"Transflective Film": Testing Shows It Fails to Create Sunlight-Readable Displays, Despite Industry Claims

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AMLCD displays are increasingly popular for billboards and other outdoor applications, and manufacturers are focusing on developing sunlight-readable AMLCDs. Previously, a display that provided 400 nits with a good reflective surface was acceptable – now the demand has increased to 1,500 nits. To reduce backlight power consumption while improving display readability, the display industry has tried various approaches. One such approach, adding a "transflective film to an AMLCD display, sounds like an cost-effective, after-market solution. Some display manufacturers claim that the sun is so bright, by using a transflective film to reflect sunlight, a standard display can output 1,500 nits without requiring any additional power.

But in reality, as testing by Insync Peripherals demonstrates, transflective film is marketing hype: it sounds good, but doesn't work.

The term "transflective" combines "transmissive" and "reflective." The idea behind a transflective film is that it is supposed to transmit light, letting the backlight shine through; and also reflect sunlight, using ambient light to create a brighter display. In old black-an-white LCDs (STN varieties), the passive matrix element itself is transflective: The partial reflectivity of the passive LCD provides a good display image under direct sunlight, while its partial transmissivity provides a good display image via a backlight for day and nighttime viewing.

Low power using optics rather than increasing power usage is important because power generates heat, which can cause the display to go black beyond its clearing temperature and also reduces brightness when the lamp temperature goes above +80C.

To get true sunlight readability, the backlight continues to be the most important component. In addition to an AMLCD with a high percentage of light transmission, the other important contributing factor is an anti-reflective film (AR film) laminated on top of the AMLCD or an anti-reflective glass (AR glass) bonded on top of the AMLCD.

Why Transflective Film is not Important

From our investigation, it turns out that the limiting factor in how much brightness can come from direct sunlight is not the reflectivity of the transflective film. It is the percentage of light transmission of the AMLCD, where the sunlight passes through the AMLCD and then reflected back out though the AMLCD. This is the so-called light transmission Square Factor. For example a 7% light transmission AMLCD, the sunlight goes through the AMLCD and is then reflected back thought the AMLCD to the viewer. The resulting light received by the viewer is 7% x 7% x 80% of the sunlight. Given a transflective film with 80% reflectivity and 10,000 ft-C sunlight, the sunlight that reaches the view is only 134 nits. On the other hand, an AMLCD with a higher light transmission of 9% can yield 222 nits in direct sunlight.

Display Brightness Gain from 10,000 ft-C Sunlight.

AMLCD light transmission	3%	5%	7%
Brightness	**25 nits**	**69 nits**	**134 nits**

Test Setups
We have evaluated four different types of film- DBEF, DBEFM, BEF and white sheet- for reflectivity under direct sunlight. DBEFD, DBEFM and BEF are manufactured 3M. The white sheet is manufactured by Toray. The white sheet represents almost 100% reflectivity.

Figure #1 shows the display and optical stack arrangement for the brightness measurement. For sunlight readability, one must laminate an anti-reflective film on top of the LCD to minimize the front surface reflection. We choose a 15" AMLCD by AU Optronic because of its light transmission, clearing temperature and panel cost. The light transmission of the panel with a laminated AR film is approximately 7.3%. The backlight is comprised of a diffuser, a plastic light guide and a white sheet. These are the original display module backlight components. We tested DBEFD film serving as the "transflective" film. Next we tested the other films by replacing the DBEFD film by above mentioned films, including a white sheet and a black felt one at a time. This black felt arrangement will be used to obtain front surface reflection for brightness calculation.

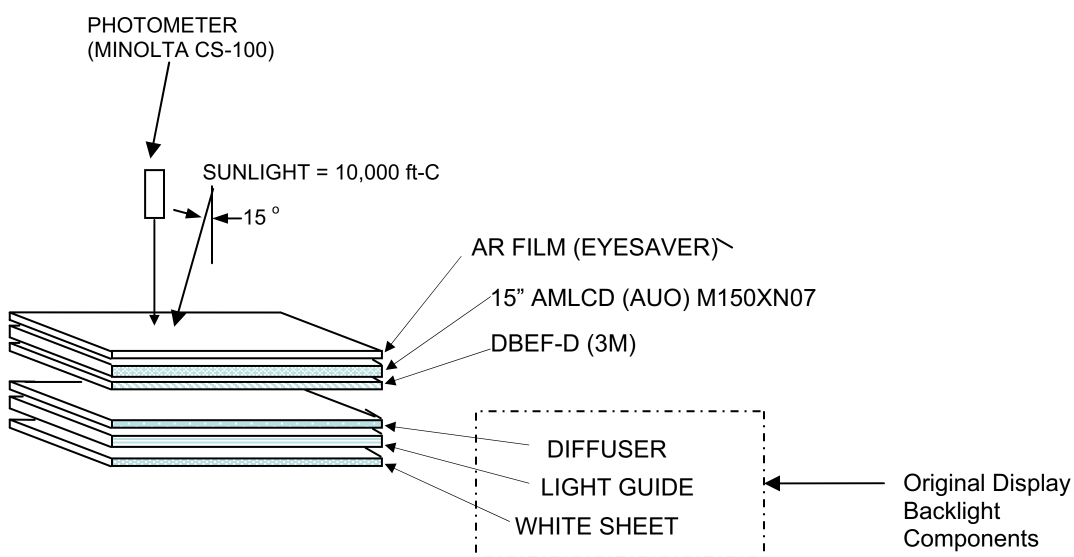

Figure 1

Table #1 shows the test results under 10,000 ft-C for various test configurations. Columns under white sheet and black felt, represent two most extreme conditions. The white sheet column represents maximum possible light reflection and the black felt column represents minimum possible light reflection under sunlight condition in a display system. As shown, the maximum brightness contributed by the sunlight of 10,000 ft-C in our set-up (15" panel, AR film and white sheet) is 130 nits. The brightness contribution due to DBEFD and DBEFM film in direct sunlight are 78 nits and 120 nits respectively.

Table #1

Film	DBEFD	DBEFM	BEF	White Sheet	Black Felt
Measured Brightness	113 ft-L	125 ft-L	121 ft-L	128 ft-L	90 ft-L
Brightness minus front surface reflection Note 1	23 (78 nits)	35(120 nits)	31(106 nits)	38(130 nits)	-

Note 1. For example: Column Figure 1a, 23 ft-L = (113-90) x 3.43 = 78 nits.
Note 2. Test condition is sunlight 10,000 ft-C (100,000 lux).

Insync has recently developed a line of 15" hi-bright display modules for sunlight readability. The display screen can survive +85C temperature under solar loading. These display modules are open frame. Table #2 has the brightness performance and backlight power consumption. The brightness components are separated by those contributed by the backlight and those contributed by the sunlight.

Table #2

Model #	Backlight Power Consumption	Brightness contribution by backlight	by 10,000 ft-C sunlight	Note 3
10D1521-182	32 watts (+12V)	1,480 nits	120 nits	1,600 nits
04D1521-180	16 watts (+12V)	880 nits	120 nits	1,000 nits

Note 3 Brightness to the viewer contributed by both the backlight and sunlight.