ADHESIVE FILMS – TAPES BEYOND PSAs

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Introduction

Pressure-sensitive tapes are widely used in technical applications. Especially double-sided tapes are used for mounting in lots of technical applications. The most common applications can be found in the fields of automotive, electronics, building and construction and graphics (fig. 1).

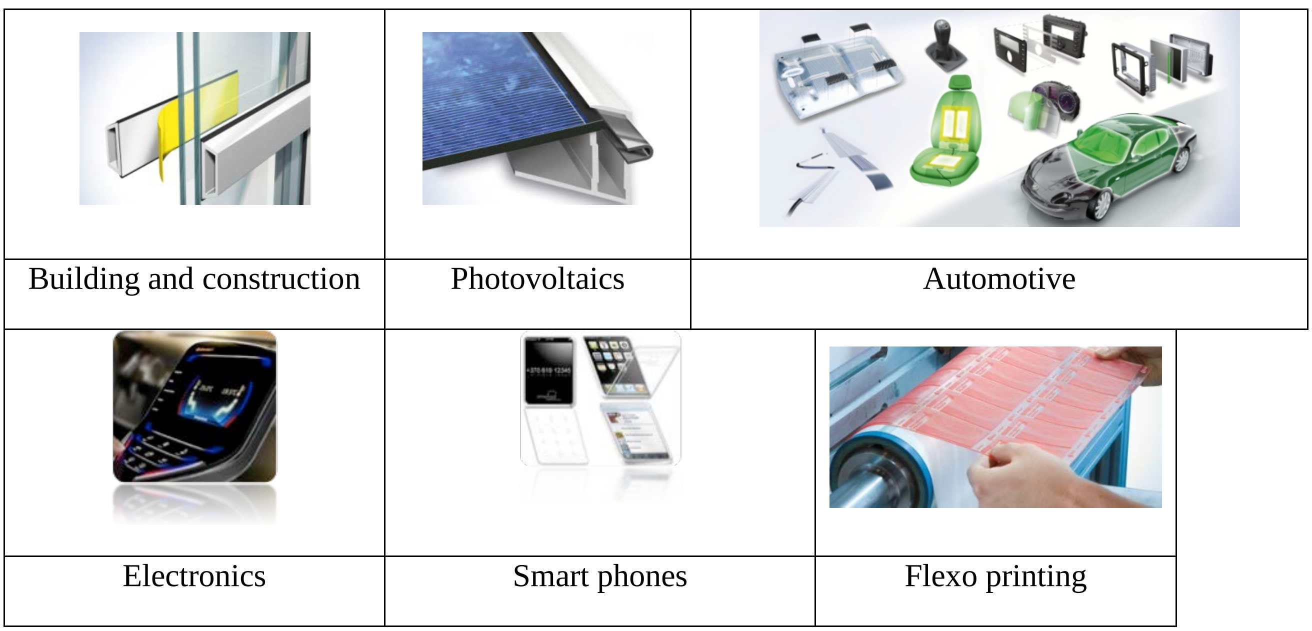

Figure 1. technical applications for double sided tapes

In most applications, the performance data of double-sided tapes are sufficient for a reliable mounting process. Table 1 shows common data for double-sided mounting tapes. Additional to the data shown in table 1, there are specific demands for dedicated applications. Tapes for automotive interior, for example, have to have low fogging values; tapes for electronics are mostly showing low ion content; tapes for building and construction have be applicable at low temperatures (0-5°C) etc.

Table 1: common data for mounting tapes

Property	**Value**
Peel strength	> 25 N/inch
Shear strength	> 125 N/sqinch
T max (long term)	100 – 120 °C
T max (short term)	150-180 °C
UV-resistance	yes

Mounting tapes for mobile electronic devices

For the assembling of mobile electronic devices like mobile phones, smart phone, tablet PCs, MP3 – Players, etc. lots of double sided tapes are used since years. Figure 2. shows applications for tapes in mobile phones. The design of the mobile phone shown in figure 2 is a standard design used until 2006 / 2007. Until then keyboard and display were separated, and the display was relatively small.

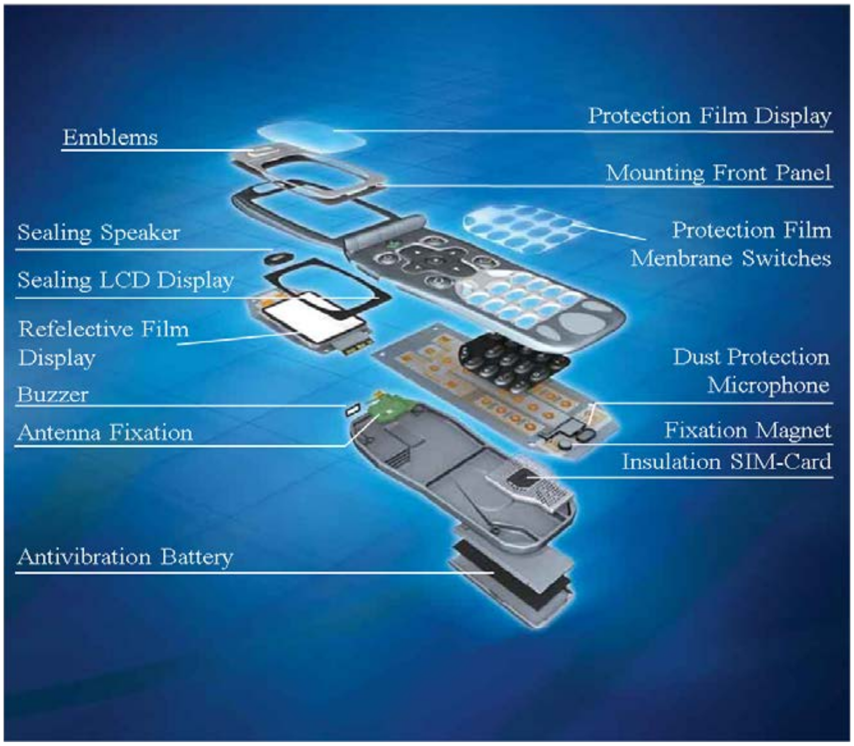

Figure 2: application of tapes in mobile phones

Since 2007 more and more smart phones were introduced to the market. Displays became larger and larger and more and more touch panels became start of the art in mobile devices. In figure 3, the change in design of mobile phones from 2001 to 2011 is shown.

Figure 3. Change in design of mobile phones

As a result of the change in design, the ratio between frame and display became smaller. This led to the effect, that the absolute bonding area for the mounting of the display became smaller and smaller. Until 2007 thin foam tapes with a pure acrylic PSAs on both sides were used for display fixation. The performance of the tapes was sufficient for reliable mounting processes. With large displays coming to the market, the performance of these standard tapes wasn't high enough for the small bonding areas provided by the low frame to display area. Thus new approaches are needed for the bonding of displays.

Adhesive Films

For the production of mobile phones, several demands have to be fulfilled. Due to the high volumes produced every year, the production process has to be very fast. The materials used are mostly plastics like polycarbonate and ABS. Thus very new adhesives that can be used in mounting of displays have to fulfill the following requirements:

- Instant bonding
- No or low curing times
- Proper adhesion to PC and ABS (sometimes glass)
- Low curing temperatures
- Flexibility
- Shear values: 2 to 4 to ten times higher than standard PSAs

The new approach that was developed, is:

Providing a semi-structural adhesive as a film, which undergoes fast chemical cross linking at elevated temperatures. For this approach, a polyurethane film was developed, which undergoes a chemical cross linking at 100 to 120 °C and is stable at room temperature. This was achieved by using a polyurethane with high amount of OH-groups and a solid isocyanate cross-linker, which melts at 50 -60°C and cross links the polyurethane matrix, when heated up to 100 to 120°C as shown in figure 4.

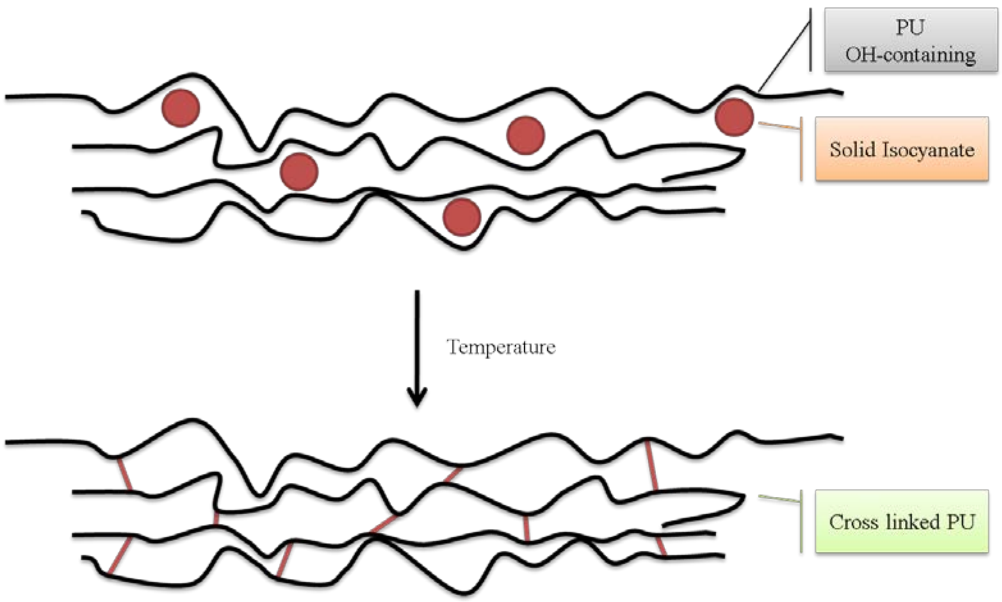

Figure 4. Cross linking of PU by solid isocyanate cross linkers

The solid isocyanate cross linker can be based on TDI or IPDI monomer. Thus the reactivity of the system can be adjusted by use of different cross linkers. TDI based materials are slightly faster, or can be cross linked at lower temperatures than materials based on the cycloaliphatic IPDI monomer, which is slightly slower. On the other hand, due to the correlation between reactivity and stability (the higher reactive the material, the less stable it is), IPDI based adhesive films are more stable at room temperature. It has been seen, that the IPDI based material is fast enough for the application. Thus in the following only the IPDI based material is discussed. In figure 5 the DSC measurement of the film is shown. During the first heating of the film a melting point can be observed at approx 55 °C ´followed by a cross linking reaction starting at approx. 100°C.

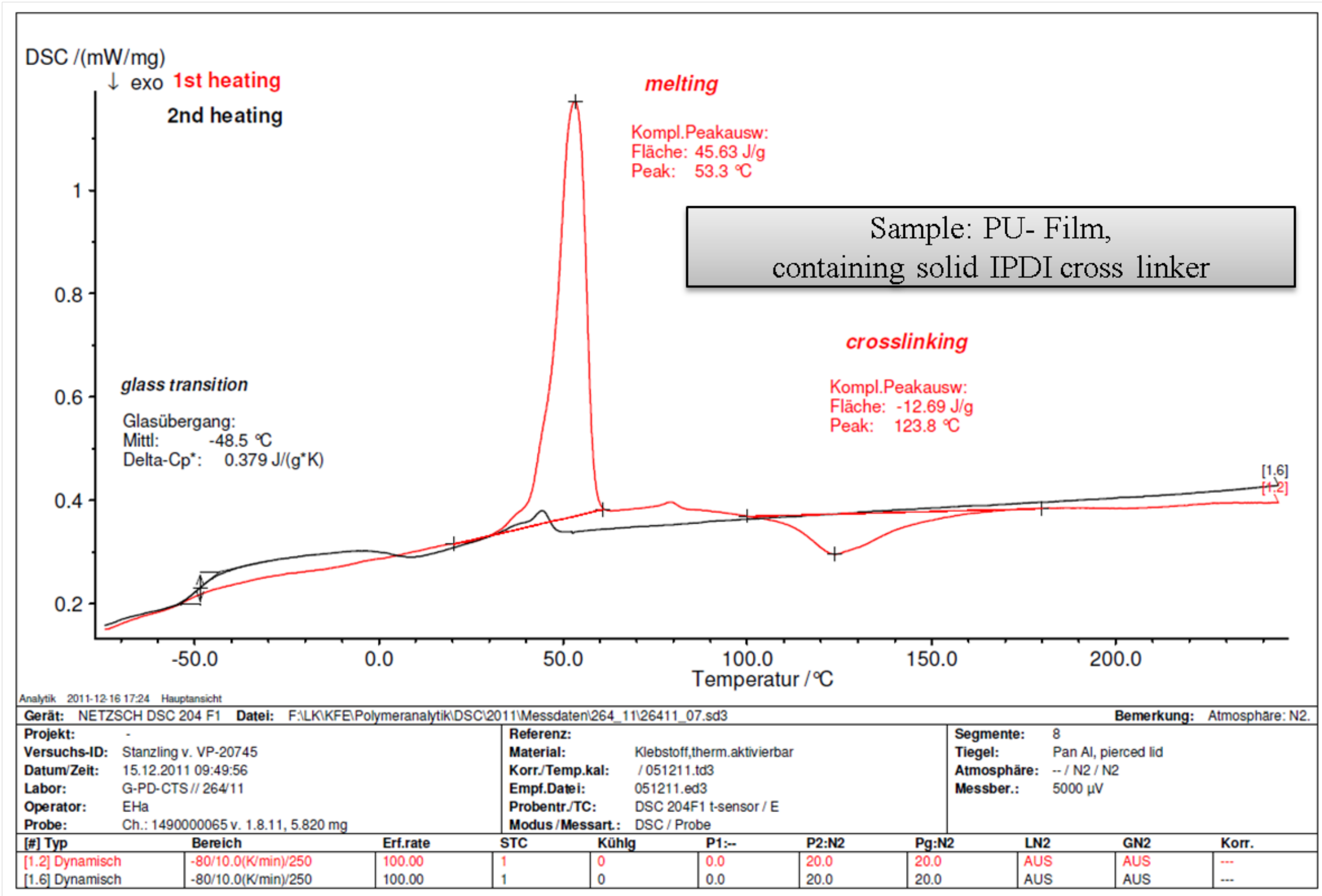

Figure 5. DSC measurement of IPDI containing PU-film

In the next step of development the bonding strength over time was investigated. Figure 6 shows the development of the shear strength and temperature resistance over time, depending on the initial cure time. A 50 µm thick PU film was used form bonding polycarbonate plates. The curing time was 30 s and 180 s at 60, 80, 100, 120 and 140 °C. The materials were reconditioned for 24 h at 23 °C and 50 % rel. humidity before measurement. The results are showing, that the PU material with very short cure time shows always lower shear strength and temperature resistance. For a reliable bonding strength a temperature of 100 to 120 °C is recommended.

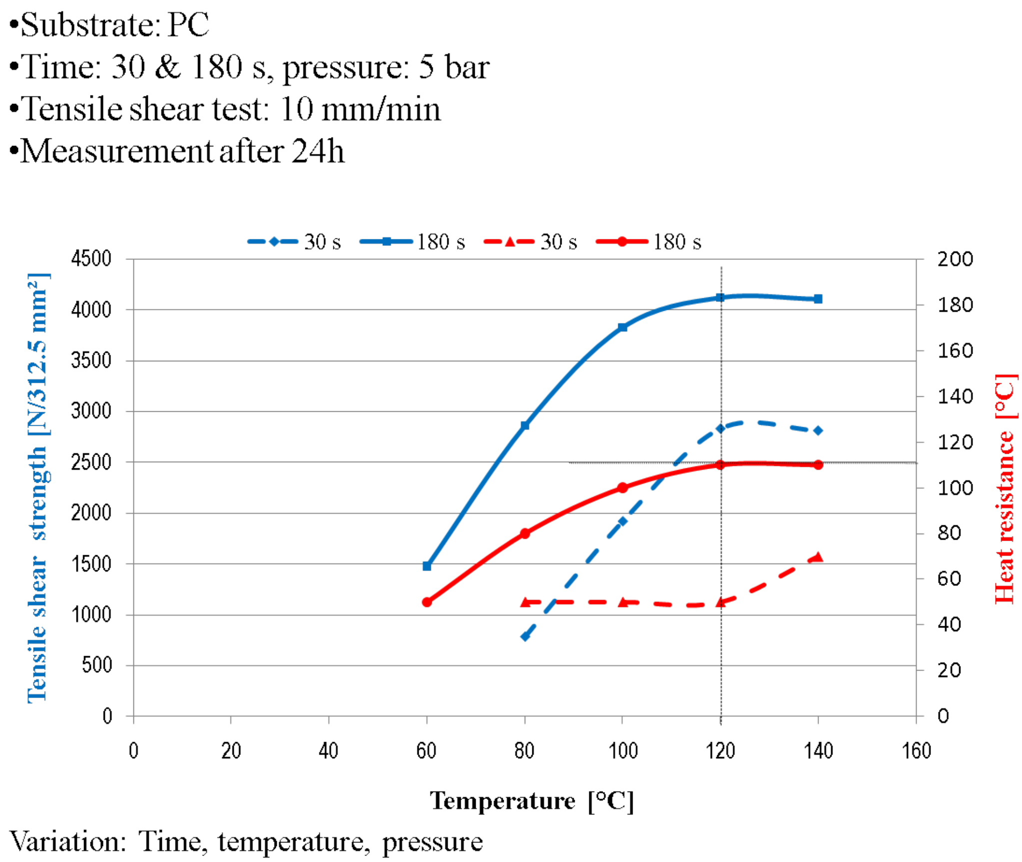

Figure 6. Correlation of cure time, temperature and performance

Given one of the main applications is the production of portable electronic devices, where materials are mostly PC and ABS, the performance of the material on several substrates was measured. A 100 µm PU film was bonded to several substrates at 120°C, 180 s at 5 bar. The materials were reconditioned at 23°c and 50% rel. humidity for 24 h before measurement. It can be clearly seen, that the adhesive film can be used on several plastics and metals, but can't be used on polyolefins and polyamides.

Finally, the resistance of the cured material against media and climate was investigated. A 100 µm PU film was used for bonding PC at 120°C, 180 s and 5 bar. After storing for 24 h at room temperature, the bonded materials were stored at elevated temperature and humidity, in petrol and water, and at -40°C. for several days after storage the shear strength was measured. In table 2 the results are summarized. It can be seen, that water and high humidity is decreasing the shear strength of the material. This is a widely seen effect in polyurethanes, caused by the hydrolysis of the urethane group.

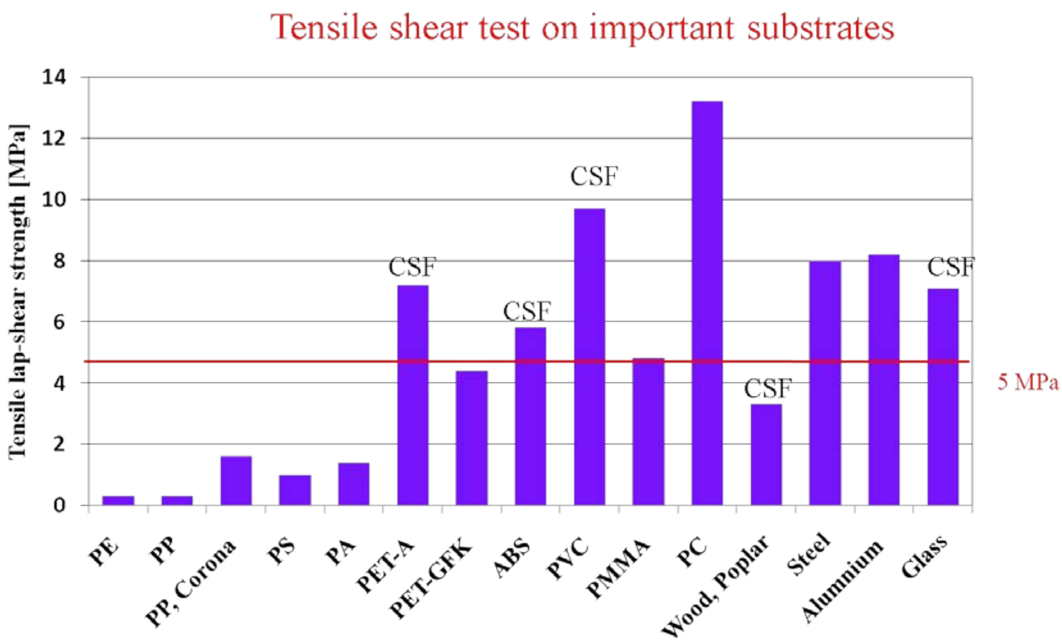

Figure 7. Shear strength on several substrates

Table 2. Storage conditions vs. shear strength

Storage	**Tensile shearing strength [N/312.5 mm²]**
Reference storing, RT	4295
14 days @ 70 °C	4298
1 day in petrol	4286
14 days in water	3316
14 days @ +40 °C, approx. 100% rel. hum.	1708
14 days @ -40 °C	3902

The intention of the development was to obtain an adhesive in film form that can be processed as a standard PSA (rolls, spools, die cuts) but has a bonding strength several times higher than standard PSAs. Therefore, some die cuts were made. For making die cuts, the PU-film was transferred from a paper liner to a slightly sticky filmic liner. After that, die cuts (fig. 8) were made by rotary die cutting.

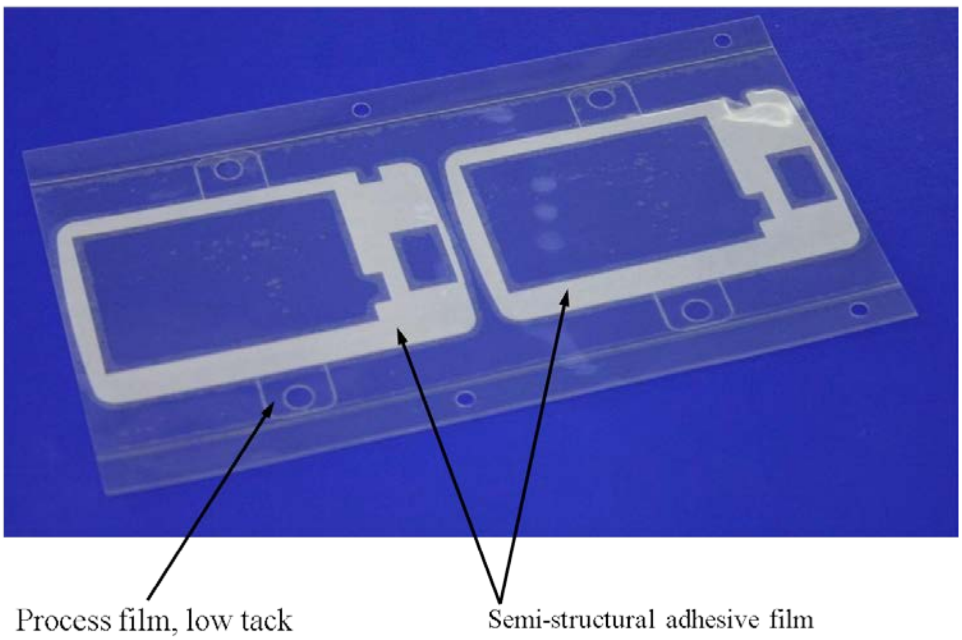

Figure 8. die cuts

The die cuts can be pre laminated to the substrate at 60 °C on , where the materials weaken and becomes slightly tacky, and than cured later at temperatures of 100°C and above (fig. 9).

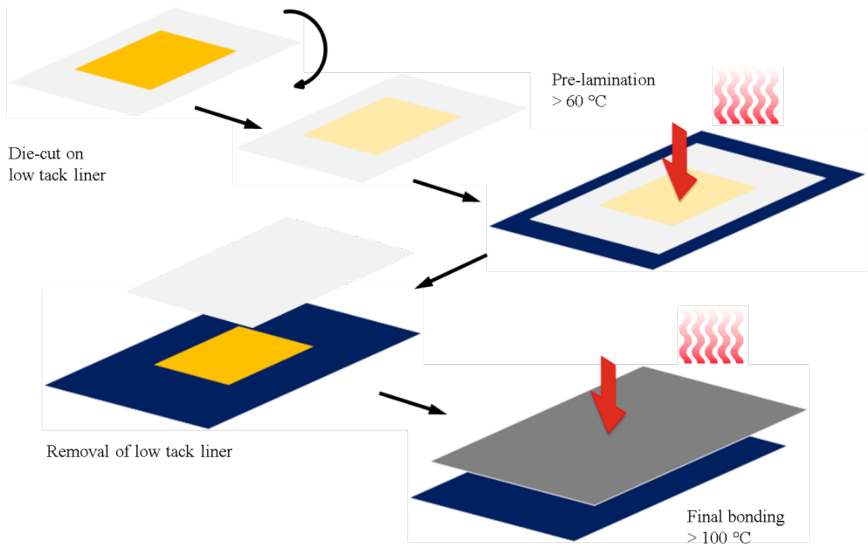

Figure 9. Pre lamination of die cuts

Summary

PU films which can be cross-linked by elevated temperatures in relatively short curing times were made. Compared to other structural adhesives, the semi structural films are showing half and less the shear strength of structural adhesives. In figure 10, the comparison between several adhesives is shown. The bonding strength is high enough for several applications, like mobile devices, were only 2 or 4 times higher bonding strength, compared to standard PSAs is needed. The results show clearly, that the reactive PU films are closing the gap between standard PSAs and structural liquid adhesives.

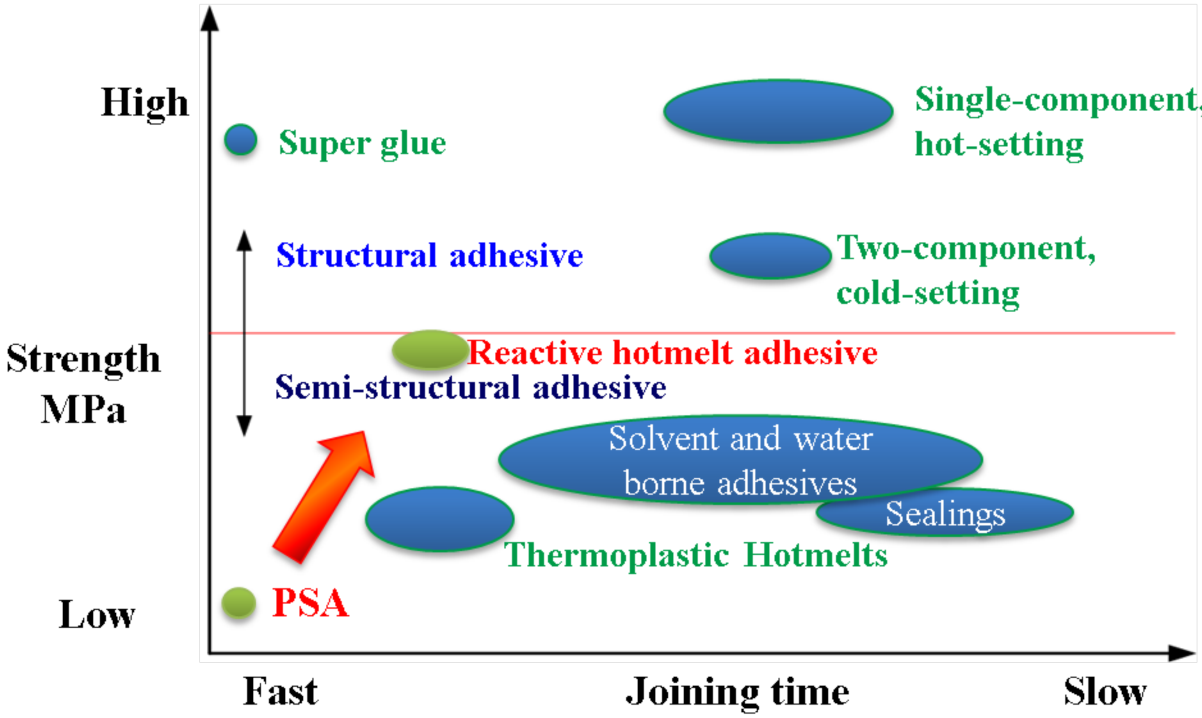

Figure 10. Comparison of several types of adhesive

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