Chapter 2

Liquid Crystal Displays

Materials, Operating Modes, and Applications

The modern history of liquid crystals is closely related to the development of electronic displays, whose main advances are summarized in this chapter. For a more enthusiastic report, dense of interesting details, the reader is referred to the already cited paper by Hirohisa Kawamoto, “who was part of the story from 1970” [K2002], and from which paper several data and information included in the chapter are taken:

... (it) is a story of the hard work, disappointments and successes of worldwide competition and cooperation that encompassed the U.S.A., Europe and Japan. Each industrial center contributed its particular strengths: in America, it was the quickness of forming new ideas and demonstrating their feasibility; in Europe, it was the fundamental science and synthesis of basic materials; and in Japan, it was the process of perfecting implementation and moving it to the production line

2.1 Towards The First LCD

During the first half of the 20th century, an accurate model of the LC phenomenon, based on the molecular basis, was developed. Nevertheless, very few and marginal applications were found.¹

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¹The first patented application of LC technologies was the Liquid Crystal Light Valve, by the Marconi Wireless Telegraph Company and dates back to 1936 [LL1936]. In the 1940s, following the works of Zöcher, the American scientist John F. Dreyer refined the rubbing technique to obtain oriented lyotropic LC films of uniform thickness that could serve as base for polarizers, and with which he fabricated polarized lenses for sunglasses. He also made the first 3-D movie glasses [D1946–D1957].
2.1.1 The First LC Application

In 1956, Westinghouse Electric, Pennsylvania, assigned to James L. Fergason to explore ways of using thermal imaging in making vacuum tubes for televisions. Fergason observed the optical properties of LCs for the first time in November 1957 and decided it would be the subject of his research. At Westinghouse, Fergason formed (with some difficulties) the first non-academic scientific group focused on LCs. At this purpose he said:

*I had to get people to believe there was such a thing as liquid crystal, even though it’s colorful and all that sort of thing, and get them to believe that it was more than just a lab curiosity. And it took a lot of measurements and a lot of work. Then I had to show them not only that liquid crystal was important but also that what you did with liquid crystal was important.*

In 1958 he invented the first significant application, cholesteric liquid crystals that turned colors considerably as the temperature changed. We showed in Section 1.3.7 this effect. Liquid crystals allowed to determine temperature just by looking at the color of the thermometer. By mixing different compounds, a device for practically any temperature range could be built.

Since then, Fergason started to see many LC applications and worked even on the implementation of an optical-display system, but he was not supported toward product development at Westinghouse. It took from 1957 to 1964 for the potential of liquid crystal in products to be recognized for the first time. Flexible films and tapes that could be applied to the surface of objects to record temperatures were produced. They could be applied also to the skin of a human body to locate veins and arteries and to electronic circuit boards to locate trouble spots [F1964]. In the following years such thermal mapping application was further improved to screen for breast cancer and other medical conditions. However it was not well sold.²

The outstanding and prolific aptitude of Fergason (he now holds more than 150 patents in the U.S.A, and in 1998 was inducted into the U.S.A. National Inventors Hall of Fame) made him a protagonist in the evolution of the LCD industry.

2.1.2 The Pioneering Role of RCA

Still in the early 1960s only a few institutions were studying and performing research experiments on LC materials. The RCA (Radio Corporation of America) was one among these. At that time, RCA was the leader of the electronics market.

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²In reality, there was an intrinsic inaccuracy to much of the medical imaging. For instance, Bayer Corporation developed equipment that used a plastic-enclosed liquid-crystal plate for breast exams, but this system affected the temperature of the skin when they pressed against it. Liquid crystal thermal imaging was eventually replaced with high-resolution digital infrared imaging, using remotely cameras and computers.