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EXPERT ARTICLE OPTICAL BONDING

A ROBUST UNIT – BRILLIANT DISPLAYS THANKS TO OPTICAL BONDING

Fact check

- The most common processes at a glance
- Scope of application for automated LOCA bonding processes
- PIA systems operate with high cycle rates and precision
- A range of processes available, depending on the end device and application

PRECISE MANUFACTURING TECHNOLOGY FOR BRILLIANT DISPLAYS

INDIVIDUAL COMPONENTS PERFECTLY COMBINED

What is currently likely the most widely used application for optical bonding can often be found in purses or pockets: the smartphone. Once activated, what is colloquially known as the display lights up and shows the time, weather, or other notifications. However, the actual display is behind the front glass, with a touch sensor installed between the glass and the display. The process used to bond two or more components is called optical bonding. Depending on the end device and intended use, there are several different processes in use in the industry.

This article discusses the most common optical bonding processes, identifies the differences between them and shows the possible applications and potential for automated LOCA bonding processes (Liquid Optical Clear Adhesive Bonding), which is considered the superior process when it comes to optical bonding. Companies like PIA Automation offer special systems for this purpose, which assemble the individual components in high cycle rates and with high precision.

Whether it's operating a smartphone or navigation system, adjusting the steamer or watching TV on a flat screen in the living room at night: We come across small and large displays all day long, from the early morning until late at night. In this context, capacitive systems, which are touch screens that react very sensitively to touch and can be controlled precisely, are increasingly in demand. The requirements for displays intended for professional use are often much higher than for those used in the private sphere. Displays used in industrial applications often have to withstand difficult, sometimes dusty or wet environmental conditions, must be easy to operate and easy to read, and should process the user's control commands precisely, whether they use their bare hands or wear gloves.

OPTICAL BONDING IS THE METHOD OF CHOICE

The optical bonding process has established itself as the method of choice for connecting the individual display components. Originally used primarily for applications in the military or in aviation, this process began its triumphant advance with the spread of smartphones. Today, displays bonded with this method are used not only in the consumer goods industry but also, for example, in the automotive industry, in medical technology and in industrial plants. A distinction is made between three main variants: LOCA bonding (liquid optical clear adhesive bonding), air gap bonding (also known as tape bonding or air gap bonding) and OCA bonding (optical clear adhesive bonding).

Which variant is best suited for which device depends on various factors, like indoor or outdoor use, temperature and weather conditions, or even lighting conditions at the place of use. How robust the displays need to be also factors into the choice of the suitable bonding variant. If the displays are intended to be used in harsh working conditions and exposed to vibrations, for example, the components need to be bonded in a particularly strong way.

LOCA BONDING: A FLUID PROCESS

LOCA bonding uses a so-called bonding fill compound. It is applied between the components to be bonded and spreads without gaps over the entire surface during bonding.

In this process, the gap between the components is completely filled with bonding fill compound, which has a number of advantages: Firstly, the display transmits more light, which leads to better readability, especially in bright ambient light. LOCA bonding also significantly reduces light reflections due to the special refractive index of the bonding fill compound. Furthermore, the additional layer increases the stability of the entire bond. Displays bonded in this way are therefore significantly more robust against mechanical impact.

The fill compound also keeps out moisture or dust. Touch displays bonded using LOCA bonding boast a very high operating accuracy. Today, the process is generally standard for high-quality smartphones and for many other displays that demand high quality and excellent readability.

After UV curing of the bonded components – displayed is a control unit for a home appliance – the process is complete.

AUTOMATED OPTICAL BONDING PROCESSES

There is a reason that LOCA bonding is often referred to as “the highest form of bonding”. This bonding process is technically complex; errors in the process have an immediate and literally visible effect on the end device. This is why systems for automated LOCA bonding are in increasingly high demand.

They have to deliver consistently high quality, high cycle times, precision and repeatability. Environmental conditions such as temperature or humidity also have a direct impact on the quality of the end product. PIA Automation builds on many years of experience with these systems and has implemented projects for customers from various industries, ranging from the consumer goods industry all the way to automotive customers. PIA’s systems are designed to be operated in a clean room.

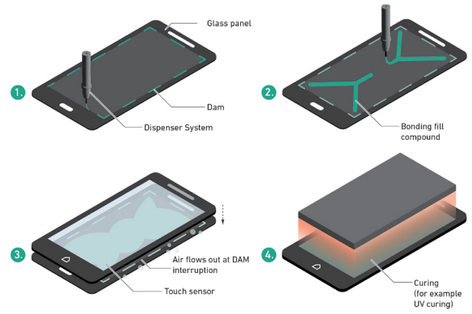
Such systems usually consist of several cells, just like in the production of control units for high-quality household appliances. The first cell in PIA’s systems prepares the various components for the actual bonding and for downstream process steps. For example, the main components as well as connecting parts can be activated with plasma in this cell. The plasma generated by an electrical generator, an ionized gas, activates the surfaces of the components so that they can be optimally processed later. Plasma activation also positively impacts the flowing properties of the adhesive. Robots compatible with clean room applications can also be installed in such preparation cells, for example to remove protective films that are often applied to touch sensors or front glass panels.

The heart of the system is the cell in which the components are joined to form a robust composite. For this purpose, a dispenser system first applies the dam to the front glass panel — a highly viscous protective agent. It acts as a barrier and guide for the bonding adhesive, which later fills the air gap between the various components over the entire surface. The height of the dam is crucial for the subsequent success of the optical bonding.

This is why PIA has integrated smart tools that automatically measure the height on the glass panel so that the dispenser can apply the dam in a path-controlled manner, at a constant distance from the glass surface and in the perfect dosage. If necessary, the dam can then be cured with UV light.

The bonding fill compound is then applied to the active layer, which is the part of the display that will be visible later. Here, too, extreme precision is required. For its systems, PIA successfully cooperates with the Viscotec company for this production step: Viscotec supplies the metering units that apply the compound to the respective components in exactly the desired quantity and viscosity. For a perfect bonding result, these must be joined in a plane parallel to each other after the fill compound is applied. To do this, PIA systems are equipped with measuring systems that automatically detect exactly where the active layer is located. Based on the measuring points determined, two spindle drives align the position of the component as required underneath the workpiece carrier. The touch glass is then placed exactly on the glass panel, and the bonding fill compound can subsequently also be cured under UV light if required.

In downstream cells, for example, connecting parts can still be bonded to the front glass. After automated optical bonding is complete, a visual inspection is usually carried out by experienced machine operators, after which the displays are ready for further processing. Using these systems, PIA Automation reaches cycle times of around one minute.



Systems for automated LOCA bonding enable an efficient and reliable production of displays of various types.

OCA BONDING: RELIABLY BONDED

With OCA bonding, full-surface adhesive foils are used between the individual components to avoid reflections. The adhesive film is bonded to the components using a roll lamination system. Subsequently, an autoclave — a gas-tight sealable pressure vessel — removes any air pockets and also cures the assembly. The OCA bonding process offers cost advantages, but it can only be used to create displays up to a diagonal length of around 30 inches. Height differences between the individual components can only be compensated for to a limited extent by the adhesive film. This makes displays bonded in this way more sensitive to impact. Displays joined together by OCA bonding are mainly used indoors.

AIR GAP BONDING: TWO ARE BETTER THAN ONE

In this process, the individual components are joined to the frame of the components with a double-sided adhesive tape. The process offers cost benefits since both large quantities and smaller batches can be processed cost-effectively in a short time. However, there are disadvantages in terms of readability: Due to the air gap, light reflections can occur and affect the brightness of the display. In addition, the air gap increases the risk of dust particles or moisture getting trapped between the components. Displays assembled by air gap bonding are suitable for outdoor applications only to a limited extent.

An important prerequisite for perfect bonding processes is that the bonding fill compound is applied to the respective components via metering systems in the desired quantity and viscosity.

CONCLUSION: A SUITABLE TECHNOLOGY FOR AN EMERGING MARKET

Displays manufactured using the LOCA bonding method are significantly clearer and more color-intensive than displays bonded in other processes. They are also less susceptible to reflections and more robust.

They are becoming increasing more common, and the market for touch displays alone has been growing steadily for years. Analysts at Fortune Business Insights calculated a market volume of $59.57 billion for 2021. It is expected to grow to $166.12 billion by 2029, an annual growth rate of almost 14%. Presumably, display manufacturers will increasingly demand equipment for automated LOCA bonding in the future.

They can be operated around the clock, offer absolute precision and high repeatability — and consequently form the backbone of efficient display production.

creating efficiency.

We make high-quality products available to everyone – sustainable and worldwide – that is what we stand for at PIA.

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