MicroLEDs to have their moment

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MicroLED displays have been quietly biding their time, waiting for their moment in the sun. Well, Andy Ciddor writes, that time is now.

MicroLED, like so many LED-based technologies, has been around for quite a while, waiting patiently in the wings for the developments that are finally bringing its moment to shine as a direct display technology. MicroLEDs are simply very small (1 to 10μm) crystalline LEDs, based around a classic PN semiconductor junction (see box: *Light Emitting Diodes 101*) and clustered together in pixel arrays on a single substrate. This makes them easy and cheap to fabricate, fast, energy efficient and endows them with long lives.

MicroLED arrays should not be mistaken for the individual full-sized LEDs on standard SMD (surface-mount) chips that have long been used in the LED panel modules of the high-brightness displays used in LED walls, stage screens and digital signage applications. LED panel modules are expensive to manufacture, heavy and power hungry, and thus require substantial infrastructure to drive, configure, install, transport, support, suspend, power and maintain. This may be viable if you're a major public event; a well-funded production; an outdoor advertising company; or a sports organisation that can collect revenue from advertisers, but it's hardly a mainstream display technology. There are also physical limits to the pixel densities possible in this format, although these boundaries are being pushed by the use of SMD LED chips carrying multiple RGB pixels.

LEDs built on organic substrates (OLEDs) and microLEDs have many similarities in display applications. They're both microscopic light emitting technologies that can be fabricated in arrays on black, light-absorbing substrates, which make their blacks quite black – unlike the best-case darkish-grey of the blacks in light blocking technologies such as LCD displays. This also enables contrast ratios as high as the millions, resulting in the richness of colour so often noted in OLED displays.

Where OLED and microLED sharply diverge is that crystal-based LEDs are more energy efficient than OLEDs. They have very much longer lives (currently 150k+ hours), and don't suffer from OLED's progressive degradation in the shorter wavelengths – seen as blue fading. The ability to drive microLEDs at high levels enables displays with high brightness, and consequently allows the production of displays with a wide brightness range (HDR and beyond) and an extended colour range (currently approaching Rec.2020).

By now you're probably wondering: why, if microLED is so wonderful, isn't it already in wide use? The answer comes in two parts: (1) MicroLED is difficult/expensive to package and complex to connect up the individual LEDs for use in RGB pixel-based displays, and (2) Blue microLEDs with a white phosphor coating are already in wide use; quite likely as the LED backlights of every modern LCD display you can shake a stick at.

Experiments with technologies for mounting and connecting microLEDs as RGB pixels for displays have been going on for some years, and while generally successful, none have reached the manufacturing yields and price points required by the commercial display market. Perhaps the best known of these experimental prototypes are the two 55" HD 'CrystalLED' televisions that quietly appeared on the Sony booth at the 2012 International Consumer Electronics Show (CES). While they attracted a lot of attention, and not a few sales enquiries, these were merely a technology demonstration that it was possible, if not economically feasible, to fabricate and connect up 6.2 million (1920 x 1080 x 3) individual microLEDs in a single device, if you have the resources of Sony's many R&D departments.

Sony currently does manufacture products in its Crystal LED range. However, like most microLED-based products currently on the market, its ZRD family are high resolution (1.26mm pitch) panel modules that each weigh 10kg, measure about 400 x 450 x 100mm, are 320 x 360 pixels (using 345,600 microLEDs) and pull 200W of power. While the quality of the images from these panels is gorgeous, they're not exactly the kind of display that you want on your mobile phone or laptop.

More recently, Samsung has been knocking the socks off visitors to its booths at the 2018 CES, ISE, NAB and InfoComm trade shows, with 'The Wall' (no known connection to Pink Floyd). Billed as a 146" 'modular television screen', this 8K display was indeed spectacular, as demonstrated by the totally eye-wateringly-coloured demo reel that was screening. For me it was a reminder of the early days of colour television when producers demanded that every scene contained as many colours as possible, just to reassure the viewers that they were right to spend all that money on a colour TV. Although The Wall was assembled from hundreds of smaller, 9.37” (238mm), microLED modules, it was essentially a finer-grained version of the LED panel approach. Not exactly a lounge room TV on which to watch your 8K holiday videos or re-scanned 8K re-runs of *M*A*S*H*.

What Samsung has done with The Wall appears to be the trend with newer microLED displays from many display players. Smaller encapsulated microLED modules, around 220 x 210mm (≈240mm diagonal), with pixel pitches in the 0.9mm to 2.5mm range, and bit depths approaching 16-bit, are being mounted onto 400+mm carrier frames that provide mounting, power and signal distribution for several modules. The frames in turn provide the same kind of mounting, power, and signal distribution infrastructure that we’ve come to expect in discrete LED panel systems. Essentially, the microLED module has become a component of the higher resolution LED panel ecosystem.

With a 1mm pixel pitch between encapsulated 10μm microLEDs in a module, there is a vast amount (over 99%) of black substrate between microLED pixels. While this spacing does help to enhance the display’s contrast, it also leaves a lot of room for more microLED pixels when packaging and connection technologies can accommodate them. However any such high density displays are sitting in R & D departments.

As a case in point: in 2014 Apple acquired microLED technology specialist LuxVue. At the time many industry observers expected to see a microLED display on the next Apple Watch, as this was small enough display, in a high-value market, to possibly reach critical mass for economic production. So far the fabled high-definition microLED display hasn’t yet materialised, but it may even be in production while this magazine is at the printers. Things may be getting that close.