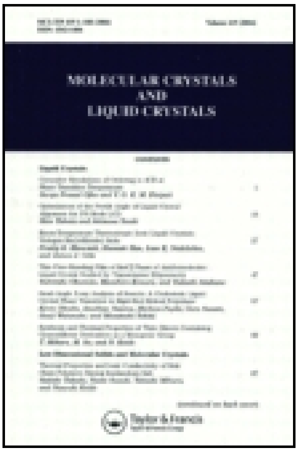

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A Review of “Liquid Crystal Displays: Fundamental Physics and Technology”

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Book Review

Liquid Crystal Displays: Fundamental Physics and Technology by Robert H. Chen, John Wiley & Sons, 2011; ISBN 978-0-470-93087-8; 520 pp.; $95.00. This volume is also available as an E-book.

Robert H. Chen's book "Liquid Crystal Displays. Fundamental Physics and Technology" is an example of how a fairly complicated material on modern science and technology can be presented to a broad readership in a manner that illuminates and inspires. The book educates its reader in many aspects. The rich history of liquid crystal displays condensed many facets of societal developments over the last decades. The book shows how a modern technology becomes possible through great breakthroughs in fundamental physics and chemistry, how it emerges in response to industrial demands and developments, how it is guided by human perseverance and ambitions at the level of individual researchers, companies, and nations, and how it is shaped by swings of world economy.

The book's opening four chapters deal with the fundamental physics of light and matter, double refraction, Faraday's experiments, Maxwell equations, and light propagation and polarization. Although one can find descriptions of birefringence and electromagnetic theory in many other textbooks, placing the material as the starting point of the journey into the fascinating world of modern electronics is an excellent pedagogical decision, as it teaches its readers how deeply the marvels of technologies are rooted in the work of generations of scientists whose sole desire was to understand the material world, to find the unifying principles that set it into action. In most cases, this "fundamental' science is very remote from the industrial practices of the time and the immediate benefits of it are not clear even to those who spend countless hours analyzing and experimenting.

The dawn of the liquid crystal science described in Chapters 5–12 is seemingly about deeper dwelling into the abstractness of fundamental physics, but in fact it is also a story of a value hidden in the pursuit of "pure" knowledge. Friedrich Reinitzer, studying the chemical composition of carrots, notices that some cholesteryl derivatives produced in his laboratory show two different "melting" temperatures. Although the finding has no obvious implications for carrots, Reinitzer tries to understand the phenomenon and, finding it difficult, asks his colleague Otto Lehmann for help. Lehmann, equipped with state-of-the-art optical microscopes, realizes that the mysterious state between the two melting temperatures combines fluidity with birefringence, an optical feature previously associated with crystals. Thus, a new state of matter is discovered, a "liquid crystal". For the next 70–80 years, the liquid crystals remain a curiosity that is difficult to describe in terms of scientific models developed for other materials and, maybe more importantly, with no clear indication of what they might be good for. Nevertheless, the subject finds its explorers, as Max Born, Maier and Saupe in Germany, Frederiks and Tsvetkov in the Soviet Union, Bragg, Frank and Leslie in UK, Fridel, Grandjean, Mauguin, and de Gennes in France and many others establish a firm foundation to understand the physical properties of these materials. The book describes all the fundamental pillars of liquid crystal science, from molecular-statistical models of long-range orientational order to the field-induced elastic distortions and anisotropic flows. The aim is not to derive the theoretical description rigorously, but rather to present the "flavor" of the liquid crystal physics, "as if detailed derivation ... are presented, the forest of subscripts and superscripts unfortunately may well overwhelm any single trees of understanding" (page 201). The confession should not mislead, as the text leaves no doubt that the forest of subscripts and superscripts is precisely what one needs to master in order to make a mark in the field.

Chapter 13 leaves the conundrum of condensed matter physics behind and describes the pioneering attempts to produce a liquid crystal display. A public announcement on May 28, 1968 by the Radio Corporation of America Laboratories (RCA Labs) that a new platform technology has been developed for television, shutters, digital cloaks, and much more, transformed the curious chimera of research labs into Cinderella of electronic displays. Alas, the first shoe-test in terms of commercial survival turned out to be a failure, as there were "wrong" physical phenomena and chemicals used. RCA that started not only the liquid crystal displays but also the semi-conducting technologies such as thin film transistors to operate them, decided to wind down further developments. The announcement, however, ignited the minds and hearts of scientists and engineers around the globe and within a short period of time, a "right" combination of physics and chemistry has been worked out to pave the way for modern-day LCDs. Chapter 14 describes the chemistry of robust liquid crystal materials pioneered by George Gray at Hull University. Chapters 15 and 16 introduce the "Twisted Nematic" display proposed by Fergason, Helfrich, and Shadt, in which the electric field (rather than current) was used to realign the dielectrically anisotropic liquid crystal in order to shape an optical response. Chapters 17, 19–25 focus on many other technological elements, such as active matrix addressing, transistors and integrated circuits, color filters, optical compensators, LED backlight, glass panels, etc., that made the LCDs a technology of choice in presenting information nowadays. The description of LCD technology is intertwined with the history of traditional CRT-based television and personal computers that were the ultimate driving force in LCD expansion in 1980s and 1990s, before the modern age of big flat-panel LCD television sets. In the book, each turn of the development is personalized, with vivid descriptions of business and sometime political decisions made by nonscientists, "Eureka" moments of researchers, patents rights infringements and settlements. A culmination of this broad description of LCD technology as a focal point that has melded together scientific advances with economy and politics is Chapter 26, in which the author contemplates on the global LCD business development. How and why did it happen that the companies that first introduced the breakthrough technologies could not follow and set up a meaningful scale of manufacturing to reap the benefits they were entitled to by the talent of their scientists and engineers? What does it take to become successful in manufacturing industry? Is the success story of Korea, Taiwan, Japan, and China in consumer electronics related to the high values, these societies assign to science and engineering? These and other questions are analyzed using the LCD industry as an example, but the lessons learned are clearly useful in a much wider range of economic developments. The final Chapter 27 overviews the latest trends in the field, hybrid materials, such as polymer-liquid crystal composites, 3D television, and electronic paper.

The author fulfills his promise to a reader: The book describes the basic physics and technology behind the modern LCD in a simple and understandable manner. It gives an intuitively clear picture of forces and laws of physics that drive the response of a liquid crystal to an applied electric field and explains how that response translates into slick and beautiful images on our TV and PC screens. However, the book offers much more than that. It also shows cultural, business, and political forces that shape the societies and what the societies pursue. This picture is by far less clear than the physics of liquid crystals, but for an interested reader it provides plenty of material to ponder about.

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