

# MICROLED DISPLAYS - INTELLECTUAL PROPERTY LANDSCAPE AND ANALYSIS 2021

Market & Technology Report - April 2021

*Joining Apple, Samsung, LG, XDisplay, PlayNitride, Facebook and others, newcomers are accelerating microLED patenting activity.*

## WHAT'S NEW

- Fully updated intellectual property landscape with over 1640 new patent families
- Identify new players, spikes in activity, changes in hot areas
- Identify new technology trends for each segment including transfer and assembly, pixel and display architecture, driving, monolithic microdisplays, color generation and conversion, light shaping and extraction, tiling, in-display sensors etc
- Key technologies and maturity levels

## KEY FEATURES

- Extensive Excel database with 4100 patent families with hyperlinks to original documents, abstracts, assignees and applications in each family
- IP leadership, newcomers and major trends
- Key patents and emerging trends
- IP collaboration networks between players
- Portfolio strength ranking for each technology node
- Time evolution of filings by company, country, technology node and company type
- Geographic trends by country of filing and company headquarters
- Overview of China's IP trends

## AFTER A LATE START, DISPLAY MAKERS NOW STRONGLY DOMINATE IP ACTIVITY

Our micro-Light Emitting Diode (microLED) display report now features close to 9,000 patents from 480 organizations. Most existing display makers were late to the microLED game. Many were initially either dismissive of the technology, or unprepared to tackle its many challenges. Key MicroLED enabling technologies such as mass transfer and LED chips are far from display makers' traditional core expertise. But in 2014, Apple's acquisition of Luxvue put microLEDs on the map. Panel makers realized that it could someday become a credible display technology, disrupt the supply chain and challenge their position.

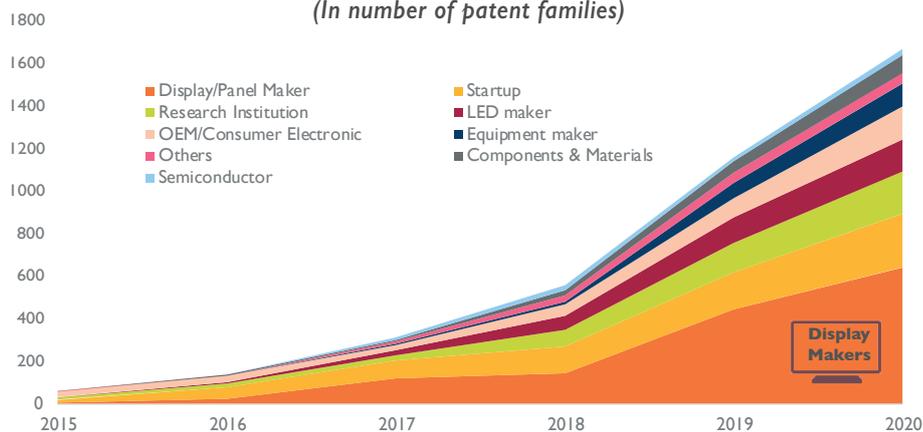
As a result, intellectual property (IP) activity and microLED investment have been increasing exponentially since 2015. All leading consumer electronic companies, panel and LED makers accelerated their microLED development efforts. By 2018, they were joined by equipment makers, material suppliers, and others who, as microLED edges closer to volume

manufacturing, are seeing opportunities to serve the industry with dedicated tools and materials.

More recently, microLEDs' position in leading panel makers' R&D portfolio and technology roadmaps has started to move from defensive to strategic. Companies that have missed the Organic LED (OLED) opportunity, sometimes limited in their ambitions by the massive capital expenditure requirement or a weak intellectual property position, see in microLED a leveled playing field with a lower entry price.

MicroLEDs could rapidly become the dominant display technology in Augmented Reality (AR) glasses. In most high-volume consumer applications however, the risk that microLEDs will ever fully displace Liquid Crystal Displays (LCD) or even OLED remains low. Nevertheless, microLEDs' unique features could guarantee a comfortable share in many high-end segments with attractive profitability and become a key income generator.

**Time evolution of microLED patent publication by company type**  
(In number of patent families)



(Yole Développement, April 2021)

## PANEL MAKER HEAVYWEIGHTS TAKE THE LEAD, BUT STARTUPS AND NEWCOMERS ARE READY TO CHALLENGE

Activity is strongly dominated by Chinese companies, followed by Korea. LG and Samsung made strong showings in 2019 and kept up the pace in 2020 in terms of new applications. Samsung made a remarkable push with more than 130 new patent families, revolving for the

most around its Display division's self-assembled nanorod LED technology, often referred to as Quantum Nanorod Emitting Devices (QNED). The patents show the technology maturing, and a commitment to tackle the challenges associated with moving QNED from the lab to the fab.

This report has been performed in collaboration with KnowMade and includes in-depth analyses of 5448 patents and patent applications grouped in 2453 patent families.

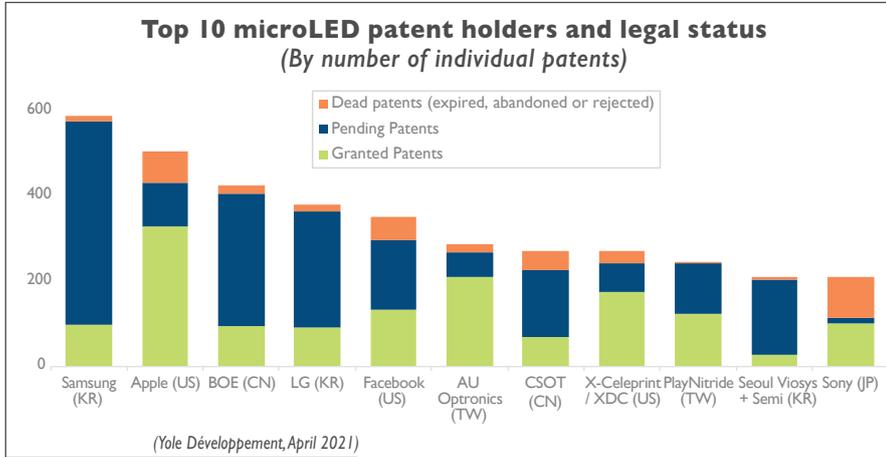


CSOT and BOE led patenting activity in 2019 and remained close to the top in 2020. With similar levels, startup PlayNitride, which raised another \$50M in 2020 to expand capacity, plays in the same league as leading panel makers and OEMs. Aledia, which moved into a new R&D facility in 2019 and raised close to US\$95M in 2020 to build a fab, is also accelerating its IP effort, inching closer to

historical leaders such as XDisplay. Panel makers that were missing have now entered our patent corpus including Japan Display, CEC Panda, HKC and Sakai Display.

The field is getting crowded but there is still time for ambitious newcomers to build credible portfolios. In late 2019 and early 2020, Konka and Visionox announced plans to invest \$365M and \$175M respectively in mini and microLED development and production ramp ups. Konka only filed its first microLED patent in 2019 and Visionox in 2017, but both already have sizable portfolios of pending applications, some showing a surprising level of maturity.

Activity at Apple peaked in 2017. However, the quality and details of new applications shows how far the company's technology has advanced. The acquisition of Tesoro indicates a focus that is shift or expansion toward enabling volume production rather than fundamental technology development. TSMC, which is expected to be one of Apple's key partners, appears for the first time in our corpus.



### INCREASING TECHNOLOGY MATURITY AND EVOLUTION TOWARD SOLVING MANUFACTURING CHALLENGES

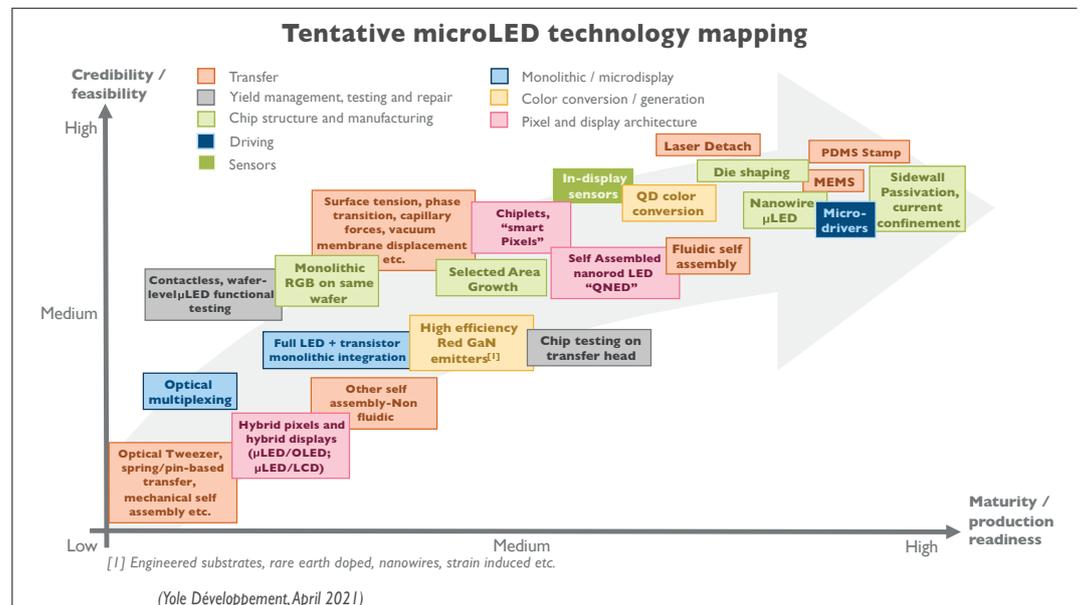
Many recent patents feel “closer to reality”, going deep into details of pixel bank structures and backplanes, or aiming at improving manufacturing efficiency. Detailed analysis shows that most of the IP leaders are moving beyond concepts and lab prototypes and tackling the challenges of bringing microLEDs to mass production. Inventors never seem to run short of new ideas to improve capabilities, cost of ownership, and enable freedom of operation in an increasingly crowded IP landscape.

Growing numbers of applications describe backplanes with testing functionalities, redundancies, and repair management. Efforts to improve small chip efficiency are accelerating on all fronts, including passivation, current confinement, tunnel junctions and plasmon resonance.

New transfer processes keep emerging, exploiting materials' contraction, expansion, phase changes or

surface tension. Polymer stamps still lead, but laser-based transfer dominated activity over the last two to three years. The 2019 comeback of self-assembly was sustained in 2020. Notably, many of LG's recent applications revolve around a technology ecosystem to enable its fluidic self-assembly process. Transfer is only the first step. With bonding pad sizes and gaps shrinking below 5 μm, die interconnects are challenging at microLED scale. Effort on this issue is therefore accelerating.

Growing the three emitter colors on the same wafer is also a hot area. Pixel chiplets that integrate emitters and driving circuits into a microsystem with redistribution layers are on the rise. For AR or light field, optical multiplexing is an intriguing option worth monitoring.



**COMPANIES CITED IN THE REPORT (non exhaustive list)**

Acer, AGC, Aledia, ANK, Aoshi, Apple/Luxvue, Applied Materials, Appotronics, APT, ASTI, AU Optronics, BOE, CEA, CEC Panda, Century Display, Changelight, HKC, Comptek, Cooledge, Corning, Cree, Dai Nippon Printing, Elux, EPilight, EPistar, Erised, Facebook/Oculus, Foxconn, , General Interface Solution, GLO, Globalfoundries, Goertek, Google/X Development, HC Semitek, HCP Technology, Himax, HiSense, HKC, HP, Huawei, IBM, IMEC, Innolux, Intel, ITRI, Jade Bird Display, Japan Display, Konka, , Kyocera, LG, Lightizer, Longli Tech., Lumens, Lumileds, Luxnour Technology, Mikro Mesa, MTC, Nationstar, Nichia, Nitto Denko, Nthdegree, Optovate, Osram, Ostendo, PlayNitride, Plessey, Point Engineering, Prilit Optronics, PSI Corp, Qisda, QMC, Rohinni, Raxium, Sakai Display, Samsung, Sanan, Seoul Semiconductor, Seoul Viosys, Sharp, Shineon, Siphoton, Sitan Technology, Sony, SUSTECH, Syndiant, TCL, TCL-CSOT, Terecircuits, Tianma, Toray Engineering, , Ultra Display Technology, Unimicron, V Technology, Visionox, Vitrolight, Vuereal, X-Celeprint/X-Display, and more.

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**REPORT OBJECTIVES**

- Industry and intellectual property trends: including timeline, geographic trends, shift in leadership, emerging players, and organization types
- Identify leaders and emerging players
- Show leadership per region and company type
- IP leadership and portfolio strength of leading companies, and their technology/application focus
- Deep insights into the status of microLED display technologies, identifying emerging technologies and trends for each technology node
- Show which organizations are developing similar concepts
- Identify IP collaborations between various organizations



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## ABOUT YOLE DEVELOPPEMENT

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. 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.

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Bank code: 30056  
Branch code: 00170  
Account n°: 0170 200 1565 87  
BIC or SWIFT code: CCFRFRPP  
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- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning a Product or any derivative thereof.

6.3 If the Buyer would like to use data coming from a Product for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement’s Public Relations Director (info@yole.fr) to get an official authorization and confirm that the data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.

6.4 The Buyer shall be solely responsible towards the Seller for any infringement of the obligation described in Article 6.3 above, whether such infringement originates from the Buyer’s employees or any person to whom the Buyer has sent the Products. Furthermore, the Buyer shall initiate and personally take care of any related proceedings in coordination with the Seller, and the Buyer shall bear the related financial consequences in their entirety.

6.5 The Buyer shall define within its Company an identified user who shall serve as a contact person for the License purchased by the Buyer. This person will be the recipient of each new report. This person shall also be responsible on behalf of the Buyer, for compliance with all copyrights and other obligations relating to the protection of the Seller’s IP rights and general compliance with the terms of the License purchased by the Company. In the context of Bundle and Annual Subscriptions, the contact person shall decide within the Buyer which person(s) shall be entitled to receive the protected link that will allow the Buyer to access the Products.

6.6 It is acknowledged and accepted by the Buyer that whether purchased in the form of Bundles or Annual Subscription, all unselected reports will be deemed cancelled and lost after a period of 12 month following acceptance of the corresponding order by the Seller in accordance with provisions of Article 1.3 above .

6.7 It is further acknowledged and agreed by the Buyer that any investor in the Buyer Company, any external consultant of the Buyer Company or any joint venture done with a third party in which the Buyer Company is involved , is not entitled to use a Product, without paying to the Seller the full price for a license to the required Product..

#### 7. TERMINATION

If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be incurred by the Seller, pursuant to such cancellation or postponement.

#### 8. MISCELLANEOUS

8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing and shall be effective upon receipt by the other Party.

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

#### 9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.