Driven by microLED displays and power devices, epitaxy equipment shipment volumes will multiply more than threefold over the next five years.

**KEY FEATURES**

- Comprehensive analysis of the major applications currently using epitaxy growth methods, and potentially attractive applications that could require the use of epitaxy growth technology in the future
- Describe the key benefits and added-value of epitaxy growth technology in More than Moore field
- Epitaxy growth process application roadmap
- 2019-2025 epitaxy growth equipment market forecast: breakdown by device type, by substrate type and by equipment technology
- Describe the competitive landscape and identify key players in technology development
- 2018 global epitaxy growth equipment market share in the More than Moore area and 2019 trends
- 2018 epitaxy equipment market share by substrate type and by device type and 2019 trends
- Overview of the major players using epitaxy growth equipment, by device
- Discuss technology processes, specifications and value chain

**COMPOUND SEMICONDUCTOR EPIWAFERS ARE MAKING SERIOUS INROADS INTO THE MORE THAN MOORE INDUSTRY**

Epitaxial growth is used today for silicon-based devices as well as in the III-V compound semiconductor industry. It is a key technology to grow high-quality material for device circuits. Epitaxy-ready wafer demand exceeded the equivalent of 7.8M 6-inch wafers in 2019, driven by LEDs as well as power devices. This demand is expected to increase and peak at the equivalent of almost 21.3M 6-inch wafers by 2025, strongly driven by microLEDs, power devices and laser diode applications.

In terms of semiconductor substrate, GaN material represents the major epitaxy market after silicon substrates, mostly driven by the traditional LED GaN-devices. However, the overall visible LED industry is currently diversifying its activities to towards more specialized UV and IR LEDs based on GaAs substrates. Additionally, LED manufacturers are developing new types of LEDs to continue creating value in the consumer displays, such as miniLEDs and microLEDs. Apple is starting this with adoption in its higher-end 2021 smartwatch model. In the best case scenario, microLEDs could also spread into smartphone products, which will definitely reshape the epitaxy-ready wafer market.

On the other hand, wide band gap materials like SiC substrates have found opportunities in the power electronics market. Despite the high market price of SiC substrates are a strong asset for high-voltage applications, and thus are considered as a technology choice for some MOSFET and diode products.

Looking ahead, photonics products like laser diode (VCSELs) operating in the infrared spectrum and typically processed on GaAs, are making serious inroads into the epitaxy growth market. In addition, GaAs is especially advantageous for radio frequency products such as small-cell implementation, for both sub-6GHz and the first mmWave small cells in the 28GHz-39GHz range. Thereby, with the cellphone transition from 4G to 5G, we expect GaAs to remain the mainstream technology for sub-6GHz instead of CMOS. Choosing the right substrate technology will strongly depend on the technical performance associated with device requirements, as well as the cost.

This report offers a comprehensive overview of epitaxial semiconductor substrates used in More than Moore (MtM) applications. Moreover, a detailed analysis of the wafer forecast, split by wafer size and substrate type, has been calculated for the 2019-2025 timeframe.

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**THE EPITAXY EQUIPMENT MARKET WILL BLOW UP OVER THE NEXT FIVE YEARS, DETONATED BY VCSEL AND DISRUPTIVE LED DEVICES**

The epitaxy growth equipment market for MtM devices was worth close to $990M in 2019, including silicon and non-silicon based applications. It is expected to reach more than $6B by 2025 in the aggressive scenario.

From a technical point of view, Metal-Organic Chemical Vapor Deposition (MOCVD) services the majority of the III-V compound semiconductor epitaxy industry, such as GaAs and GaN based devices. High-Temperature (HT)
CVD serves the majority of mainstream silicon-based components and SiC devices.

Today’s market is mainly driven by LED and power applications. In fact, massive subsidies in China have led to an excessive LED capacity build-up. The MOCVD market is now in a situation of significant overcapacity for GaN LED production compared to what is actually produced. MOCVD investment is particularly tough to forecast in the next few years and could change year to year. The situation could be reversed if the government decides to strictly prevent the major LED manufacturers from producing more GaN wafers. Therefore, different scenarios have been considered for the traditional LED and microLED markets in this report.

For traditional LED GaN-based devices, the MOCVD investment trends will not follow LED wafer demand. Specific upsides and downsides with respect to LED GaN devices might arise as used to happen in the past. Nevertheless, given recent competitive trends in China, the general lighting and backlighting markets have become commoditized. Hence, epitaxy vendors do not expect significant revenue from these markets going forward. However, requirements for microLED epitaxy in terms of defects and homogeneity are more stringent than traditional LEDs. There are credible roadmaps for improvement in tools and equipment to reach approximately 0.1 defects/cm² or less based on defects larger than 1µm. Tighter requirements are needed in clean rooms, including for automation and wafer cleaning, compared to traditional LED manufacturing. This is especially true for the smallest dies, below <10µm, which will have smaller killer defects.

Meanwhile, laser diodes represent an additional fast-growing opportunity as the consumer goods industry massively adopts edge-emitting lasers and VCSELs.

By contrast, MEMS industry is a small niche of the overall epitaxy growth equipment market, as their production capacity is very well established.

The MOCVD reactor market could be affected by possible technology transitions to Molecular Beam Epitaxy (MBE) for compound semiconductor-based devices like laser diodes, microLEDs and VCSELs. In fact, MBE could bring greater advantages in terms of yield and uniformity for VCSELs but also for high-frequency 5G RF applications.

In the case of SiC power, MOCVD manufacturers are trying to identify and develop new MOCVD technologies to address the SiC market where HT CVD is mostly used.

This report offers a detailed analysis of the epitaxy growth equipment market forecast by volume and value, for the 2019-2025 timeframe, broken down by MtM device application, substrate type as well as by technology.

**Disruptive Non-Silicon Based More Than Moore Devices Lead to a More Competitive Epitaxy Growth Landscape**

When looking at the competitive landscape, the epitaxy growth equipment market is occupied by a variety of epitaxy equipment makers coming from three different categories:

- **Top-tier semiconductor equipment suppliers** like Tokyo Electron Limited and Advanced Materials offering CVD equipment optimized for the epitaxy process, who are typically absent from the MOCVD space;
- **Specialist MOCVD equipment vendors** like AIXTRON, Veeco, and AMEC that have respectively developed their expertise dedicated to solid state lighting products, where RF front-end suppliers do not have any products;
- **Equipment suppliers coming from the power SiC sector or high level RF applications providing HT CVD systems like LPE or Nuflare or developing dedicated MBE equipment lines such as Riber.**

In 2018, three equipment makers represented almost 60% of the epitaxy growth equipment market. AIXTRON is leading the GaAs market with a strong position in laser diodes as well as LED GaAs based devices. AMEC is very well positioned in the LED GaN business. Considering the complex relationships between China and the United States intellectual property disputes, Veeco has lost market share in China to AMEC. There is
a risk that such disruptions will continue with the trade barriers and additional taxes. These challenges might strongly impact Veeco’s share and reduce the competitiveness of Veeco in the Chinese market.

COMPANIES CITED IN THE REPORT (non exhaustive list)

TABLE OF CONTENTS (complete content on i-Micronews.com)

Executive summary 23
- Device overview based on epitaxy layers
- Comparison of epitaxy equipment technologies
- Competitive landscape
Introduction and context 56
Epitaxial growth process technologies 73
- Introduction to epitaxy technology
  - Deposition technologies – Overview
  - Epitaxy definition and principle
  - Epitaxy growth film types
  - Epitaxy technology classifications
Epitaxy growth applications 111
- Epitaxy applicability in the field of semiconductors (Solid State Lighting including LEDs and laser diodes, RF devices, power electronics devices, MEMS devices)
- Epitaxy drivers by semiconductors application
Epitaxy equipment technologies 122
- Epitaxy equipment technology - Classification
- Comparison of the different tools available on the market
- Benefits and drivers
Market forecast 135
- Overall epitaxy growth equipment market in terms of market size (volume, value)
- Epitaxy equipment market by application, substrate and technology type
- Epitaxy growth equipment for LED: breakdown by LED type in units and revenue
- Epitaxy growth equipment for laser diodes: breakdown by laser diode type in units and revenue
Epitaxy equipment suppliers: Competitive landscape 165
- Overview of the major epitaxy equipment suppliers in the field of semiconductors
- Epitaxy equipment supplier positioning by substrate type and application
- Epitaxy equipment players’ market share and revenue
- In-depth analysis of epitaxy growth technologies, by end application

Solid State Lighting introduction 190
- Traditional LED, MicroLED, MiniLED 196
- Blue/Green LED
- ROY and IR LED
- UV LED
- MicroLED
Laser diodes 232
- Edge emitting laser (EEL)
  - Epitaxy drivers and challenges for EEL
  - Epitaxial growth requirements
  - Type of epitaxy integrated into EEL
- Epitaxy drivers and challenges for EEL
- Epitaxy equipment system choice
- VCSEL
  - Epitaxy drivers and challenges
  - Type of epitaxy integrated
  - Epitaxy drivers and challenges
  - Epitaxy equipment system choice
Epitaxy for power devices 249
- Types of power devices using epitaxy process
- Epitaxial growth requirements
- Structure, thickness, cycle time
- Types of epitaxy integrated
- Substrate/layer types
- Epitaxy drivers and challenges
- Epitaxy equipment system choice
Epitaxy growth for RF devices 277
- Types of RF devices using epitaxy processes
- Epitaxial growth requirements
- Structure, thickness, cycle time
- Types of epitaxy integrated
- Substrate/layer types
- Epitaxy drivers and challenges
- Epitaxy equipment system choice
Conclusions and perspectives 291
Yole Développement presentation 300

REPORT OBJECTIVES
- Detailed analysis of epitaxy growth technologies for More than Moore (MtM) devices
- Give the current status of epitaxy growth adoption and the various technologies available on the MtM market
- Provide an overview of epitaxial growth technological trends for MtM applications
- Define the key drivers for using epitaxy growth technologies
- Offer market metrics at epitaxy growth equipment market level for MtM devices (2019-2025)
- Evaluate market developments in terms of market size (volume, value) by MtM device and substrate type
- Provide a competitive landscape identifying key players in technology development and manufacturing
- Give an overview of who is doing what, and details of each market

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Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and image sensors, Compound semiconductors, RF Electronics, Solid-state lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO, KnowMade and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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