MAHATMA GANDHI INSTITUTE OF TECHNOLOGY

(AUTONOMOUS)

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TECHNICAL SEMINAR
ON

ORGANIC LIGHT EMITTING DIODES

(OLEDs)

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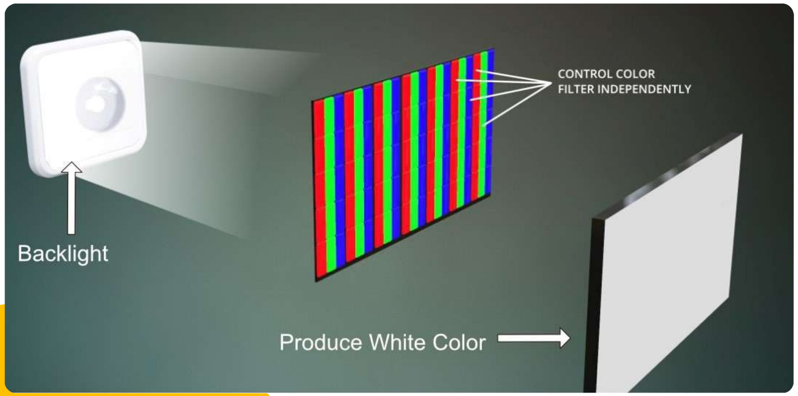
ELECTRONICS AND COMMUNICATION ENGINEER

Contents

What is OLED?



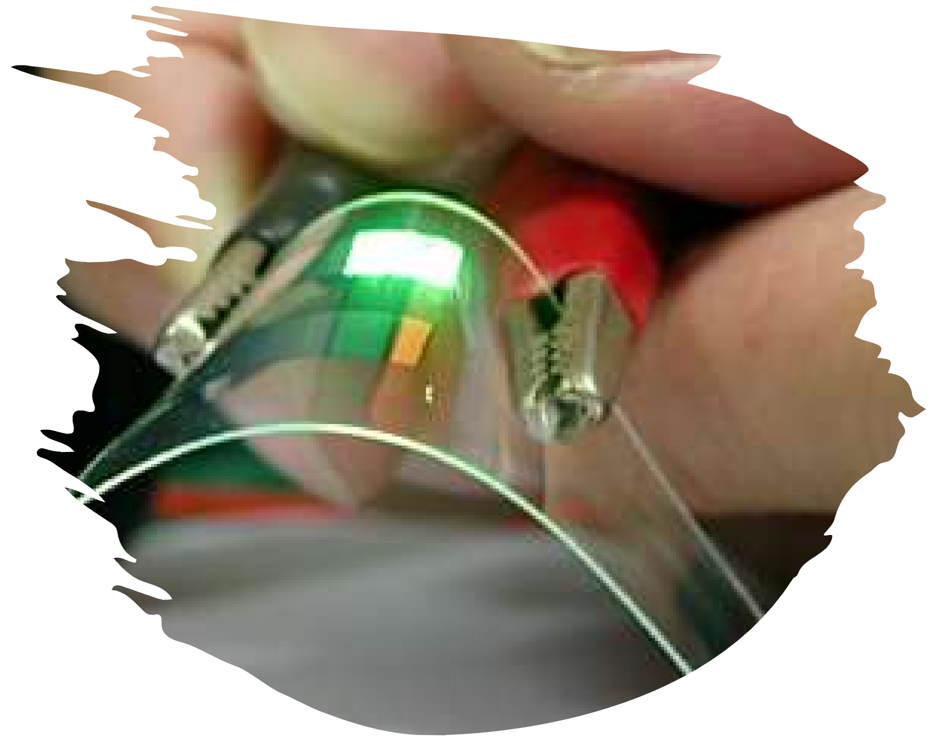
- An OLED display follows the same principle as a LED display, but operates in a slightly different manner.
- A LED panel requires a dedicated backlighting setup to produce light. However, an OLED panel can produce its own light. All this is possible due specially constructed OLED diodes.
- An OLED diode is made of six different layers with two of them retaining organic properties.
- OLED displays are not just thin and efficient - they provide the best image quality ever and they can also be made transparent, flexible, foldable and even rollable and stretchable in the future.
- OLEDs represent the future of display technology!

So what's organic about OLEDs?

- OLEDs are organic because they are made from carbon and hydrogen.
- There's no connection to organic food or farming - although OLEDs are very efficient and do not contain any bad metals - so it's a real green technology.
- OLEDs consist of an organic film/layer that sits inside the panel in front of the glass screen, which is why they are called ‘organic’ LEDs.

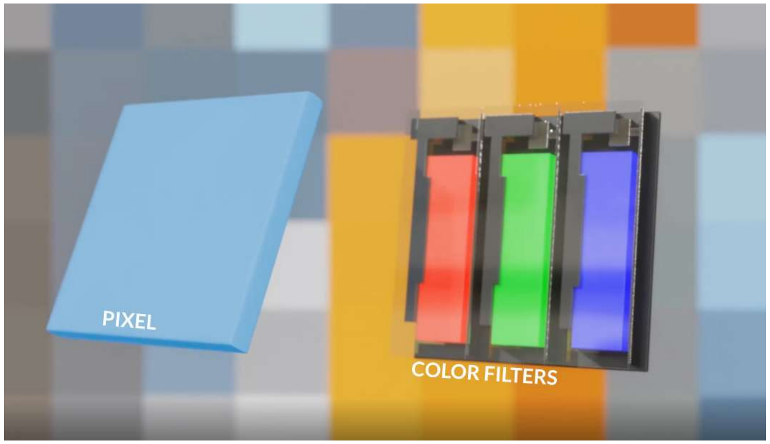
Who invented OLEDs?

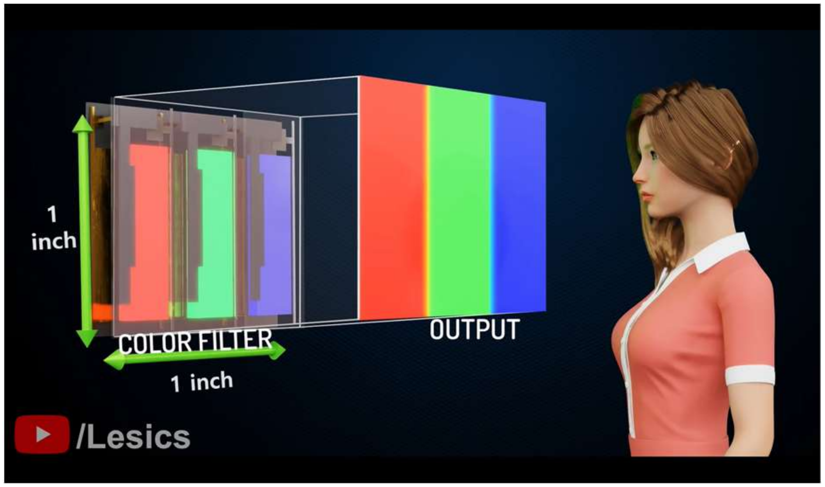
- Organic semiconductors were discovered in the mid-1970s by Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa, who shared the Nobel Prize in Chemistry in 2000 for their work.
- The first efficient OLED—described as "a novel electroluminescent device... constructed using organic materials as the emitting elements"—was developed by **Ching Tang** and **Steven VanSlyke**, then working in the research labs at Eastman Kodak, in 1987.
- Milestones in the development of OLEDs since then have included the first commercial OLED (Pioneer, 1997), the first full-sized OLED display (Sony, 2001), the first OLED mobile phone display (Samsung, 2007), commercial OLED lighting systems (Lumiotec, 2013), and large-screen commercial OLED TVs (by Samsung, LG, Panasonic, Sony, and others in 2012 and 2013).

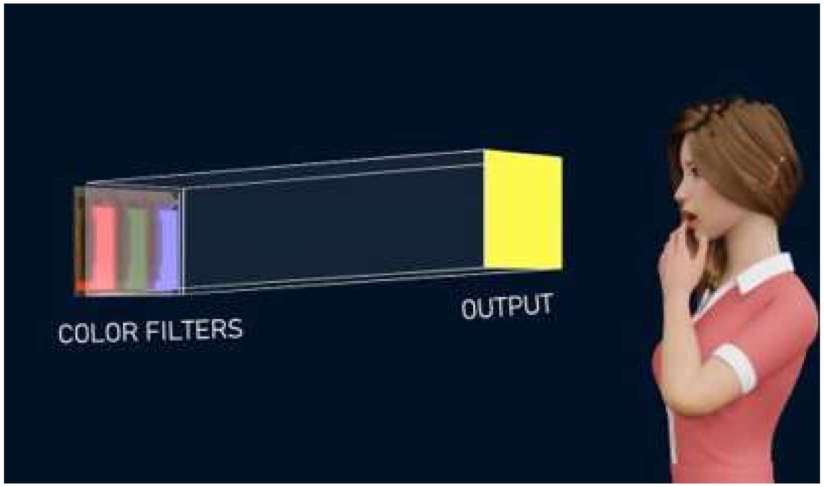


How does a Pixel create?

- Interestingly, the fundamental image reproduction mechanism is the same in all the display technologies.
- The smallest display unit is an element called a pixel.
- Three different color filters inside a pixel.
- The most amazing thing is that we can achieve any color just by illuminating these filters at different intensities.
- You will see the combined color of all. This is due to the limited visual resolution of the human eye; it can't differentiate between subpixels.



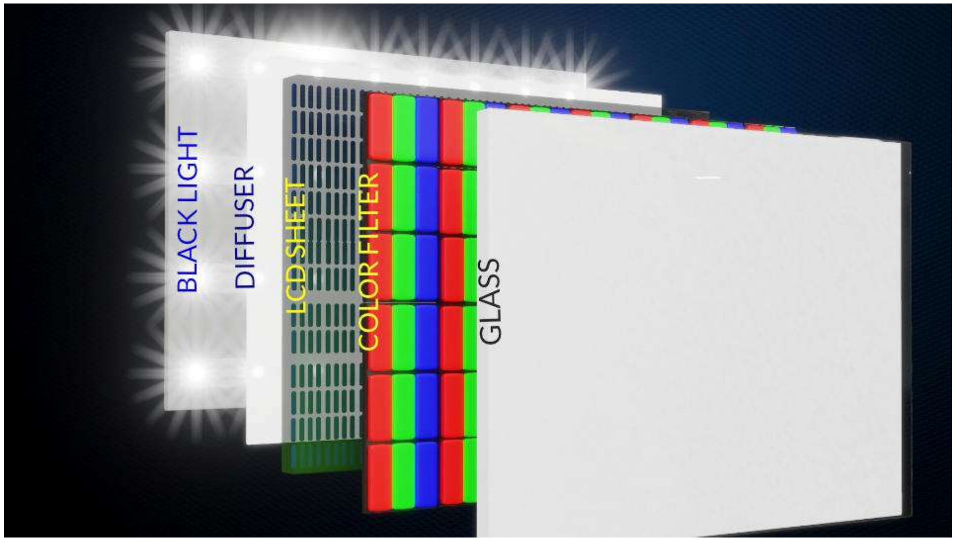




- Let's study this phenomenon with a simple example in a 1 by 1 inch pixel we can see that the colors are distinctive.
- Let's reduce the pixel size slowly have you noticed some differences after a certain pixel size.
- The individual colors are not distinguishable we will see the combined color of all.
- This is due to the limited visual resolution of the human eye it can't differentiate between subpixels.

Now let’s convert these pixels into digital so each pixel has its own position and color data this data is stored in digital form for future reproduction of the image.

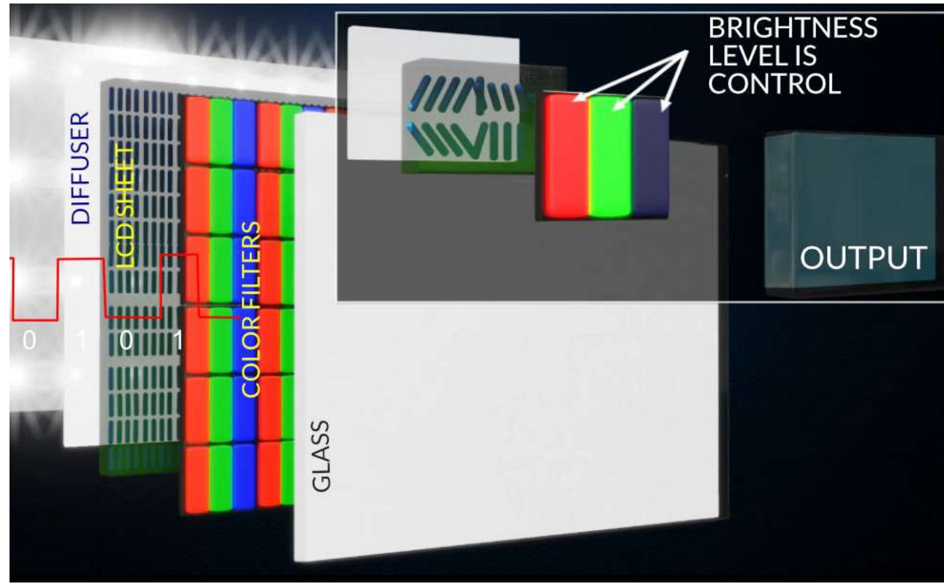
Practical image reproduction

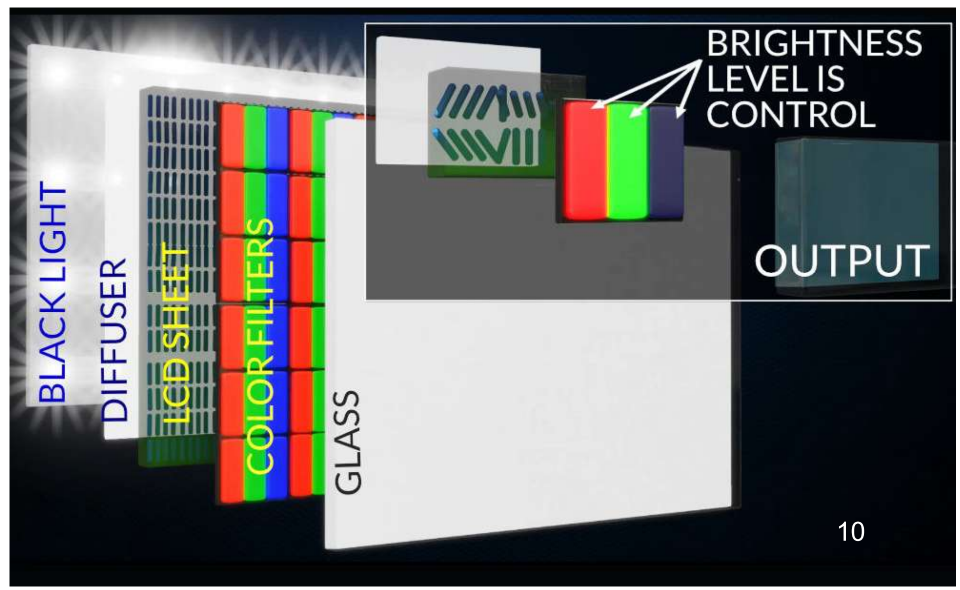


- Now let's see how the image reproduction is done practically.
- Take a uniform white backlight source.
- Keep a color filter containing multiple small red blue and green colors in front of it again place a glass.
- Screen in front of it as soon as we turn on the backlight all the filters will glow with equal intensity,
- And what we get at the output is just white color.

LCD or LED Display

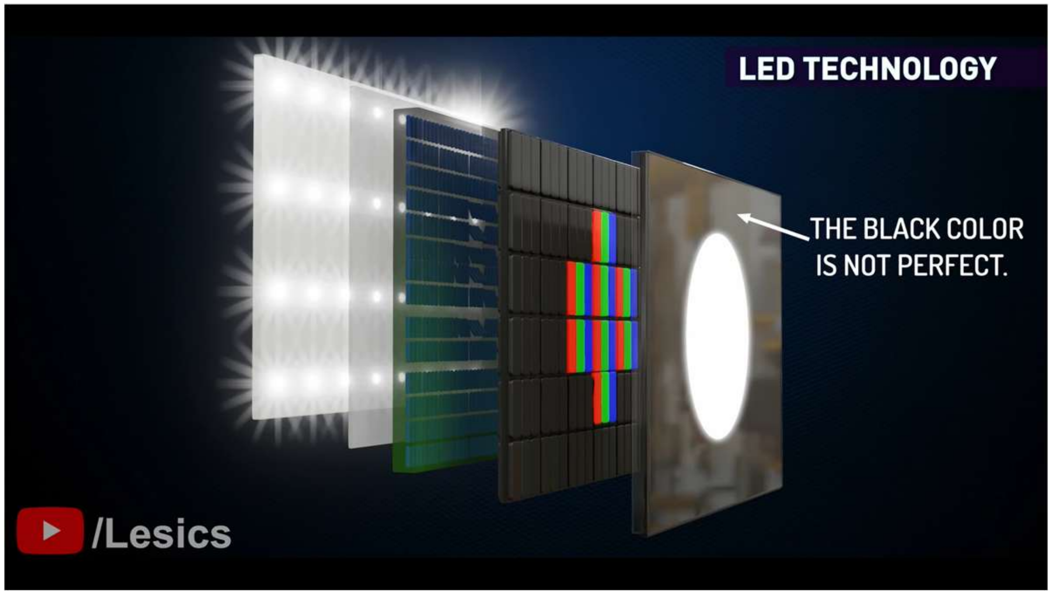
- Now to get the other colors, I just need to get different brightness levels for the sub-pixels. To do this, I will use an LCD sheet and a small circuit.
- The polarization of the LCD crystal can be adjusted, and we will easily get different brightness levels in the subpixels.
- Now, it's time to convert the digital signal we stored to electrical signals. These electrical signals are fed into the circuit. When the signal is received, the crystal in the LCD rotates and polarizes the light. In this way, we successfully produced our original image.

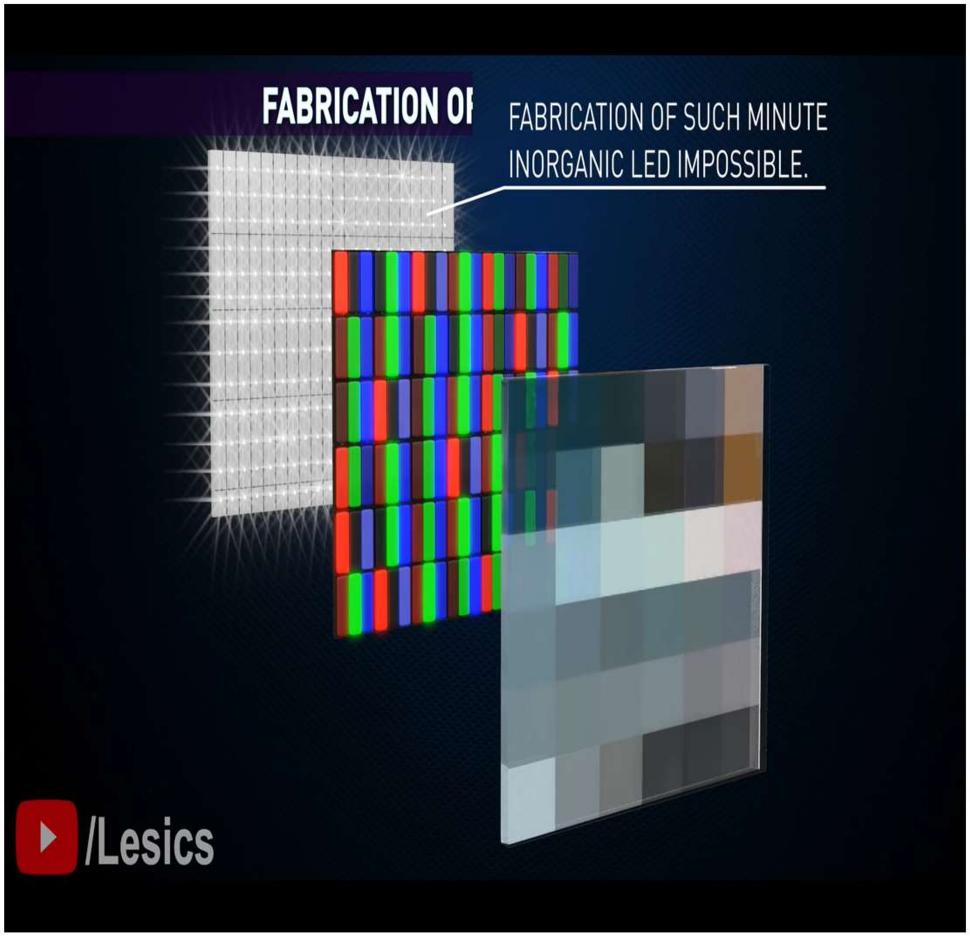




Foundation of OLED

- There are several disadvantages of this display technology the color reproduction is not that accurate.
- For example when we try to produce a perfect black color using this technology, this is what we get this is due to the continuous backlight.
- The energy consumption in those display types is quite high.
- Blue Hazard.
- Temperature responsiveness.

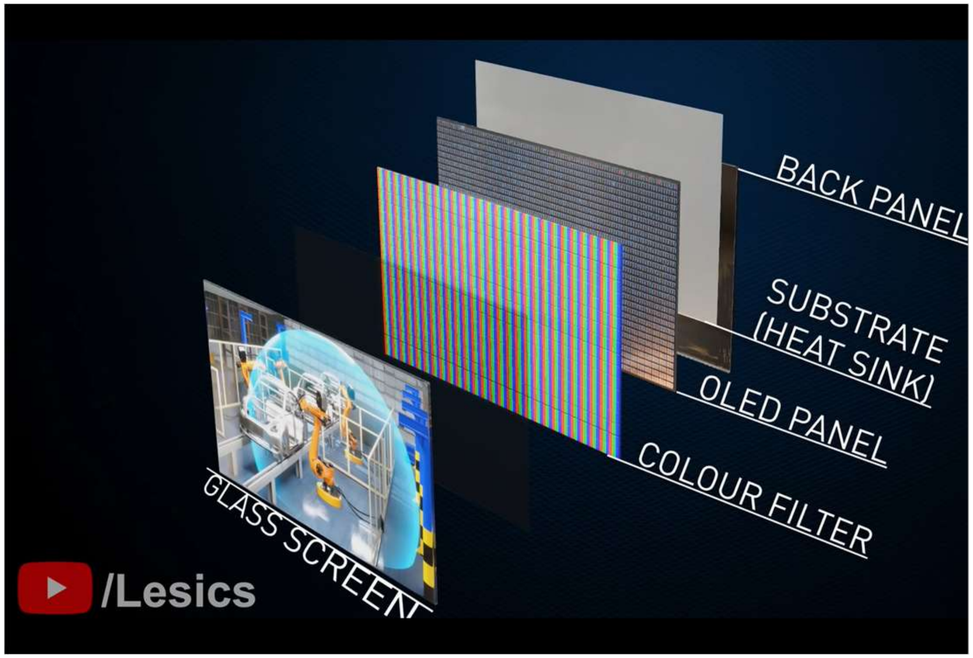


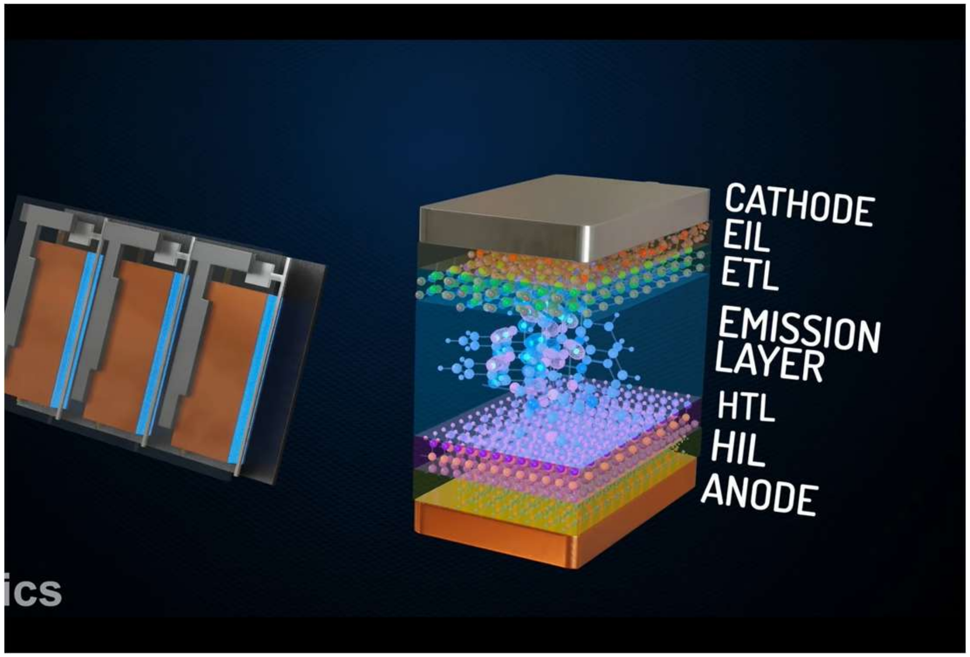


- What if we provide each pixel with its light source and control it?
- However the issue is that fabrication of such minute LEDs in the range of micrometers is not practical due to the issue of surface irregularities,
- And their solid nature at room temperature they cannot be miniaturized into micrometer ranges.
- This is why organic led comes into the picture they can be fabricated as small as 6.3 micrometers.

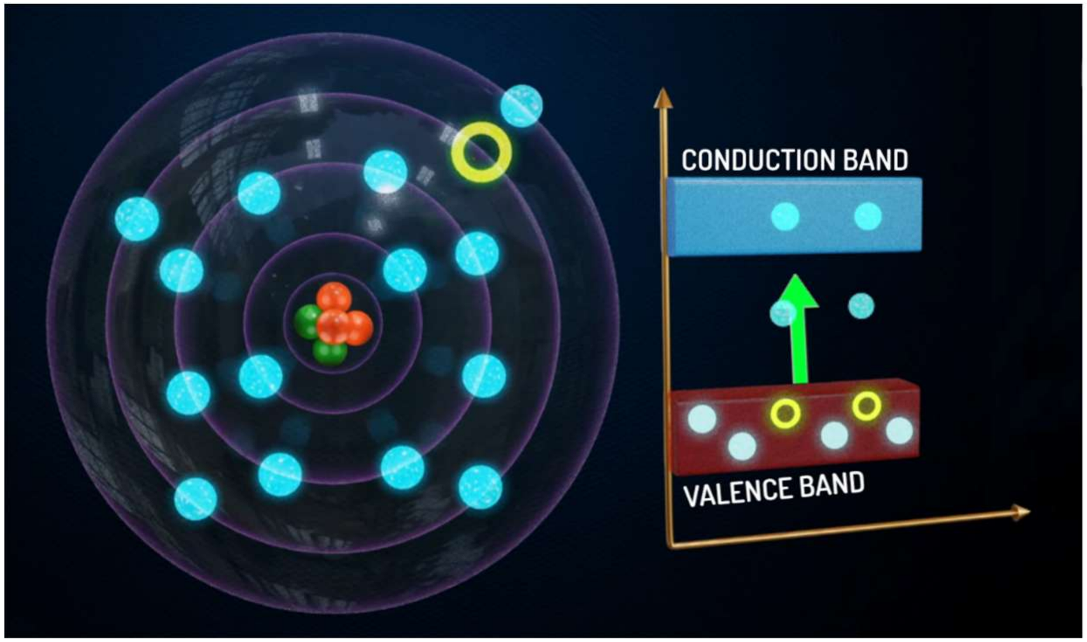
LAYERS OF OLED

The basic OLED cell structure consists of a stack of thin organic layers sandwiched between a conducting anode and a conducting cathode. **Breakdown of an OLED structure:**



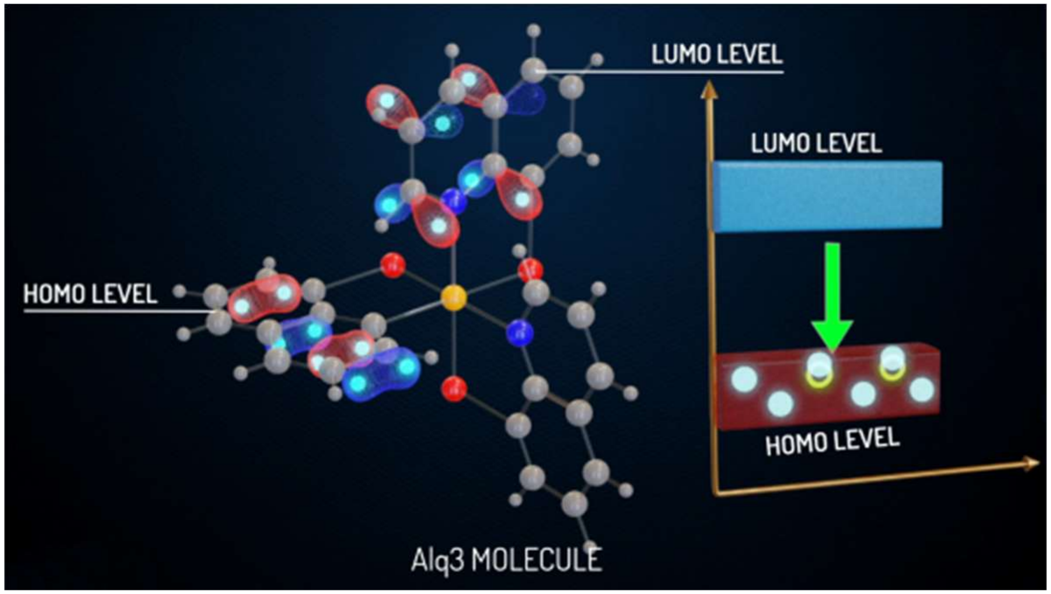


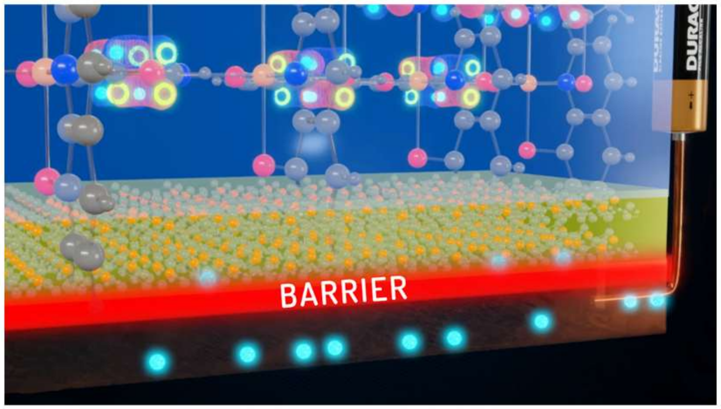
How does an OLED works?

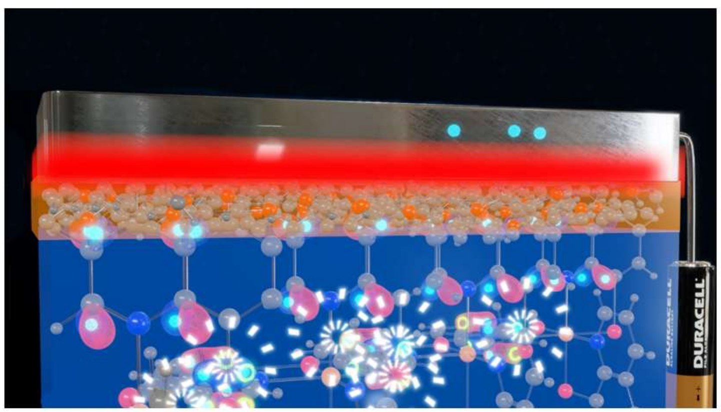


- Any LED technology works based on electron-hole pair recombination in semiconductor materials.
- Please note that only those materials with a suitable bandgap in their atoms can emit light in the visible range.

- In organic semiconductors, the energy levels of molecules are considered rather than atoms.
- The electrons in a stable state are located at the HOMO level, and those in an excitation state are located at the LUMO level.
- Let's connect this organic semiconductor to an external power supply using anode and cathode. Due to this, electrons move from the HOMO to the LUMO levels via a power supply and create holes.
- As soon as these electrons enter the LUMO layer, they recombine with the holes and emit light due to the natural tendency.







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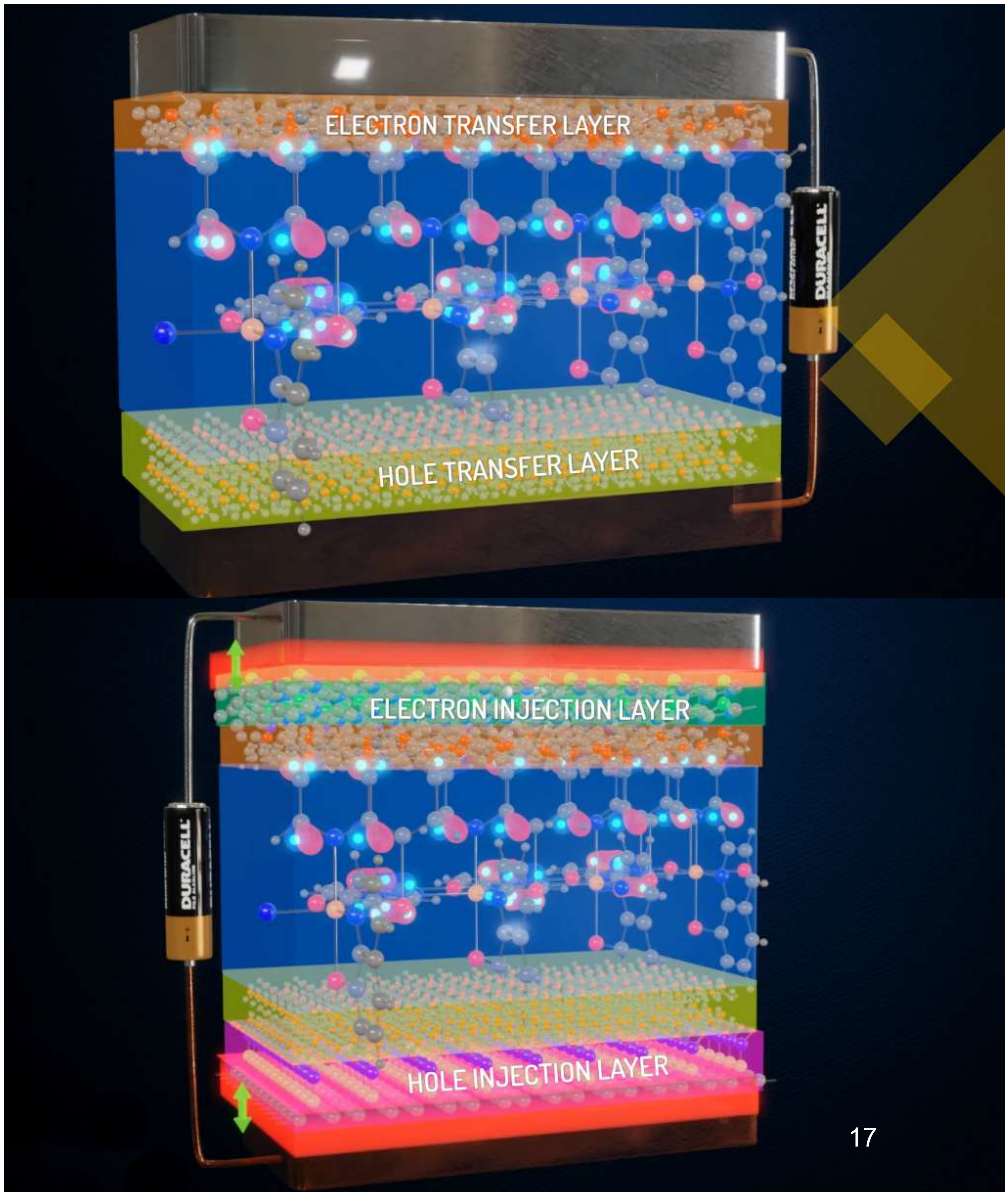
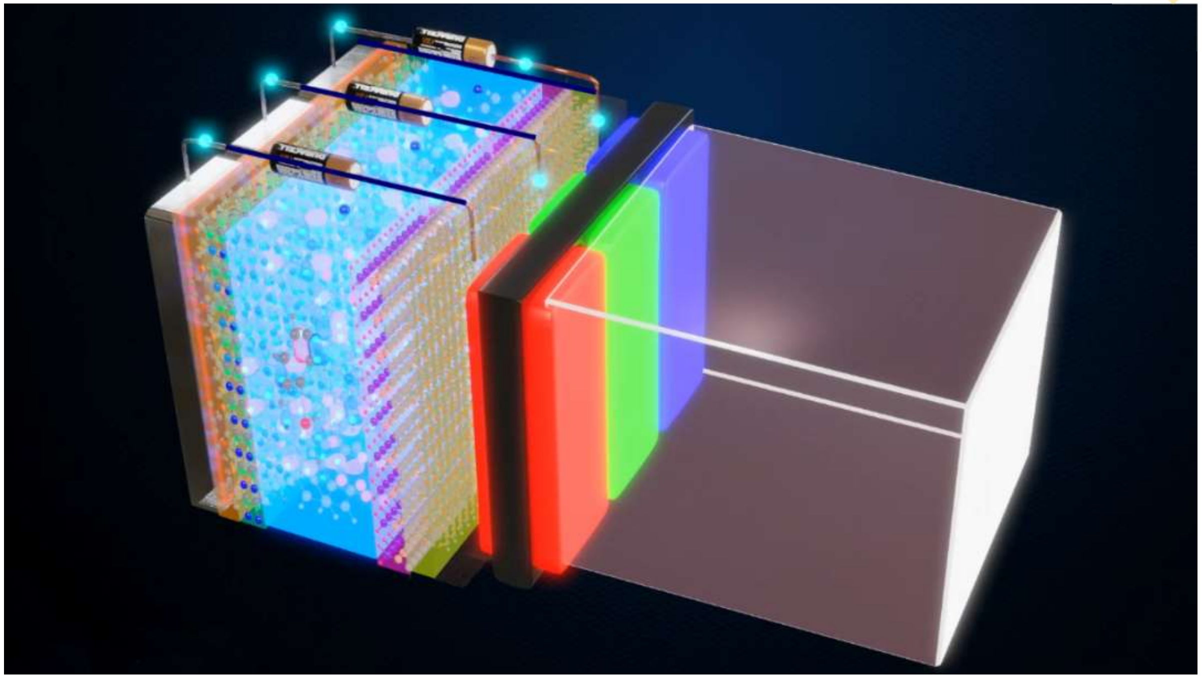
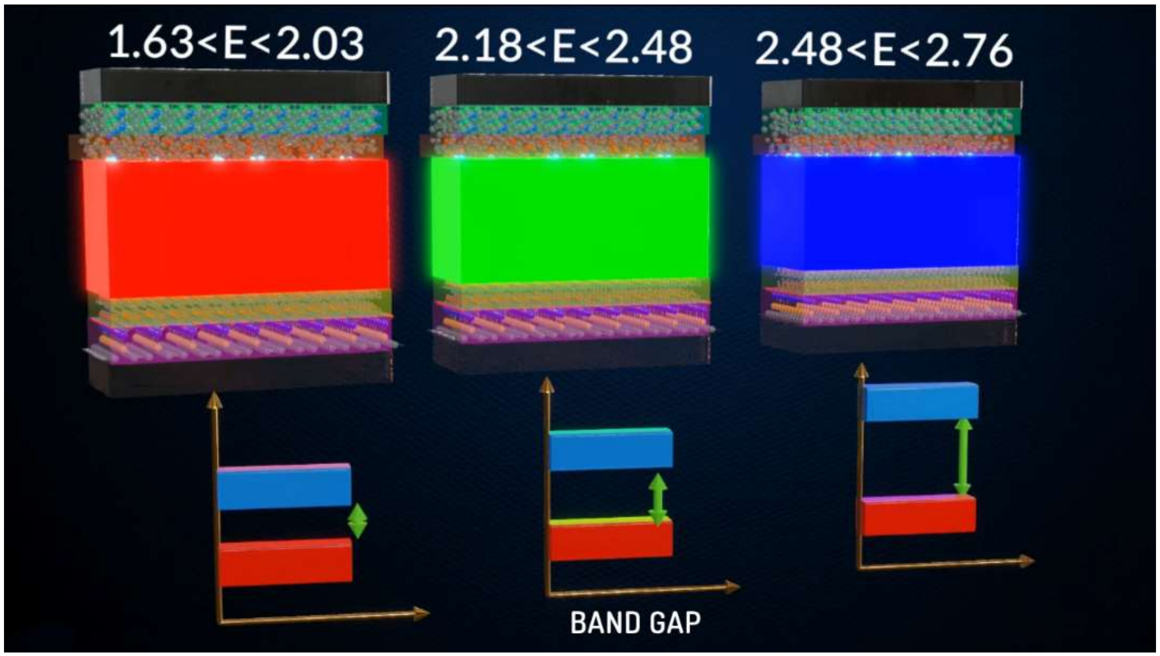
- However, this process is not simple. You can see in figure the anode side first.
- When we connect the battery's positive terminal to the anode, it tries to extract electrons from the organic layer.
- However, there is an energy difference between the HOMO level of the organic layer and the anode, which will act as a barrier for electrons.
- The same is the case with the cathode side.
- So, the cathode won't be able to inject electrons easily and consumes more energy, as I have illustrated in figure beside.

- This problem is solved by adding two different layers between the electrodes and the organic semiconductor.
- Due to the addition of those intermediate energy layers, the barrier will be reduced, and electrons can be easily injected or extracted from the organic layers.
- However, here, charges have very low mobility due to hopping between the molecules.
- For this reason, we add more intermediate layers to further reduce the energy barrier and reduce power consumption.



- Let's place such three organic LEDs behind a filter to control each subpixel independently.
- Just by varying the external power supply, we can control the electron flow or recombination rate and reproduce any image.
- It is quite obvious that black color reproduction can be perfectly achieved using this technology.





- The current OLEDs produce only white light. A cool and promising feature of OLED technology is that we can even avoid the usage of color filters with its help.
- What if we directly obtain RGB color light emission from the OLED source itself?

i. This is certainly a possibility. Currently, various OLED manufacturing companies are working on developing RGB color emitting OLED devices by adding various doping materials in emission layers.

ii. Due to the addition of doping material, the bandgap of an emissive layer is changed accordingly, changing the color of light emission.

Advantages

- Higher contrast levels - 180 degree viewing angle
- Wide viewing angles
- 100% Colour Fidelity
- Improved image quality

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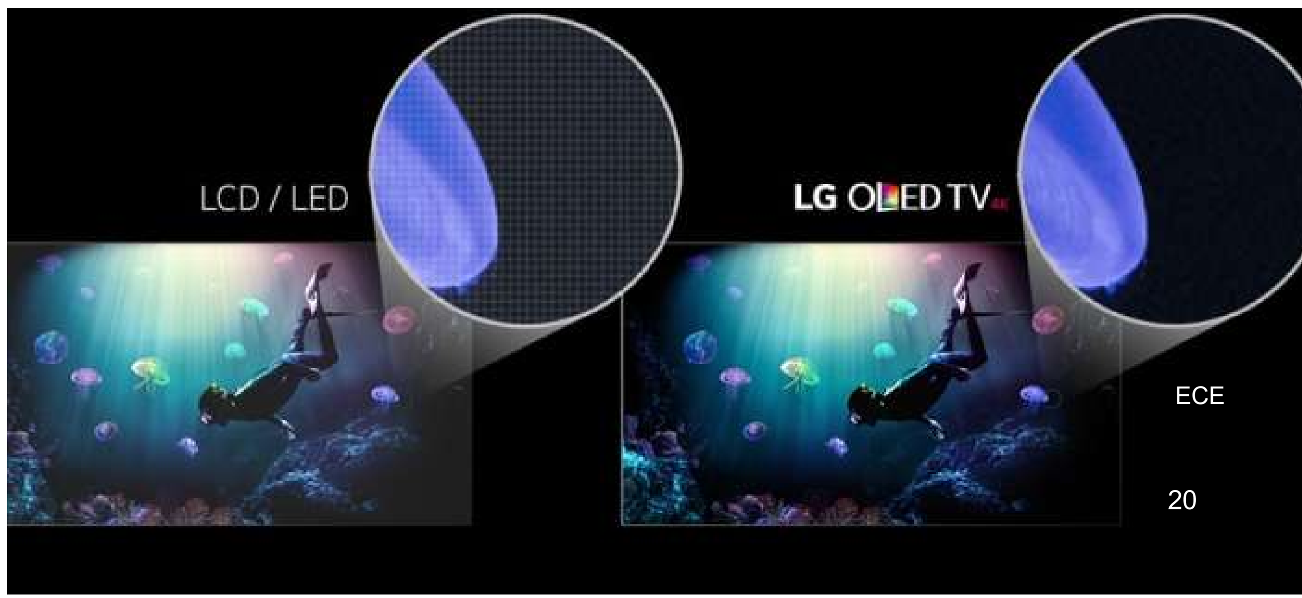


ECE

- Flexible
- Transparent
- White OLEDs

- Faster Response Time
- Real-time video speeds – excellent for 3D
- Low Blue light
- Flicker Free – eye safe
- Higher Recyclability

- Under Panel Camera
- Thinner, lighter and more attractive
- OLEDs are already cost-effective for mobile applications
- Infinite contrast ratio and an infinite dynamic range
- Self-emissive display
- On- cell touch without sacrificing fill factor
- Low UV output
- Low drive voltage
- Low operating temperatures, cool to touch
- Long lifetime
- Easy to control

Disadvantages

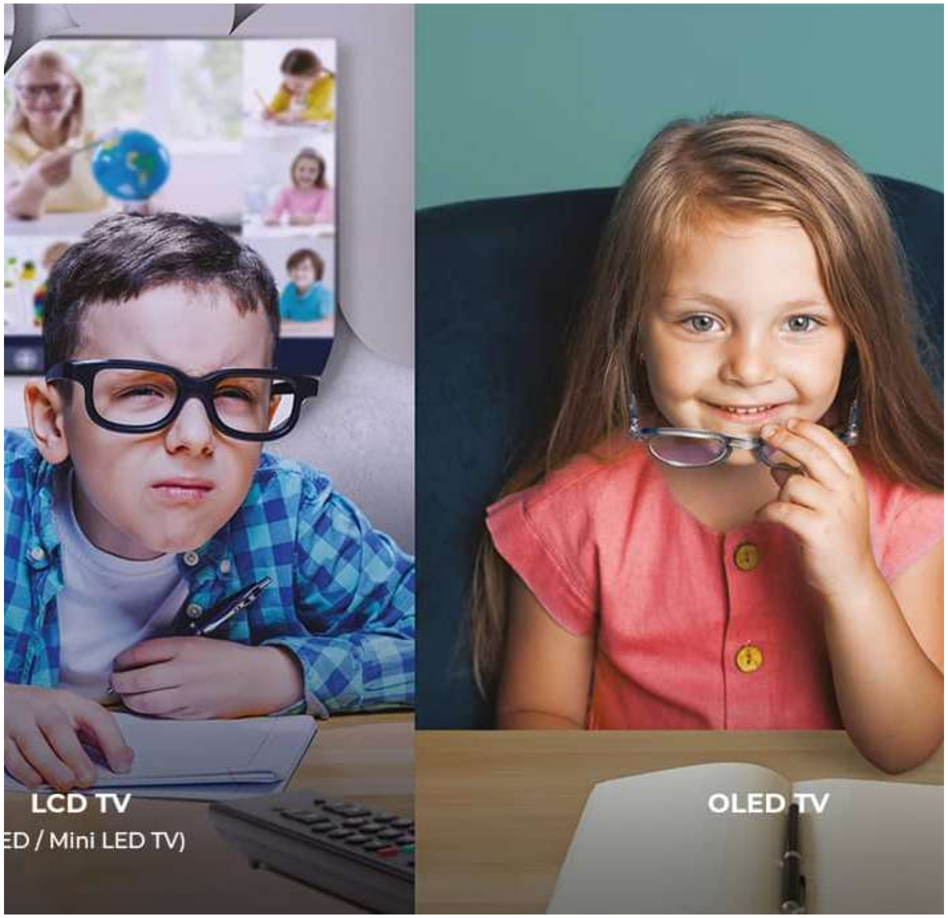
- First of all, it costs more to produce an OLED than it does to produce an LCD
- OLEDs have limited lifetime (like any display, really), that was quite a problem a few years ago.
- OLEDs can also be problematic in direct sunlight, because of their emissive nature. Display makers however, soon upgraded their OLED displays to increase performance.

Where can I find an OLED display today?

- ✓ OLEDs are used today in mobile phones, digital cameras, VR headsets, tablets, laptop's, TVs and signage.
- ✓ In 2021, over 500 million AMOLED screens are produced - mostly to satisfy demand of above products.
- ✓ The leading AMOLED producer is Samsung Display.

Is OLED screen bad for the eyes?

- OLED screens are better for the eyes compared to other devices like LCD because they emit less blue light. **The backlights of other displays emit lots of blue light**. OLED has much less blue light (34%) compared to LCD displays (65%).



Conclusion

- OLEDs offer many advantages over both LEDs and LCDs.
- They are thinner, lighter and more flexible than the crystalline layers in an LED or LCD.
- They have large fields of view as they produce their own light.
- Research and development in the field of OLEDs is proceeding rapidly and may lead to future applications in heads up displays, automotive dash boards, billboard type displays etc.
- Because OLEDs refresh faster than LCDs, a device with OLED display could change information almost in real time.
- Video images could be much more realistic and constantly updated.

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Any Doubts?

Thank You