

NEXT GENERATION TV PANELS: NEW TECHNOLOGIES, FEATURES AND MARKET IMPACT 2019

Market & Technology Report - June 2019

With flat unit-volumes, heavy capex, and low profitability, the TV panel industry is at a crossroads and must prepare for the next generation of TVs.

REPORT KEY FEATURES

- Emerging TV features (panel size, 8K, wide color gamut, HDR):
 - Driving forces
 - Trends
 - Adoption
 - Six-year volume forecasts
- Emerging TV panel technologies (quantum dots, phosphors, perovskites, nanocell, miniLED, dual cell LCD, microLED, WOLED, RGB OLED, and QD/OLED hybrids):
 - Description
 - SWOT analysis
 - Key players
 - Supply chain
 - Volume forecast per technology
- TV panel capacity analysis (four-year forecast by fab generation, company, region, and technology)
- Key players' technology
- Manufacturing strategies

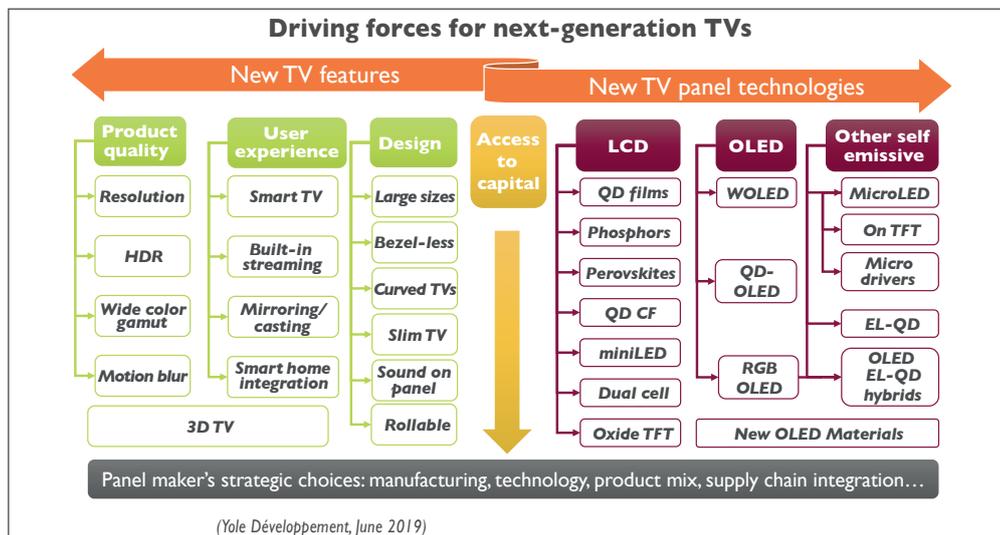
THE TV PANEL INDUSTRY NEEDS A GAME-CHANGER

With unit sales stagnating, TV panel makers are entering what is likely to be a period of prolonged excess capacity. This translates into commoditization and shrinking profitability in an industry that is very capex-intensive.

Players are therefore striving to push larger panels and develop new features like 8K, wide color gamut (WCG), and high dynamic range (HDR) in order to convince consumers to upgrade their TVs with newer, more expensive models. However, these features can be expensive to implement - and with 80% of TVs selling for less than \$500, the industry must find a way to effectively educate and convince consumers that premium sets will deliver a superior viewing experience that is worth the extra money. Another challenge is in creating a full HDR, 8K, and WCG production and content delivery ecosystem. Content creators and broadcasters will be wary of making significant investments in something that could be obsolete with the next product cycle.

An unprecedented variety of technologies are emerging that could deliver some or all of the new advanced TV features required to stimulate demand and pricing. However, in 2019 LCD still dominates with 98.5% of the TV market volume, and will remain unchallenged on entry-level models. Some of the aforementioned technologies are attempting to leverage LCD's manufacturing infrastructure, while others require completely new paradigms and significant capital expenditure. Some, like inkjet-printed OLED and EL-QD, have long-term potential to become cost-competitive with LCD and penetrate mid-range segments. Others will remain confined to the high-end.

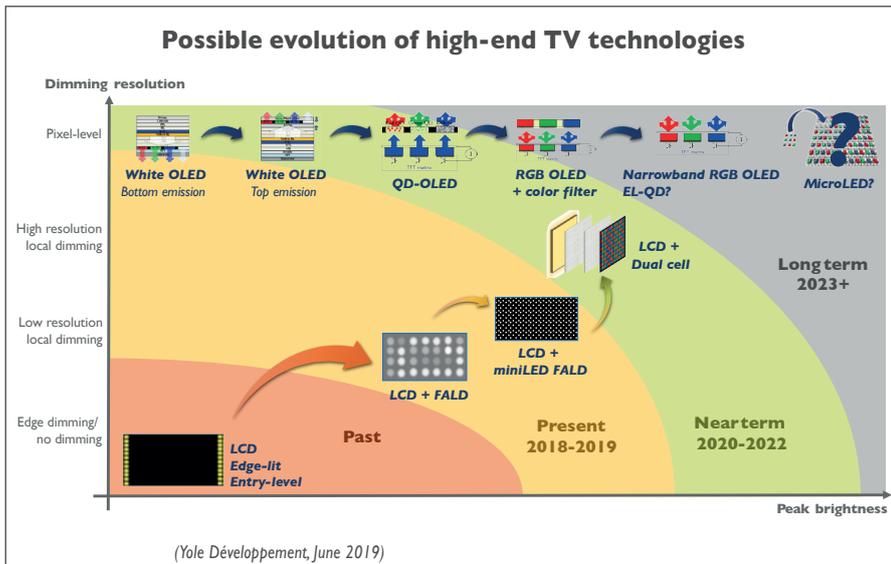
This report analyzes a range of new TV features and the technologies best positioned to deliver them, and looks at the various intersections as a means of understanding the impact on the leading panel makers' strategies.



PANEL MAKERS CANNOT AFFORD TO BET ON THE WRONG TECHNOLOGY

Improvements such as QD films and local dimming have reduced the performance gap and allowed LCD to hold up pretty well against white OLED (WOLED), the only self-emissive technology currently available and which has so far been capacity-limited. Until LG Display ramps up its G10.5 fab in 2021, WOLED will have limited short-term opportunities to significantly reduce cost for the largest panel sizes (>65"). And with the large amount of capacity developing

at BOE, CSOT, and Foxconn's G10.5 fabs in China, the LCD camp has a unique opportunity to create a strong price gap between LCD and WOLED at 65" and 75" panels. In parallel, LCD makers can deliver close-enough performance while leveraging LCDs superior brightness (which is WOLED's major weakness) for further differentiation. Even when LG Display lifts the constraints on WOLED capacity and reduces cost, the window



of opportunity will soon close and the rest of the industry will need to address the high-end market with technologies that can combine perfect blacks, pixel-level dimming, high brightness, wide color gamut, good viewing angles, and fast response times. The leading contenders are inkjet-printed EL-QD and RGB OLEDs, with possible stop-gaps such as QD-OLED and hybrid EL-QD/OLED.

Although still an outsider, microLED is attracting increased attention since it could deliver performance equal to or better than any other technology, and enable the manufacturing of displays of any size without requiring large-size TFT substrates. If successful, microLED would signal the end of the 20+ year evolution towards ever-larger substrate sizes, and disrupt the high-end TV supply chain. However, the road is long and the technology still must demonstrate an ability to scale-down costs to levels acceptable for consumer products.

A STRONG “CHINA PUSH” IS DISRUPTING THE INDUSTRY AND THE SUPPLY CHAIN

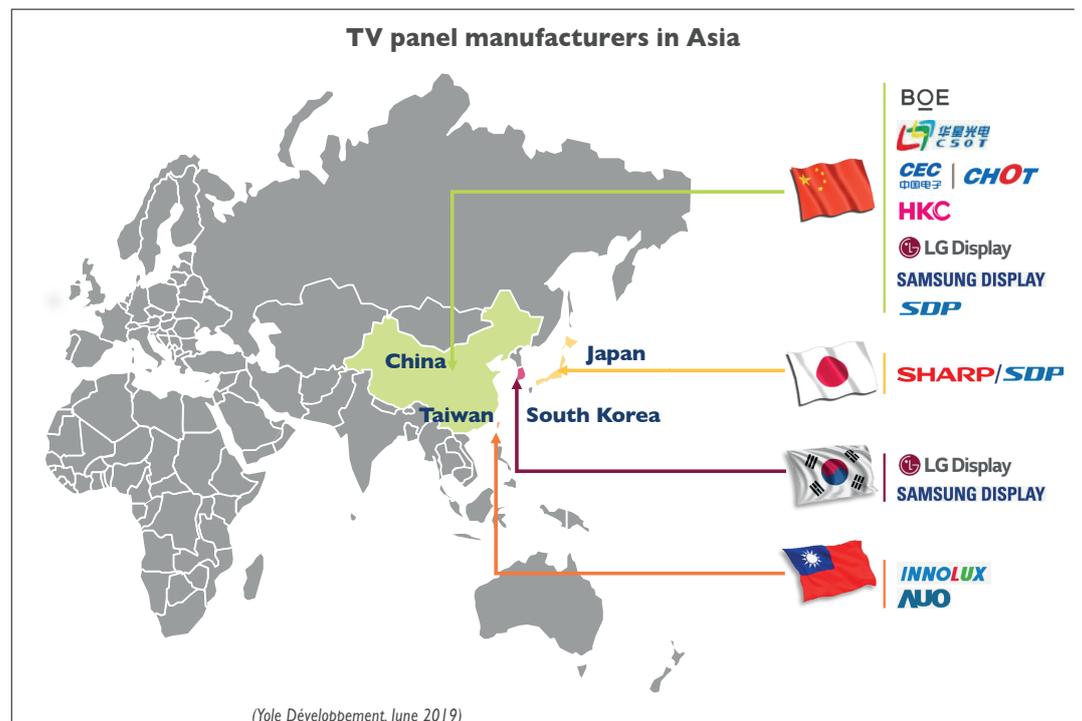
Over the last five years, China has become a dominant player with increasing claims of higher added-value products. Indeed, by 2021 China will possess 55% of global TV panel capacity. To fend-off China’s rise, Korean players must deploy highly differentiating technologies. LG Display got a head start with WOLED, but this could be challenged by 2021 if Samsung Display (SDC) successfully unveils its QD-OLED panels. In any case, WOLED will become mostly obsolete when inkjet-printed RGB OLED or electroluminescent QD are ready for prime time, delivering lower cost and better performance.

With its “supercharged” TV sets, Samsung Electronics has so far resisted the rise of Chinese manufacturers and LG’s advance in OLED. Samsung could keep pushing LCD until Samsung Display’s EL-QD (its end-

game TV technology) is ready, but this would make it difficult to differentiate from Chinese competitors that can improve their LCDs in similar fashion. In addition, LG is unlocking the WOLED capacity bottleneck. Samsung might therefore be forced to rapidly invest in QD-OLED while knowing that it too might become obsolete when printed RGB technologies are ready. Should the company invest large amounts in a technology with a narrow window of opportunity?

Even less envious is the position of Taiwanese manufacturers who are caught between a rock and a hard place, with no mid-term next-generation TV technology in the pipeline and Chinese makers bound to dominate LCD.

Differentiation is the name of the game, but Chinese panel makers are no longer simple followers focused



solely on cost, capacity, and duplication of technologies. Rather, the leading companies like BOE and CSOT now have world-class R&D efforts for OLED, QD, and more. Additionally, generous government subsidies have helped propel these players to the top of the LCD-maker mountain, and could allow them to move faster and bigger

than their competitors on the next generation of TV technologies. The only downside is that access to certain core IP and technologies needed to support and fuel these innovations might prove challenging, given the current trade war and stricter control of technology transfer.

REPORT OBJECTIVES

This report's objectives are to present and analyze the key features of next-generation TVs, understand which technologies are best-positioned to deliver them, and explore the intersections in order to understand the impact and strategies of the leading panel makers.

- Main drivers and obstacles for new TV features?
- Which technologies could deliver these features?
- What technologies and manufacturing strategies are deployed by individual panel makers?
- How can Korean and Japanese manufacturers defend against China's ascendance?
- What are the capacity constraints and the overspending risks?

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