

NEXT-GENERATION HUMAN MACHINE INTERACTION IN DISPLAYS 2019

Market & Technology Report - April 2019

Sensors directly integrated in displays: still a long way to wow!

REPORT KEY FEATURES

- Analysis of trends related to displays integrating HMI functions
- Analysis of key challenges related to sensor and actuator integration, under or in display
- Technical analysis of integration possibilities
- Analysis of related industrial ecosystems
- Analysis of future trends and landscape evolution

REPORT OBJECTIVES

- Provide an understanding concerning the current status of the main sensing and actuating functions in most display-based applications
- Explore the trends toward increasing the display area
- Analyze the core sensing and actuating function technologies, and observe their compatibility with under-display or in-display integration
- Discuss future trends in displays, sensors, and actuators, and their evolution and impact on the ecosystem

OPPORTUNITIES FOR A LARGER SCREEN AREA IN DISPLAY-BASED DEVICES ARE HERE

Since the beginning of the smartphone era, we have observed a continuously-improving trend regarding screen-to-body ratio increase. This is true for any display one can think of: not just smartphones, but also televisions, laptops, smartwatches, etc. And the trend persists, so much so that new display technologies have been developed in order to facilitate the increase.

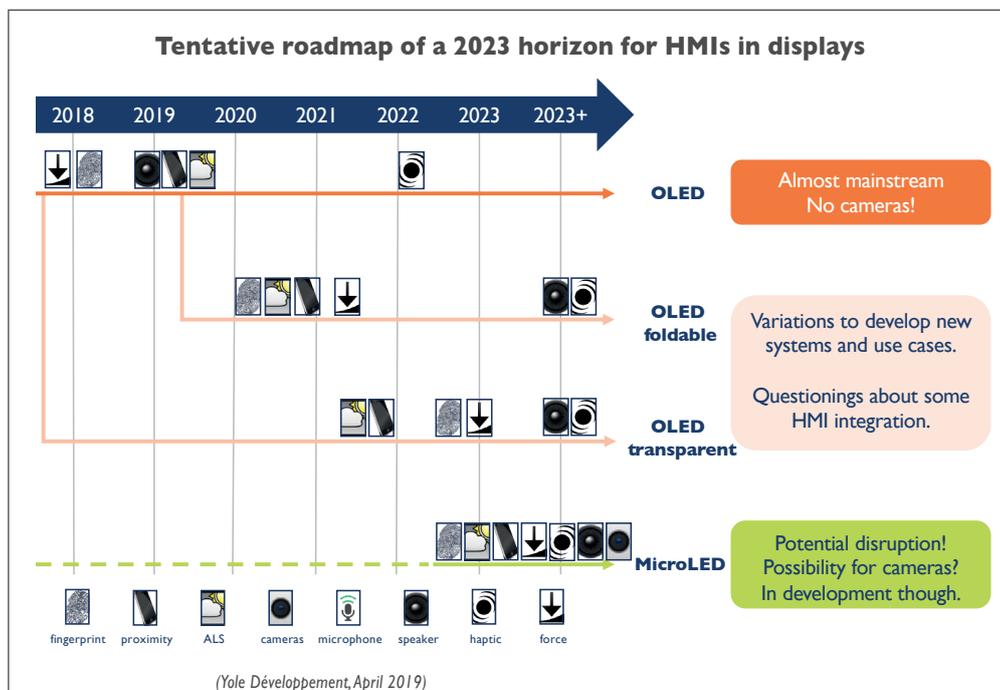
In parallel, since the beginning of the internet of things (IoT) age, billions of connected display-based devices are interacting with one another and acquiring even more sensors and actuators to help them interact with the world, and human beings. Since humans' way of receiving information depends primarily on visual cues, it makes perfect sense to maximize a device's screen-to-body ratio.

To ensure this ratio is maximized to its fullest, human machine interaction (HMI)-based sensors and actuators must be integrated underneath

or on top of the display, within the panel stack. Today, some are, but arguably the most important sensors - front-side cameras that have completely changed the way people interact - are way too big and complex to be integrated simply. This prompts panel makers to cut their devices with "punch-holes" or "notches" that are not UI-friendly nor design savvy.

The question then becomes: can panel makers directly integrate some functions in their panels - and if so, will the supply chain be disrupted because of value absorption by these panel makers? Furthermore, how are these HMIs accomplished today, is there a trend for them to be easily integrated, and when?

This report presents a review of the trends in today's sensors and actuators and the players involved (and their supply chains), and analyzes the possibility of integration directly under or in the display.



MODIFYING DISPLAY PANEL MANUFACTURING FOR HMI INTEGRATION IS NOT COMMONPLACE

Actually, when talking about display integration, the focus is likely on OLED panels since they are the ones offering the most flexibility in terms of sensor

and actuator integration because they are thinner, do not require backlight units, etc. However, their manufacturing process is long and complex.

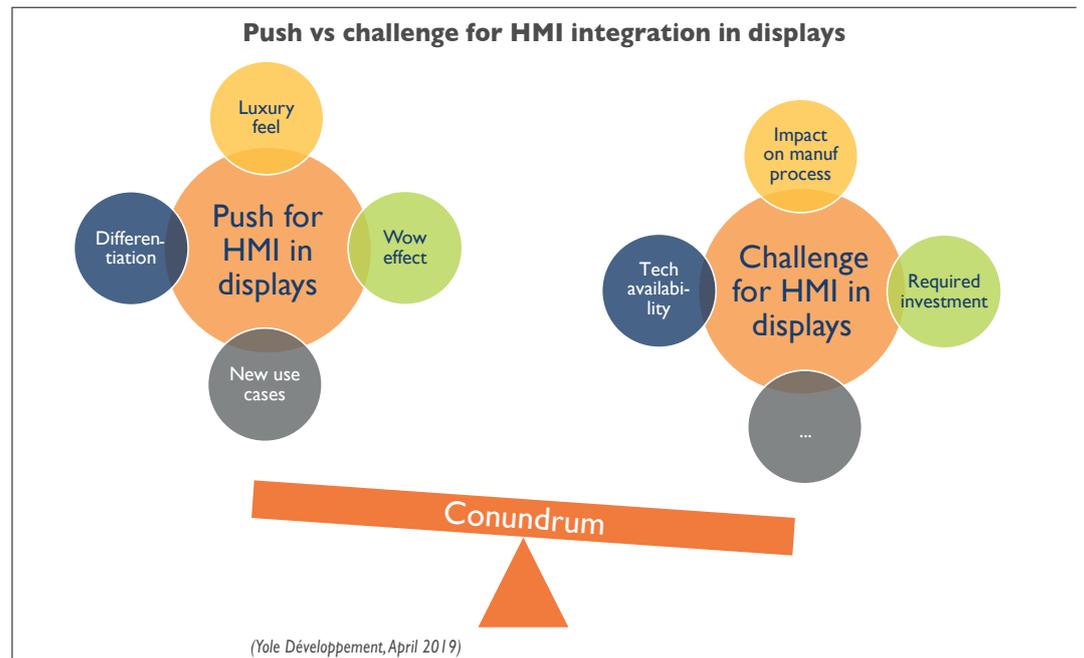
Another limiting factor is that for fabs which cost several billions of dollars, with several tens of steps to follow in order to produce a display panel, a single change in the process flow could drastically diminish the overall yield. And as the current environment is one of overproduction, price competition, and even growing fab capacity, this is not something desirable to panel makers.

Panel makers are hence reluctant to embrace the idea of “intelligent backplanes”, and though some are pursuing R&D efforts to try and integrate sensing functions in backplanes, the majority of panel makers and their associated OEMs are working towards the idea of integrating sensors under or on top of their displays, rather than inside the displays. So most

HMIs will remain, under the condition that they can fight against the harsher conditions of being under the display.

As for front-side cameras, given their size and sheer complexity there does not seem to be a possibility in the next few years to make them disappear - unless they are put into slide-up or pop-up mechanisms as can already be seen, but which raise questions concerning reliability.

This report presents a detailed analysis of display requirements, with a comprehensive overview of display structures and manufacturing, as well as HMIs, and through a thorough presentation of current and potential future solutions analyzes what can/cannot be done for their integration in the display.



SOME FUTURE DISPLAY TECHNOLOGIES COULD ALLOW FOR EASIER INTEGRATION OF SENSORS AND ACTUATORS

The challenge of backplane integration will likely not be accepted by panel makers due to the way displays are made today. Now, is there a display technology that would allow for a way to circumvent this panel manufacturing issue, avoiding TFTs? MicroLED

displays, being right around the corner, could be an opportunity. In fact, the excitement around MicroLED displays is real, even more so since Apple bought Luxvue in 2014.

Display technologies vs HMI functions matrix for possible 2023 integration

Segment	Fingerprint on display		Under panel sensing				Sound on display				Haptics on display					
	Fingerprint sensing		Proximity sensor		ALS		Cameras		Microphone		Speaker		Haptic feedback		Force sensing	
Technology	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In
Under panel or in panel stack	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In	Under	In
OLED																
Foldable OLED																
Transparent OLED																
MicroLED																

Mature
In development
Unlikely

(Yole Développement, April 2019)

However, the challenge exists in how to assemble these panels. The assembly process appears to be one of critical steps that would allow the MicroLED display opportunity to materialize. Today, dozens of processes are being developed for microLED assembly. For each, multiple assembly strategies can be envisioned, i.e. small stamps, large stamps, interposers, etc. The spread in terms of the number of transfer cycles, for example, could be staggering. For instance, we can describe assembly strategies for TVs with more than a 200-fold spread in terms of the number of operations required.

But if the opportunity materializes, it could be a game-changer because, due to the low pixel fill-factor the microLED chips would exhibit

per pixel, a tremendous space would exist for possible front-plane intelligent integration, and the possibility to add sensors for example. This may be the next big thing in terms of HMLs directly integrated in displays, even though the trend taken by OLED panel-user OEMs may seem good enough for everything, even if the most difficult sensors to integrate (i.e. camera modules) could be left aside.

This report offers an overview of microLED displays and discusses the challenges keeping them from disrupting the field, especially in terms of front-plane integration. This report also presents a comprehensive overview of optical structures, current challenges, and key research directions.

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TABLE OF CONTENTS (complete content on [i-Micronews.com](http://i-micronews.com))

Executive summary	13	> Market trends	
Introduction	30	> Players & supply chains	
The display point of view	48	> Technology trends	
> Applications & drivers		Sound on display	195
> Market forecasts		> Market forecasts	
> Market trends		> Market trends	
> Players & supply chains		> Players & supply chains	
> Technology trends		> Technology trends	
Fingerprint on display	136	Haptics on display	215
> Market forecasts		> Market forecasts	
> Market trends		> Market trends	
> Players & supply chains		> Players & supply chains	
> Technology trends		> Technology trends	
Under panel sensing	160	Prospects	229
> Market forecasts		Yole Développement corporate presentation	250

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