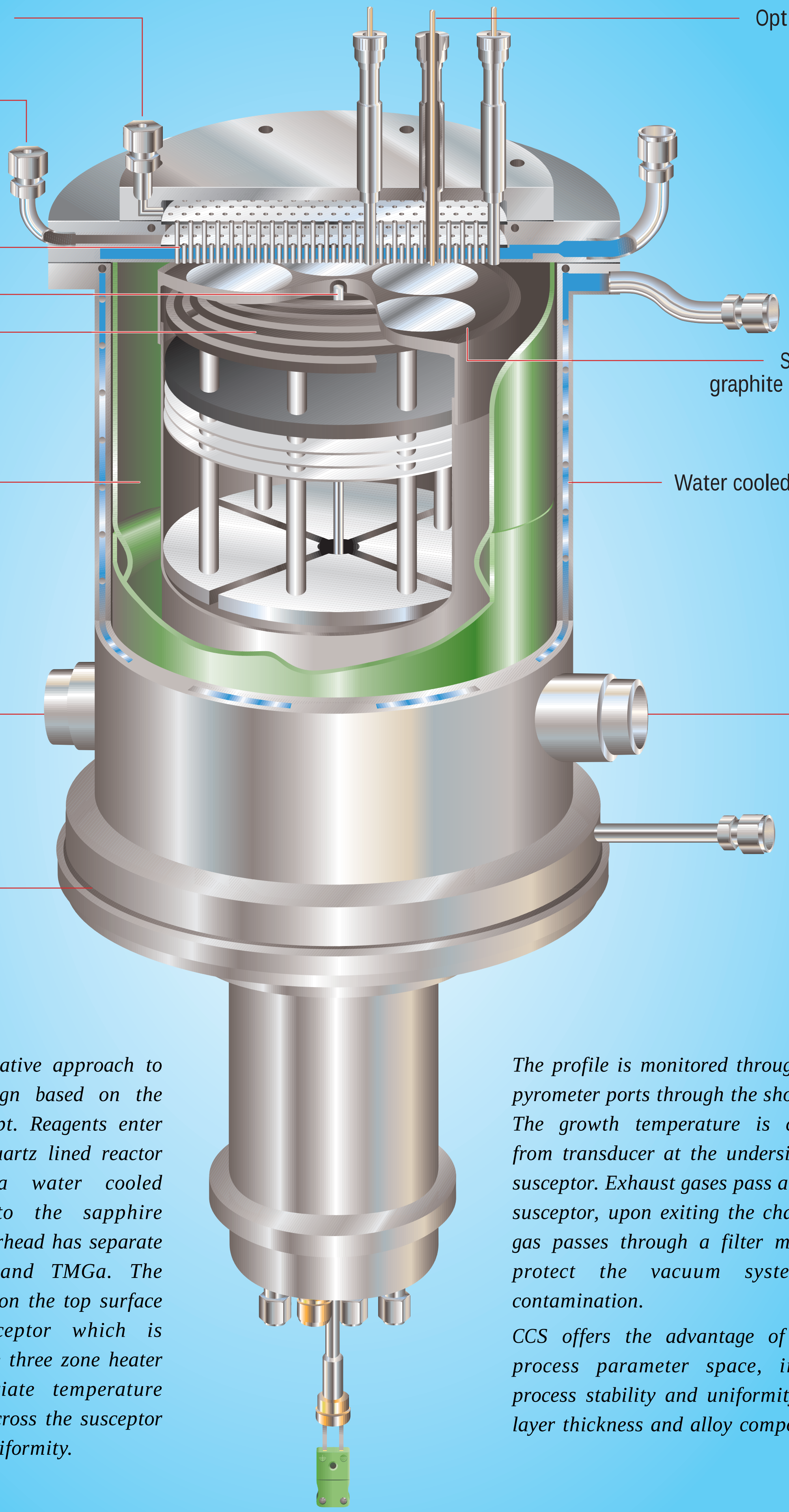
CCS technology is ideally suited for the growth of commercial BLUE and GREEN LED's

CCS Technology features

Reactor Process Chamber	- *Cold walled vertical chamber with quartz liner*
Reagent injection	- *Temperature controlled and cooled showerhead injector*
Reagent isolation guaranteed	- *Use of multiple gas plenums*
Mixing	- *Homogeneous mixing of reagents very close to the substrate*
Rotation	- *Wafer rotation ≤100 rpm to optimise uniformity* - *Maximum rotation available = 600rpm* - *Double magnetic fluid seal (ammonia compatible)*
Heating	- *Three zone independent concentric tungsten heater* - *Use of optical pyrometer to establish precise temperature uniformity (2-5°C)* - *Temperature uniformity maintained at all growth temperatures (500-1200°C)*
Environment	- *Glovebox and loadlock operation, nitrogen atmosphere consistently maintained.*
Platform availability	- *1x2", 3x2" and 7x2" (19x2" available Q4 2000)*

*Patented technology

CCS MOCVD Reactor (6x2")



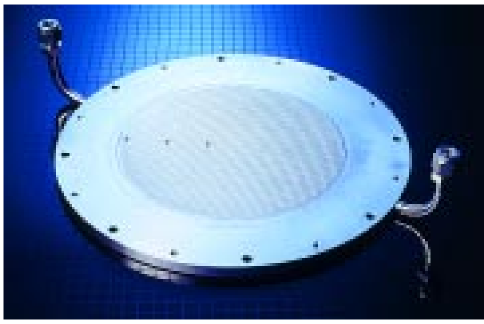
The CCS is an innovative approach to MOCVD reactor design based on the stagnant point concept. Reagents enter the stainless steel, quartz lined reactor chamber through a water cooled showerhead close to the sapphire substrates. The showerhead has separate injection for NH3 and TMGa. The substrates are placed on the top surface of a rotating susceptor which is resistively heated. The three zone heater enables an appropriate temperature profile to be set up across the susceptor for optimisation of uniformity.

The profile is monitored through optical pyrometer ports through the showerhead. The growth temperature is controlled from transducer at the underside of the susceptor. Exhaust gases pass around the susceptor, upon exiting the chamber the gas passes through a filter medium to protect the vacuum system from contamination.

CCS offers the advantage of a wider process parameter space, improving process stability and uniformity of both layer thickness and alloy composition.

Technology Benefits

- Excellent uniformity of thickness and alloy composition
- Mono-layer abruptness of interface
- Reagent Utilisation 30-50%
- Linear rates of growth (>8µm/hr)
- Process stability and reproducibility
- Very low ammonia consumption
- Low V/III ratios
- In-situ growth monitoring



Technology Rationale for CCS

Q Why choose a close-coupled showerhead reactor for III-nitride?

A There is no other solution that provides such a compelling argument in support of its case to be acknowledged as the growth technology of choice for III-nitride materials.

Q How does the close-coupling of the showerhead and the susceptor deliver on uniformity of layer thickness, uniformity of alloy composition, abruptness of interface and reproducibility of product?

A

- By reducing the dependency that exists between the boundary layer and position on the susceptor (stagnation point flow is facilitated). Boundary layer thickness is a first order parameter in determining growth rate in a mass transport limited regime.
- By suppressing thermal buoyancy driven recirculation cells.
- By limiting the development of the parabolic and non-ideal flow profile within the chamber

Q How does the design of the Thomas Swan showerhead deliver performance on uniformity of layer thickness, uniformity of alloy, abruptness of interface and reproducibility of product?

A

- By utilising a dual plenum showerhead to eliminate reagent pre-reaction
- By using an interleaved layout and a high density of tubes from each plenum (~100/ square inch) giving complete separation before the reaction zone and total mixing in the reaction zone
- By matching the showerhead and susceptor dimensions and presenting a uniform flow of homogeneous mixed reagents over the entire susceptor

Reactor Gas Control System

The gas control system is configured to allow for individual customisation to ensure that the reactor capability is optimised for the material requirements of the customer. A system is built-up from a series of modules for both organometallic and hydride sources. Each module is comprised of an appropriate number of mass flow controllers and pneumatic valves, with temperature (organometallic only) and pressure control systems. Reagents are switched into chamber process from a differential pressure controlled vent-run fast switching manifold. For GaN systems an essential characteristic of the system is that the main carrier gas is selectable between hydrogen and nitrogen for the main process ambient gas and each of the organometallic sources. This ensures that growth can be carried out in a pure nitrogen or hydrogen atmosphere, and organometallic sources can be fully purged without lengthy pauses being introduced into the growth recipes.

Standard technology features

- Modular design
- Dead volumes eliminated throughout gas system
- N2/H2 switching
- Solenoid based five port vent-run manifold switching
- Differential pressure control for abruptness of interface
- Serviceability of design, providing access to all components
- Integrated leak test capability
- Component selection based on performance
- Hydrogen detection provided
- Provision for the use of organometallic gas concentration control systems

Production Reactors

The close-coupled reactor for GaN materials has now been scaled to accommodate a maximum of 6x2" (3x3") substrates, with the 19x2" (6x3") option to be introduced in Q4 2000. A product development which addresses the needs of the epi-wafer manufacturers to provide value through operational efficiency. Thomas Swan is committed to customer training and complete process back-up with guaranteed demonstration during commissioning. Extended warranty and service contracts are available. As a member of the AIXTRON group of companies, worldwide service and spares support is available.

Peripheral Equipment for GaN

- EpiCat Ammonia scrubbing system
- Epison gas concentration monitor

Agents

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