

Innovations in LED Manufacturing Equipment Not Only Cut Costs, But Also Boost Quality and U.S. Market Share

Thanks to research partially funded by DOE, a new generation of equipment manufactured by Veeco is cutting the cost of producing high-brightness LEDs by improving the efficiency and yield of a key step in the process—helping to strengthen the U.S.’s role in a key part of the multibillion-dollar LED manufacturing supply chain.

A critical first step in LED manufacturing, metal organic chemical vapor deposition (MOCVD) deposits light-emitting semiconductor layers on a substrate wafer that’s processed into LED chips. Veeco, which makes thin-film processing equipment for the data-storage, electronics, and photonics industries, has developed a line of innovative MOCVD equipment used by LED manufacturers the world over to reduce cost and improve quality.

MARKET IMPACTS

of Veeco’s MaxBright System

- Wavelength uniformity improved by 24%, with wafer yield increasing to about 90%.
- MOCVD cost reduced by more than 30%.
- Epitaxial process cost reduction 2X faster than U.S. DOE forecast (2010–12).

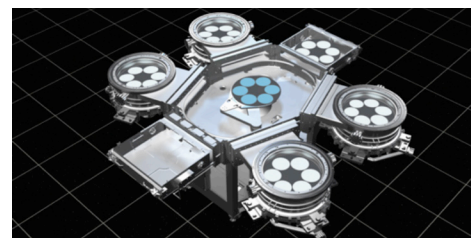


Veeco’s MaxBright® multi-reactor MOCVD system, which is sold globally, incorporates innovative technologies developed in part with the use of DOE funding and is lowering the manufacturing cost and increasing the quality of high-brightness LEDs. *Photo credit: Veeco.*

Having purchased the MOCVD division of New Jersey-based Emcore in 2004, Veeco now does all of its MOCVD product development and testing in Somerset, New Jersey, outsourcing most of the MOCVD equipment manufacturing to a company in New York. Veeco employs more than 175 people in the U.S. in engineering and manufacturing its innovative MaxBright® multi-reactor MOCVD system—to say nothing of the company’s key manufacturing partners and component suppliers, many of whom are also U.S.-based. Demand for Veeco’s new system comes from both the domestic and export markets, with many customers located overseas.

Public-Private Partnership: The Fast Track to Market

Veeco received one of DOE’s first awards under the Solid-State Lighting Manufacturing Initiative, launched in 2009 with funds from the American Recovery and Reinvestment Act.



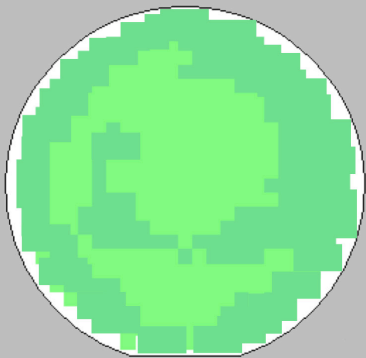
Rendering of a four-reactor MaxBright system in action. *Image credit: Veeco.*

“DOE funding accelerated our ability to bring MOCVD tools to the marketplace that have significantly higher productivity and yield than previous generations. Innovations in product design, automation, throughput, and reactor optimization have resulted in a lower cost of ownership for our new systems, enabling our global customers to make lower-cost LEDs and drive solid-state lighting adoption.”

— Jim Jenson, senior vice president and general manager of Veeco’s MOCVD business

Excellent Within-Wafer Uniformity

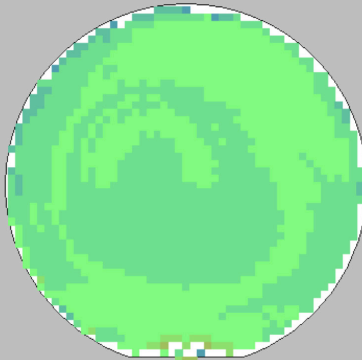
54 x 2"



1mm edge exclusion

>90% yield in 5nm bin
 $\lambda = 450\text{nm}$

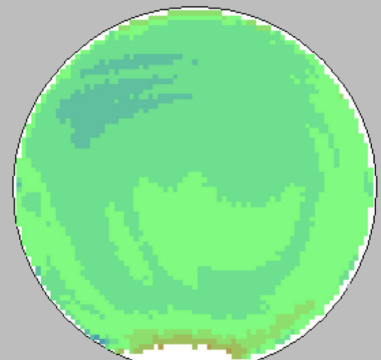
14 x 4"



0mm edge exclusion

90% yield in 5nm bin
 $\lambda = 450\text{nm}$

6 x 6"



0mm edge exclusion

90% yield in 5nm bin
 $\lambda = 455\text{nm}$

The company worked in partnership with Sandia National Laboratories and Philips Lumileds on several enhancements to the MaxBright system, with a focus on improving temperature measurement and control methods to increase MOCVD yield. For example, two different types of pyrometers developed by Sandia and Veeco were tested by Philips Lumileds to control the substrate temperature, which helps determine the emission wavelength λ , or color of the LED.

Market Impact

Veeco also developed an advanced wafer carrier design that offers 2", 4", 6", and 8" wafer sizes in various configurations to increase the capacity, along with optimized pocket shaping, in which the wafer holders are contoured to improve temperature uniformity. The introduction of optimized pocket shaping has resulted in a within-wafer wavelength uniformity improvement of 24%. Consequently,

the wafer yield for a 5-nm wavelength bin has increased to about 90%. All told, Veeco's MaxBright tool can reduce an LED manufacturer's MOCVD costs by more than 30% by improving throughput, growth uniformity, yield, and temperature stabilization. This has helped Veeco increase its market share from ~25% in 2009 to over 60% in the face of stiff foreign competition—bringing overseas business to the U.S.—and remain a leading fabrication equipment supplier for the global LED market. The average price of an LED bulb was about \$50 in 2010 but, aided by Veeco's MOCVD technological advancements, today is in the neighborhood of \$10 and is expected to drop as low as \$5 by 2020. This dramatic price decrease will speed the growing adoption of LED usage for general lighting purposes. ■

DOE SSL R&D INVESTMENTS

GOALS

1. Maximize the energy efficiency of SSL products in the marketplace.
2. Remove market barriers through improvements to lifetime, color quality, and lighting system performance.
3. Reduce costs of SSL sources and luminaires.
4. Improve product consistency while maintaining high-quality products.
5. Encourage the growth, leadership, and sustainability of domestic U.S. manufacturing within the SSL industry.

WHY IT MATTERS

- Technology innovation fuels U.S. economic growth and job creation.
- LEDs that are more cost-competitive will accelerate markets for energy-efficient solid-state lighting, saving energy for American homeowners and businesses while reducing carbon emissions.