09:00 – 09:30 **M&M Network-ING**
DE-Mainz
Dr. Michael A. Kraus*, Dr. Michael Drass

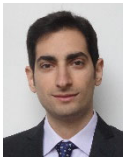
CONSTITUTIVE MODELLING WITH PHYSICS-INFORMED MACHINE AND DEEP LEARNING - A CASE STUDY WITH TSSA ADHESIVES

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.

09:30 – 10:00 **Dr. Ing. h.c. F. Porsche Aktiengesellschaft**
DE-Stuttgart
Dr. Frank Burbulla

MODELLING OF ADHESIVELY BONDED JOINTS IN CAE-MODELS AT PORSCHE - THE FUTURE CHALLENGES

10:00 – 10:30 **Sika Services AG**
CH-Zürich
Dr.-Ing. Claudio Di Fratta*, Marko Zivaljic



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

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].

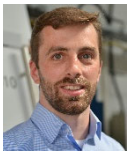
Sika AG has developed two innovative adhesive technologies, Powerflex and Curing by Design, which allow overcoming the state-of-the-art performances of the most used bonding products for commercial vehicle assembly [2]. Powerflex technology enables the formulation of flexible adhesives with enhanced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

10:30 – 11:00

TU Braunschweig[1] and GNS mbH[2];
DE-Braunschweig



Niklas Günther[1]*, M. Griese[1], E. Stammen[1], K. Dilger[1], E. Ince[2], J. Krost[2]

CONSIDERATION OF PROCESS-RELATED ADHESIVE DAMAGE IN COMPUTATIONAL STRUCTURAL SIMULATIONS

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.

11:00 – 11:30

Total – Cray Valley* and
Deutsche Institute für Textil- und Faserforschung DIFT**
FR-Saint-Avold and DE-Denkendorf

Olivier Defrain*, Susanne Segel**, Jean-Marc Monsallier* and Arnaud Minella*

RESORCINOL AND FORMALDEHYDE FREE COATING TREATMENT BASED ON FUNCTIONALIZED POLYBUTADIENE

Textile reinforcements are considered as an essential element for some composites in the Rubber Industry. The adhesion between cords included in the textile reinforcements and rubber compounds is a key parameter for composite performances in mechanical rubber goods (MRG) and tire applications.

For several decades, Resorcinol-Formaldehyde-Latex (RFL) system has been the most popular technology to coat cords and textile fabrics as this treatment enables to achieve satisfactory bonding strength between fibers and rubber compounds. However, formaldehyde has been recently classified as carcinogenicity category 1B substance and resorcinol is also under scrutiny by some Authorities due to potential exposure issues. As a consequence, some alternatives to RFL system have been developed and tested for more than 10 years.

New formaldehyde and resorcinol (RF) free dipping technologies can be based on functionalized polybutadienes. The latter enable to formulate dipping systems exhibiting required adhesion performances between fiber and rubber compounds, which could be crosslinked either by sulfur-based systems or by organic peroxides.

A dispersion containing a low Mw functionalized polybutadiene, Ricobond 7004 grade, can be combined with one or more latexes to formulate free RF treatment solution for textile reinforcements. A global evaluation of this unique emulsion has been performed:
- with three fibers: PES, Nomex and PA 6,6;
- the adhesion tests are carried out with a sulfur-cured rubber compound, as well as with one EPDM rubber compound crosslinked by organic peroxide.
The performance and formulation data will be reviewed, as well as some ways to optimize adhesion performances of RF free dipping treatment based on Ricobond 7004 dispersion.

11:30

KEYNOTE

INM - Leibniz Institute for New Materials
DE-Saarbrücken
Dr. rer. nat. René Hensel

ADHESIVES IN SPACE – OPPORTUNITIES AND CHALLENGES

11:30 – 14:00 **NETWORKING with Airmeet**

14:00 – 14:30

OST – Eastern Switzerland University of Applied Science
CH-Buchs
Arno Maurer*[1], Debra Carolina Cortés Gómez[1]; Alex Itten[2]; Michael Ewart[3], Alex Huber[3]
[1]Institute for Microtechnology and Photonics, OST Campus Buchs, CH-Buchs
[2]Lenze Schmidhauser, CH-Romanshorn
[3]APM Technica AG, CH-Heerbrugg

LIFETIME ASSESSMENT OF FUNCTIONAL POLYMERS USED IN ELECTRONIC PACKAGING

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

---

14:30 – 15:00

University of Freiburg / Department of Microsystems Engineering – IMTEK
DE-Freiburg im Breisgau
Anas Hallak*, Juergen Wilde

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

In recent years, adhesive bonding has been established as one of the most important joining processes and this technology has been used in metal-plastic hybrid structures. In the current project, an adhesion promoter is used as an intermediate layer between the metal inlay and the plastic housing. The main aim of this layer is to create a self-sealing effect in this structure since this layer should flow into micro-damages such as interface cracks and inhibit them from growing and close

them. In this study, adhesion promoter's properties for instance, flow behavior, thermal stability, chemical properties, viscoplastic properties, and their thermal relationship have been tested for two purposes. On one hand, the results are to be used creating an experimental design as a first step to get the self-sealing effect. On the other hand, primers data are needed as input for FEM-simulation.

15:00 – 15:30

Jowat SE
DE-Detmold
Dr. Hartmut Henneken

NOVEL HOTMELT ADHESIVES FOR OPTIMIZED PHOTOVOLTAICS WAFER PRODUCTION PROCESSES

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.

15:30 – 16:00

[1]SKZ-German Plastics Center
DE-Würzburg
Heinrich Leicht*[1], E. Kraus[1], B. Baudrit[1], T. Hochrein[1], M. Bastian[1]
Maurice Langer[2], A. Klotzbach[2]
[2]Fraunhofer Institute for Material and Beam Technology IWS; DE-Dresden

ENHANCING THE ELECTRICAL CONDUCTIVITY OF FLEXIBLE ADHESIVES USING NANOCARBONS

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.