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Adhesives and sealants' unique properties in electronics and disassembly functions

FEICA, the Association of the European Adhesive & Sealant Industry, is a multinational association representing the European adhesive and sealant industry. Today's membership stands at 16 National Association Members (representing 17 countries), 25 Direct Company Members and 24 Affiliate Company Members. The European market for adhesives and sealants is currently worth more than 17 billion euros. With the support of its national associations and several direct and affiliated members, FEICA coordinates, represents and advocates the common interests of our industry throughout Europe. In this regard, FEICA works with all relevant stakeholders to create a mutually beneficial economic and legislative environment.

Adhesives and sealants unique properties in the electronics sector

In light of the transition to an increasingly circular economy, FEICA actively supports efforts to improve product efficiency and circularity to help create a more sustainable society. The use of adhesives and sealants in many sectors, including electronics, contributes to improved durability, recycling, CO₂ reduction, reparability, upgradability and material efficiency of final products. It is of paramount importance to FEICA and its members to raise awareness of the adhesive and sealant industry's contribution to sustainability, internally and externally, in terms of both activities to improve the sustainability of its own industry and help for customers and end of supply chain industries (recyclers) to operate more sustainably.

The use of adhesives as a joining technology in electronics allows the extension of the life span of products and components, offering increased durability, with waterproof capabilities. Adhesives bear many advantages in the manufacturing processes, for example, energy and material efficiency. With regard to the climate goals of the EU Green Deal, the complete life cycle of a product should be taken into account. Modern thin and seamless device designs are achievable only by the use of adhesive solutions.

These solutions allow designs for lighter, more shock-resistant and better sealed products. They enhance features such as resource efficiency through increased durability and lifespan of the product, leading to fewer repairs and conservation of resources as well as convenience and safety for the consumer.

Adhesive bonding technology facilitates smartphone design and manufacturing to increase reliability, structural stability and waterproofing, and to enable automation of manufacturing lines. Enhancements due to adhesives largely contribute to resource efficiency and durability during the use phase of the device. Certain adhesives enable the design features, all the while decreasing usage and the footprint of plastics, metals and other raw materials. This is done through thinner bondlines and uniform distribution of stress, together with high strength and high impact resistance that mechanical fasteners cannot accomplish due to space constraints. Adhesives enable

consumer electronic device features because their small bonding areas allow smaller devices, which generate lower weight of the plastic enclosures, which means less waste.

Water damages are identified in Ecodesign studies as the second leading cause for product failure. Further, as presented during the stakeholder web meeting on 18 December 2020 for the Ecodesign study 'Mobile phones, smartphones and tablets' from Fraunhofer, the waterproof aspect in terms of functionality scores up to 66% -the highest- when the question is asked, 'Which features are important to you when purchasing a smartphone next time?' (source: [stakeholder web meeting on 18 December 2020 slides](#), Bitkom, 02/2020).

The latest smartphone models are designed to be waterproof and can withstand a continuous immersion in water or other liquids, even at a depth of 1 meter, for up to 30 minutes and longer. Adhesives play a substantial role in making smartphones waterproof since they seal potential entry points, protecting against any type of liquid like beverages, cleaning chemicals, lotions or perfumes, to which smartphones are exposed. In other words, adhesives perform at the same time a twofold function of bonding and sealing, therefore enhancing the durability of the device significantly.

Modern electronics often requires joining and sealing parts of dissimilar materials (e.g., glass/polymer or polymer/metal joints). Joining dissimilar materials comes with challenges related to the different coefficients of thermal expansion of each material. In many cases, adhesives are the only available joining option to maintain a free-of-stress interface. This holds particularly true in the case of smartphones, which could be exposed to shock-like temperature changes in real use conditions: A black phone could be exposed to the sun or be used at very low temperatures (a change from 37,°C in one's pocket to 0 °C or even lower).

Despite mechanical and process-related advantages, adhesives are able to add 'function' to the joining connection. This may include an optical function (as demonstrated by the 'display' example below), but also holds true for electrical (isotropic conductive, anisotropic conductive or insulating), dielectric (tailored relative permittivity) and even decorative functions.

Examples in displays

FEICA would like to give an example of the use of adhesives in displays, in particular between the 'display unit' and the 'front panel digitiser unit'. It is crucial to add an adhesive in-between the layers as:

- a. The presence of air between the two elements (display and front panel digitiser unit) creates light distortion due to different refractive indexes. This means that the screen resolution could be affected, and the digitiser must be recalibrated. Hence, an optically clear adhesive (OCA) or optically clear resin (OCR) with matching refractive index must be placed between the two elements.
- b. If each layer has independent movement, alignment between those elements can change over use, creating a mismatch between 'what we see vs. what we touch', so the touchscreen needs to be recalibrated often. Thus, an adhesive needs to be placed between the layers to enable accurate touch functionality.

Such technology (display and front panel digitiser unit) cannot be achieved without the use of adhesives between the two units. The use of an OCA or OCR improves mechanical, optical and electrical performance of the display module and device.

Examples in batteries

It has to be considered also that the adhesives used for embedded batteries often provide not only the function of precise positioning of the batteries in the device but also additional functionalities

like, e.g., sealing (watertightness), thermal and electrical management (isolators or conductors), safety (flame retardance), design freedom, and protection against dropping.

Adhesives enable an efficient heat management of the batteries and, thus, significantly enhance the product lifetime. There are significant enabling technological advances in the field of battery mounting and removal. The technological trend regarding batteries is a shift from solid housing towards thinner and flexible batteries with higher capacity. Along with this trend, the mounting of batteries into smartphones has changed as well, from mechanical fixation towards adhesive bonding, allowing the safe introduction of thinner and flexible batteries into smartphones.

Electronics disassembly, and adhesives and sealants functions enabling electronics reusability, repairability and recyclability

FEICA members support the need for Ecodesign to encourage end-of-life reuse and recycling solutions for electronic products and components. The aims for reducing waste and ensuring full circularity of the economy go beyond what economic actors can achieve alone. FEICA has already been an active advocate of the Ecodesign legislation proposals for electronics and supports the principle that design for circularity is important.

The value proposition of adhesives and sealants is an integral part of many global value chains. Adhesive technologies make the sustainability benefits of next generation goods possible. Wishing to engage in constructive dialogues with interested stakeholders, FEICA also wishes to better explain to the recycling industries how adhesives and sealants perform at the end of life of electronic devices (e.g., in the case of mobile phones, laptops and tablets).

Adhesives are an outstanding and versatile fixing solution. The use of appropriate adhesive bonding solutions to facilitate repair and recycling should be properly planned and engineered during the design phase of a product.

Adhesive solutions in electronics promote recycling by applying innovative solutions that offer debonding-on-command type adhesives, enabling the easy separation of bonded components for repair or recycling. For adhesive bonding, DIN/TS 54405 was published in 2020 as a guideline for separating bonded joints (source: DIN/TS 54405-04/2021, Konstruktionsklebstoffe – Leitlinie zum Trennen und Rückgewinnen aus geklebten Verbindungen, Beuth-Verlag Berlin, 2021). Due to high investments during the last years, today many adhesive bonds are 'reworkable'. This means they debond through the application of heat or other available techniques to facilitate dismantling of the product's components. Adhesive and sealant products can be provided which are able to debond on demand with the use of electromagnetic irradiation (i.e., thermal treatment) that is focused on the bonding line and is nondestructive to the assembled parts. Other debonding solutions entail chemical or mechanical techniques.

The Ecodesign study 'Mobile phones, smartphones and tablets' Task 6 report (Chapter 5.1, page 75) from Fraunhofer underscores the versatility of adhesives as being releasable and removable, if so designed. This versatility offers great benefits for the final product in respect to the circular economy aspects and factors. For additional information we would like to cite the study 'Circular economy and adhesive bonding technology', as published by [Fraunhofer](#).

It is well known to skilled persons (professional workers) in the field of adhesives that the definition of the adhesive failure mode with respect to the substrate is a very important criterion for the design of adhesive formulations. More information about the adhesive failure or cohesive failure can be found at Fraunhofer IFAM [here](#) or [here](#). Formulators (adhesive manufacturers) are used to designing products with regard to the substrates to be bonded as well as the bond strengths needed for the

dedicated purpose. Adjusting the performance of an adhesive to the forces needed in the interfaces between substrate and adhesives is state-of-the-art.

One of the options to build trust and to influence the relationship between consumers and business, with the aim of extending the useful life of goods, is repairability by professionals. This means repairs by a manufacturer, seller or independent repairer. FEICA believes that the professional repair by operators having skills, tools and knowledge is in general the recommended way to replace spare parts, since this guarantees the correct end-of-life handling of the parts intended to be replaced, with regard to the circular economy and EU Green Deal principles.

Professional repairers can collect the replaced and damaged spare parts, i.e., batteries, and return them into recycling material streams, for example, back to the manufacturer. A layperson, on the other hand, might not have access to a waste collector able to correctly sort the different materials.

The adhesives and sealants industry recommends that electronic devices be repaired by professionals to ensure not only the quality of the replaced product but also the continuity of the market of professional workers. More trust is to be given to an electronic product repaired by a professional repairer. Professional repairers could establish prolonged or renewed warranty periods after repair. These would help to motivate and strengthen consumers' rights and trust in repaired devices.

Furthermore, the handling, manipulation and disposal of the removed battery pouches by inexperienced users, despite the facilitated process, presents an increased risk of thermal runaways. Those events can lead to serious injuries, as was proven when devices with inadequate batteries were offered to the public (e.g., [Samsung Galaxy Note 7, recalled in October 2016](#)). Therefore, it can be argued that making fragile battery packs inaccessible is a deliberate decision to ensure user safety.

The adhesives and sealants industry will continue to cooperate by reaching out to relevant sectors or contributing to consultations of Ecodesign studies from the Commission to optimise durability and end-of-life solutions through options such as recycling and repair potential. We would be happy to further engage with relevant experts, as needed, to support a societal and pragmatic shift to a more sustainable future.

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