Fachhochschule
Münster University of
Applied Sciences

Liquid Crystal Displays and Backlights

A presentation in the lecture „Incoherent light sources“
by Prof. Thomas Jüstel

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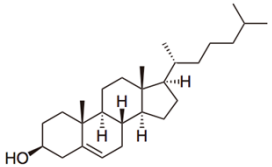
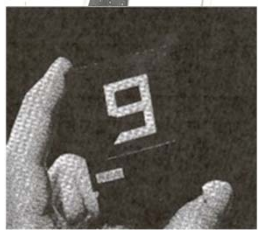
Agenda

- History of LCD
- From Liquid Crystal to the Display
  - Liquid Crystals
  - Function Principle
  - Backlights
- Todays Challenges

History of LCD

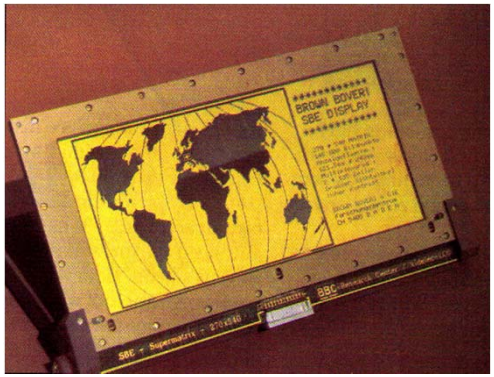
- In 1888 liquid crystals were first discovered, in cholesterol extracted from carrots, by Austrian botanist and chemist Friedrich Reinitzer
- Between 1964 and 1968 a team of engineers and scientists led by George H. Heilmeier (+ April 22nd, 2014) in Princeton devised a method for electronic control of light reflected from liquid crystals and demonstrated the first liquid crystal display (dynamic scattering method DSM).
- in 1969 twisted nematic field effect of liquid crystals invented by James Fergason → Display Devices utilizing Liquid Crystal Light Modulation
- In 1972, the International Liquid Crystal Company (ILIXCO) owned by James Fergason produced the first modern LCD watch based on James Fergason's patent (Original Price in 1972: $200)

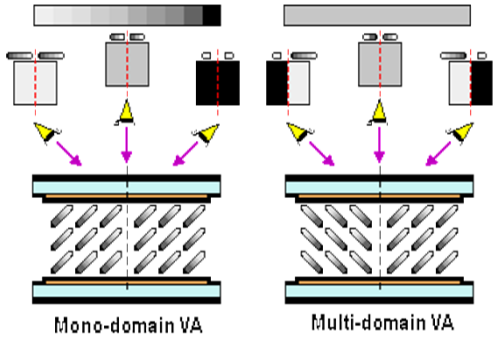




History of LCD

- In 1972, the first active-matrix liquid-crystal display panel was produced in the United States by T. Peter Brody's team, in Pittsburgh, Pennsylvania
- In 1983, researchers at Brown, Boveri & Cie (BBC), Switzerland, invented the super-twisted nematic (STN) structure for passive matrix addressed LCDs
- In Early 1990, Hitachi and NEC became early manufacturers of active-matrix addressed LCDs. →large-screen LCDs getting acceptable visual performance
- In 1996, Samsung developed the optical patterning technique that enables multi-domain LCD → dominant LCD designs through 2010
- In the fourth quarter of 2007, LCD televisions surpassed CRTs in worldwide sales for the first time.





From Liquid Crystal to the Display – Liquid Crystals

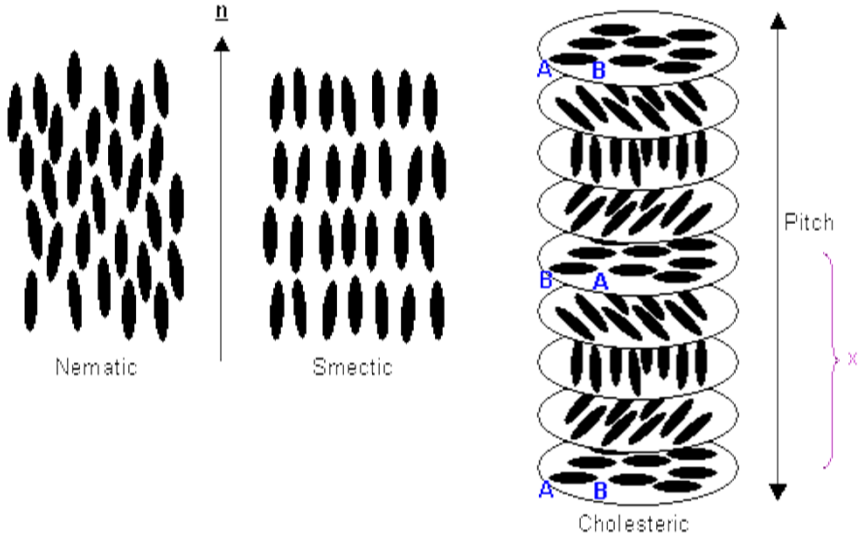
What are Liquid Crystals?

- matter in a state that has properties between those of conventional liquid and those of solid crystal→ flow like a fluid, molecules arranged like a crystal

- There are three types of liquid crystals:

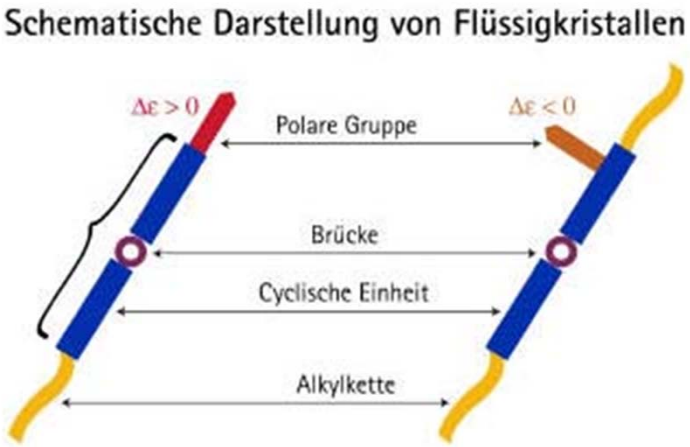
  → **twisted nematics** (TN), is naturally twisted
  → untwists under electrical voltage

- Characterisitcs of electrical performance, translucency, viscosity, and stability have a high relevance due to the application → Leading manufacturer: Merck KGaA

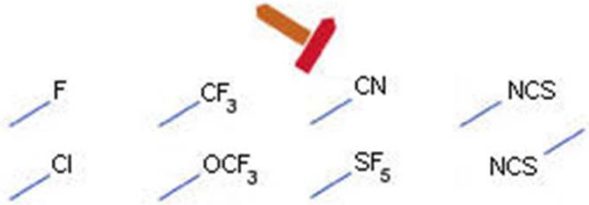


Liquid Crystals

- Calamitic (oblong) structure through carbo- and heterocycles



- Polarity (inhomogeneous charge distribution) through polar substitutes



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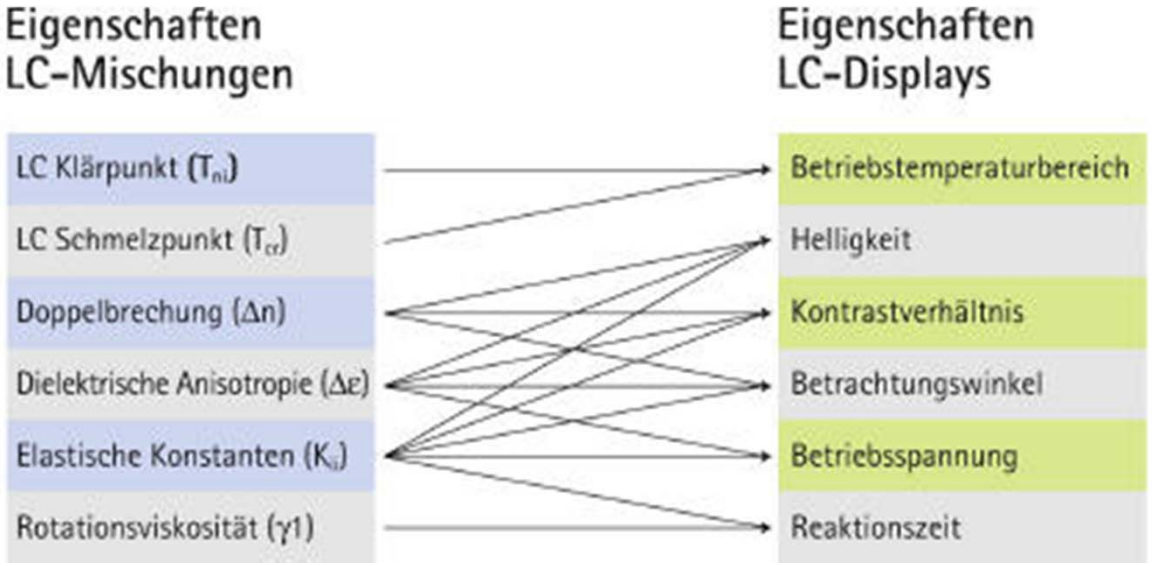
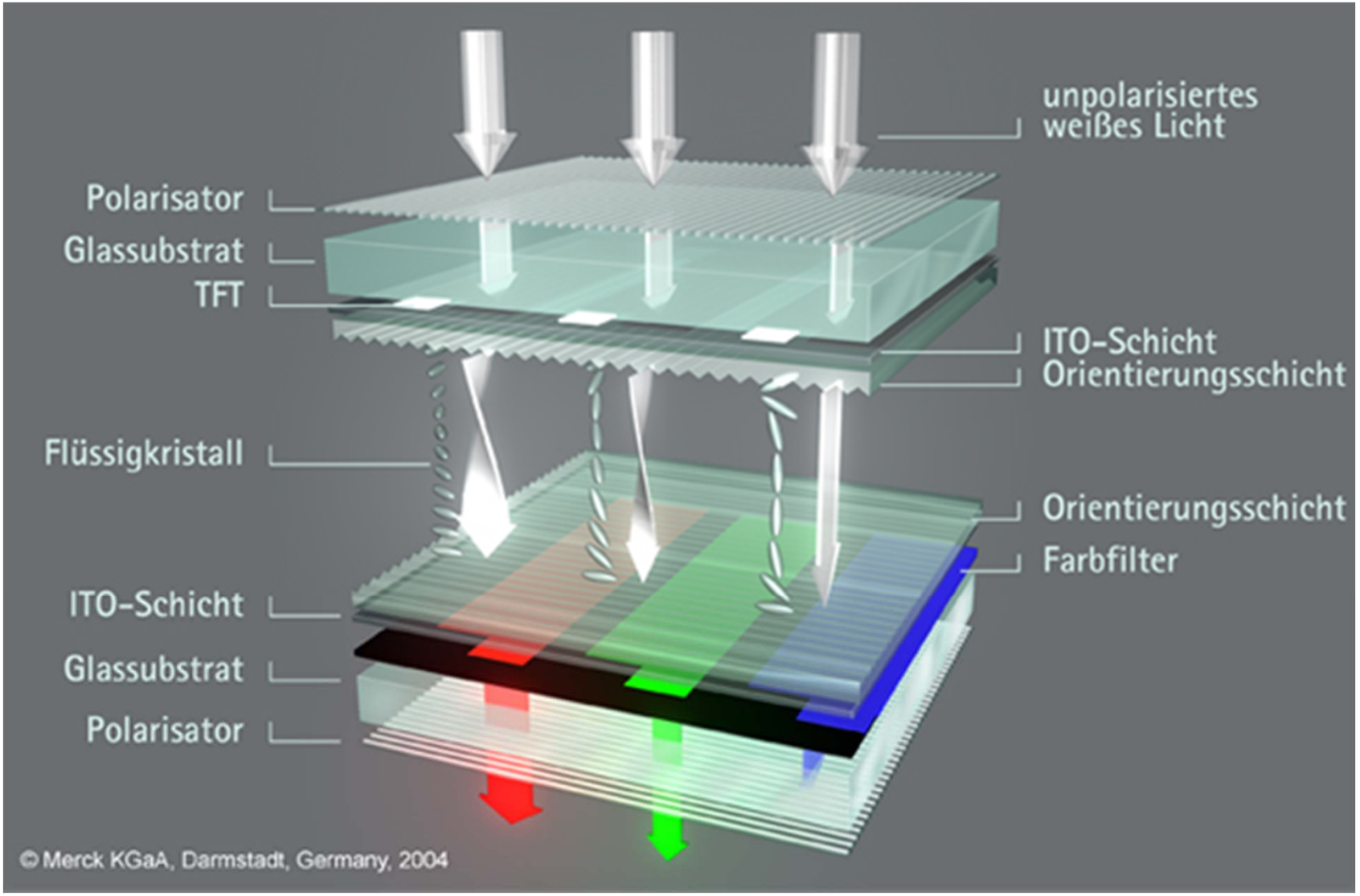
1 Olaf Minte; 10.05.2014

Liquid Crystals

Side chains determine the characteristics of the LC



Function Principle



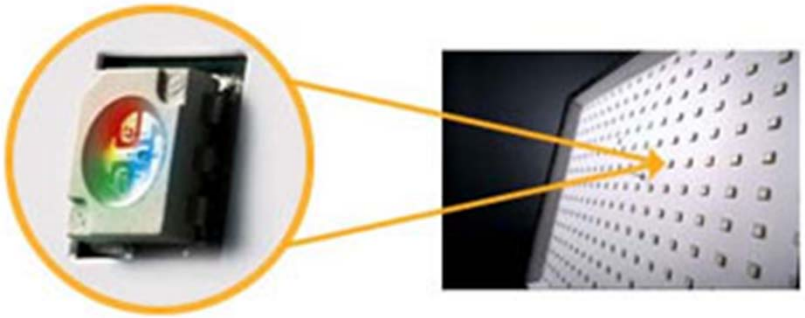
Backlights

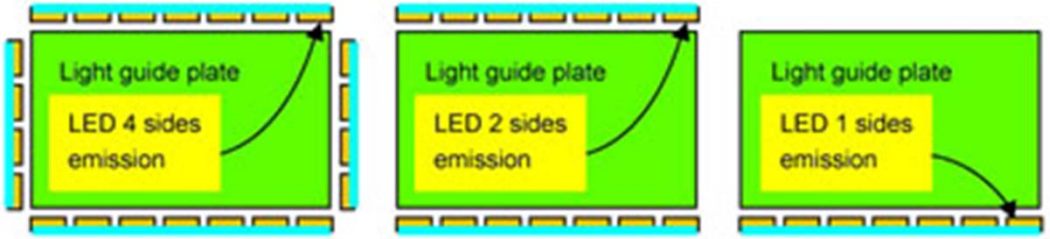
In almost all cases very bright, white light is needed

- light-emitting diodes (LEDs)
- cold cathode fluorescent lamps (CCFLs)
- electroluminescent panel (ELP)
- hot cathode fluorescent lamps (HCFLs)
- external electrode fluorescent lamps (EEFLs)
- incandescent light bulbs

Backlights

light-emitting diodes (LEDs)





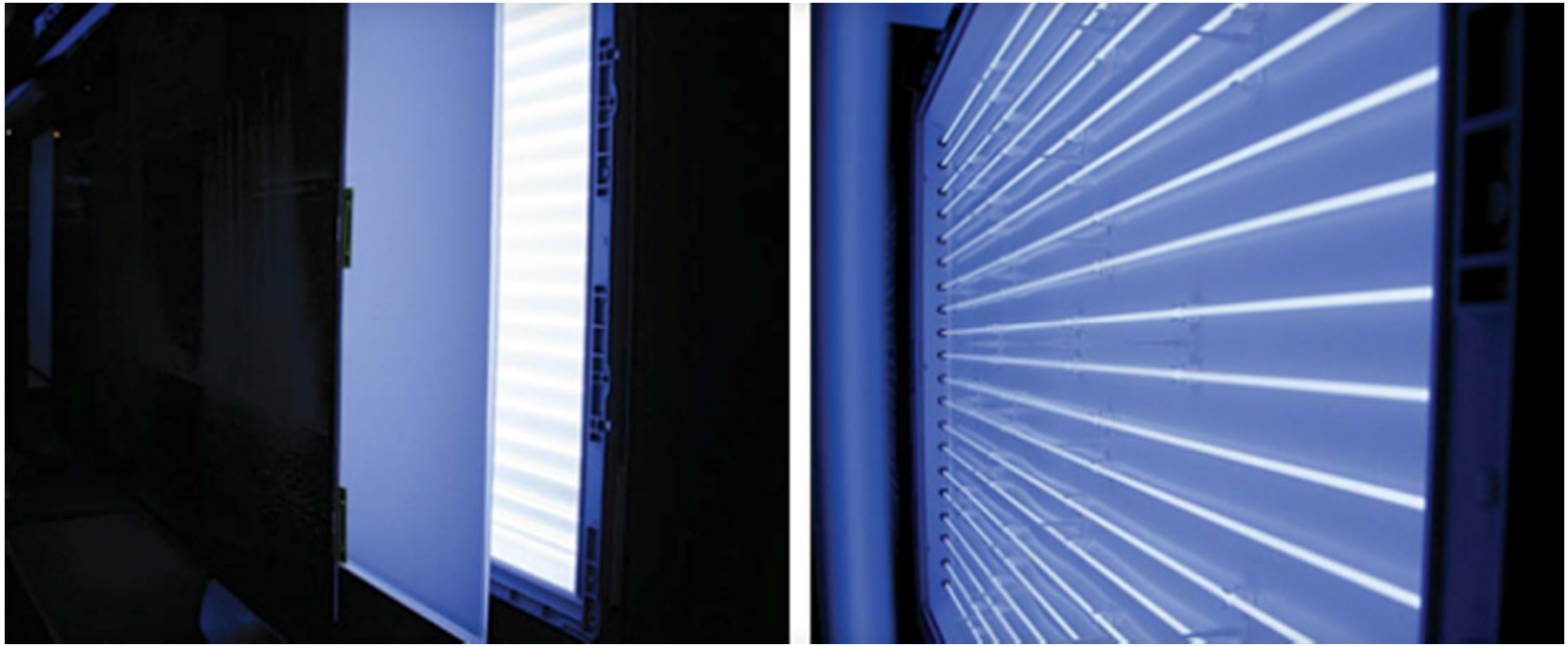
Backlights

cold cathode fluorescent lamps (CCFLs)

- until about 2010, the preferred backlight for matrix-addressed large LCD panels

hot cathode fluorescent lamps (HCFLs)

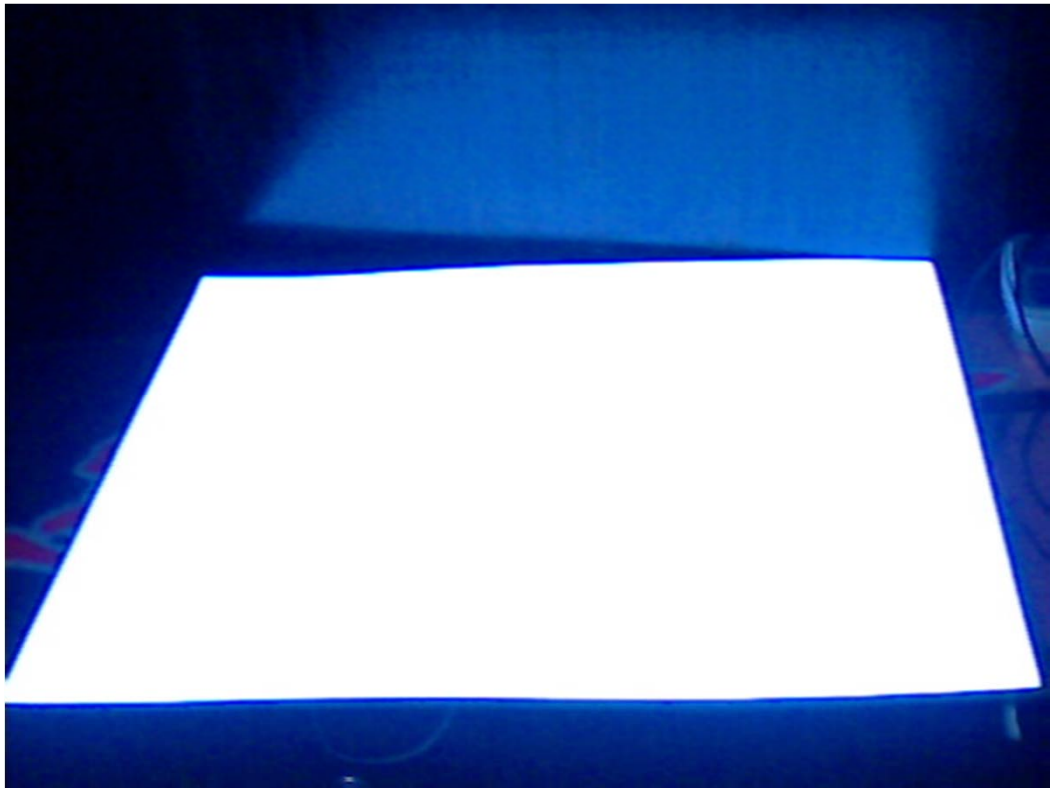
external electrode fluorescent lamps (EEFLs)



Backlights

electroluminescent panel (ELP)

- especially for larger displays



Backlights

incandescent light bulbs

Few architectures made for large/bright applications

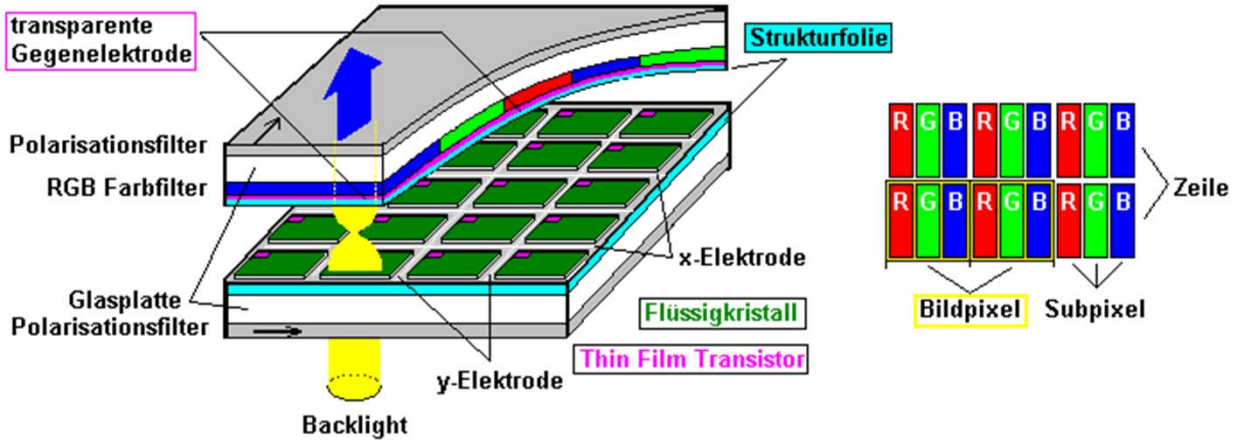
But:

- Poor lifetime
- Heat radiation destroys LC

  Materials

Todays challenges

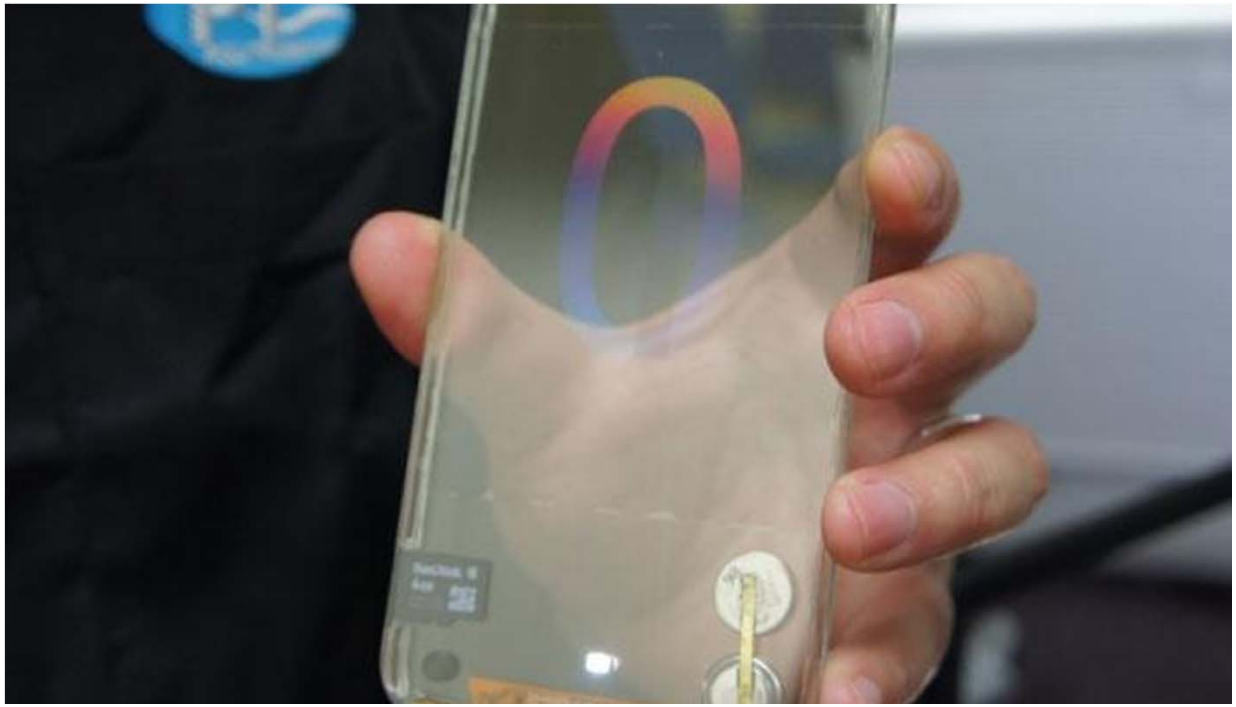
- Higher Resolution (> 2K)
- Higher Framerate (> 800 Hz)



- TFT ususally made of a-SI until now
  - Poor electrical performance
  - Nontransparent
- Solution: Metal oxide materials (IGZO, InO, ITO)
  - Up to 100x the performance of aSi
  - Translucent up to 99%

Todays challenges

Transparent LC – Display



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Thanks for your attention