This Week's Citation Classic

Heilmeier G H, Zanoni L A & Barton L A. Dynamic scattering: a new electrooptic effect in certain classes of nematic liquid crystals. *Proc. IEEE* **56**:1162-71, 1968. [RCA Laboratories, Princeton, NJ]

The then new electrooptic effect of dynamic scattering in nematic liquid crystals is disclosed and shown to be due to the disruptive effects of ions in transit. Real time dynamic scattering displays with good contrast ratios, low power consumption, and modest voltage requirements are demonstrated. [The *SCI*® indicates that this paper has been cited over 285 times since 1968.]

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"In 1962 at RCA Laboratories I decided to look at the potential of organic materials for reducing the large voltages (kilovolts) required for Pockels effect laser modulators. Pondering ways to control the local fields of materials by means of applied electric fields led me to the work of Richard Williams of RCA on the orientation of nematic liquid crystals in external electric fields. I reasoned, perhaps naively, that the local fields in the nematic liquid crystal were determined by the molecular order which, in turn, was a function of the applied field.

"A strong dye was selected and used to dope the nematic liquid crystal butoxy benzoric acid. The mixture was sandwiched between two glass slides coated with transparent tin oxide electrodes and placed under a microscope with a hot stage. Heating was required because there was no known material at the time which had a nematic liquid crystal phase at room temperature. A DC voltage of several volts was applied and we watched the cell change from red to colorless as a function of the applied field. It was found almost immediately that the effect was more dramatic with a polarizer in place. The device was drawing less than a microwatt of power per square centimeter and we were switching color with voltages of less than ten volts in some cases! No one cared that our original theory was not operative. What counted was the dramatic new effect of the change in the absorption spectrum of the dyes as their orientation was electrically switched relative to the polarization of the incident light.

"While pursuing the practical problems associated with the 'guest host' effect, a number of new liquid crystal phenomena were noted.[1] An important one was that for certain classes of nematic liquid crystals, the material exhibited a marked turbulence that turned it from transparent to white. The milk-white appearance required no polarizer to observe—it was purely a light scattering effect. We had discovered how to electronically control the reflection of light in a most striking and dramatic way. We coined the term 'dynamic scattering' for this effect.

"Coauthor Luke Barton was instrumental in the development of nematic materials while coauthor Louis Zanoni designed and fabricated prototype devices. The paper has been highly cited because it describes a new phenomena of widespread, continuing interest,[2] gives a theoretical basis for the phenomena, and gives the performance characteristics of operating devices.

"A key factor in the outstanding success of our research in nematic liquid crystals was that I was an electrical engineer working with organic chemists and none of us was afraid to show his ignorance concerning the others' fields.[1] However, the product department saw only the problems and not the opportunities in liquid crystal displays. It was left to other companies to exploit them commercially and our research team broke up and drifted away."

1. **Heilmeier G H.** Liquid crystal displays: an experiment in interdisciplinary research that worked. *IEEE Trans. Electron Devices* **ED-23**:780-4, 1976.
2. *Molecular crystals and liquid crystals: proceedings of the Eighth International Liquid Crystal Conference, Kyoto, Japan, July 1980.* London: Gordon and Breach Science Publishers, 1981. Vols. 63, 66-8, 70, 74. Nos. 1-4.