## Bostik

Jean-Francois Chartrel, Stefano Gherardi

### NEW CRACKLESS PROCESS FOR CYANOACRYLATES PRODUCTION

Abstract:
For more than seventy years, Cyanoacrylates and particularly Methyl and Ethyl-Cyanoacrylate monomers have been produced via a process of condensation, cracking and distillation, following the Knoevenagel route.

With the **"New Crackless Process"** (Patent W0/2015/150882), Bostik has changed the game by creating a one step process, offering improvements in **Productivity** *(fast reactions, high yields, cost effective, …),* **Quality** *(monomer purity, reactivity, stability, reliability with high a level of automation and process control,…)* and **Sustainability** *(low waste, no solvents, low energy consumption, lower $CO_2$ footprint).*

Without aggressive thermal cracking, the new process gives access to an array of Specialty CA monomers and adhesives, allowing for:
**Higher molecular weights** *(up to C18, proven as of today (solid product), but without real limit)* resulting in **lower vapor pressures** *(low odor and blooming)* **More sophisticated structures offering specific properties** *(flexibility, hydrophobicity, adhesion on low surface energy materials, crosslinkable with multifunctional CAs (ex: BisCA) …)* **and added functions** vs. standard CAs.

**An enlarged product portfolio** has been created with **new differentiated monomers** *(formulation precursors for Cyanoacrylate(s), Acrylate Hybrids, Epoxy Hybrids, Silicone Hybrids, etc… )* **, adhesives and coatings**, serving both standard and high-end markets: Electronic, Medical, Optical.
These new formulations are adaptable to different processes & functionalities *(1K, 2K, UV, dual cure)*, offering **friendly labelled products** and introduce **debonding behaviors** for recycling *(Tunable thermal debonding).*

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## Covestro Deutschland

Dr. Christoph Thiebes*, Wolfgang Arndt, Peter Kueker, Dirk Achten, Winfried Jeske

### POLYURETHANE ADHESIVES FOR CONTACT BONDING APPLICATIONS

Abstract:
Polyurethane adhesives for contact bonding applications
Despite some new developments in the past, polyurethane adhesives are still playing a niche role in contact bonding applications.

However, new market requirements and circumstances are constantly developing, creating a need for alternatives to the currently used technologies.

Hence, during this lecture we will evaluate the performance of polyurethane adhesives in contact bonding applications for different markets served today with alternative technologies.
Also, alternative application methods of contact adhesives will be presented.

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## Croda

Tina Arbatan

### FUTURE HIGH-PERFORMANCE SOLUTIONS FOR ADHESIVES

Abstract:
In modern society the demand of smart and multi-functional adhesives is becoming continuously more important. Adhesives are an extremely versatile in use and suitable for high-demand applications as automotive and electronic industry.
But today the market is also requesting solutions that can reduce the carbon footprint and have a concrete sustainability benefit. Finding a reliable raw material able to provide performance and sustainability in one single solution is a major challenge.
Croda is a leading global solution provider of high-performance bio-based building blocks that provide a variety of smart effects and benefits in a wide range of polymer types and applications. Croda has a broad portfolio of 100% bio-based diacids and diols, polyols up to 100% bio-based and 100% bio-based dimer

diamines. Among these, Pripol 2043 is the latest innovation Croda brought to the market: a higher functionality dimer diol for PU adhesive to help our customers to tackle this challenge.

The use of these products can support the formulators to modify adhesive systems, offering flexibility, extreme hydrophobicity, improved flow and low moisture absorption. Furthermore, a unique combination of improved adhesion to various substrates, including low-polarity substrates.

With our innovations we offer formulation freedom to the adhesive market, enabling new and exciting high-end applications for example in electronics, automotive and sportswear.

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## Fracture Analytics

Dr. Martin Brandtner-Hafner

### A NOVEL HOLISTIC EVALUATION SYSTEM FOR RATING ADHESIVE BOND SAFETY AND PERFORMANCE

Abstract
Adhesives are already in use in the most diverse industries. Their flexibility allows them to occupy ever newer areas of joining technology. However, a look at industrial practice shows that there are no holistic evaluation methods available to assess the failure behavior of adhesive composites authentically. Furthermore, there is an almost unmanageable mix of possible external parameters that could be considered influencing bond performance and safety. To handle such challenges, a specially developed mathematical evaluation algorithm was utilized. It incorporates the relative performance of a distinct set of adhesives under consideration by a predetermined set of inputs and outputs. With that, a novel adhesive performance index (API) was created to focus comprehensive informational value for adhesive evaluation into one single metric. Next, comparable peer groups were formed from which an authentic adhesive rating was derived. Finally, a case study on different adhesive systems from SIKA and MUREXIN demonstrated the efficacy of this novel rating technique. Decision-makers are thus given the opportunity to optimize their choice of adhesives under different conditions and boundaries.

**Keywords:**
Evaluation System, Adhesive Bond Safety, Adhesive Bond Performance, Adhesive Performance Index, Bonding Process, Adhesive Rating, Selection Support

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## IGB-Tech

Dr. Stefanie Wellmann

### ARE YOU SURE THAT YOUR ADHESIVE IS CURED?

Abstract
Coming soon!

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## Jowat

Dr. Hartmut Henneken

### NOVEL HOTMELT ADHESIVES FOR OPTIMIZED PHOTOVOLTAICS WAFER PRODUCTION PROCESSES

Abstract
The global demand for solar-generated electricity is growing rapidly, and the photovoltaic industry is facing increased competition. This applies to machine and plant suppliers, but above all to producers of solar wafers, cells and modules. In order to survive on the market, production costs must be permanently reduced and sustainable innovations introduced. The approaches pursued so far are usually aimed at increasing the system efficiency and thus reducing the price of the kilowatt output. The focus is less often on seemingly unspectacular aids and operating materials, which are, however, indispensable for the overall process, such as adhesives and adhesive technology.
Every year, worldwide billions of wafers are produced from silicon blocks using multi-wire saws. The silicon block (workpiece) is glued on the one hand to a workpiece carrier, the so-called beam, which is glued to the metal tool carrier of the saw on the other hand. All currently used beams are applied with crosslinking adhesives on two opposite surfaces using automated application equipment at the wafer manufacturer site before the sawing process. Jowat has now developed a new technology based on a novel beam in conjunction with a new thermoplastic adhesive system. This beam can be bonded to the silicon block using new hotmelt adhesive formulations without the need of complex dosing systems. On the one hand, the

adhesive absorbs the mechanical load and vibrations during the sawing process, but can then be easily detached, without destroying the fragile ultra-thin solar wafers.
Two different thermoplastic hotmelt formulations have been developed, which can be used successfully for the two common processes (slurry and diamond wire). The new developments offer significant cost advantages already on the adhesives side, but especially for the overall process. In addition the adhesives are very sustainable formulations, as they are based on more than 40% renewable raw materials. The work took place within the framework of a joint project (finished 2020) with the Fraunhofer Institutes "IFAM" (Bremen), "CSP" and "IMWS" (Halle, Saale) and the company PV Crystalox Solar Silicon GmbH (Erfurt). The overall goal was also the development of a new base beam material, this presentation covers only the adhesive developments by Jowat.

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## M&M Network-ING
Dr. Michael A. Kraus*, Dr. Michael Drass


## SEMI-PROBABILISTIC DESIGN OF SILICONE ADHESIVE JOINTS USING NOVEL FAILURE CRITERA AND A MESH-INDEPENDENT FEM APPROACH


Abstract
This presentation deals with the semi-probabilistic design of structural silicone sealants acc. to EN 1990 (Eurocode 0) and introduces a new Eurocode-conform design concept for verification of silicone bondings for a stretch-based limit state equation. A short repetition section delivers background on semi-probabilistic modelling and the general framework for deriving partial material safety factors at a level I stage for structural sealants. Afterwards, the new concept is compared to the current international (ETAG002) legal situation for designing with structural silicone sealants in façades. Then the specific material partial safety factor (MPSF) for DOWSIL 993 silicone using existing experimental data, obtained under the ETAG 002 testing protocol, is determined for a stretch-based failure criterion. A subsequent section deals with the specific requirements of a finite element based static verification of design limit states analysis using the MPSF within a semi-probabilistic design to reach a mesh-independent structural verification computation. A Structural Sealant Glazing (SSG) example illustrates the new concept and enables comparison of different design approaches. This research found, that the correct level I calibration of a MPSF for structural silicones leads to significantly lower MPSF values compared to currently existing estimates. This allows for a great optimization of structural sealant design situations with potentially high economical as well as ecological / sustainability gains in the future. As this is a reliability- and mechanics-based approach, the methodology can easily be transferred to the automotive industry.


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## M&M Network-ING
Dr. Michael A. Kraus*, Dr. Michael Drass


## CONSTITUTIVE MODELLING WITH PHYSICS-INFORMED MACHINE AND DEEP LEARNING - A CASE STUDY WITH TSSA ADHESIVES


Abstract
Recent developments in the field of artificial intelligence (AI) related to natural as well as engineering sciences formed the terms physics-informed / theory-guided AI, which is a field, where the authors of this talk are also active in. The aim here is to achieve two goals:
compensate data sparsity and utilize available theoretical knowledge in a formal way. Together with the expressive capabilities of modern machine and deep learning algorithms to describe data sets, this approach offers great capabilities of providing new models for modelling of complicated materials such as polymers used for adhesive purposes. This talk will present recent work of the authors for using physics-informed machine (ML) and deep learning (DL) for the constitutive modelling of TSSA silicones (hyperelasticity). After an introduction to AI and physics-informed ML and DL, we show the necessary steps to develop and implement such a physics-informed AI material model for use in industrial practice together with semi-probabilistic evaluations to ensure Eurocode-compatibility for use in civil engineering practice. As the development method is mechanics-based, the procedure as well as the results are transferable to automotive industry and mechanical engineering as well.


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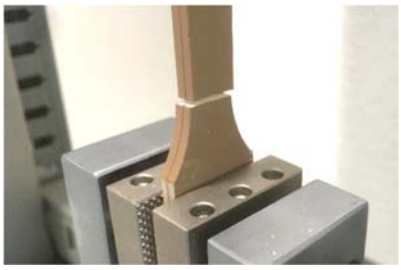
## LIFETIME ASSESSMENT OF FUNCTIONAL POLYMERS USED IN ELECTRONIC PACKAGING

Abstract
Functional polymers, such as thermally conductive adhesives and pottings, are widely used in electronic packaging and power device cooling. However, such polymers are composite materials that are subject to degradation by thermal, mechanical and environmental loads over the electronic device's lifetime, which may extent to several decades. Hence, in order to estimate the reliability of composite materials and to ensure the serviceability of the device, accelerated aging tests in the laboratory are frequently applied, according to various general and industrial standards. The findings of such aging procedures are then used to predict the longtime behavior of materials and components under test. The current project aims at highly thermally conductive pottings needed for the thermal management of power inverters used in electric drives. These pottings are filled with ceramic powders and will have to last over many years at operation temperatures up to 150 °C. Suitable aging procedures as well as basic modeling approaches will be reviewed and some results of aging tests on thermal pottings will be displayed in this presentation.



**Keywords:** functional polymer, electronic packaging, reliability testing, accelerated aging, lifetime estimation

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**Rolls-Royce plc**
Dr. Hollie Baker*, Ted Warner, Phil Wallace, Angelo Sigona, Dr Gary Jones; UK-Derby
Dr. Ewen JC Kellar – Adhesives Technology Consultant, TWI Ltd, UK-Cambridge

## THE APPLICATION OF ADHESIVES IN SENSING ADVANCED STRUCTURES

Establishing optical fibre sensing within the nuclear industry to measure temperature, stress and strain, provides a significant cost reduction, simplicity and reduced safety justification for nuclear plants.
An external sensing capability is being developed to retrofit optical fibres onto new or existing nuclear components. This technological leap within the nuclear industry will enable active monitoring and accurate 'real world' analysis of the plant. In turn, this data can be used to validate computer models and analyse specific plant regions.

To enable retrofitting of the optical fibre to nuclear components, adhesives have been identified as a promising technique. However, it is crucial that the chosen adhesive provides a durable and stable attachment solution under the harsh in-service operating conditions.

An industrial survey has been conducted to identify adhesive solutions that best meet the requirements for this application. Six adhesive based solutions were identified. However, the three most promising adhesives were down selected: RM-1005 Polyimide adhesive paste, Polybenzimidazole (PBI) solutions (S10, S16, S18 and S26) and, finally Ceramabond.

This paper will present the work conducted to assess if the three adhesive solutions have the capability to meet the in-service operating conditions and can be used to retrofit optical fibres onto nuclear components. This will be done through using thermogravimetric analysis (TGA) to determine strength and stability performance at ambient and upper operating temperature limits. Single lap shear strength measurements will be performed to quantify strength retention over time. Fibre peel tests will be used to measure the adhesive performance to 316 stainless steel. Furthermore, x-ray computed tomography (XCT) will be completed to evaluate the quality and integrity of the attachment. Including, any lack of fusion or defects between the fibre optic attachment and the steel.

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Sika Services
Dr.-Ing. Claudio Di Fratta*, Marko Zivaljic

## NEW ADHESIVE SOLUTIONS FOR DESIGNING AND BONDING COMPOSITE STRUCTURES IN COMMERCIAL TRANSPORTATION

Abstract:
Commercial transportation industry sees the progressive introduction of new design solutions based on lightweight materials like carbon- or glass-fiber reinforced composites. At same time, commercial vehicle manufactures are constantly challenged by increasing production efficiency and reducing costs. While assembly bonding represents a desirable option to join the different vehicle components, standard structural adhesives bear several limitations to fully satisfy the current industrial needs and trends [1].

Sika AG has developed two innovative adhesive technologies, Powerflex and Curing by Design, which allow overcoming the state-of-the-art performances of the most used bonding products for commercial vehicle assembly [2]. Powerflex technology enables the formulation of flexible adhesives with enhanced

modulus and strength, which ensure stable properties at extreme climatic conditions over the whole service life. Adding also the Curing by Design technology in the formulation, the developed adhesives show an immediate curing reaction at a precise time after application: the adhesive open time can be customized to match the specific process requirements of the manufacturers.

As a result, these innovations can successfully tackle the main challenges of commercial vehicle assembly with composite materials, such as: (1) stable and durable joints under a variety of environmental and temperature conditions; (2) high strength and elongation in one system for effective management of different thermal expansion coefficients (e.g., in bonding composites to aluminum); (3) maximal production efficiency by providing the longest possible working time, followed by quick handling time.

[1] C. Di Fratta, D. Vogt, Key Features of Two-Component Adhesives for Structural Composite Bonding, in: SAMPE Europe Conference 2018, Southampton, UK (2018).
[2] C. Di Fratta, M. Zivaljic, A. Corsaro, et al., Structural Adhesives with Customized Fast Curing, Adhes Adhes Sealants 17, 18–23 (2020).

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SKZ-German Plastics Center
Heinrich Leicht

## ENHANCING THE ELECTRICAL CONDUCTIVITY OF FLEXIBLE ADHESIVES USING NANOCARBONS

**Abstract:**
Electrostatic discharges (ESD) cause millions of dollars in damage to the economy every year. Today's commercially available systems for adhesive bonding and encapsulating components relevant to ESD are often based on epoxy resins, which especially provide a limited elasticity. The aim of the investigations is to show how existing application restrictions can be effectively eliminated by the development of new adhesives while at the same time reducing follow-up costs caused by ESD.
In line with this topic, the targeted modification of flexible polyurethane- and silicone-based polymers using carbon nanotubes (CNTs) has been investigated within the scope of the project "ESDBond" (IGF-No. 20459 BG) funded by the Federal Ministry of Economics and Energy (BMWi). It has been shown that electrically conductive networks can be formed within the otherwise electrically insulating polymers by integrating CNTs with a content of < 0.5 wt.%, decreasing the specific volume resistance by up to 16 orders of magnitude. This enables corresponding discharge capabilities in combination with minimal influences on the remaining property profile. In the scope of this presentation the latter will be shown e. g. by means of viscosity, adhesion or ageing behaviour for different fillers as well as filling degrees.

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University of Alicante - Adhesion and Adhesives Laboratory
José Miguel Martín-Martínez*, Mónica Fuensanta, Abbas Khoshnood

## DOES THE STAGE OF ADDITION OF THE INTERNAL EMULSIFIER IN WATERBORNE POLY(URETHANE UREA)S SYNTHESIS DETERMINE THEIR ADHESION PROPERTIES?

**Abstract:**
**Introduction:** Waterborne poly(urethane-urea) dispersions (PUDs) are colloidal systems consisting of hydrophobic poly(urethane-urea) (PU) particles dispersed in a continuous water phase. The stabilization of the particles is generally achieved by surface hydrophilic moieties of short internal emulsifier covalently bonded in the PU chains, the most common is 2,2-bis(hydroxymethyl)propionic or dimethylolpropionic acid (DMPA). DMPA contains two hydroxyls and one carboxylic group. During PUD synthesis, the two hydroxyls groups react with the di-isocyanate during prepolymer formation producing hard segments and, later, the carboxylic group is de-protonated by reacting with tertiary amine.
The structure of the PUD particles consists in soft and hard domains, and ionic interactions. The hard domains are produced by reacting isocyanate with DMPA, polyol and low molecular weight amine chain extender, and the soft segments correspond to the interactions between polyol chains; the ionic interactions are due to anionic carboxylate groups on the PUD particles and the quaternary ammonium cations in the water phase.
The most of previous studies have proposed the addition of DMPA before prepolymer formation, i.e., DMPA was mixed with the polyol and, later, the di-isocyanate was added. However, the stage at which DMPA is added, i.e., before, during or after prepolymer formation will change the structure of the PUD, but this aspect has been very scarcely studied, particularly its influence on the adhesion properties. Therefore, in this study, DMPA was added before, during and after prepolymer formation during the synthesis of PUDs, and, in order to assess their structure-properties relationships, their structural, thermal, rheological, viscoelastic and, particularly, the adhesion properties have been compared.

**Materials and experimental techniques.** The PUDs were synthesized by using MEK (methyl ethyl ketone) prepolymer method, an NCO/OH ratio of 1.5 was used. The reactants were isophorone diisocyanate (IPDI), polyadipate of 1,6-hexanediol of molecular weight 2000 Da, 5 wt.% DMPA internal emulsifier, trimethylamine neutralization agent, dibutyltin dilaurate catalyst, and hydrazine chain extender.
The PUDs were characterized by pH, viscosity and particle size measurements, and the structure of the PU films was assessed by infra-red spectroscopy, differential scanning calorimetry, X-ray diffraction, thermal gravimetric analysis, plate-plate rheology and dynamic mechanical thermal analysis. The adhesion properties of the PUDs were measured by cross-hatch adhesion and T-peel test.

**Results and discussion:** The stage of the synthesis at which DMPA is added should produce structural dissimilarities in the PUDs. Thus, the addition of DMPA before and after prepolymer formation (i.e., the reaction of the isocyanate and the polyol) should produce ordered DMPA-isocyanate hard segments as well as polyol-isocyanate hard segments, but the distribution and length of the hard segments will be different. However, the addition of DMPA during prepolymer formation will produce random DMPA-isocyanate and polyol-isocyanate hard segments. Thus, depending on the stage of the synthesis at which DMPA is added, the structure of the hard segments and the degree of micro-phase separation of the PU will be different, the properties should be different too.
The lowest pH value and the highest mean particle size were found in the PUD made by adding DMPA after prepolymer formation. The highest viscosity and noticeable shear thinning were obtained in the PUD made by adding DMPA during prepolymer formation. Depending on the stage of addition of DMPA, the length of the prepolymer varied and the PU films showed different degree of micro-phase separation. Because the shortest prepolymer was formed in the PU made with DMPA added before prepolymer, this PU showed the lowest storage moduli and early melting indicating higher degree of micro-phase separation. The highest storage modulus, later melting, higher temperature and lower modulus at the cross between the storage and loss moduli corresponded to the PU made by adding DMPA after prepolymer formation, because the longer prepolymer produced during synthesis. The lowest thermal stability corresponds to the PU made by adding DMPA during prepolymer formation and the structures of all PU films were dominated by the soft domains, the main structural differences derived from the hard domains. Whereas DMPA-IPDI, urethane and urea hard domains were created in the PU made by adding DMPA during prepolymer formation, the other PUs showed DMPA-IPDI, polyester-IPDI and two different DMPA-IPDI-polyester hard domains. Finally, the adhesion properties of all PUDs and PU coatings were excellent and they were not determined by the structural differences caused by adding DMPA in different stages of the synthesis.

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## CONSIDERATION OF PROCESS-RELATED ADHESIVE DAMAGE IN COMPUTATIONAL STRUCTURAL SIMULATIONS

Abstract
The CO2 fleet consumption target is a major challenge for the automotive industry that is difficult to achieve without increased sales of electric and hybrid vehicles. Above all, the high vehicle weight generated by the batteries requires the use of lightweight construction technologies and materials. In this context, adhesively bonded multi-material structures are increasingly being used. However, the combination of different materials in the established production processes in the automotive industry represents a challenge for manufacturers. Manufacturing induced adhesive damage can therefore occur, particularly during the paint drying process. Currently, it is difficult to determine the location of the failure or the degree of damage without extensive prototype testing. With the aim of detecting the adhesive layer failure and reducing or even avoiding the stress in the manufacturing process, a prediction by means of finite-element simulations is necessary. In cases where stresses in the adhesive layer cannot be avoided, the effects of the process history during manufacturing must also be taken into account.

This work contributes to the understanding of the adhesive layer stress generated during the manufacturing process and its effect on the subsequent load carrying capacity of the joint. A temperature dependent cohesive zone model will be used to predict damage during the drying process. Therefore, the parameters for a temperature-dependent model were determined and validated on lap shear specimens at process temperatures. It can be shown that it is generally possible to predict the temperature-dependent damage within the adhesive layer sufficiently accurate using a cohesive zone model. Furthermore, a continuous process chain for numerical simulation is presented which allows to determine the adhesive layer damage by means of a process simulation and to consider the changed mechanical properties in the structural simulation. For a simplified application of this procedure, a software tool was created to automatically apply the described steps. The developed procedure is tested and validated by means of various structural-mechanical calculations.

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## ASSESSMENT OF HIGH-TEMPERATURE RELIABILITY OF ADHESION PROMOTER FOR SELF-HEALING MECHANISMS IN THERMOPLASTIC, MEDIA-TIGHT INJECTION MOLDED HOUSINGS?

Abstract:

**Introduction**

In electronics, mechatronics or sensor technology, the protection of sensitive components from harmful environmental influences, such as moisture, media or reactive substances required to get a reliable function of these components. As a rule, plastic housings are used for this, which can be inexpensively and mass-produced by injection molding. Connections, preferably in the form of metallic lead frame structures, through the housing wall are required for their electrical supply or control. As a result, material phase boundaries cross the protective plastic housing wall. In a system made of plastic housings with metallic lead frame, different thermal expansion coefficients (α) of the metals and plastics and low compatibility of the materials used represent additional influencing factors that lead to the formation of leakage paths within the hybrid structures. For that a new mechanism, such so-called self-healing mechanisms, have been tested and precisely examined. A wide variety of methods are described in the literature with which micro-cracks in plastics can be inhibited or sealed. The selected strategy of self-healing in this study is based on using of flexible / viscous intermediate layers (adhesion promoters) between the metal insert and plastic housing, which penetrate into damages such as cracks and prevent them from growing or close them directly in the development phase. In summary this paper describes the assessment of primer for thermoplastic, media-tight injection molded housings. all resulting in a recommended procedure for identifying and qualifying high temperature stable, media-tight encapsulants.

**Content**

Drivers for HT use are on the one hand the introduction of power electronic devices; these need modules to operate at temperatures higher than 200 °C, forming internal heat sources. On the other hand, electronic devices will be implemented considerably closer to external heat sources as engines, gear boxes etc. with ambient temperatures ≥ 175 °C. Achieving self-healing mechanisms of injection molded housings requires high temperature applicability of all components and materials involved. Special focus lies upon Primer, as the adhesion primer is the material most influenced by elevated temperature. Success of this self-healing strategy based mainly on the flow behavior of adhesion promoter, which should be highly viscose. For that flow behavior (viscosity), chemical properties and their thermal relationship should be well understood and precisely tested, which what has been done in this study to get strong basis to achieve what so-called the self-healing mechanism. In this study, Acrylates with two reaction stages were selected as adhesion promoters. In these, the first stage provides fixation to the lead frame directly after the coating step. This can be done within seconds using UV light. In the second stage, the material will be thermally hardened during injection molding. For testing the adhesion promoter many techniques such; Impedance analyzer, DSC, TGA, TMA, DMA and Rheometer have been involved. Mainly the primer properties have been tested in temperature range of - 40 °C to 170 °C. Parallel to, the exposure time and their influence on the primer properties has been tested. For instance, the degree of crosslinking of the adhesion promoter could be characterized in a reproducible manner using a dielectric impedance measurement. Routine DSC (dynamic differential calorimetry) and TGA (Thermo-gravimetric analysis) techniques, used to characterize polymer, have been used for investigate the physical and chemical properties such as thermal stability and reaction kinetics. In addition, Rheometer has been used in order to be able to better estimate the flow behavior of the selected adhesion promoter in the preferred temperature range and other rheological properties have been determined. The adhesion promoter viscosity was measured over temperature range -22-175 °C and with different UV-exposure times (12, 24, 48 and 96 s). Last but not at least, the temperature-dependent expansion coefficients of adhesion promoter of a fully cured sample have been tested. The expansion coefficients have been measured between -70 °C and 170 °C using TMA measurement. Finally, the viscoelastic properties of the adhesion promoter were determined for further simulations using dynamic mechanical analysis. The modulus of elasticity at different temperatures were calculated using a linear fit of the resulted stress stain curves.

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## USING HAND-HELD SPECTROSCOPIC ANALYSIS DEVICES FOR QUALITY ASSURANCE OF ADHESIVE BONDING PROCESSES

Abstract

Glass is used in a wide variety of industrial sectors: In the automotive industry, in architecture (including photovoltaic/solar thermal or facade construction), in rail vehicle construction, in shipbuilding and in the furniture industry. Glass surfaces to be bonded have their own specific requirements for the adhesive and the surface pre-treatment. For safety-relevant bonded glass assemblies, clean surfaces and pre-treatment processes are crucial for the long-term durability of bonded joints. Therefore, there is a high demand for economical, process-integrated surface analysis methods that enable technical quality assurance and quality documentation of bonded glass joints. Surface analysis of glass for in-line and non-destructive quality assurance of cleaning and treatment processes are missed until now. With this background, the project aim is to provide a cross-industry quality assurance concept for glass bonding and validation of in-line capable surface-sensitive inspection methods. Hand-held spectroscopic analysis enables fail-safe resistant glass bonding by ensuring that the bonding surfaces are sufficiently free of contamination after cleaning and by detecting the effectiveness of adhesion promoters and primers.