The developments in the expansion of colour gamut and dynamic range of televisions

One of the current areas television manufacturers are trying to improve is in colour gamut and dynamic range, as despite what may be common belief TVs are not capable of reproducing all colours. As it stands OLED technology is the current market leader for overall picture quality with about 500 million OLED displays shipped to manufacturers in 2017 (Microled-info.com, 2018). But there is some newly developing technologies that could give OLED a run for its money. Because of the standard set by OLED and these new technologies it would be fair to say that, the gamuts and dynamic range of televisions is better than ever before with even more promise for improvement on the horizon.

Samsung's QLED, the main rival to OLED, is a photoluminescent screen which despite its name uses LCD technology with the addition of quantum dot crystals to boost colour. Quantum dots are the key part of this technology and one of the significant steps of TV development. According to Samsung's own measure of 'Colour Volume' (Withers, 2018) their QLED TVs score very highly with one even achieving 100% (Samsung.com, 2017). Though care should be taken on these statistics as it is a measurement pioneered by Samsung that is a combination of peak brightness and colour reproduction, which just happen to be QLEDs key strengths over OLED. There is however no arguing QLEDs dominance over OLED in these fields with Samsung saying their QLEDs can produce up to 2000 nits (Withers, 2018) in comparison with OLED's 800 and that they can reproduce more than 100% of DCI- P3. Which has to an extent been proved by an independent survey which found the Samsung 'Q7FN' covers 99.57% of DCI- P3 (Demers, 2016). In addition to improved colours and brightness quantum dot manufactures Nanosys also predict they will be up to three times more efficient than current technologies (Morrison, 22/01/2018). Which would mean less power is needed to achieve the higher brightness.

However QLED has its pitfalls too as it is currently let down by their pairing with LCD technology. Where a blue LED backlight coated with a quantum dot nano filter pasees through a LCD layer that produces the actual image (Microled-info.com, 2018). As the backlight is always on the pure black we get from the electroluminescent OLED where the required pixels just turn off is simply not achieved by current QLED technology (Withers, 2018). QLED also fails to achieve the same viewing angle consistency that OLED does and suffers from the LCD pitfalls of slow response time for fast moving images and poor contrast ratio (Withers, 2018). Development and research is now going into pairing quantum dot technology with electroluminescent technology or to make the crystals electroluminescent themselves, 'direct quantum dot'. But that is still a few years off yet.

One option for improving the use of quantum dot technology is to pair them with the newly emerging MicroLED technology. Like normal LEDs these can achieve true black and are electroluminescent. But as they are non organic they are a lot more durable and brighter (Digital Trends, 2018). This all sounds very promising but there are some substantial drawbacks to consider too. Currently the use of MicroLEDs in TVs is at a very early stage making its first

appearance at CES 2018 in a whopping 146” Samsung prototype dubbed ‘The Wall’. Whilst Samsung has said it hopes to have this model on sale within the second half of this year, practically, MicroLED TVs are a few years off, particularly for TVs of a more normal size due complications in reducing pitch size (Morrison, 06/2018). Samsung itself has admitted “a 75 inch or smaller version is still 2 plus years away”. This is not even taking into account if they were to be paired with quantum dot technology. Pairing the two is an even more complex process that “requires a very high level of technical sophistication”(Mu-Hyun, 04/2018). So it is likely several years off till they find a practical way of combining the two incredibly small components, with quantum dots being smaller than 1/10,000th of a human hair in size (Samsung.com, 2018). All that said these are essentially teething problems and MicroLEDs are a growing market. In 2016 in South Korea the home of both Samsung and LG, 67 patents were filed for MicroLED technology. In 2017 that nearly doubled going up to 120 patents (Mu-Hyun, 03/2018). With both LG and Apple also looking into quantum dot technology for their displays (Microled-info.com, 2018). So there is a lot on the horizon for this technology and with many benefits but plenty of teething problems and development challenges to overcome first.

There is also now a range of technologies on offer to further aid the process of achieving blacker blacks and whiter whites. The current market leader in this area is HDR10 primarily due to availability, as manufacturers do not have to pay a licensing fee to use it as an ‘open standard’ (Morrison, 10/2017). The trade off is that it is not as technically advanced as some of its competitors. It is also not backwards compatible or compatible with broadcast. It is therefore mostly used for gaming and OTT viewing which still offers plenty of content and Samsung and Amazon are currently working together to produce around 100 HDR compatible shows including ‘The Grand Tour’ and ‘The Tick’ (Mu-Hyun, 2017). HDR10 does also bring other advantages as it offers 1000 nits with a peak of 4000 nits offering more life like white detail and it reproduces 10 bit colour. Whereby there are 1024 shades of rgb compared to the 256 in 8 bit. This means that it is capable just over 1 billion colours which is a massive improvement over the 17 million of standard 8 bit viewing **(***King, 2017)*.

The current main rival to HDR10 is Dolby Vision or DV, which is more technically advanced than HDR10 offering a peak of 10,000 nits which is roughly that of looking at the midday sky (Morrison, 30/01/2018). In addition it also offers 12 bit colour which has a colour gamut 64 times larger than that of 10 bit (*King, 2017)*. With 4096 shades of rgb and 68 billion total colours. However Dolby Vision comes with similar disadvantages to HDR10 and many more besides. Like HDR10 it is not broadcast or backwards compatible (Morrison, 09/2017) and is mostly restricted to DVDs, OTT and gaming (Archer, 2018). As it is owned by Dolby manufactures have to pay for the use of it (Morrison, 10/2017), though Dolby are involved in the installation of it and make sure everything is working correctly. Health considerations should also be considered here when dealing with 10,000 nits. Having a TV that is capable of that level does not mean it will be at that brightness the whole time. It will be reserved for the brightest parts of an image, but regulations will likely have to be put in place to moderate the use of such brightness. The level of 10,000 nits does not pose a major risk and to put it into perspective the midday sun is roughly 1.6 billion nits (Morrison, 30/01/2018) but it should at least be considered. There is also

the practical issues to consider for example producing the 10,000 nits needed for accurate production of 12 bit colour requires a lot of power. That is not to say it is not feasible particularly with the efficiency savings of quantum dots (Morrison, 2018) and MicroLEDs, it just all needs to be carefully combined in some way.

Owing to HDR10's shortfalls compared to DV and the licensing fee that comes with DV, Samsung, Panasonic and 20th Century Fox have recently teamed up to develop HDR10+ to try and take on DV. It is said to be "punchier, more dynamic and have more depth than standard HDR10" (Parsons, 2018) and also utilises 10 bit colour and the same open use format as its standard counterpart. Its advantages continue with the fact that as with DV it uses 'Dynamic Metadata' meaning better extreme light and dark content across the whole programme. It also has plenty of promised film and OTT content (Roberts, 2018). Though as with HDR10 and DV falls down in its broadcast compatibility and it also falls short of DV's 12 bit colour offering, meaning billions less colours. However if 12 bit content is not actually being widely produced then that does not pose too much of problem and as there is no licensing fee for the manufacturers to pay they are likely to be able to be sold slightly cheaper. So depending on your preferences this would be the highest quality option for the least money as things currently stand. Its availability in TVs is limited though as LG seem unwilling to opt into it due to it being developed by their rival Samsung.

The final form of HDR technology currently on offer is Hybrid Log Gamma (Morrison, 09/2017) or HLG, which has been jointly developed by the BBC and Japan's NHK. This is a particularly significant development as it is designed for use in broadcast which is where DV, HDR10 and 10+ fall down. It is still very much in development with next to no availability of hardware or content but it is a promising option for use in the future. The unavailability of HLG hardware should not be too much of a concern however as it is likely most HDR enabled TVs will be upgraded to support HLG content (Morrison, 10/2017), so that problem can be easily overcome. It would essentially offer the same colour range as the other two options but would lack capability slightly in the bright saturated colours. This is though overshadowed by its major advantage of being able to be used in broadcast. HDR10, 10+ and DV hit a sticking point here due to the complications in making the content compatible for both SDR and HDR TVs. But the BBC and NHK have learned from how they tackled the initial introduction of colour and producing shared content for colour and black and white TVs. They have done this by developing a way of storing more bright detail content that will be applied by HDR TVs and ignored by SDR TVs (Morrison, 09/2017).

From this research there is really two sets of conclusions to be drawn. The first is what is the best option available now. An interesting question as there is no obvious clear cut winner. As outlined in this essay each one has advantages and equal disadvantages. In terms of the current HDR technologies any of them will do at this stage. Dolby Vision obviously offers the best colour range and brightness but that is less widely available due to the licensing issues. So HDR10 and 10+ are perfectly acceptable substitutes. More focus at this point should go on screen technologies as they will apply to more content than what is currently available for HDR.

In terms of current screen technologies it is ultimately up to personal needs. QLED will offer better brightness and colour range but carries the defects of LCD technology. OLED will not be as bright and in general have a narrower colour gamut, but does offer pure blacks and escapes the issues of LCD but carrying its own issues of burn in and decay. Overall though OLED still seems like the best bet as quantum dot technology has not been fully optimised yet.

As for the future that is a entirely different question. If all current research and development goes as planned the watch words are MicroLEDs, quantum dots and HLG. The most promising future for quantum dots is to use electroluminescent technology. That could really challenge the competition and key development to look out for in future. Ultimately the promise lies in either ‘direct quantum dot’ or their coupling with MicroLED. Which in its own could become a strong player once manufacturers have found a way round the pitch size reduction issues and sheer technical complexity of making displays out of them. As for HDR technology, HLG is the one to look out for. This will likely be the first to develop once they have finessed its development and produced HLG compatible hardware and content. That said half an eye should be kept on HDR10+ and particularly Dolby Vision with its 12 bits and 10,000 nits, as to whether they achieve better backwards and broadcast compatibility.

Regardless though of which technology is the best now and which is going to thrive in the future. The one thing that is proven is that yes, thanks to recent developments the gamut and dynamic range of televisions is better than it has ever been before with even more promise on the horizon.

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