White Paper

Optical bonding

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1 GENERAL

Optical bonding is the affixing of two optical elements to one another, using a liquid adhesive. Using the qualifier *optical* implies that the adhesive is transparent, has a suitable refractive index and is made under adequate control that there are no significant variations in optical properties.

Barco uses front bonded displays where the protective glass is bonded directly to the LCD panel. Barco has developed unique bonding capabilities to protect the LCD against extreme environmental conditions (temperature, shock, vibration, humidity, EMI, …) and to significantly improve optical performance and protection against condensation.

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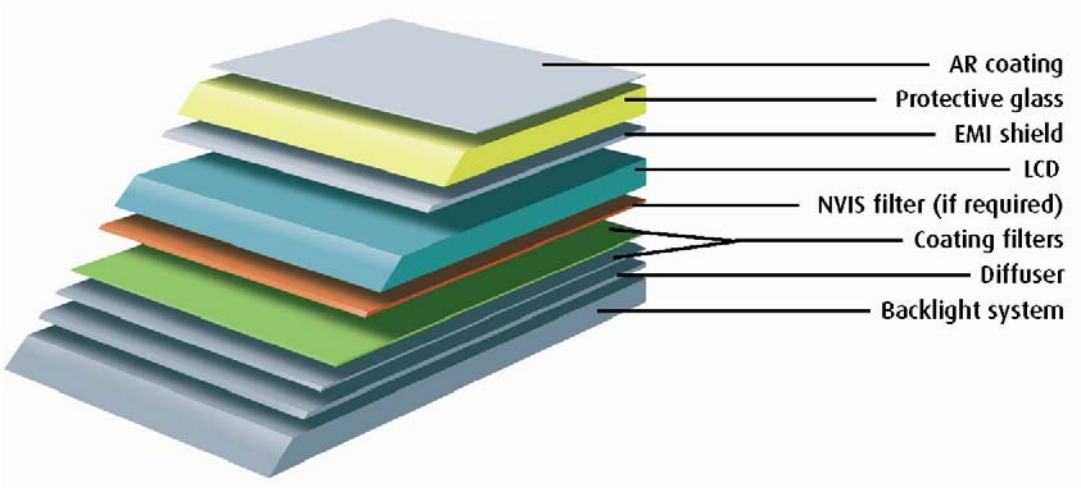
2 OPTICAL STACK

Barco's ability to bond large-size LCD panels is giving the company a differentiator in its target markets, compared to many competitors offering non-bonded panels.

The complete optical stack is depicted below and consists of several elements.



Optical Stack

- The **backlight system** produces the necessary light to have a bright image on the display. It can have Cold Cathode Fluorescent Lamps (CCFL) or Light Emitting Diodes (LED).
- The **diffuser** will evenly distribute the light across the entire display area.
- Additional **filters** can improve the light output and viewing angles. On some displays, an NVIS filter can be added for Night Vision compatibility.
- The **Front Bonded LCD** will add ruggedization to the complete display unit and is explained more in detail in next paragraph.

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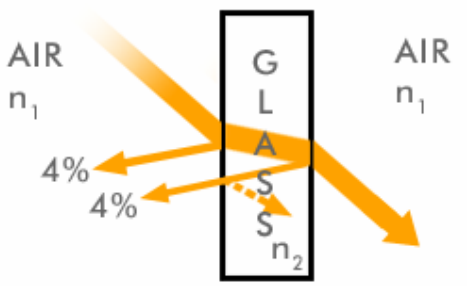
3 FRONT BONDING

Only protecting the LCD panel with a front glass for use in harsh environments will not be sufficient, as the optical performance will degrade due to additional reflections and glare. Also, other factors are playing a role in the overall display performance, such as temperature (below zero temperature), EMI/EMC, humidity and vibration/shock.

Next, we will explain what is done in the optical stack to improve the environmental and optical features.

3.1 About optical bonding

Every optical surface will have a reflection loss. The magnitude of the reflection is a result of the differences in refractive indices between the two optical media. This phenomenon can be derived from the mathematical Fresnel equations.



(© General Digital)

Reflections

This can be compared to the electrical impedance mismatch, causing reflections (resulting for example in ghost images on screens).
The goal of optical bonding is to minimize the differences in refractive indices, thus to minimize those reflections.
A normal air to glass transition results in a 4% reflection loss. Using appropriate coatings, this lost can be decreased to only about 0,5%.

3.2 Temperature

Barco guarantees operational use of its rugged displays below zero temperatures.
Background: An LCD display consists of liquid crystals molecules and its principle is based on the rotation of those molecules. However, these molecules will 'crystallize' at temperatures below 0°C so that no useable picture can be obtained.
The rugged solution consists of adding a heater between the front glass plate and the LCD panel (on the back of the front glass). This heater is an ITO coating (Indium Tin Oxide), which is conductive and transparent. Adding power makes this a heating element that warms up the LCD display so that a useable picture can be obtained at low temperatures.

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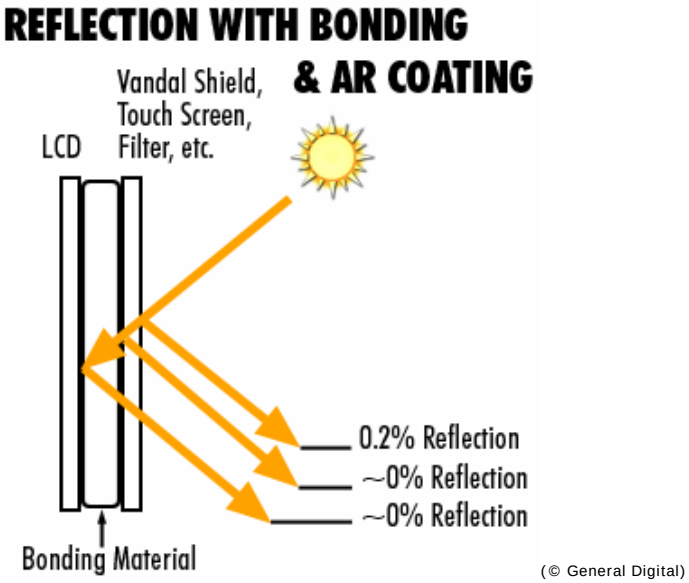
Note that, as stated in the above paragraph, this ITO coating is chosen so that the refractive indices match closely to reduce optical reflectance.

3.2 EMI / EMC

The front of the display is a 'gap' for electromagnetic waves (no metal shielding), so as well for EMI (ElectroMagnetic Interference) as for EMC (ElectroMagnetic Compatibility) this is a source for problems. Those waves can come from the inner electronics of the display and may interfere with the correct operation of other electronic or electrical devices in the neighbourhood (hence EMI). Following the inversed path, waves coming from neighbouring electronic and electrical devices can cause incompatibility with the display (hence EMC).
Solving this, a shield covering that gap is implemented by means of another conductive layer of ITO coating on the front of the glass. As always, this coating has to be index matched.

3.3 Antireflection

A user typically distinguishes two types of reflection, specular and diffuse. Specular reflections bounce off a surface like seen in a mirror (smooth surface). Diffuse reflections scatter incoming light in all directions (rough surface). The most annoying reflections are specular reflections.
Barco displays have Anti Reflection (AR) filters on the front of the protective glass plate. This treatment consists of depositing multiple layers molecule by molecule on the front glass substrate. This carefully lowers the specular reflectance of a normal glass surface of 4% down to less than 0.5%.



Reflections with bonding and AR coating

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3.5 Humidity

The front glass filter as described above is placed in front of the LCD glass. Without any additional treatments, there remains an air gap between the two glass plates. This causes two disadvantages:
Optical reflections between glass-air-glass
Condensation problems with higher humidity

Moist filled air can enter the air gap and as the outer glass filter gets colder, condensation forms in front of the image which renders the display unusable for an amount of time. This can partly be solved by adding a micro fan, but problems remain as dust and dirt can enter and be blown across the surface.

Barco therefore opts for front bonding. The LCD glass and the front glass filter are bonded together with a transparent and optically matching layer. This solution eliminates both problems that arise with the air gap.

3.6 Vibration / Shock

Now that the LCD is covered with a front bonded glass filter, the display is now more resistant to rugged environments. An additional bonus is that the glass plate adds more mechanical robustness to the total display assembly.
Additionally, front glass filters can be treated so that extended robustness is achieved by means of heat tempered glass or chemical threatened glass.
Where normal glass will scatter in higher vibration and/or shock environments, these glass filters can even survive hammer blows.

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4 CONCLUSION

Front Bonding is achieved through bonding the front filter to the front of the LCD. This provides the following unique advantages:

- LCD Ruggedization: Front Bonding gives the necessary strength to allow the AMLCD panel to survive substantial shock and vibration in rugged environments and provides the heating mechanism for the LCD for cold start-up.
- Excellent optical performance: reflections are reduced and parallax is reduced to a minimum
- No fogging (100% condensation free): eliminates the possibility of condensation build-up on the viewing surface.

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