

EV Display Technology Solution Guide

A Quick & Easy Guide to Developing Improved EV Displays Utilizing the Proper Engineered Material and Thermal Solutions

Overview

Boyd Corporation has been the leading innovator in Automotive and Mobile Display solutions since the introduction of smartphones and touch screens. In this article, Boyd leverages this experience and expertise to develop a quick Guide to Engineered Materials and Thermal Solutions for optimized E-mobility Displays. This article covers technologies for advanced telematics and display innovation as well integrated solutions and manufacturing processes that help OEMs reduce weight, lower total landed cost, and streamline supply chain. It includes the full spectrum of solutions ideal for E-mobility advanced display applications.

INTRODUCTION

The Automotive Industry is quickly changing with the evolution of Electric, Hybrid, and Autonomous Vehicles as well as the increase of connectivity across the vehicle. These major market changes are prompting disruptive technologies to evolve just as quickly. This is especially noticeable with smart technologies, communications, and displays. Intuitive Display Technology is an especially quick evolving segment as it expands beyond simple, traditional console displays and controls. The connectivity of everything within the vehicle has proliferated smart display technology across most applications, with sophisticated user preferences and expectations for a flawless and rich visual experience with high quality graphics, visibility in any user environment, vivid colors, and responsive touch. LCD, OLED, and smart displays are taking over the entire dashboard and augmenting additional applications throughout the vehicle like Heads-Up Displays (HUD), Smart Mirrors, eMirrors, Back Window Displays, Driver Monitoring, and improved Human Machine Interfaces (HMI) for enhanced safety and marketable differentiation.



Multiple Integrated Displays work together to improve driver safety and connectivity

This guide covers Engineered Material and Thermal Solutions that help make these new technologies possible for differentiated displays that perform better, are lighter weight, and more reliable.

DISPLAY APPLICATIONS IN E-MOBILITY

Center Console/ Dashboard

Displays are replacing the entire dashboard with superior navigation and improved infotainment, safety, and preventative communication through smarter systems that are more responsive to users' needs and vehicles' performance. Information available to drivers and passengers is exponentially increasing well beyond standard navigation. With increased connectivity and the introduction of advanced driver assistance systems (ADAS), drivers receive more up to date information regarding road, traffic, and system performance conditions as well as convenience features like where to stop along the road for charging or fuel stations.

Dashboards no longer contain predefined dials and buttons for a limited set of vehicle features, but rather sleek designs that allow drivers to view full diagnostics as well as easy access to more functionality and connectivity through the vehicle, providing a safer driving experience.



Newer Full Dash Display



Older Dash Layout

Heads-Up Displays (HUD)



Heads-Up Display

These displays project information as a transparent overlay on the windshield allowing drivers to safely view data while not looking away from the road. HUD devices require streamlined, low-profile designs, performance optical films and adhesives, thermal management, and tight tolerance control to operate reliably and accurately.

Smart Mirrors / eMirrors / Rear & Side Mirrors

Smart Mirrors work with cameras to allow a 360° view of the vehicle, eliminating blind spots and enabling Road Safety and Collision Warnings. They can record collisions and track damage incidents as well as provide improved views for auto reverse parking.

These systems are especially helpful with larger vehicles such as semi-trucks where blind spots are a significant safety factor and a primary cause for accidents. Smart Mirrors can be used both on the sides and back of the vehicle to display full surroundings for improved safety.



Smart Mirrors & Camera Systems

WHY MATERIALS & THERMAL SOLUTIONS ARE REQUIRED

Each of these applications require appropriate Engineered Material Solutions to ensure that the display has the appropriate mechanical strength to withstand harsh road conditions and shock impact (NVH (Noise, Vibration, and Harshness) - or BSR (Buzz, Squeak, and Rattle)), as well as securely staying affixed in or on the vehicle over long lifetimes. Each display requires screen protection and specialized optical films to maximize visibility and enhance readability in environments with varying light sources and levels. Each display must be waterproofed and dustproofed against unpredictable user conditions to combat contamination. Increased connectivity of newer vehicles has introduced many new electronics into a limited design space meaning displays must also be protected against electromagnetic interference (EMI), spark voltage, and dielectric crosstalk.

Electronics with increased power and processing speeds, combined with prolonged consumer usage in various environments and temperature extremes, depend upon thermal solutions to spread, block, or shield heat, eliminate hot spots, or conduct waste heat away from sensitive electronics. This includes graphite and material heat spreading, board level heat sinks, and two phase cooling technology like vapor chambers.

By integrating multiple engineered material and thermal technologies into efficient multi-function solutions, Boyd develops thinner, lighter, better performing products with less material waste, lower landed cost, and a streamlined supply chain.

Display Enhancement

Displays are susceptible to many challenges that negatively impact visibility, legibility, accuracy, vivacity, and usage without optimized enhancements. This can render the display useless and be dangerous for the driver. There is a wide range of specialized films that are often used together in technology stack-ups that enable improved displays with multiple functions. This includes enhancing clarity, brightness, color trueness, digital display legibility, and control over the display in various environments.

Popular Specialized Enhancement Films:**• Anti-Glare & Security Films**

- Reduce unsafe driving conditions by decreasing display glare and reflection, critical for automotive screens that are used in environments with varying levels and sources of both natural and artificial light.
- Control the viewable angle of LED, OLED, and LCD screens with microlouvers to assure display messaging and visibility is optimized for the user. Microlouvers block light from exiting the sides of a display and direct light to the middle viewing angle, typically around 60°, to reach the viewer's line of sight freely and optimally.
- Reduce reflection onto glass surfaces throughout the vehicle like windshields, windows, and mirrors.
- Improve contrast for liquid crystal displays (LCDs).
- Options:
 - Most often on polycarbonate (PC) substrates
 - Available with or without a matte hard coat
 - Anti-Glare Films can be combined with a reflective polarizer
 - Installation between the touch panel and LCD, outside of an LCD, or within the backlight of a liquid crystal display



Raw Anti-Glare Film

• Brightness Enhancement Film

- Integrate into a display backlight architecture to increase brightness, decrease weight, mitigate heat and improve power efficiency for displays with improved safe operation during vehicle use and a better user experience.
- Manage the angle that light is output from a backlight unit and compress light through refraction to better direct visibility to the user. Improved management of light increases the efficiency of the display and uniformity of graphics.



Light Enhancement Film

- **Reflector Films**

- Improve display efficiency and brightness with reflector films that integrate into a backlight unit to reflect emitted light towards the field of vision and reduce waste light directed to the sides or back of a display. 100% polymer reflector films feature no metals and will not conduct electricity or heat for improved isolated performance in thin display stacks.
- >98% reflectance across the entire visible spectrum maximizes the recycling efficiency of LCD backlight units.

- **Polarizer & Orientation Films**

- Allows one polarization of light to pass through the display (i.e. horizontally traveling light) while reflecting the other polarization of light (i.e. vertically traveling light) to the backlight to recycle it for improved display vivacity and performance.
- Reflective Polarizers increase light transmission through the LCD.

Display / Screen Protection



Screen Protection

Protection Films provide an optically transparent barrier to improve a display's resistance to scratches, impact, UV, and water, while maintaining optical transmittance. Protective Films can be designed for longer term applications throughout vehicle use or more temporary to guard screens throughout manufacturing, build, and sales processes to be removed by the owner. This assures that displays are flawless at purchase.

Optical films for long term consumer use protect sensitive components like glass, screens, and other surfaces from scratching or cracking during frequent and repeated use or touching. This includes Anti-Shatter and Reinforcement solutions.

Optically Clear Adhesives & Bezel Bonding

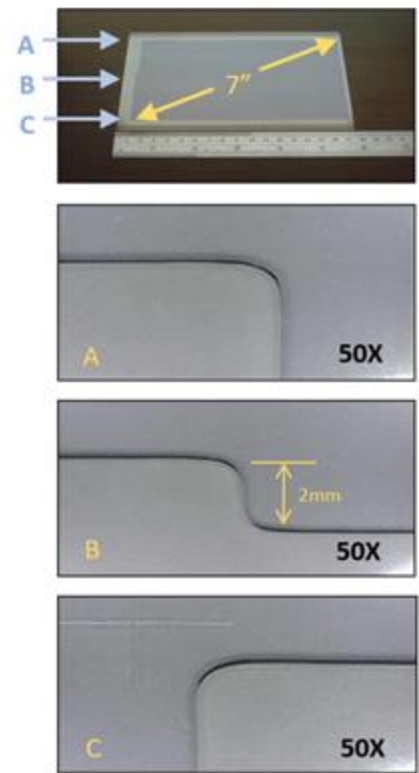


Bezel Bonding

Optically Clear Adhesives (OCAs) are highly transparent adhesives used to bond visually clear components into an optically clear lamination without bubbles or distortion. OCAs laminate transparent materials and layers together, enabling complex optically clear assemblies to transmit as much light as possible through optimal refraction and refractive index matching. Optimizing the refractive index of laminated display components improves contrast ratio and optical clarity while reducing reflected light, which improves the viewability, vivacity, clarity and readability of LCD, LED, and OLED screens. OCAs create a differentiated automotive display experience with improved safety.

These adhesives are used specifically for their superior optical and mechanical attachment qualities. Optically Clear Adhesives have high dimensional stability, low shrinkage, and resist whitening over time. Integrating layers with the right OCAs enable rugged, long lasting bonds in complex optically clear laminations. OCAs come in a variety of formulations to accommodate a broad array of applications but are typically composed of acrylic, polyvinyl acetate (PVA), polyurethane (PU), silicone, or epoxy. The optical transparency of OCAs and application directly between the display and the user's field of vision mean that they must be coated, handled, and fabricated with zero defects or visual flaws. It's recommended to handle, fabricate and assemble OCAs in high cleanliness environments certified to Class 100.

OCAs also offer ingress protection and reduce the width required for bezels to maximize screen space, better waterproofing the display, protecting it against contaminants, and creating a more immersive display experience. OCAs are often utilized with bezel bonding techniques and integrated display gaskets for high performance, ultra-tight tolerance, streamlined touch display mounts.



OCAs

Display Gaskets & Sealing Solutions

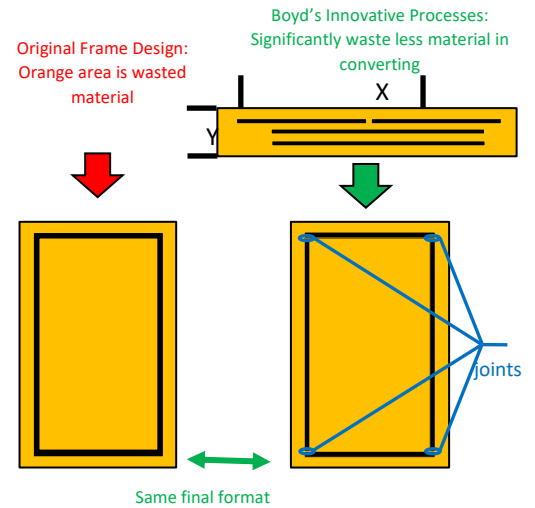
Display gaskets are flexible, resilient, and most often utilized to ruggedize screens and improve durability. They absorb shock and vibration to prevent screen cracking and dust ingress while also enabling heat dissipation, and acoustic or mechanical energy damping. Gaskets also protect sensitive internal display electronics and sustain long term optical clarity against dust, water, heat, oil, or other contaminants. Combine a display gasket with thermal spreading, electrical insulation, and static dissipative seals for safer, improved performance. By integrating multiple engineered material and thermal technologies into one efficient display gasket solution, Boyd develops one streamlined, multi-functional component for greater assembly efficiency and simplified sourcing complexity.

Boyd Segmented Frame Processes

Segmented Frame Technology is a high precision, reel-to-reel manufacturing process that utilizes Boyd’s proprietary high-speed production lines to eliminate waste, maximize material utilization, and optimize component cost. Material waste is eliminated by spacing and orienting release liners, bonding tapes, optical films, and optically clear adhesives in such a way that material is cut to maximize yield while components are assembled with zero-gap tolerances, assuring excellent quality and efficiency to drive down landed costs.



Segmented Frames for Multi-layer Solutions



Additional Engineered Materials Available

- ***Diffuser and Black-Out Films***
- ***ITO Films / Electrically Conductive Films***
- ***Lightguides***
- ***Laminating Tapes/ BLU Lamination***
- ***Graphite Heat Spreading Films***
- ***Ring Tapes***
- ***EMI Films***
- ***Foam Gaskets, Dampers & Spacers***
- ***High Heat Polyimide Tapes & Electrical Isolation***
- ***Double & Single-Sided Adhesives***
- ***Foam Tapes***
- ***Insulating Films***

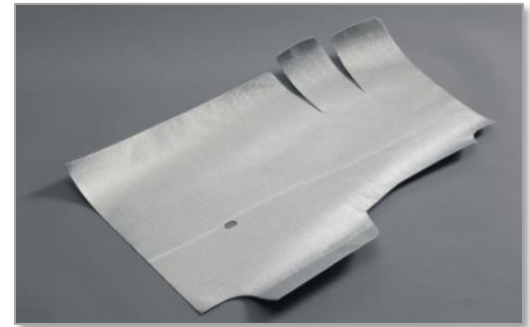
Display Integrations utilize multiple technologies



Thermal Management & Heat Spreading

The rise in display processing power, smart functionality, and connectivity generates more heat. This heat can cause high touch temperatures, device overheating and failure, and degradation in accuracy and performance.

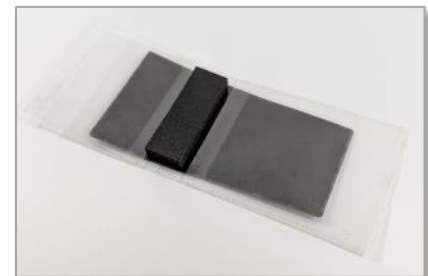
Implement Heat Spreading to move heat quickly and efficiently away from sensitive components, remove hotspots and prevent reaching critical temperatures. Heat Spreading methods are easily integrated with engineered materials for multi-functional display systems with streamlined supply chains and lower landed costs.



Heat Shields

Popular thermal solutions include:

- Graphite Pads & Films for improved in-plane thermal conductivity with low mass and high heat transfer. They offer high performance and uniform heat spreading in ultra-thin, easy to integrate geometries.
- Heat Pipes & Vapor Chambers for superior heat spreading and long-term reliability in ultra-thin form factors. Copper and stainless steel vapor chambers at 0.4mm thickness offer 4X the thermal conductivity of graphite spreaders. For ultra-high performance applications, titanium vapor chambers at 0.4mm thickness offer 12 to 18X the thermal conductivity of graphite spreaders.
- Flexible Heat Pipe technology for heat transfer in movable components.
- Thermal Interface Materials improve the interface between a heat source and the thermal management system through conduction cooling and heat spreading. They can also offer mechanical strength, vibration damping, and adhesion.
- Board Level Cooling for PCBs that handle processing and device control.



Integrated Graphite Solution



Small Form Factor Heat Pipe Solution

- Heat Shields stop radiant heat from transferring from hot components to sensitive surfaces, devices, and systems. These light, low profile, and flexible solutions are ideal for light weighting in minimal to zero clearance areas. They can also offer:
 - UV Resistance
 - Incombustible or Fire Resistance
 - Tear & Puncture Resistance
 - Flame Blocking
 - Easy Cleanability
 - Vapor & Fluid Blocking
 - Moisture, Corrosion, & Solvent Resistance

INTEGRATIONS & PROCESSES

By utilizing Boyd's advanced processes and integrated solutions, engineers can increase material utilization and reduce waste cost, simplify supply chain and end device assembly, and maximize reliable display functionality for an overall total lower landed cost and enhanced consumer experience. E-mobility Display applications require innovative manufacturing processes that enable extremely tight tolerances for precision assemblies, little to no waste of expensive, innovative, performance-enhancing materials, cleanroom manufacturing for Foreign Object Debris (FOD) control and visually flawless displays, fast prototyping and design for accelerated speed to market, and high-volume, globally available production with lower overall cost.

Boyd is an expert at evaluating a full display system design to identify complementary components with the potential to be manufactured and delivered to customers in a streamlined assembly. Boyd has collapsed as many as 12 unique, individual display bill of material items into one streamlined component; helping to speed design, manufacturing and delivery cycles, improve quality and tolerance, and reduce display thickness, supply chain complexity, and logistics costs. Specialized skills and processes like this and Boyd's Segmented Frame "zero gap" tolerance gaskets that reduce material waste help customers improve performance and better manage total cost.

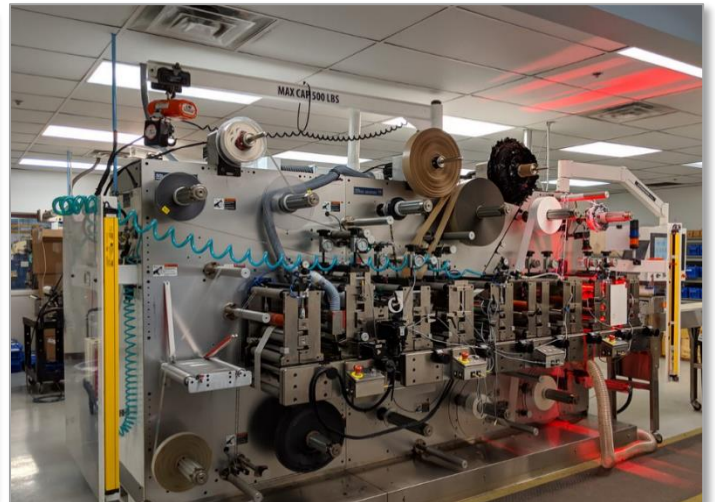
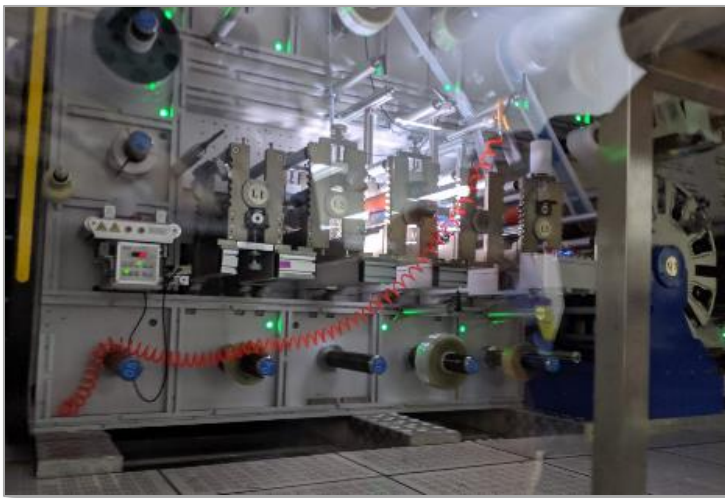


Clean Room Rotary Die Cutting

For decades Boyd has fostered strategic partnerships with the world's leading display material innovators, global suppliers, and design engineers. These partnerships, along with global manufacturing innovation and facilities, enable Boyd to stay at the forefront of display development and innovation. This has heavily contributed to one of the widest portfolios of Materials, Suppliers (including 3M and Nitto), dedicated processes, and global manufacturing for Displays.

Multiple Integrated Components – One Pass Manufacturing

Boyd's advanced rotary die cutting is an industrial science that has refined a proprietary process to cut and assemble multiple display components that can feature a variety of raw materials and thicknesses with unique component configurations and functionality in one complex stack. Each input component is cut and introduced to the rotary production line using proprietary industrial design techniques and assembled with extremely tight tolerances in one pass through the manufacturing line. Innovation and complexity increase monthly with continuous research and development to advance what is achievable. Customers benefit from increased precision, faster turnaround, shorter lead times, higher performance, thinner displays, and greater cost efficiency.



Advanced Rotary Die Cutting available globally.

Working Towards Lower Landed Costs & Supply Chain

Boyd has longstanding market leadership in advanced display components and a competitive advantage in display module bonding, cushioning, heat spreading, shielding, and laminating optical films. Strong relationships with the world's leading display material innovators and numerous existing vendor codes with leading display module companies means that Boyd has established design partnerships and logistics to easily integrate into your display value chain. Boyd's extensive material supply partnerships with the world's leading innovators in optical films and display adhesive raw material suppliers assure the earliest and continual access to the best performing, most technically advanced raw materials globally available. We're often the global Preferred Converting Partner with these raw material innovators with relationships dating 50+ years and manufacturing processes and clean room environments optimized to handle and fabricate sensitive materials.

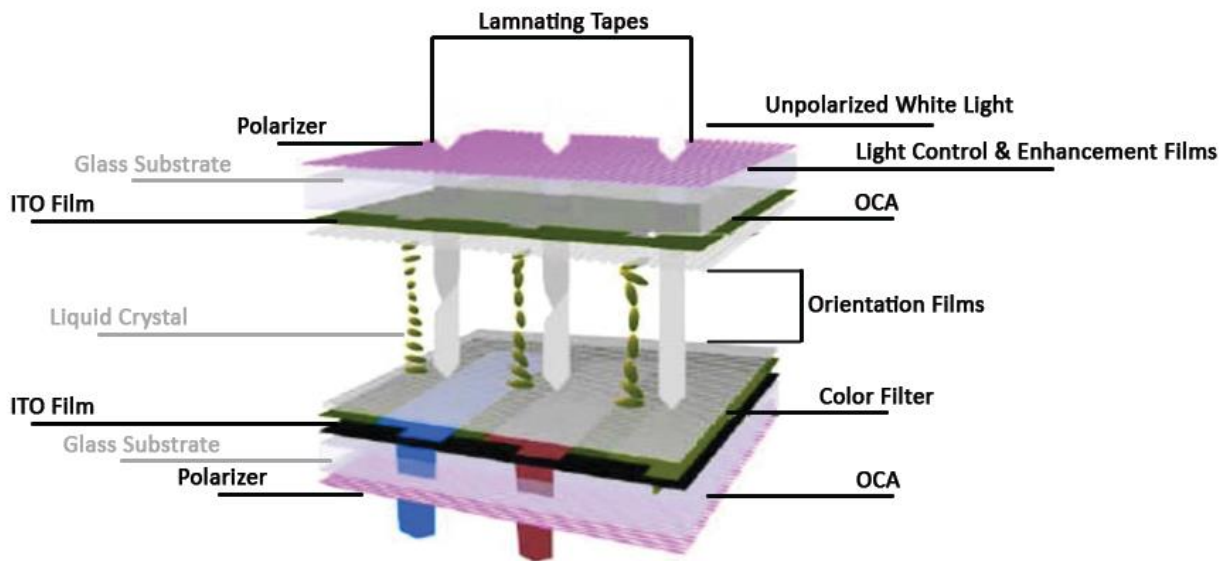
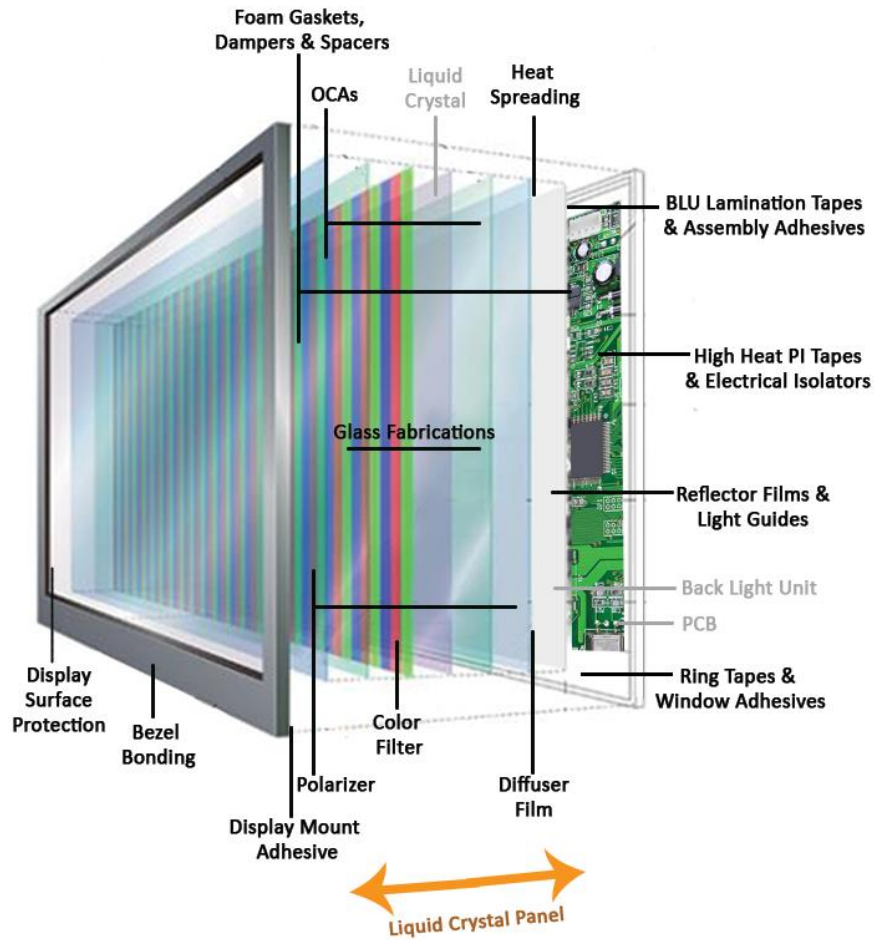
With IoT and the connectivity of everything, displays are now integrated into transportation, industrial automation, healthcare, appliances, smart home equipment, retail services, gaming equipment, wearables and power markets – all of which Boyd currently supports. With vast experience and innovation in display technologies as well as the new markets they are proliferating across, Boyd is uniquely positioned to help you develop innovative display applications that provide marketable differentiation with a design velocity that accelerates speed to market.

Example Product Integration/ Stack Up

Integrated Displays vary based on the application and device functionality; however, many have a similar mix of materials. Below are examples of potential integrations that can be accomplished with Boyd advanced rotary manufacturing.



Display Examples



WHAT'S NEXT?

As the market for Hybrid, Fully Electric, and Autonomous Vehicles continues to expand rapidly, the needs and customer expectations for Display quality and functionality will also grow extremely quickly. Design specifications will become more stringent, drivers will demand more functionality, and processing power and electronics will continue to break boundaries. Safety features communicated and presented via the Display will be key to driver satisfaction and purchasing decisions. Therefore, it is vital that vehicle manufacturers stay on the forefront of display and telematic technologies.

With decades of innovation expertise, experience, and supplier partnerships, coupled with the unique approach of integrating multiple technologies into a streamlined product, Boyd Corporation will continue to stay at the forefront of innovation and improved manufacturing with lower landed costs. If you are looking to solve current issues or tackle new challenges for the next generation, start by contacting Boyd Corporation to learn more about engineered materials, thermal solutions, customizations, and improved processes for Electric and Autonomous Vehicle Displays.

To receive more information, please visit www.boydcorp.com.

BOYD
CORPORATION