MicroLED Association

White paper:

Monolithic MicroLED Integration - Technology and Challenges

August 2023

Yenrich

Monolithic MicroLED Integration – Technology and Challenges

By the MicroLED Industry Association (MIA)

MicroLED Association

A major challenge in producing MicroLED displays is the transfer stage, also known as Pick and Place. This production step is responsible for transferring individual LEDs from the original wafer to the final display.

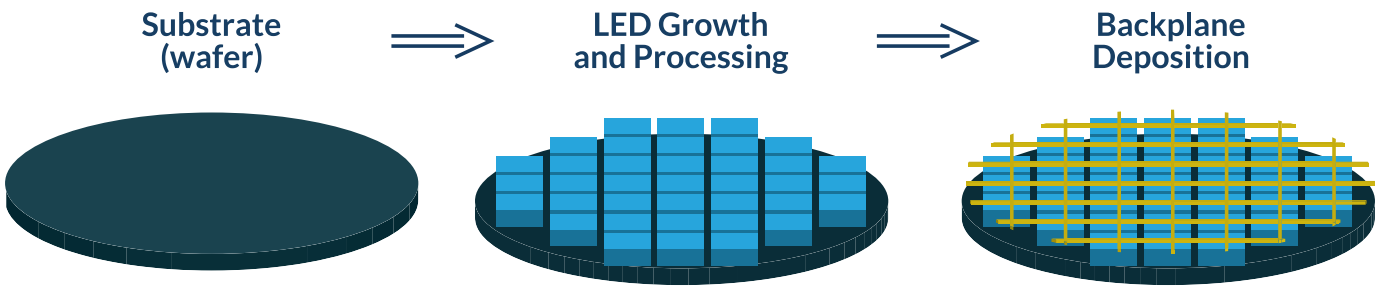
In some cases, it is possible to (more or less) skip this stage and transfer the LEDs directly to the final display through a process called monolithic microLED integration.

This document will focus on such a process, discuss various options for its execution and examine the types of displays and applications it is suitable for. This white paper also details solutions and technologies for monolithic processes by MicroLED Industry Association members.

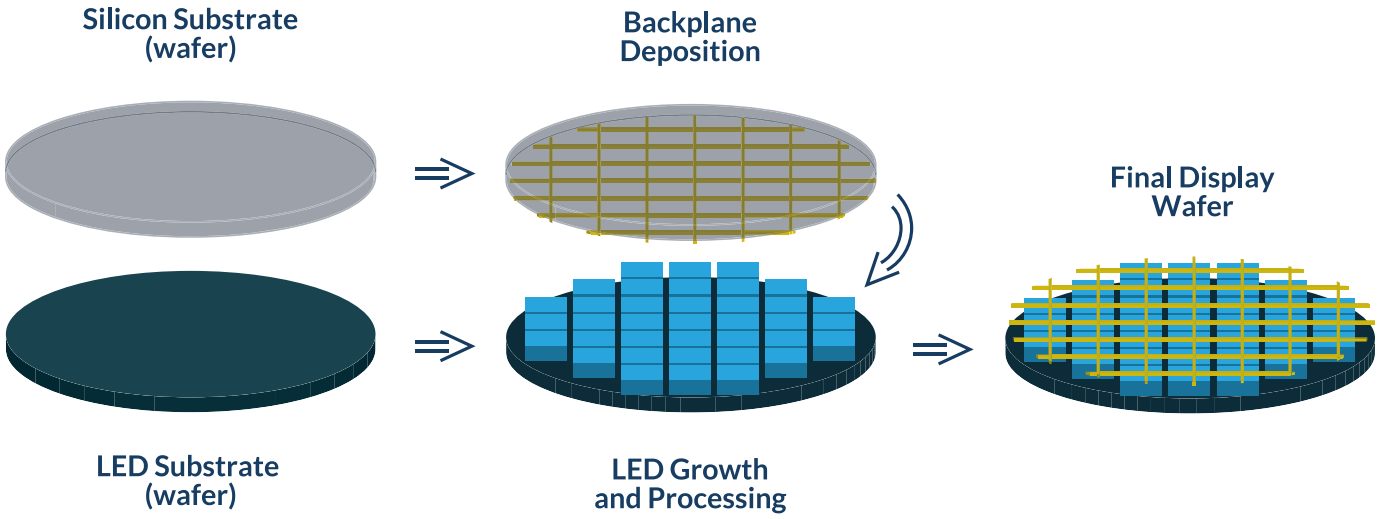
What is a Monolithic MicroLED Process?

There are two ways to go about a non-transfer MicroLED production process:

1. Manufacturing the backplane on top of the LEDs – a very complicated and problematic concept as the production process for backplanes is usually destructive for the LEDs.



2. Manufacturing two different wafers (backplane wafer and LED epiwafer) and then “bonding” the two wafers together in a precise manner, without moving individual LEDs. This is called wafer to wafer bonding.



When is Wafer to Wafer Bonding the Logical Choice?

When bonding together two wafers, one must pay attention to a number of things:

1. The resulting display will be very limited in size, as even the largest wafer is no more than 300 mm in diameter. This is the reason why this technology is only suitable for small displays – like near eye microdisplays or wearable displays [1].
2. The display is based on a silicon CMOS backplane. This means an efficient and high-performance backplane, that is also very expensive (compared to other solutions like TFT on glass).
3. This technology does not separate the LEDs that were produced on the epiwafer, meaning that the original pitch on the wafer will be the pitch on the final display. That results in a relatively high-resolution display.

In fact, the high price, limited size, and pixel density render near eye microdisplays the only type of display suitable for this process (for applications like AR). Near-eye applications require excellent performance (resolution, speed, brightness, efficiency) in a market that can endure premium prices.

Some companies are contemplating the use of this technology for the production of displays for wearables, like smartwatches. This can work for some of the ultra-premium segments of this market but will be very challenging to accommodate reasonably priced displays for the main segments of the smartwatches field. Note that these displays need to compete with AMOLED, LCD and e-Paper displays, that deliver very good performance, excellent image quality and low prices.

Wafer to Wafer Bonding Technologies and Challenges

Wafer to wafer bonding is a relatively straightforward process to implement. However, some challenges exist, such as:

* The ability to precisely connect the LEDs so that they are placed in the exact place (requires sub-micron level alignment).
* The ability to remove the original substrate and get properly exposed LEDs.
* The ability to test and correct individual LEDs at the end of the process.

The relatively steep components cost, and the high quality required form the final display dictates an extremely precise process. The latest solutions and technologies will be detailed later in the whitepaper.

How to Achieve Color with Wafer-to-Wafer Bonding

Producing color displays is one of the challenges standing before the wafer to wafer bonding process. In principle, a single LED epiwafer is used to make the display, so producing a full color screen is not at all trivial.

A potential solution is producing a display of only blue LEDs (or UV LEDs) and implementing **color conversion** using quantum dots or phosphors to get an RGB subpixel display. This is a viable route, and several companies are following it. The main challenge here is to deposit the color conversion layer on very small LEDs in a way that does not harm the LEDs and allows for efficient conversion and sufficient creation of light. Again, this is no small task as 2-5 microns (and lower) are used in the LED and microdisplays world.

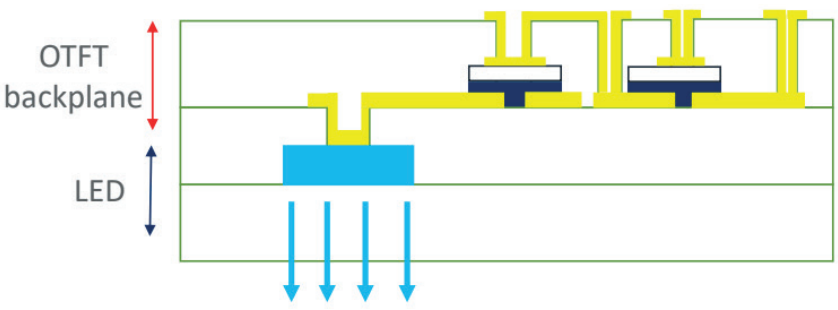
Another solution is to use **tunable LEDs**. The idea is that a single LED can emit different light wavelengths, for example by changing the current density. These technologies have major advantages (larger pixels, less transfer steps and more), and they give the ability to create color in a relatively simple manner in the wafer to wafer bonding process.

An additional solution is producing an LED epiwafer that contains an **array of RGB LEDs**, which can be stacked or side by side, and then the rest of the process remains quite simple, and the result is a full color LED array. In these solutions, the challenge is in producing the epiwafer itself.

TFT Deposition on LED Epiwafer

Another way to create MicroLED displays without a transfer process is the deposition of TFTs (the backplane part of the display) directly on the epiwafer with the individual LEDs. The main challenge in these processes is executing TFT deposition without harming the LED layer. Normally an LTPS backplane could be used, but its creation requires PECVD processing of the SiNx dielectric at very high temperatures (around 360°C), which cannot be applied here.

Some companies are developing such solutions, however. Lumiode, for example, has developed the ability to deposit a-Si and then use laser annealing that does not destroy the LED layer. MicroLED Association member **Smartkem** has also developed a backplane based on organic materials (OTFT) which can be manufactured directly on the LED array. Smartkem's technology is unique in that it allows for low temperatures (under 150°C) during the production process of the organic materials and the ability to deposit via printing methods (the materials are soluble).



OTFT microLED device design, Smartkem

Similarly to the wafer to wafer bonding process, some limitation exist:

1. The resulting display will be limited in size, consistent with LED epiwafer sizes.
2. As TFTs are made on the LED, there is no change of pixel pitch and the density of the display will be very high.

It is important to note that this method does not rely on expensive silicon CMOS backplanes, and so could be much more cost-effective compared to wafer-to-wafer bonding, but it is still highly restricted in size and carries a high cost (due to the epiwafer costs and the fact that the LEDs remain in the original pitch). The performance of the backplane may not be enough for high-demanding microdisplay applications such as AR, and a main challenge with this path will be in finding the right market to adopt high-cost displays with some limitations on performance.

As was discussed Above, UK-based SmartKem developed a backplane based on organic materials (OTFTs) that can be manufactured directly on LED arrays.

SmartKem has already demonstrated a prototype device, that achieves a brightness of over 100,000 nits and a density between 25 and 254 PPI. The technology is said to be scalable to higher brightness and much higher densities, over 1,000 PPI.

Interestingly Smartkem's OTFTs can also be produced on microLED transposer (transfer) substrates, to be used in non-monolithic processes. Such a hybrid of mass transfer and OTFT processing on top of the microLEDs avoids the low yielding evaporation lift-off processes currently used for making the fine bumps which the LEDs are bonded to. In Smartkem's route, the metallisation contact between the OTFT and the microLED are through industry-standard sputtering, photolithography and etching processes to form electrical vias.

This approach can reduce the area usage of micro-LEDs in a display by up to 2 orders of magnitude. Transposer substrates can be made on low-cost large Gen size glass substrates, upon which the OTFT backplane can be produced, possibly opening up markets for microLED panels such as TV and IT displays which currently are served by using expensive tiling approaches. The transposer substrate can even be removed from the flexible carrier to form a flexible microLED display by this route.

Footnotes

[1] Theoretically one could produce small display modules in this method, and then tiled these modules to create larger displays. As discussed in this document, this will be an extremely expensive process, and the display performance and pixel density will be quite an overkill.

Member Directory

#Lasers, #production equipment, #Mass transfer, #inspection & repair

3D-Micromac

Laser equipment for µLED forward transfer, lift-off and repair process steps - ready for high volume production

Germany-based 3D-Micromac AG is the industry leader in laser micromachining and roll-to-roll laser systems. The company develops and manufactures processes and laser systems delivering powerful, user-friendly and leading-edge processes with superior production efficiency.

3D-Micromac systems and services have been successfully implemented in various high-tech industries worldwide. This includes semiconductor, photovoltaic, glass and display industry, electronics, as well as medical device technology.

For microLED display manufacturing, 3D-Micromac offers industrial laser solutions for mass production:

- Laser-Induced Forward Transfer (LIFT) which enables the transfer of hundreds of millions of microLEDs without having to apply mechanical forces
- Laser Lift-Off (LLO) which guarantees a highly uniform, force-free lift-off of different layers on wafer and panel substrates
- REPAIR: Single die repair process at every step of the microLED production process

https://3d-micromac.com/

#materials & technologies

3M

Produces a wide range of products including electrical and electronic connecting and insulating materials, and optical films.

The 3M Company, based in the US, operates in the fields of industry, worker safety, U.S. health care, and consumer goods. The company produces a wide range of products (over 60,000, in fact) including adhesives, abrasives, laminates, passive fire protection, protection films, dental and orthodontic products, electrical and electronic connecting and insulating materials, and optical films.

3M's Display Materials and solutions Division (DMSD) is offering several products for the industry – transparent adhesives (OCAs), micro/nanoreplication technologies, printable optical materials, and multilayered optical films.

https://www.3m.com

#microdisplays, #LED epiwafers

ALEDIA

Aledia is a start-up company established in 2021 in the Grenoble area (France) to develop GaN nanostructure-based LEDs for Display applications. It has 220 people (30% PhDs), has more than 250 patent families granted or in application, and has raised €270M in four financing rounds.

Aledia has two nanowire LED platforms, one based on blue GaN nanowires on 8-inch wafers, and the second that utilizes RGB LEDs. The company targets a wide range of markets, from AR microdisplays to TVs and videowalls.

Aledia has built a factory near Grenoble (France) for high volume epitaxial growth and low volume LED processing manufacturing; high-volume manufacturing capacity is being implemented in different countries including in Asia, closer to the market.

https://www.aledia.com/

#materials & technologies, #LED epiwafers

ALLOS Semiconductors

GaN on Silicon IP licensing and technology

ALLOS Semiconductors is an IP licensing and technology company that focuses on GaN-on-Si technology.

For the micro-LED market, ALLOS offers a turn-key technology transfer to establish a super-uniform CMOS-compatible large (200 mm) epiwafer process at customers within only 12 weeks.

https://www.allos-semiconductors.com

#LED epiwafers

ams-OSRAM

In an increasingly connected world, sensing is taking a crucial role by closing the gap between the physical and the digital. Using the full spectrum of light we allow humans and machines to capture and understand the world around us. Combining sensors, software and emitters, we bring the information that our environment holds to light by capturing, analyzing and visualizing it. We sense the world and make sense of it.

https://ams-osram.com

#Mass transfer

ASMPT SEMI Solutions

Mass transfer & mass bonding equipment for MicroLED production

Globally headquartered in Singapore, ASMPT is a leading global supplier of hardware and software solutions for the manufacture of semiconductors and electronics. ASMPT's solutions range from wafer deposition and laser grooving to the others that shape, assemble and package delicate electronic and optical components into a wide range of end-user devices, which include electronics, mobile communications, computing, automotive, industrial and LED (displays).

ASMPT provides mass transfer & mass bonding equipment for MicroLED production and works close with Tier-1 microLED display makers.

https://semi.asmpt.com/en/

#MicroLED research

CEA Leti

One of the world's largest microelectronics and nanotechnology organizations

CEA-Leti is a non-profit research institute based in Grenoble, France. CEA-Leti is one of the world's largest microelectronics and nanotechnology organizations.

Leti is developing micro LED displays, with a focus on high-performance microdisplays. Leti has implemented this LED technology to manufacture high-brightness uLED arrays hybridized on silicon circuit with a 10-um pixel pitch and the institute manufactures blue and green arrays offering a brightness of 107 cd/m².

http://www.cea.fr/english

#Production equipment, #Microdisplays

ClassOne Technology

Single wafer electroplating and wet process platform for microLED production

US-based ClassOne Technology develops and sells high-performance electroplating and wet processing systems for the manufacture of advanced microelectronics, for both R&D and high-volume fab environments.

For the microLED industry, ClassOne offers its Solstice single wafer electroplating and wet process platform, which the company says is installed at several microLED developers. The company also offers its reactor technology for the industry.

In 2022, ClassOne announced that it shipped its Solstice S4 single-wafer plating system to Raxium, a microLED microdisplay developer acquired by Google. ClassOne also collaborates with the Fraunhofer ENAS to develop hybrid bonding for microLED applications.

https://semi.asmpt.com/en/

#Lasers, #production equipment, #mass transfer

Coherent

Laser-based solutions for the microLED industry: from a single laser source up to LLO, LIFT and repair systems

Coherent makes the amazing possible using the power of light. Performance, quality, and a global expert network support our customers in scientific, medical, electronics, and manufacturing markets.

MicroLEDs represents an exciting opportunity, potentially lowering the costs for very large area displays as well as some small area display applications. High energy, ultraviolet lasers are the key to success to cut production costs, increase throughput, and improve quality. Coherent provides several solutions from a single laser source, optical systems up to an integrated system for the three vital processes in MicroLED fabrication: Laser Lift-Off (LLO), Laser-Induced Forward Transfer (LIFT), and Repair/Trimming. Coherent also covers more process steps of the entire MicroLED production chain from laser cutting by ultrashort pulse lasers to Laser Assisted Bonding (LAB) by diode lasers.

http://www.coherent.com/

#materials & technologies, #LED epiwafers

Comptek Solutions

Develops quantum technology that boosts the performance of devices such as microLEDs and lasers

Founded in 2017 as a spin-off from the university of Turku, Finland, Comptek Solutions develops quantum technology (branded as Kontrox) that boosts the performance of devices such as microLEDs and lasers and makes their manufacturing process easier by solving the problem of aggressive oxidation of compound semiconductor materials.

Kontrox results in a high-quality passivation layer with substantially reduced defect densities that help to greatly decrease the surface recombination phenomena which is a predominant mechanism for such small devices.

Comptek says that MicroLED efficiencies increase significantly with Kontrox, the company has demonstrated up to 250% EQE (external quantum efficiency) improvements.

http://www.comptek-solutions.com

#materials & technologies

DELO

DELO is a leading manufacturer of high-tech adhesives and other multifunctional materials as well as corresponding dispensing and curing equipment. Their products are mainly used in the automotive, consumer electronics and semiconductor industries. They can be found in almost every mobile phone and half the cars worldwide, for example in cameras, loudspeakers, electric motors, or sensors. Customers include Bosch, Daimler, Huawei, Osram, Siemens, and Sony. The company has 1,000 employees and achieved revenues of €204 million in fiscal 2023.

Additionally, adhesives facilitate miniaturization, increase performance, and improve device functionality and reliability, from tiniest SMD component like miniLED and microLED to large size edge sealing.

https://www.delo-adhesives.com

#mass transfer

eLux

Massively parallel fluidic assembly of microLED displays

eLux Inc. was established in 2016 in the USA as a spin-out from Sharp Labs of America. eLux expertise and intellectual property development focus on the massively parallel assembly processes that enable low cost manufacturing of microLED displays.

https://www.eluxdisplay.com/

#Mass transfer

Ennostar

The holding company of Lextar, Epistar, Unikorn and Yenrich

Taiwan-based Ennostar was established in early 2021 as a joint venture between Epistar and Lextar. Ennostar is the holding company that owns both Epistar and Lextar, and together the two companies hold about 12.5% of the global LED chip market. Ennostar also holds Unikorn and Yenrich.

Ennostar official goal is to become a multinational investment platform for the compound semiconductor industries. Specifically the focus is on mini LEDs and microLEDs products and technologies.

https://www.ennostar.com/

#materials & technologies

Excyton

Commercializes a novel display architecture that reduces power and extends the lifetime and color gamut of emissive displays.

Excyton is an early-stage company that commercializes a novel display architecture that reduces power and extends the lifetime and color gamut of emissive displays.

The TurboLED architecture adds light-color emitters (red, green and blue) that help to maximize the performance of the display.

https://excyton.com

#LED epiwafers

Epistar

One of the world's leading LED producer

Epistar Corp, based in Taiwan and established in 1996, is one of the world's leading LED producers. The company specializes in high-brightness LED devices for general lighting and consumer electronics.

Epistar is developing Micro LED chips and technologies. In 2021 Epistar merged with Lextar to form Ennostar.

http://www.epistar.com.tw/index_en.php

#materials & technologies, #microdisplays, #MicroLED Research

Fraunhofer FEP

Electron beam technologies, vacuum thin film deposition techniques and technologies for organic electronics, microdisplay technology and sensorics.

The Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP is one out of 76 institutes and research units of the Fraunhofer-Gesellschaft e. V., the largest European institution for applied research. The core competences of Fraunhofer FEP are electron beam technologies, vacuum thin film deposition techniques and technologies for organic electronics, microdisplay technology and sensorics. Main activities target development and adaption of the thin film deposition technologies to a wide range of industrial applications. Fraunhofer FEP runs multiple pilot scale vacuum coating systems.

Furthermore, Fraunhofer FEP has a unique position in designing microelectronic circuits and components with application- and customer-specific adaptations of silicon circuit foundries' CMOS processes that allow these finished wafers to be subsequently processed with OLED coatings, for example. This subsequent processing is used in particular for augmenting silicon CMOS wafer functionality with optical and photonic components, such as for high-resolution OLED microdisplays.

https://www.fep.fraunhofer.de/en.html

#materials & technologies, #MicroLED Research

Fraunhofer IZM

One of the world's leading institutes for applied research and the development and system integration of robust and reliable electronics

For 30 years, more than 440 employees have been finding technological solutions in cooperation with partners from industry and academia. Emerging challenges are addressed in branches such as automotive and industrial electronics, medical engineering, ICT and semiconductor technology.

Our technologies connect the individual components, protect components and devices from vibration and moisture, and reliably dissipate heat. Fraunhofer IZM thus ensures that electronic devices continue to function reliably in even the harshest conditions. Modern packaging technologies make developing smaller and smaller products possible. We process ICs thinner than a sheet of paper. The institute, founded in 1993, disposes of a lab area of over 8,000 sqm. About 80 percent of our turnover in 2021 was earned through contract research.

https://www.izm.fraunhofer.de/en.html

#color conversion

General Electric

For more than 125 years, GE has invented the future of industry. Today, GE is best known for its work in the Power, Renewable Energy, Aviation and Healthcare industries.

GE's Licensing team provides access to GE's patent portfolio and technical and intellectual resources. Licensees receive world-leading technology paired with advice and guidance to accelerate their technology development and achieve market differentiation.

The GE LED Phosphors team has world class chemistry and physics expertise as well characterization capabilities that have resulted in commercial successes in both lighting and LCD display technologies. Multimillion-dollar yearly revenue, multiple awards, hundreds of patents, over 20 licensees of our patents, along with various publications and invited conference presentations show that this team is on the cutting edge of luminescent material development and can advance from concept to invention to commercialization.

https://www.ge.com

#inspection & repair

InZiv

Testing and inspection tools for the microLED industry.

InZiv provides testing and inspection tools for the microLED industry. InZiv's technology offers one comprehensive platform for both full wafer mapping and individual chip testing and characterization at the highest resolution. Automated PL and EL provide today's most critical measurements, including EQE and angular measurements, and Nano-PL and Nano-EL enable the user to zoom in on individual chips and sub-pixel features and defects with 100nm resolution.

InZiv integrates multiple inspection modalities in one system, and provides a comprehensive analysis of both the whole wafer and its sub-pixel features. This unique combination empowers microLED developers and manufacturers with the ability to better understand the relationship between light, color, current, and structure – directly addressing today's most critical challenges in microLED.

https://inziv.com/

#mass transfer

Kulicke & Soffa

Advanced microLED placement solutions

Kulicke & Soffa (NASDAQ: KLIC) is a leading provider of semiconductor, LED and electronic assembly solutions serving the global automotive, consumer, communications, computing and industrial markets. Founded in 1951, K&S prides itself on establishing foundations for technological advancement – creating pioneering interconnect solutions that enable performance improvements, power efficiency, form-factor reductions and assembly excellence of current and next-generation semiconductor devices.

The Company further extends its mini and micro LED technology and solutions through strategic acquisition of Uniqarta in 2021.

https://www.kns.com/

#LED epiwafers

Lextar

LED developer and microLED chip maker

Established in 2008 in Taiwan as a subsidiary of AU Optronics, Lextar Electronics Corporation is a leading global LED developer. Lextar produces LED chips, LCD backlights, automotive LEDs, lumiaires and other lighting solutions.

In 2018 Lextar introduced its first micro-LED chips – both RGB ones and color conversion ones, both suitable for mass transfer processes.

Lextar is now a part of Ennostar, following a merger with Epistar.

http://www.lextar.com/

#microLED displays

LG Electronics

The LG Business Solutions Company is a trusted partner offering innovative products and solutions for diverse industries worldwide.

With a portfolio of unique offerings, such as industry-leading OLED signage, LED signage and commercial TVs, LG is a respected name among customers around the world.
For more on LG's Business Solutions, visit www.LG.com/b2b

https://www.lg.com/global/business

#color conversion

Mitsui Kinzoku

Produces functional engineered materials and electronic materials, nonferrous metal smelting.

Japan-based Mitsui Mining & Smelting (also known as Mitsui Kinzoku) produces functional engineered materials and electronic materials, nonferrous metal smelting, minerals resource development, precious metal recycling, raw material related businesses, manufacturing and sale of automotive parts/components, etc.

For the MicroLED Industry, Mitsui Kinzoku developed a sulfide phosphor for color conversion. The material is highly durable and does not contain any hazardous material. As of 2023, the company is sampling the material for microLED developers.

https://www.mitsui-kinzoku.co.jp/mlab/en/

#Materials & Technologies

Mojo Vision

Developing RGB Micro-LED displays

The Future of Micro-LED Technology is Here

Mojo Vision is focused on developing and commercializing world-class micro-LED technology for consumer, enterprise, and government applications. Developed as a critical component of Mojo Lens and first announced in 2019, the Mojo Vision Micro-LED Display is the smallest, densest dynamic display ever made, and the Micro-LED technology platform underlying it is powerful and flexible enough to serve a wide range of applications from next generation wearables all the way up to future televisions and video walls. We believe Micro-LED will disrupt the entire $160B display industry and our unique technology puts us at the forefront of this disruption.

https://www.mojo.vision/

#display drivers

nsc innovation

Monolithically integrating GaN LEDs with silicon CMOS to enable microdisplay solutions

nsc is a groundbreaking integrated circuit design company based out of Singapore. Our chips are the first to effectively integrate silicon CMOS with GaN LEDs monolithically and at full wafer scale, while maintaining compatibility with traditional CMOS manufacturing. By doing so, nsc offers the functionality and manufacturability needed to enable widespread adoption of microdisplays. These highly efficient and cost-effective LED pixelated light engine (PLE™) chips can serve as the backbone for displays that will change the form factor of wearables, increase battery life, decrease cost, and make possible game-changing new product innovations. Our integrated chips are produced by co-opting existing manufacturing equipment and processes in order to deliver them at commercial scale.

https://www.nscinnovation.com

#Materials & Technologies

Pixelligent

Create and manufacture advanced tunable, high refractive index (RI) nanocrystal formulations and dispersions, Extended Reality (XR) devices, and sensor applications.

Pixelligent is a developer of industry-leading PixJet®, PixNIL®, PixCor™, and PixClear® Designer Compounds®. We create and manufacture advanced tunable, high refractive index (RI) nanocrystal formulations and dispersions that deliver the highest refractive index, most robust mechanical properties, and near-perfect transparency for next-generation displays, Extended Reality (XR) devices, and sensor applications.

Pixelligent has nearly 100 issued and pending patents, raised $100M in funding, been awarded over $15M in federal grant programs, and is ISO 9001 certified. Our 20,000 square-foot, state-of-the-art manufacturing and laboratory facility is located in Baltimore, Maryland and is supported by sales offices in the Republic of Korea and Taiwan and distributors throughout Asia.

https://pixelligent.com

#MicroLED displays

PlayNitride

PlayNitride Inc. was formally established in 2014, located in Hsinchu Science Park, Taiwan. The company aims to bring new thinking to Nitride industry. PlayNitride developed its proprietary solution, including epi-wafer production, MicroLED chip process, mass transfer, mass inspection, mass testing, and mass repair (SMAR•Tech).

PlayNitride developed three solutions, the PixeLED Display (TFT backplane), PixeLED Matrix (PCB) and μ-PixeLED (CMOS silicon microdisplays).

PlayNitride has built a MicroLED production line in 2019. In 2022, the company was listed on the Taiwan Stock Exchange (TPE: 6854). Through the innovative R&D and diverse business models, PlayNitride has become a leading company in the field of MicroLED technology.

https://www.playnitride.com

#LED epiwafers

Q-Pixel

Overhauling Decades of microLED Display Technology by Replacing Century-old Monochromatic LED.

Q-Pixel is an innovator of polychromatic RGB microLED which is a revolutionary device to solve several key issues with decade-old microLED display technology. Problems, such as achieving ultra-high density pixels, high-yield mass transfer, etc., can be solved with a single full-color pixel.

https://www.quantum-pixel.com

#Color conversion

Qustomdot

Cadmium-free quantum dots technology for microLED displays

Belgium-based QustomDot brings unmatched colors through quantum dot (QD) color conversion to microLED applications. The team combines QD synthesis, surface engineering and ink/photoresist formulation into patterned color conversion layers for microLED displays. QustomDot's patented technology is cadmium free and can withstand high light intensities.

https://www.qustomdot.com

#Mass transfer

Rohinni

Precise miniLED and microLED placement technology

US-based Rohinni, established in 2013, focuses on miniLED and microLED technologies for lighting and displays.

Rohinni has developed precise placement technology that can achieve speeds greater than 100Hz for mini LEDs. Rohinni's technology has been adopted in the display, automotive and consumer electronics markets.

https://www.rohinni.com

#

Safran Vectronix

Safran Vectronix AG, part of a multinational aerospace and defense company

Safran Vectronix AG, based in Switzerland, is part of the Safran Group – a multinational aerospace and defense company equipment and components.

Safran Vectronix AG designs, develops and manufactures observation devices for defense and security forces.
The company integrates microdisplays in its products.

https://safran-vectronix.com

#Materials & Technologies

Smartkem

Seeking to reshape the world of electronics with a revolutionary semiconductor platform that enables the next generation of low-cost displays and sensors.

SmartKem's patented TRUFLEX® inks are solution deposited at a low temperature, on low-cost substrates to make organic thin-film transistor (OTFT) circuits. The company's semiconductor platform can be used in a number of applications including mini- and micro-LED displays, AMOLED displays, AR and VR headsets, fingerprint sensors and integrated logic circuits. SmartKem develops its materials at its research and development facility in Manchester, UK, and its semiconductor manufacturing processes at the Centre for Process Innovation (CPI) at Sedgefield, UK. The company has an extensive IP portfolio including over 124 issued patents across 19 patent families.

https://www.smartkem.com

#MicroLED research, #LED epiwafers

Solid State Lighting & Energy Electronics Center

Researchers to advance solid-state lighting and energy efficient power switching using wide-bandgap semiconductors.

The Solid State Lighting & Energy Electronics Center (SSLEEC) at UC Santa Barbara is a collaborative center, which partners key industry leaders and UCSB researchers to advance solid-state lighting and energy efficient power switching using wide-bandgap semiconductors.

SSLEEC is focused on new semiconductor based technologies for disinfection, advanced mobile displays, energy efficient lighting, and power electronics. The objective of the SSLEEC is to provide a forum for its members – key industry partners and the faculty and student researchers at the University of California, Santa Barbara – to work in collaboration and across scientific disciplines to address the most challenging problems in these important and timely areas of research.

https://ssleec.ucsb.edu

#microLED displays

STRATACACHE

Digital signage systems developer, microLED display producer

STRATACACHE is a digital signage, merchandising and customer engagement systems developer, targeting the retail, restaurants, banking and financing, gaming, events and education markets.

STRATACACHE is constructing the first US-based complete display production facility in Eugene, Oregon, the future MicroLED E4 fab.

https://www.stratacache.com/en/

#Mass transfer, #materials & technologies

Terecircuits corporation

Photo-polymer mass transfer system for microLED production

Terecircuits develops technologies and manufacturing processes for microassembly based on a new class of photo-chemical polymers.

The company focuses on the development of a microLED photo-chemical mass transfer process.

http://terecircuits.com/

#Services

Unikorn

Professional III-V compound semiconductor foundry

Unikorn, spun-off Epistar and now part of Ennostar, is a professional III-V compound semiconductor foundry located in Hsinchu Science Park, Taiwan. Unikorn focuses on epitaxy and wafer/chip processing.

https://www.unikornsemi.com/?lang=en

#microLED displays, #mass transfer, #microdisplays

Vuereal

Micro-LED display technologies and display production

Canada-based VueReal is a startup company that develops Micro-LED display technologies. VueReal developed a cartridge-based microLED printing process that can produce high density displays at high production yields.

In addition to microLED technologies, VueReal also produces microLED displays, and offers custom display production done at its pilot production line in Waterloo, Canada.

https://www.vuereal.com

#MicroLED displays

Yenrich

miniLED and microLED direct view displays

Yenrich, spun-off from Epistar and now part of the Ennostar group, develops mini-LED and micro-LED packaging. The company is focused on direct-view displays, both miniLED based and microLED based.

https://yenrichtech.com/en/