This Week's Citation Classic®

Janning J L. Thin film surface orientation for liquid crystals.
Appl. Phys. Lett. **21**:173-4, 1972.
[Applied Research Department, National Cash Register Company, Dayton, OH]

A new method is given to align nematic liquid crystals. Instead of the previously used Chatelain technique of unidirectional rubbing of the inside surface of the display plates with a cotton swab a hundred times or so, a very thin film of silicon monoxide is deposited onto the surface at an oblique angle. The resultant alignment is uniform, permanent, and reproducible. [The SCI® indicates that this paper has been cited in over 140 publications since 1972.]

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When the first field-effect liquid crystal displays came on the scene early in 1971, we purchased several for evaluation to compare with one we were researching. The basic problems with these displays were contrast and its degradation with time. The fly in the ointment was the process used to align the nematic liquid crystal molecules. The process developed by Chatelain[1] in 1942 was to rub the glass plates with a cotton swab a hundred or more times unidirectionally before applying the liquid crystal molecules. This produced a surface that caused these cigar-shaped liquid crystal molecules to align in the direction of the rubbing.

We noted in our evaluation that if the display temperature exceeded 54° C, it was good-bye to the alignment. Even running at room temperature, the contrast uniformity was poor and changed with time.

We realized that if this were ever to be a production item, a more suitable means of alignment would be necessary. It would have to be stable, uniform, hold up at high temperature, and have long life.

I thought of an alignment film with direction sensitivity. Why not a vacuum-evaporated film deposited obliquely? This type of film should have direction sensitivity. It was worth a try. The first experiment would be to evaporate chromium at 85° to the normal and deposit to a film thickness of approximately 70 Å. A glass microscope slide was positioned horizontally for measurement purposes in the vacuum system while several other slides were positioned at approximately 85°. The 70 Å thickness was to be calculated from knowing the film thickness on the measurement slide. The deposition was carried out with no problem. The slides looked good. A liquid crystal cell was made from these slides and it was love at first sight. These films aligned liquid crystal molecules. Other deposits were made using other angles, thicknesses, and materials. At the end of my initial evaluation, the 85° angle and the 70 Å thickness still held as being optimum.

In trying different materials for alignment films, there were no real surprises until it came to copper. Copper was tried repeatedly, but always resulted in homeotropic alignment, regardless of the angle of deposit. Of all the materials tried, silicon monoxide came out the winner with its excellent properties for optical transmission, electrical insulation, and good contrast in the displays. The silicon monoxide films were heated to 500° C repeatedly with no effect on the alignment properties.

When liquid crystal display (LCD) watches and calculators began appearing in the early to mid-1970s, it was this process that became very popular with LCD manufacturers and was used widely in the industry.

No doubt the reason for the paper being cited so often is that this method provides reproducibility and stability in making LCDs, along with good contrast and long life. Today, however, many papers refer to this oblique deposition as the standard, and I had believed that the paper was rarely referenced any longer. I was surprised to learn that, contrary to my belief, the paper is still referenced regularly.

Because of the publication's effect in ushering in the LCD era, I received the NCR President's Award and was named "Outstanding Engineer" in my hometown of Dayton, Ohio.

1. **Chatelain P.** Sur l'orientation des cristaux liquides par les surfaces frottées. *Bull. Soc. Fr. Minéral.* **66**:105-52, 1943. (Cited 120 times since 1955.)

