Fraunhofer
IFAM

Debonding on demand

Solutions at Fraunhofer IFAM

A wide variety of requirements are placed on adhesive bonds, some of which are not only high but also contradictory. One wish for adhesive bonding technology, often still unfulfilled, is a controlled and residue-free release of the bonded joint. Particularly in the context of a desired circular economy, the call for a detachable bonded joint is becoming louder since this is advantageous both in the case of repair and for recycling after the product service life has expired. Another application for a releasable adhesive bond is a temporal fixation of workpieces, for example for machining.

Requirements for detachable adhesive bonds

- Like any adhesive bond, it must be stable under the specific conditions of use.
- The debonding process is only triggered under controlled conditions, exactly at the time specified by the user.
- The boundary conditions for debonding processes must be practical and comply with occupational safety and environmental regulations.
- Ideally, after debonding the adhesive should not adhere to the parts to be joined, so that they can be reused without major effort.

Release by applying an electrical voltage

For the release of an adhesive bond by applying an electrical voltage, the adhesive must be equipped with a special additive. This ensures that the bond strength is greatly reduced under very specific conditions.

For the debonding process, an electrical DC voltage is applied on the adherends. This can be 48 volts, for example. However, much lower voltages can also be used.

Often, a second trigger is desired so that the debonding process is not accidentally initiated while the bonded component is still in service. A moderate temperature increase of 65 °C, for example, can be used for this purpose. Debonding does not occur until both factors – electrical DC voltage and temperature increase – act simultaneously on the bond.

In addition to metallic joining parts such as aluminum, steel or silicon, the detachable adhesive bond can also be realized on substrates with conductive surfaces (e.g. glass with aluminum coating) on CFRP and on carbon black-filled plastics.

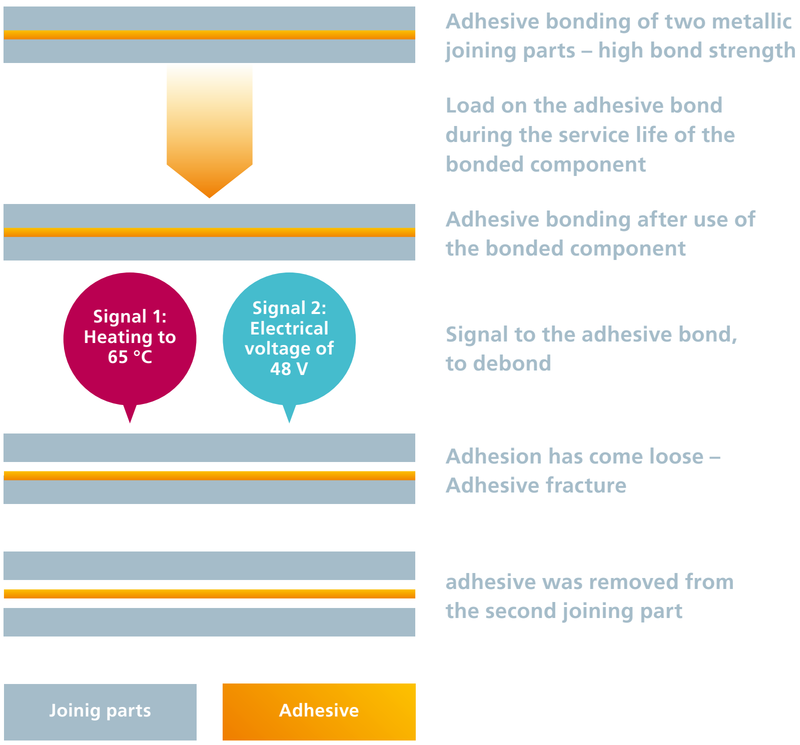
After the debonding process, the adhesive strength is greatly weakened. In tensile shear tests on aluminum, residual strengths of only 0.1 N/mm² are measured. The fracture pattern is adhesive; this means that the fracture occurs between the joined part and the adhesive. After debonding, the part to be bonded can be used for other purposes or fed to the recycling process.

Common surface pretreatment processes such as primer or plasma pretreatment are compatible with this debonding technology.

So far, this debonding mechanism could be applied to different classes of adhesives: Hot melt adhesives, reactive adhesives such as epoxy or polyurethane adhesives, and pressure sensitive adhesives. Experience shows that the principle can be applied to many but not all adhesives. An important factor is the compatibility of the adhesive with the additive.

In addition to debonding by applying an electrical voltage, other concepts for debonding are also being pursued at Fraunhofer IFAM, such as heating the bonded joint, e.g., by induction or microwave radiation, the targeted foaming of the adhesive, or the incorporation of thermolabile groups into the resin matrix.

Principle for debonding on demand



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