



Advances in MOCVD Process and Equipment Technology Enabling Solid State Lighting

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Brilliant.

February 21, 2013

Presentation Outline

- Company Overview
- LED adoption for Solid State Lighting
- MOCVD System Development
- TurboDisk Technology and Process Performance
- GaN/Si Performance
- Summary

Veeco at a Glance

We Make Thin Film Process Equipment

Growing, depositing, etching and processing thin films is our core competency

Our Technology

supports energy efficiency, consumer electronics and network storage

High Growth Market Focus

Our equipment enables the manufacture of:

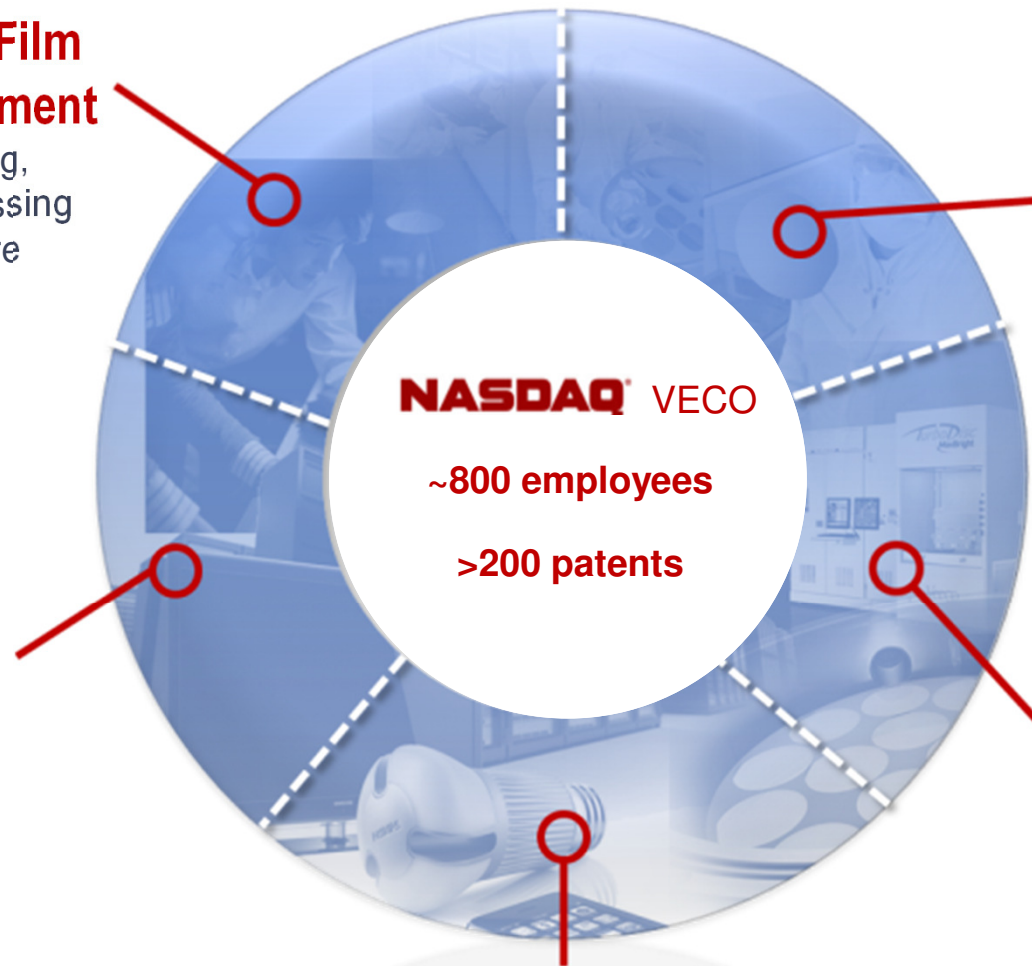
- LEDs
- Power electronics
- Hard drives
- MEMS
- Wireless chips

We are the Market Leader

- MOCVD
- MBE
- IBE/IBD
- Advanced Thin Film Process Technologies

Our R&D is Best-in-Class

Veeco's exceptional R&D organization delivers systems that enable the future



Market Leadership



GEN200® Edge™
Production MBE System



TurboDisc MaxBright MHP GaN
MOCVD Multi-Reactor System



NEXUS IBE-420Si™ Ion
Beam Etching System

- MOCVD technology leader for solid-state lighting
- Foundation Businesses MBE and Data Storage are #1
- Deep process expertise, patents and know-how
- Lowest CoO products at the technological forefront

World Leaders Use Veeco's Technology

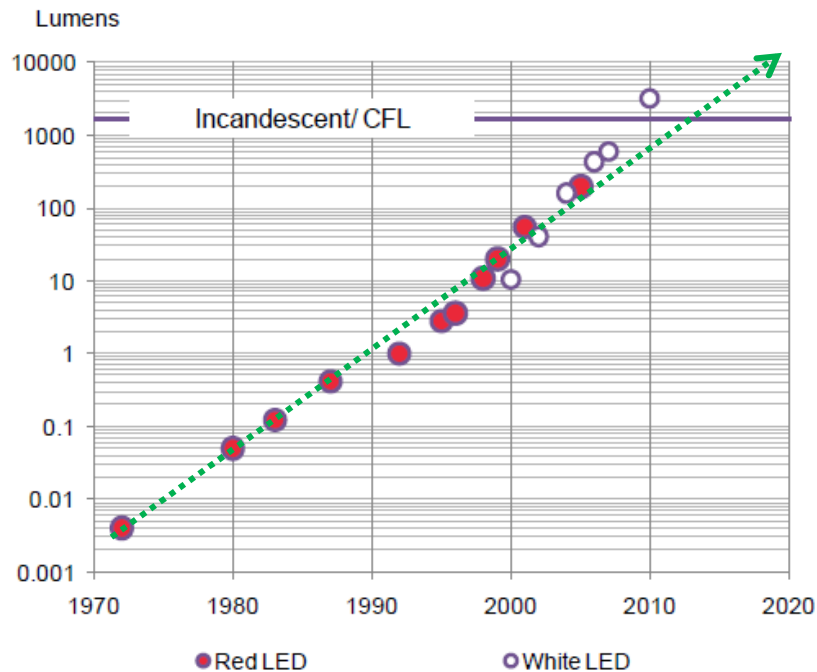


Our Technology Roadmap is Aligned To Lighting Industry Requirements

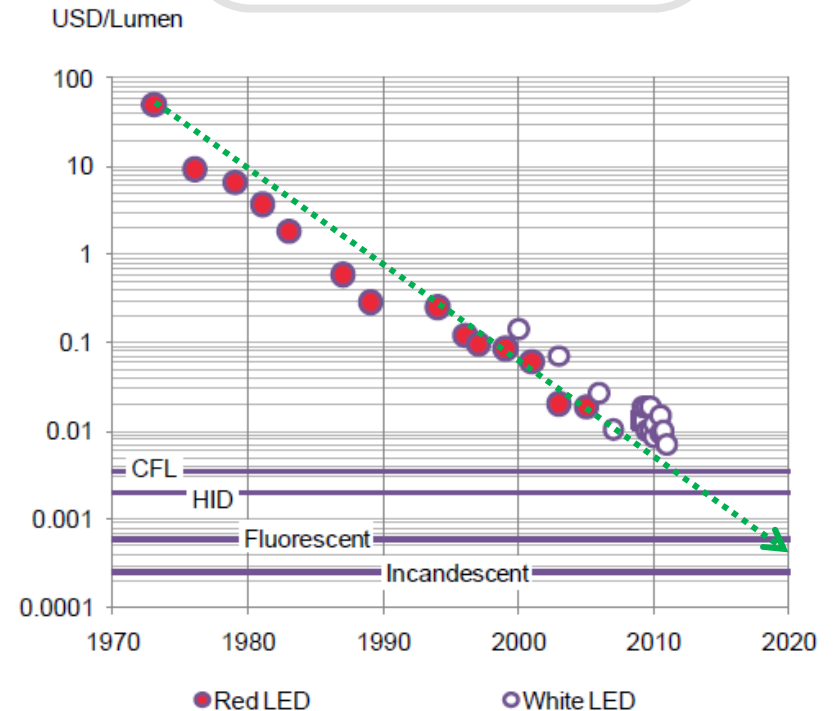


LED Lighting at the Cusp of Mass Adoption

**LED Output/Package
(Lumens)**



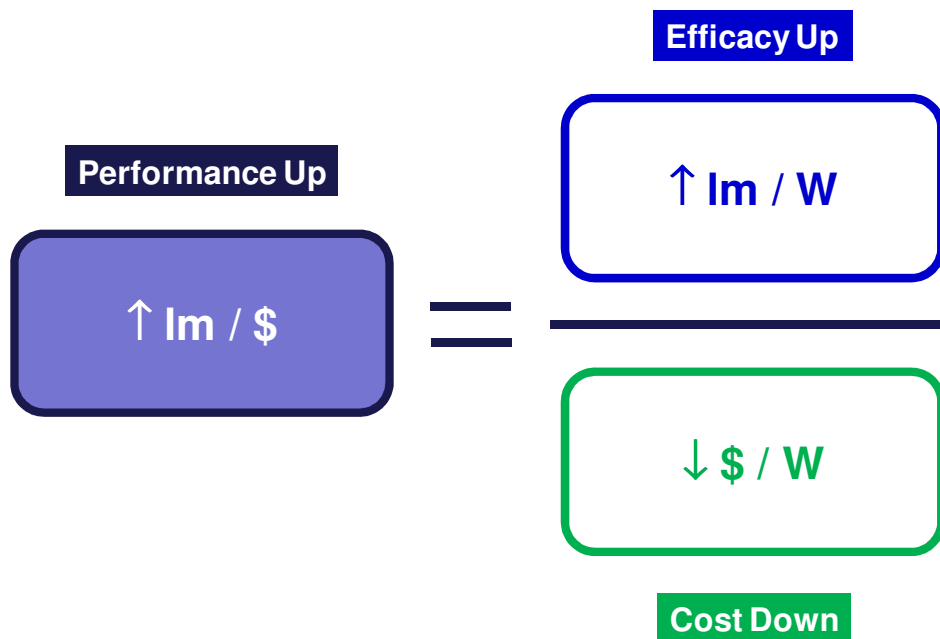
**LED Costs
(\$/klm)**



**Additional cost benefits from higher energy efficiency,
longer lifetime and ease of maintenance**

Sources: Bloomberg New Energy Finance, Haitz's law

Veeco GaN MOCVD Goals



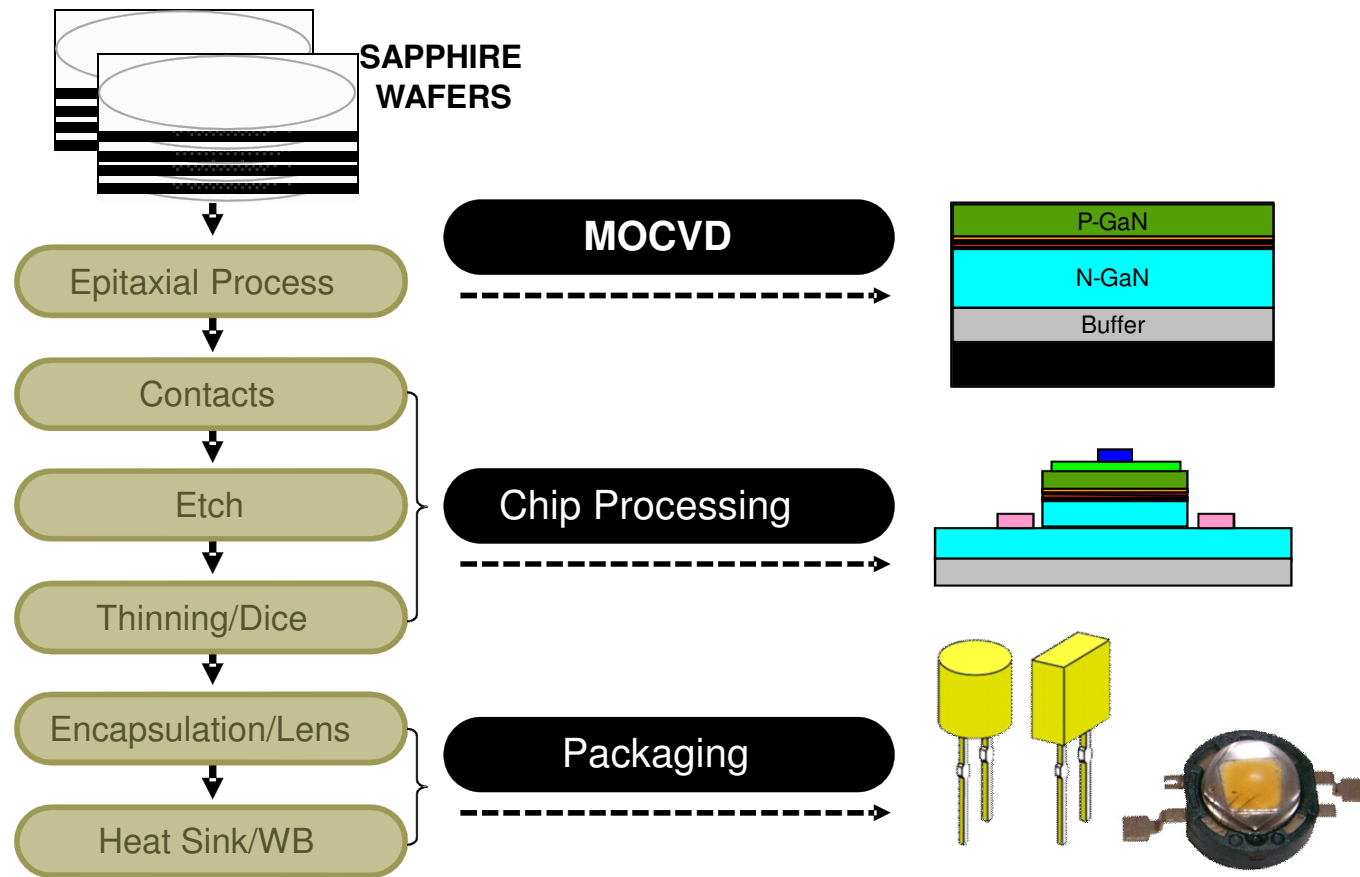
- Enable best HB LED brightness and electrical performance
 - Provide best process capability and flexibility
- Offer lowest CoO to accelerate industry adoption of LED-based solid state lighting
 - Enable >4x reduction in \$/lumen

Industry Roadmap for Blue/White LEDs

	2010	2011	2012	2013	2014	2015
High Power LED Package for Lighting (Cool White) Requirements (DOE Based)						
Lumens/Watt ↑	134	157	176	194	210	224
\$ per 1000 lumens ↓	\$13	\$9	\$6	\$4	\$3	\$2
Lumens/\$ ↑	77	106	167	271	379	500
\$/Watt ↓	1.74	1.49	1.06	0.72	0.55	0.45
OEM lamp price (\$/klm) ↓	\$50	\$31	\$23	\$16	\$13	\$10
High Power LED Package for Lighting (Cool White) Requirements (LED Companies)						
\$ per 1000 lumens ↓	\$6.6	\$3	\$2	\$1.6	\$1.2	\$1
Lumens/\$ ↑	152	328	500	638	814	1000
LED Requirements						
Blended Yield (Blue LED)	38%	40%	42%	45%	48%	50%
Substrate Size (s)	2",3",4"	2",3",4",6"	2",3",4",6"	4",6"	4",6",8"	4",6",8"
Substrate Material(s)	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire, Silicon	Sapphire, Silicon

- Improvements in Brightness & Cost Will Enable Solid State Lighting
- LED Company Roadmaps are Ahead of DOE Projections

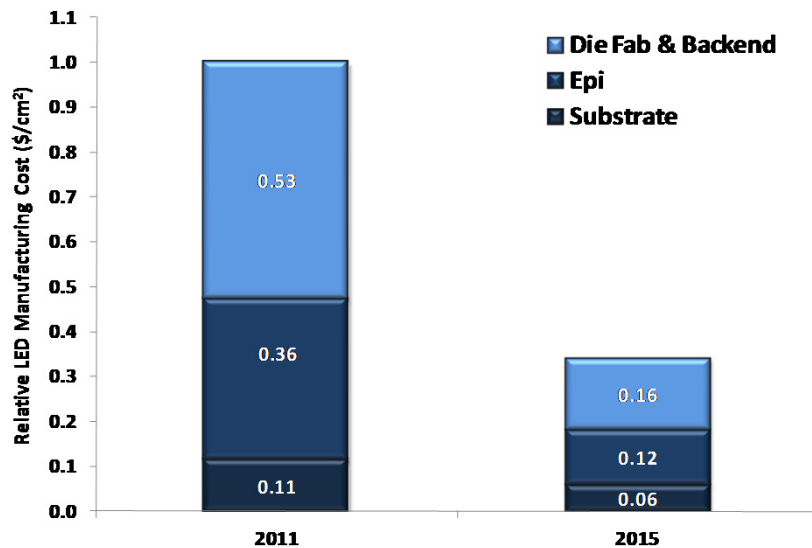
LED Fabrication – MOCVD is Critical in Determining LED Performance and Cost



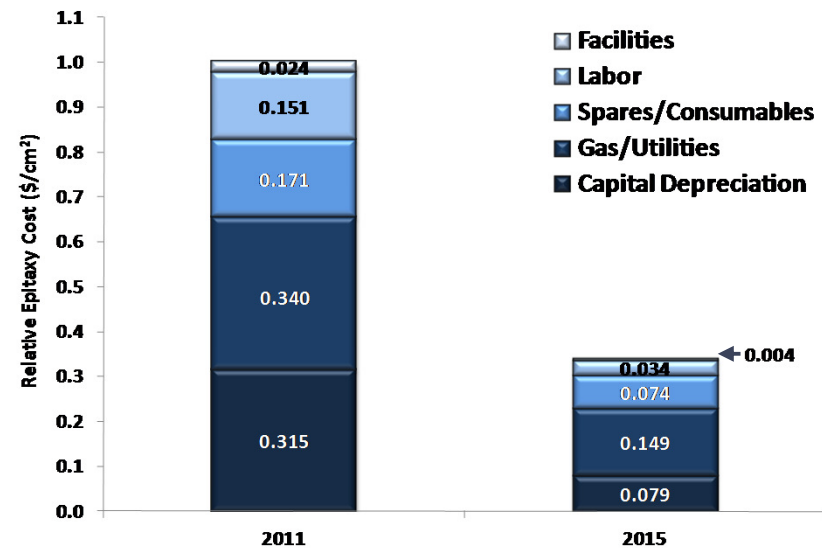
- Color, brightness, electrical properties and cost are determined by MOCVD
- MOCVD is > 50% of the LED fab capital expenditure

Veeco HB LED Epitaxy Cost Reduction Model

Relative LED Die Manufacturing Cost

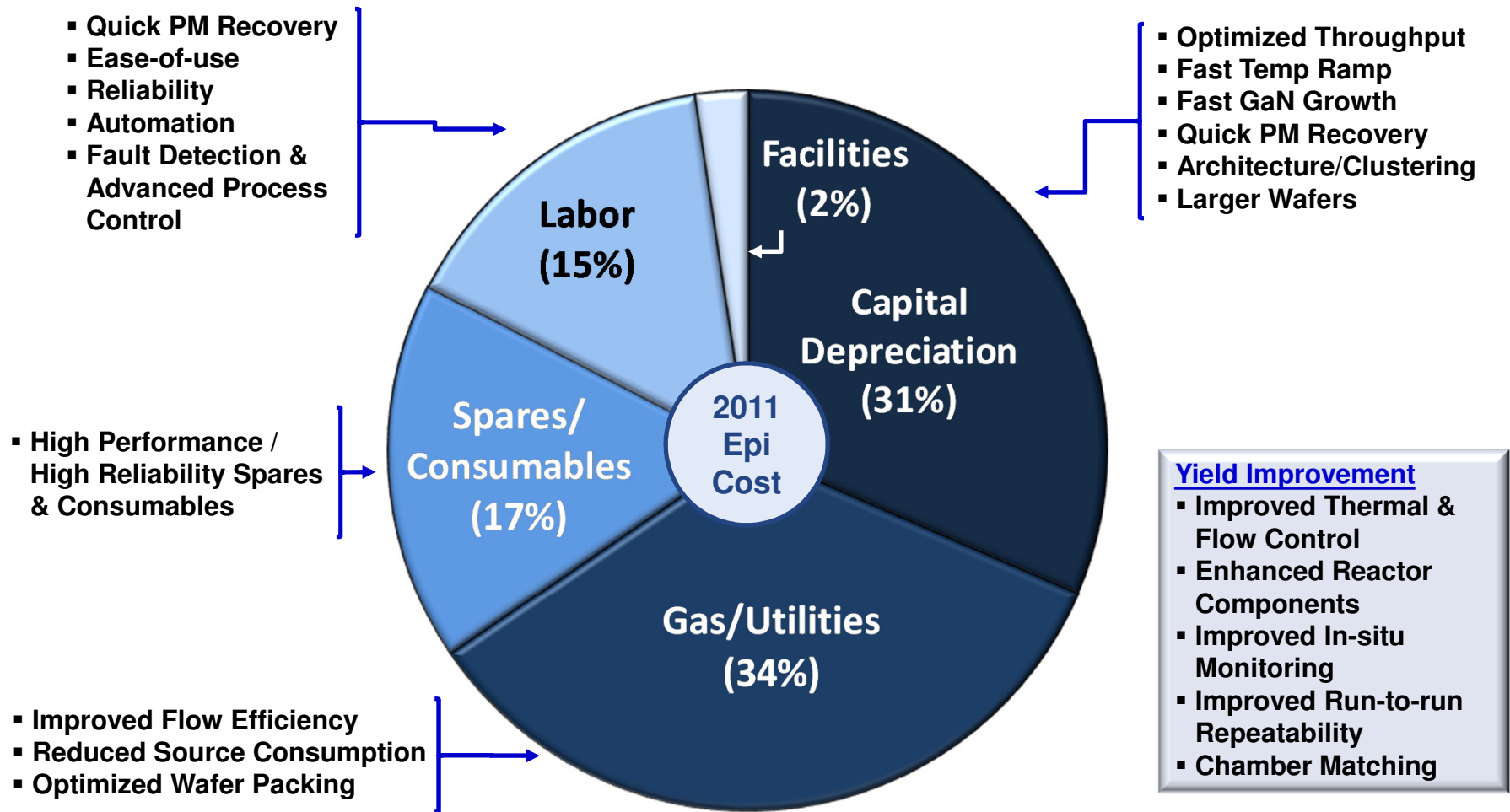


Relative Epitaxy Manufacturing Cost



Veeco is Driving ~3X Epitaxy Cost Reduction by 2015

Epitaxy Cost Reduction Approach

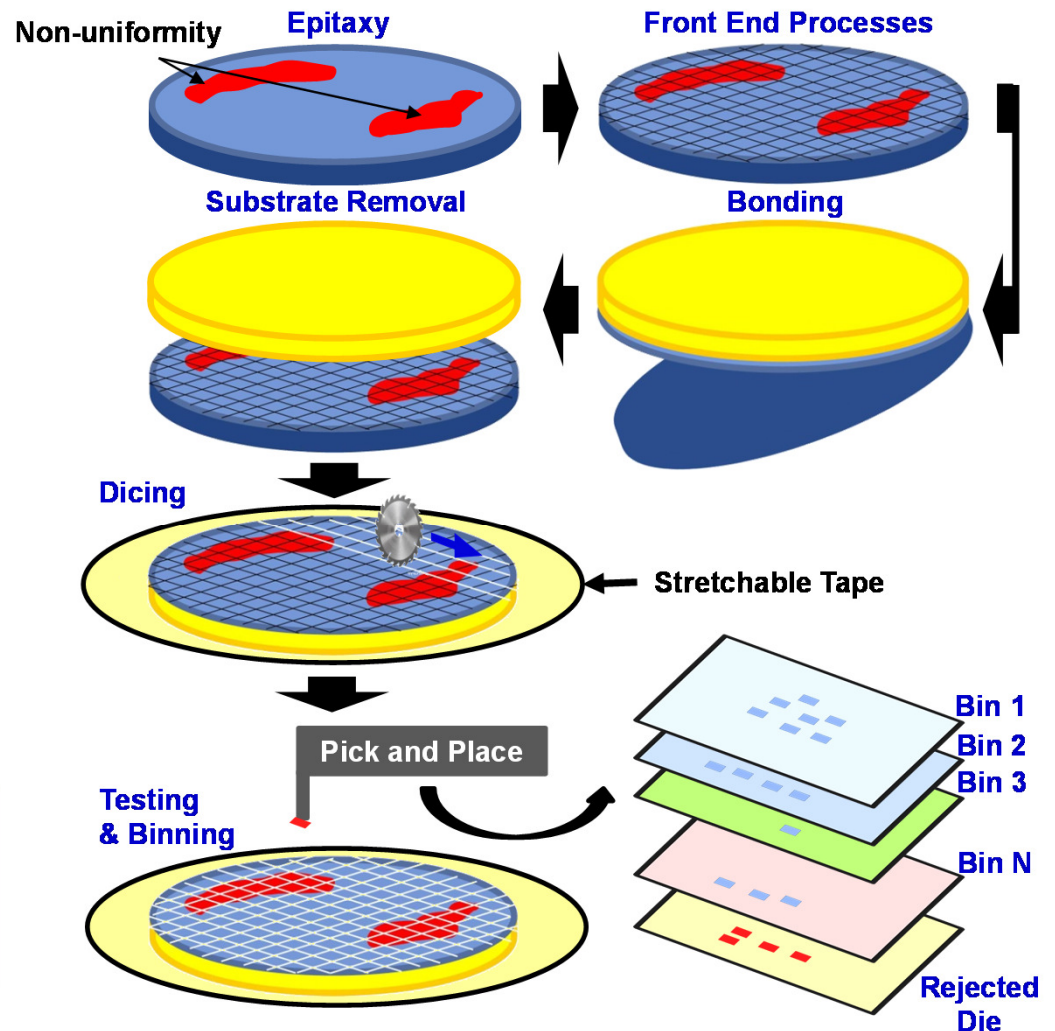


Veeco is Driving ~3X Epitaxy Cost Reduction by 2015

Epitaxy Uniformity and Binning Yield

- “Bad” die from epitaxy non-uniformity are processed through singulation along with good die
- Less uniform epitaxy increases testing & binning burden and cost
- More uniform epitaxy results in less bins and higher yield

Epitaxy uniformity has major influence on pre-packaging binning yields

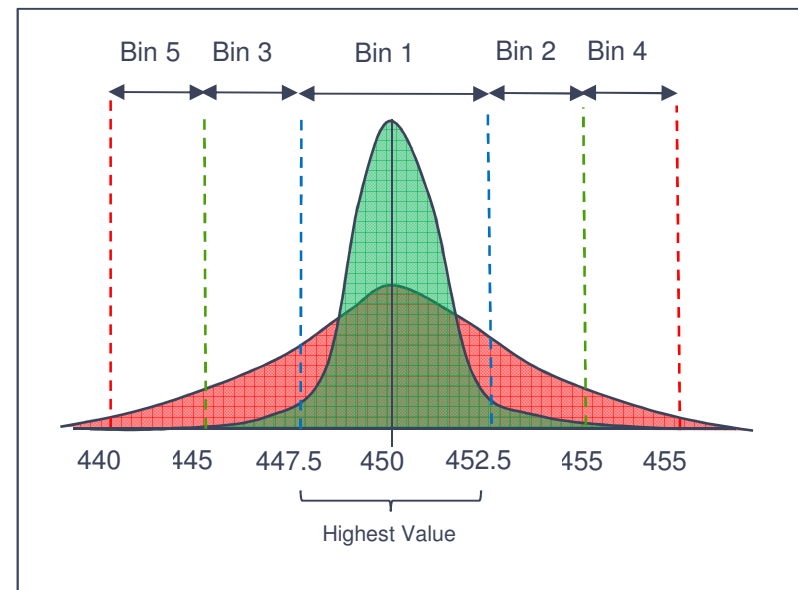


Source: Yole, Veeco

Effect of PL Wavelength Uniformity on Binning

- More die in tighter wavelength distribution (i.e. less bins, more efficient binning) → **Reduces manufacturing cost**
- More die in target bin (i.e. Bin 1) → **Increases revenue**
- Better phosphor matching with tighter wavelength distribution (i.e. better brightness consistency) → **Increases chip value**

Tighter wavelength distribution from PL wavelength uniformity improvement ($\pm 5\text{nm}$ to $\pm 2.5\text{nm}$)



PL wavelength uniformity improvement enables LED manufacturers to 1) reduce binning cost, 2) increase revenue and 3) achieve higher chip value

Accelerated Pace of MOCVD System Development

#1

K465i and MaxBright are
#1 Selling MOCVD Systems
Since Q3'10; Industry's
Highest Productivity





**2007
K465**

**2010
K465i**

**2011
MaxBright**

**2012
MaxBright
M, MHP,
K465iHP**

New “Suite” of GaN MOCVD Systems

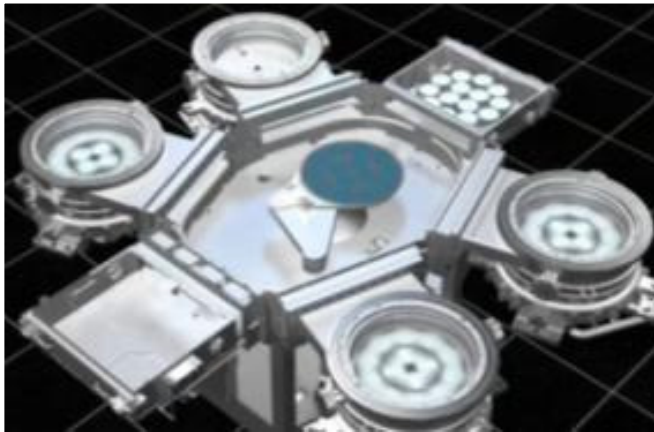
K465i HP	MaxBright M	MaxBright MHP
		
<ul style="list-style-type: none"> • Based on production proven #1 selling MOCVD platform, K465i • Advantages vs. K465i: <ul style="list-style-type: none"> – Up to 20% within-wafer wavelength uniformity improvement – >5% CoO savings • Ultra clean TurboDisc technology • Easy field upgradable from K465i to K465i HP 	<ul style="list-style-type: none"> • Based on production proven industry #1 cluster platform, MaxBright • Modular, compact design provides improved serviceability • Advantages vs. original MaxBright: <ul style="list-style-type: none"> – Up to 15% increased footprint efficiency – Improved layout configuration flexibility...accommodates various clean room requirements 	<ul style="list-style-type: none"> • Industry's highest productivity MOCVD platform with low cost of ownership and excellent yield • “High Performance” MaxBright M – <ul style="list-style-type: none"> – Up to 20% within-wafer wavelength uniformity – >5% CoO Savings • Modular, compact design and increased footprint efficiency

All Systems Available in 2”, 4”, 6” and 8” Configurations

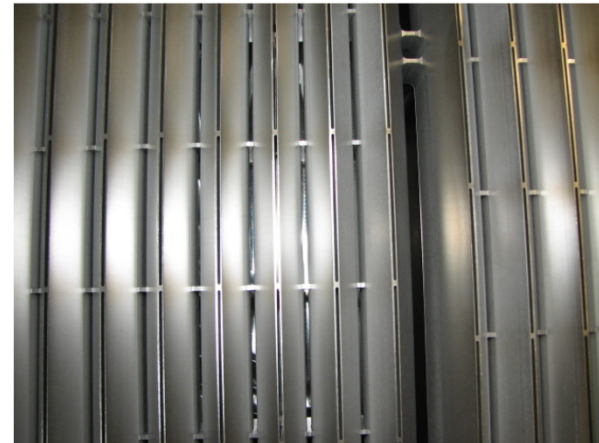
M = Modular
HP = High Performance

MaxBright = High Productivity

Automation = Higher Throughput



Quick PM Recovery = Longer Uptime



- Automation minimizes time between runs
- Clean operation and fast maintenance recovery prevents unnecessary downtime
- Fast ramp and higher GaN growth rate reduces process recipe time

Introducing MaxBright M (Modular)

Industry's most productive MOCVD platform with improved footprint efficiency and serviceability:

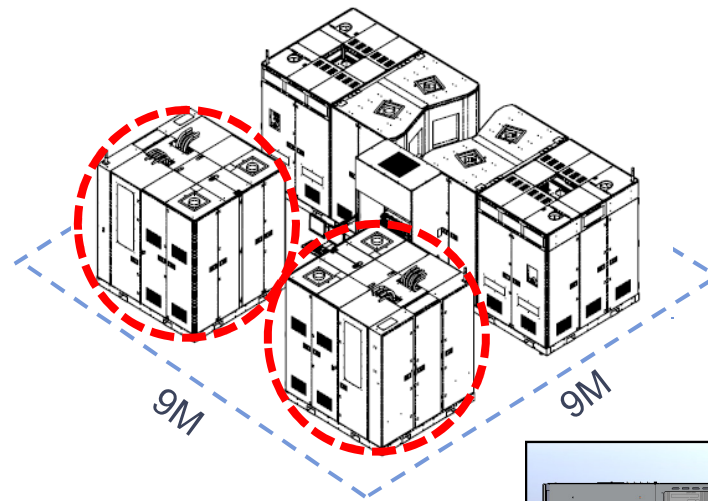
- Based on production proven industry #1 cluster platform
- Improved serviceability with modular and compact design
- Up to 15% improved footprint efficiency
- Increased layout flexibility to accommodate different fab needs



MaxBright M with improved footprint efficiency and serviceability enhances customers' fab productivity

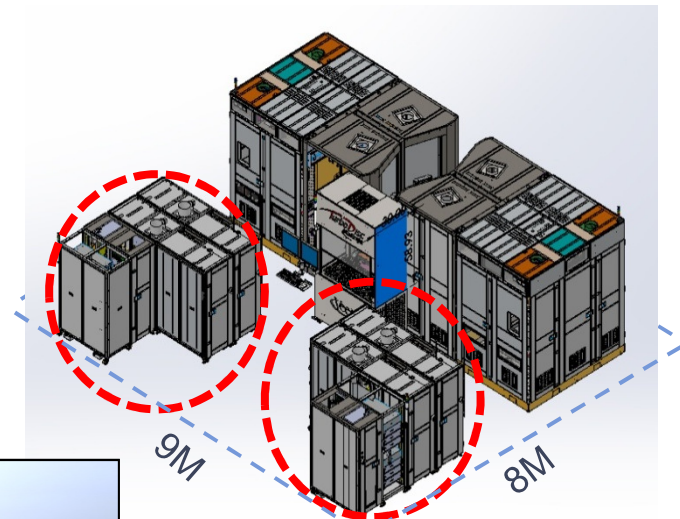
MaxBright M: Efficiently Packaged Auxiliaries to Maximize Footprint Efficiency

MaxBright

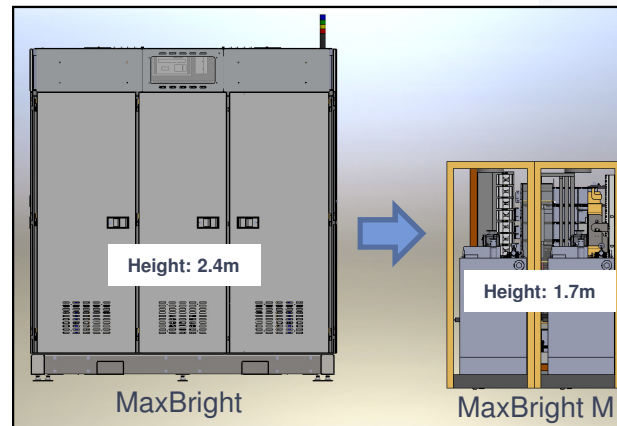


81 m²

MaxBright M



71 m²



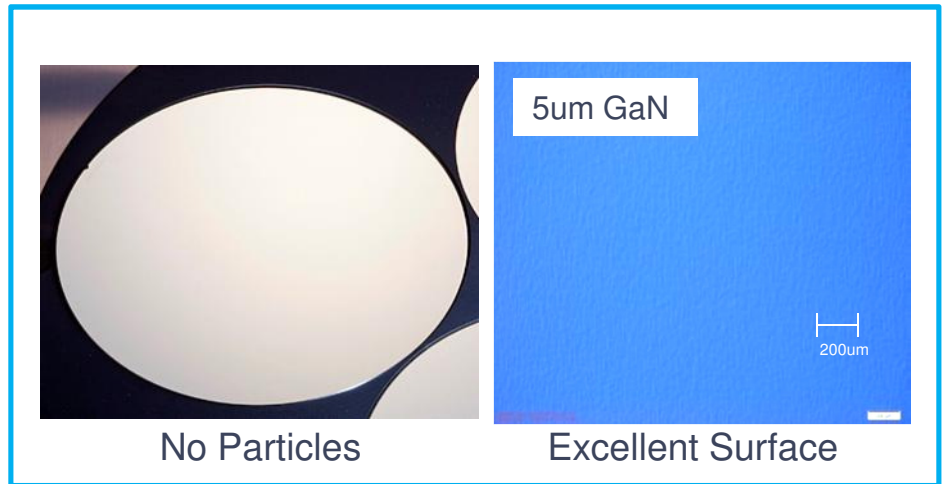
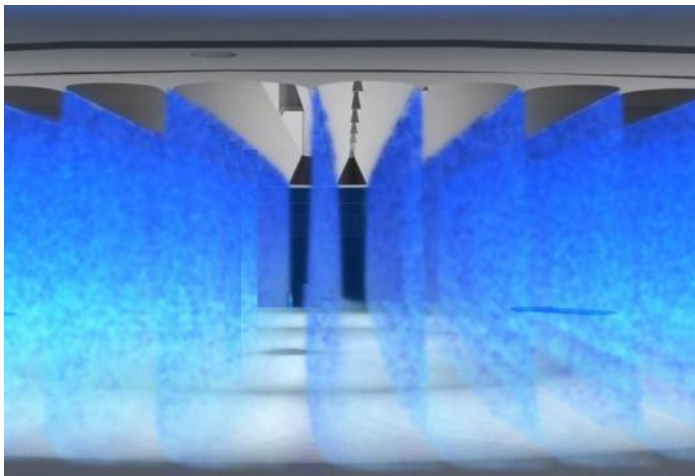
Up to 15% Footprint Efficiency

Includes
Service Area

Veeco

TurboDisc Performance Advantages

- TurboDisc Technology
 - Laminar flow
 - Longest campaigns without scheduled reactor maintenance
 - No parts change or baking between runs
 - Clean reactor operation with lowest particles
 - Stable thermal environment



**Ultra-clean TurboDisc
technology results in superior
particle performance for HB
LED manufacturing**

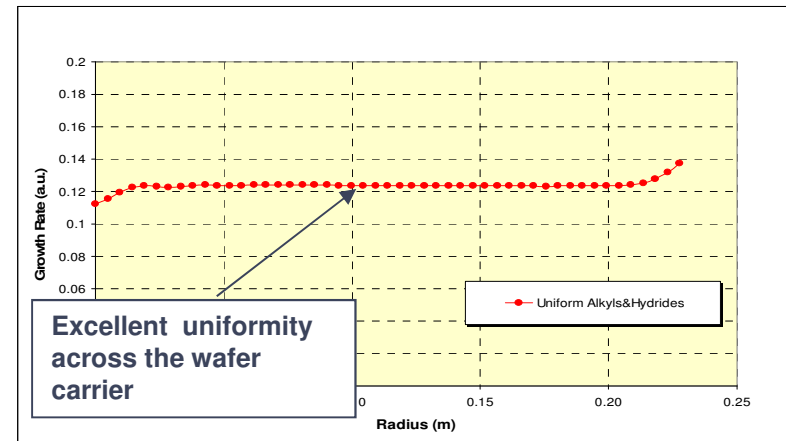
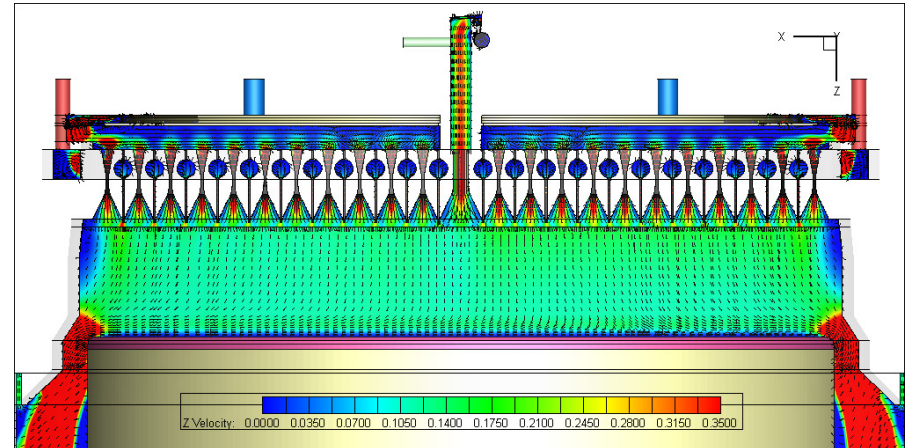
K465i Uniform FlowFlange – Excellent Uniformity and Repeatability

■ Uniformity

- Uniform gas distribution across wafer carrier without complex tuning
- Excellent yield for all wafers

■ Repeatability

- Simplified gas injection plus laminar flow provides excellent repeatability
- Reactor environment stable throughout entire run campaign

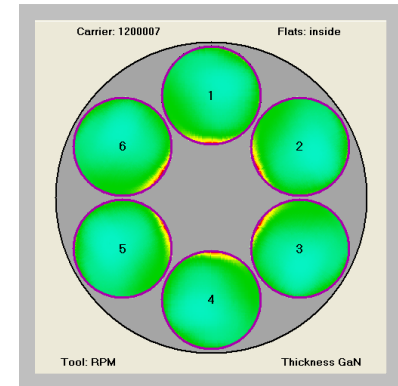
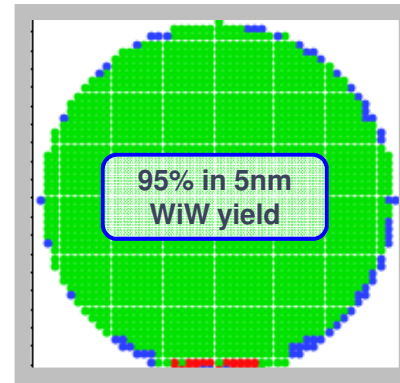


Uniformity and repeatability by design

Introducing MaxBright MHP (*Modular High Performance*)

Industry's highest productivity
MOCVD platform with low cost of
ownership and excellent yield:

- **Up to 20% WiW PL wavelength uniformity improvement**
- **Greater than 5% CoO savings**
- Improved serviceability with modular and compact design
- Up to 15% improved footprint efficiency
- Based on industry's #1 production proven cluster platform
- Increased layout flexibility to accommodate different fab needs



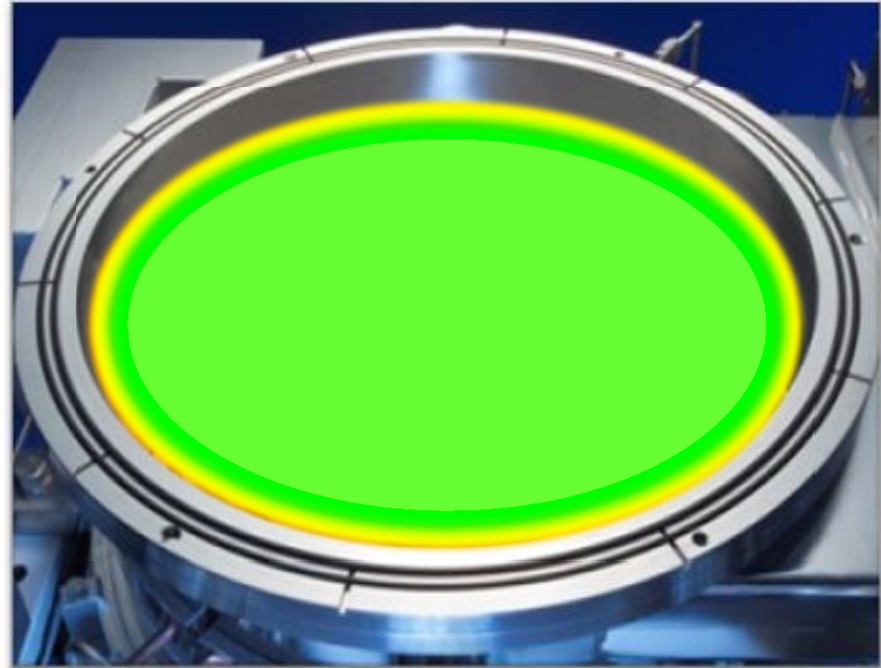
MaxBright MHP extends Veeco's product leadership with highest productivity, low CoO and excellent yield

High Performance Technology

High Performance

Key benefits:

- Extends uniform thermal and flow zone within the chamber
- Up to 20% WiW PL wavelength uniformity improvement
- Greater than 5% CoO savings
- K465i and MaxBright can be upgraded to HP
- Simple recipe transfer



New technology enhances uniformity for even higher yield

Why GaN/Si LED?

- 6" Si substrate cost \$30 vs. sapphire \$300
- 8" Si cost advantage even greater, more consistent quality than 8" sapphire
- Existing 6" and 8" CMOS fab equipment fully depreciated and can be used for LED manufacturing
- Vertical LED can use wet chemical process to remove Si, eliminate need for costly laser process to strip sapphire
- Osram and BridgeLux/Toshiba announced GaN/Si LED brightness close to that on sapphire

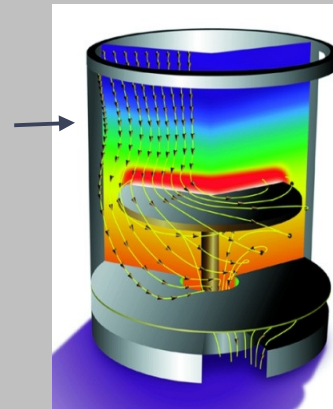
Why Veeco TurboDisc® Reactor?

TurboDisc Advantages

- No residue buildup on FlowFlange after 85 runs
- Stable process run-to-run
- Same good performance 6" Vs. 8"
- Low particle count with high Al content process
- RT directly measures Si wafer temperature
- No coating on top viewport
- Temperature control reliable

TurboDisc® High Velocity Laminar Flow High quality film

Large space
between FF
and Wafer



Clean
reactor
throughou
t entire
run

TurboDisc reactor suitable for high Al content process

Flow Flange Remains Clean after 85 Runs before PM



Veeco Technology Enabling SSL Adoption

- Drive continuous innovation in MOCVD system technology to enhance product performance
- Support customer manufacturing with broad & deep MOCVD applications expertise
- Focus on customers for production support and roadmap collaboration
- Leverage and implement semiconductor industry practices and know-how
- Drive operational excellence – flexible capacity, on-time delivery & product quality





Thank You

Brilliant.