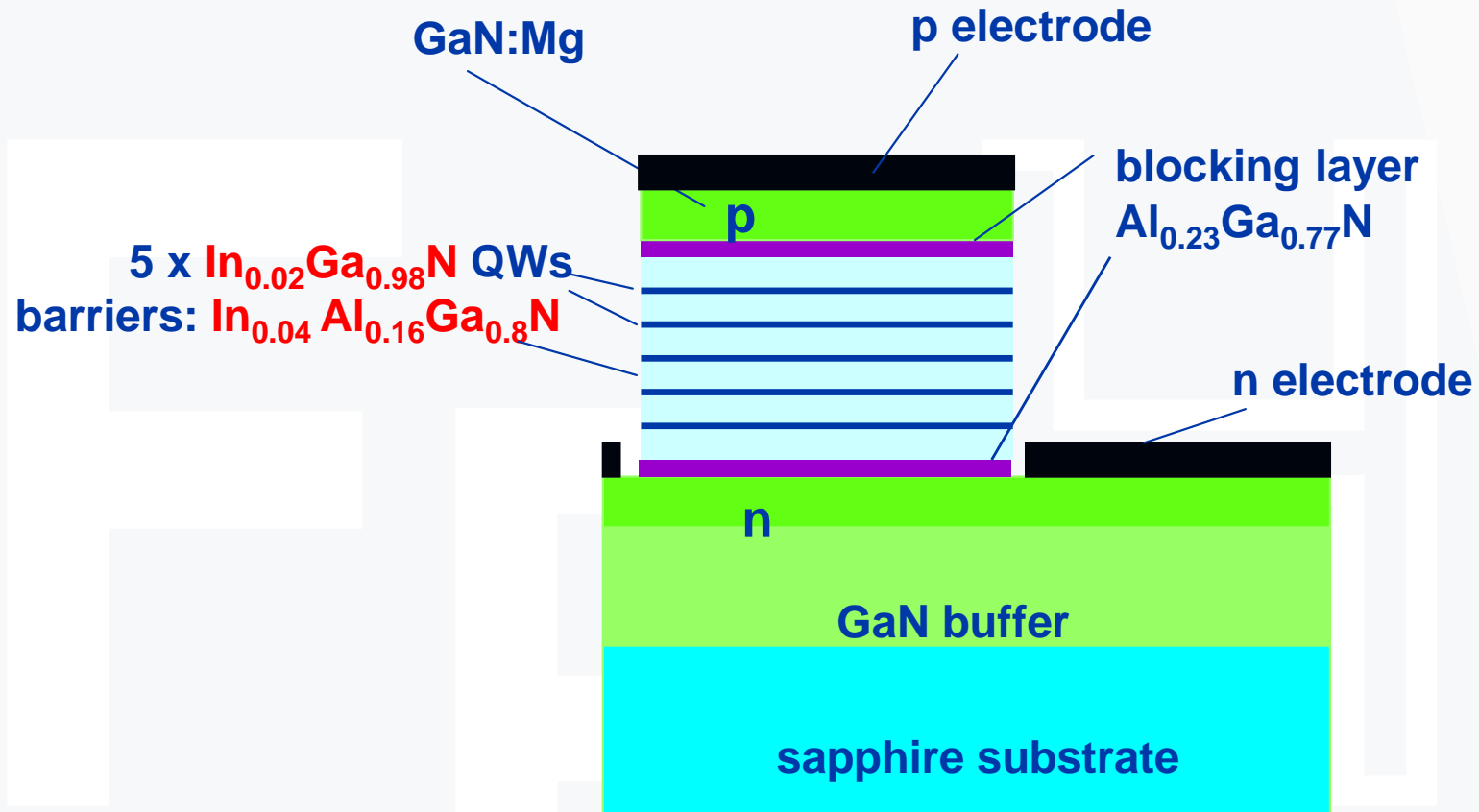


Reproducible growth of InGaN-MQWs emitting in the near UV by means of feedback in-situ temperature control

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LED Design



↓
light output, $\lambda = F(\text{In-incorporation}) = F(T_{\text{growth}})$

EpiCurveTT at Aix 200/4RF-S with 1x 2inch gas foil rotated satellite

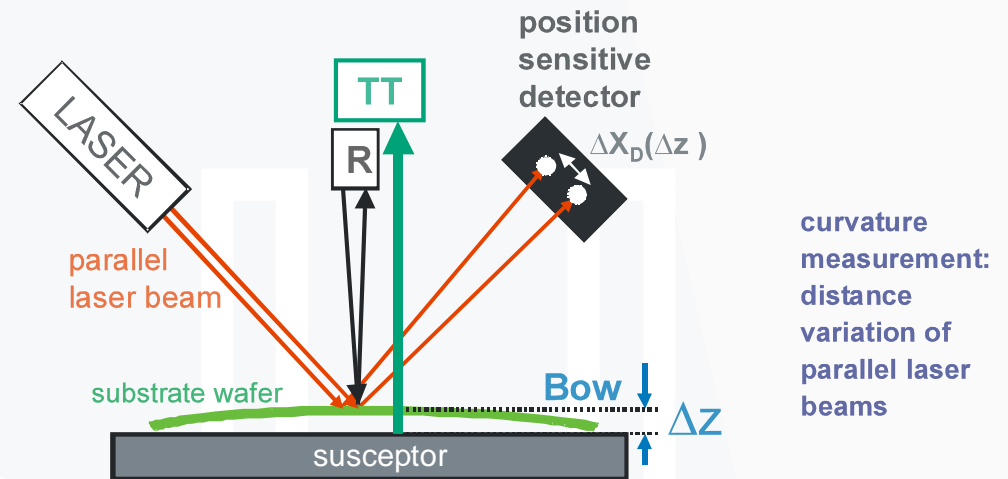


curve resolution (sensor): $\pm 0.1 \text{ km}^{-1}$
+ gas foil rotation: $\rightarrow \pm 1 \text{ km}^{-1}$

Use of GaN / sapphire templates
grown in high-yield mass- production tool
- Aix 2600 planetary reactor

Standard precursors, c-plane sapphire

EpiCurve TT: curvature + reflectance + temperature



T-sensors ($\lambda = 950 \text{ nm}$):

LayTec EpiTT: **T of susceptor top - „T_{top}“**

Luxtron pyrometer: **T of susceptor bottom**

„process-T“

- GaN transparent at 950 nm \rightarrow T_{top} susceptor

Concept of temperature control

RF-Heater control by Eurotherm

Standard → „Process T“ from susceptor bottom is integrated and used for Eurotherm input,

but RF-heating of multipart graphite susceptor with gas foil rotated susceptor plate causes varying ΔT between top and bottom

→ at constant $X_v(\ln)$ and process T from run to run :

$$\lambda(\text{MQW}) = 375 \text{ to } 395 \text{ nm}$$



New

→ Signal from susceptor top is used during QW growth as input for Eurotherm

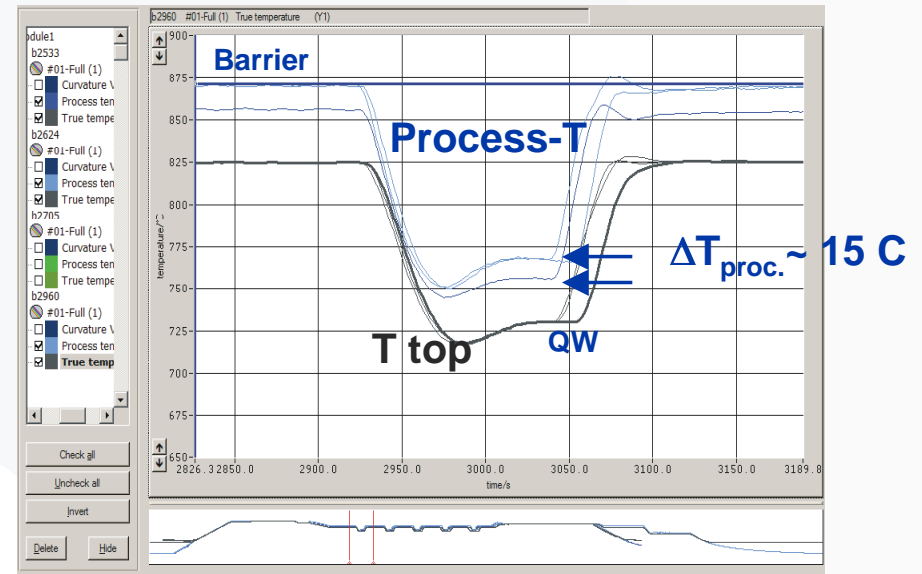
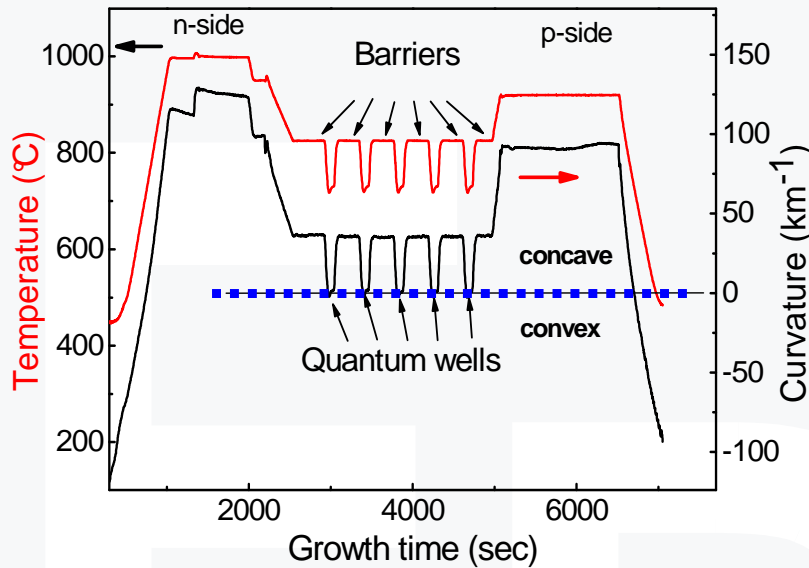
(- converting 0 to 10 V from EpiTT into 4 to 20 mA and switch the Eurotherm input channel)

→ EpiTT integrates for 3 s, quick Eurotherm control (every 0.1 s) can not be used (adaption of Eurotherm parameters needed for quicker control)

In-situ measurement of device structure growth

whole device structure growth

T- details during QW growth (3 series)



$T_{top} = \text{const}$ by feedback EpiTT control,
but $\Delta T_{proc.} \sim 15 \text{ C}$ for different series of runs

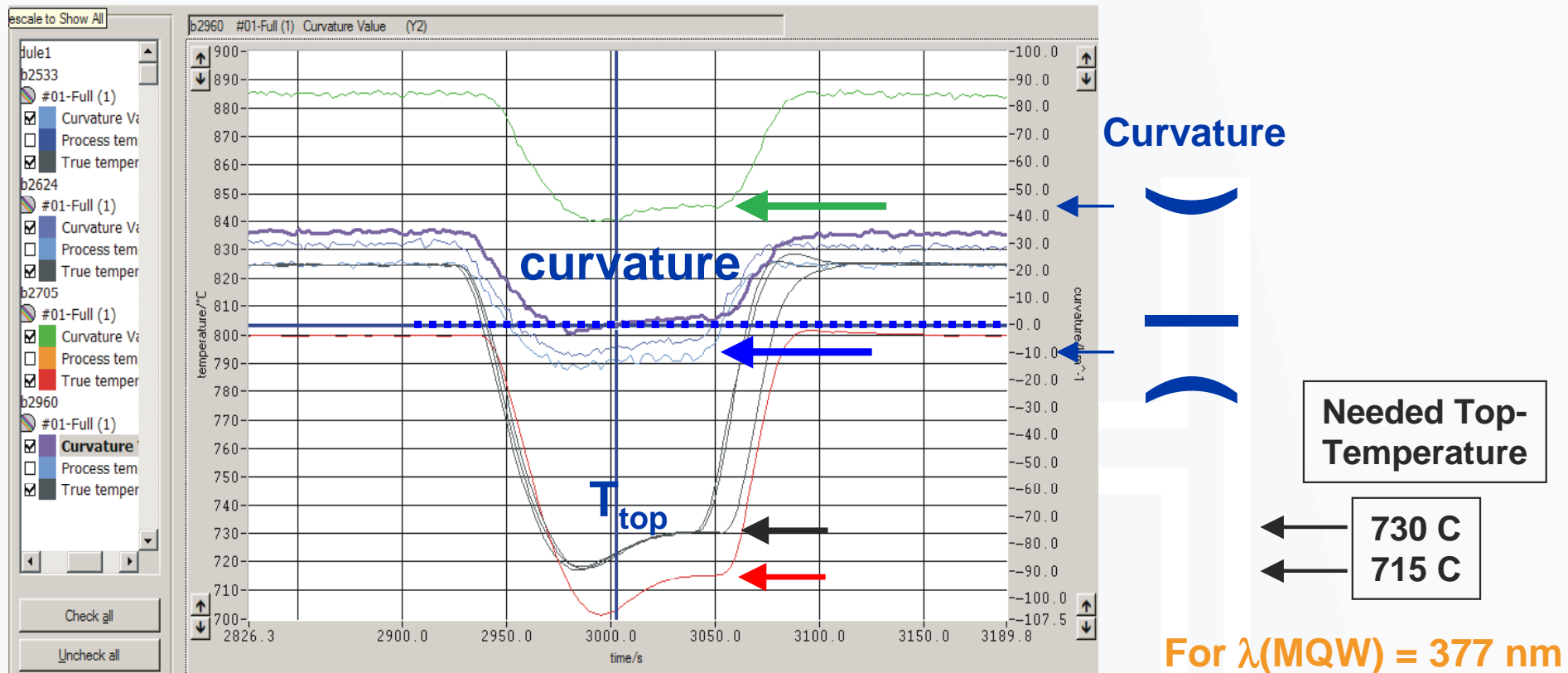
Heater control by EpiTT signal works well → at constant $X_v(\text{In})$ and T_{top} :

$\lambda(\text{MQW}) = 376 \text{ to } 378 \text{ nm}$ (3 series: B2533.., B2624.., B2960..) 😊

to be kept in mind:

- restriction of heating in case of loss of EpiTT signal
- change of n-side structure or GaN/sapphire template needs T-corrections

In-situ measurement during four QW growth runs



(„starting“ bow value at room temperature influences bow during InGaN-growth)

- concave wafer is hotter in the center (direct contact with measured point of susceptor plate)
- lower temperature needed to obtain same LED wavelength

Concept of temperature control

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→ at constant $X_v(\ln)$ and process T from run to run :

$$\lambda(\text{MQW}) = 375 \text{ to } 395 \text{ nm}$$



New

→ Signal from susceptor top is used during QW growth as input for Eurotherm

→ Curvature of wafer influences the surface temperature of wafer and has to be taken into account for setting of T_{top}

→ at constant $X_v(\ln)$ and given T_{top} : $\lambda(\text{MQW}) = 376 \text{ to } 378 \text{ nm}$



Summary:

EpiCurveTT enables reproducible growth of InGaN – MQWs in Aix200 reactor by use of feedback control with in-situ growth temperature from susceptor top taking into account the wafer bow to adjust the surface temperature of wafer constant

Thank you for attention

**and my colleagues at the FBH involved in this work
(especially, T. Tessaro – Aix 200/4 reactor control by EpiTT and
F. Brunner – planetary reactor)**

and K. Haberland (LayTec)

Compensation of wafer bow by temperature

(almost) flat wafer

concave bowed wafer

