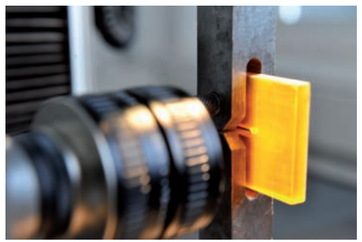
Motivation

Chemists, physicists, engineers and technicians at Fraunhofer PYCO as well as the Chair of Polymeric Materials of Brandenburg University of Technology Cottbus (Chairholder: Prof. Dr. Monika Bauer) have been developing highly crosslinked polymers (thermosets) for all applications with particular reference to aviation, information and communication technology and scientific instruments.

Fracture toughness is one of the key properties of thermoset resins. Many applications such as laminates, adhesives or molding resins require thermosets with high fracture toughness. Therefore, toughening of thermoset resins such as epoxy resins is one of the major goals of material development. Since toughening agents often lead to a deterioration in other key properties a balance of properties has to be achieved. This involves a high number of fracture toughness measurements. In the past, the time-consuming and thus expensive and nevertheless inaccurate (scattering) fracture toughness measurements have been a bottleneck in material development and research. The development of Optical Crack Tracing (OCT) provided a major step forward both in the ease of the now automatic procedure and in the accuracy and reproducibility of data.

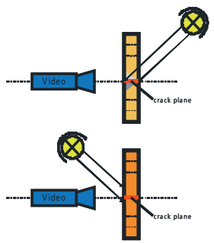


1+2 *Optical Crack Tracing with digital video camera*

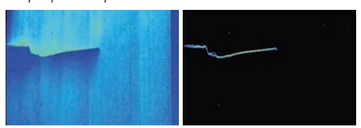
The Application Lab for Fracture Toughness of Thermoset Resins is based on the development of the OCT-method for automated fracture toughness measurements. However, it is not only a testing lab but also a competence center for the development of toughened thermoset resins.

Fracture Toughness

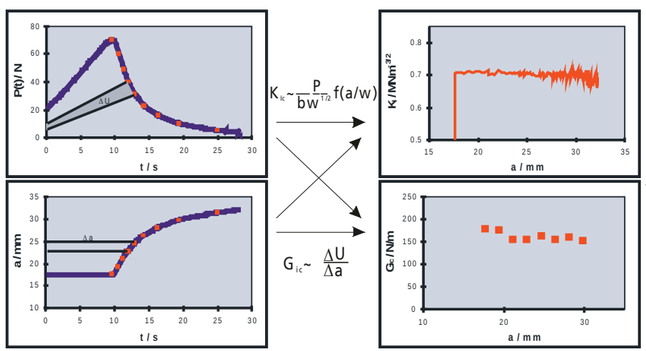
Experimental fracture mechanics comprises the testing of standard geometry specimens having a sharp pre-crack and the calculation of geometry independent fracture criteria from the crack length and the critical load for crack initiation. Such fracture criteria can then be used to predict stability of cracks in complex parts or devices. In linear elastic fracture mechanics the critical stress intensity fracture K_{Ic} and the critical strain energy release rate G_{Ic} are measured. In contrast to the common test practice OCT is not only recording one measured value for the crack initiation but the complete R-curve, i.e. K_I and G_I as a function of crack propagation a.



3 *Creation of a gradient in brightness at the crack by inclined lightning, above: transparent, below: opaque sample*



4 *Filtering of the crack out of the video image by digital filter algorithms*



5 *Simultaneous recording of load and crack length and calculation of the R-curve $K_I(a)$ and $G_I(a)$*

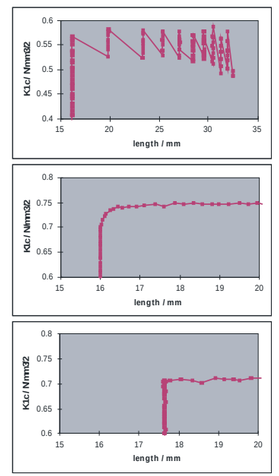
Measuring Principle

The measurement of absolute crack length is done optically by video recording of the fracture test. By applying digital image analysis algorithms the crack is reliably identified and its length measured. There is no additional sample preparation required.

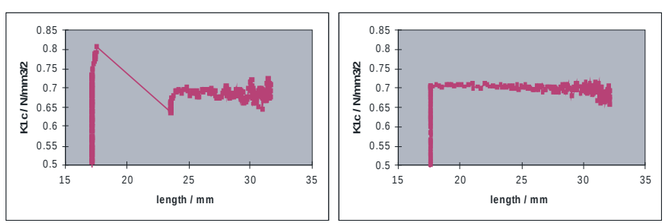
Higher Accuracy and Meaningfulness

Very often, the fracture toughness value for crack initiation is too high due to imperfect pre-cracks. With the common test practice this artefact is not identified. If OCT is used the intrinsic material parameter can be derived from the phase of crack propagation.

OCT yields information also on the mode of crack propagation.



6 *Different modes of crack propagation: stick-slip, continuous and with stable crack propagation in the initiation phase*



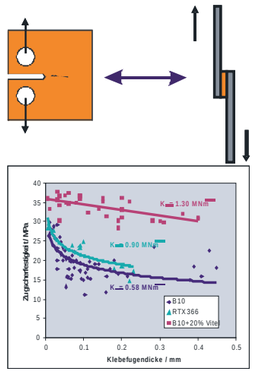
7 *R-curve for an imperfect pre-crack and for an ideal pre-crack*

Application

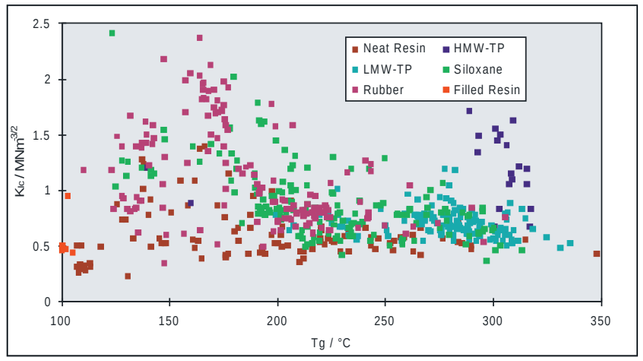
Development of new thermoset resins and formulations to

- Increase fracture toughness of adhesives
- Improve damage tolerance of composites
- Improve damage resistance of microelectronic devices to thermocycles
- Data sheets for resin manufacturers and formulators

Optical Crack Tracing (OCT) was developed in close cooperation of Fraunhofer PYCO and LaVision GmbH (Göttingen, Germany).



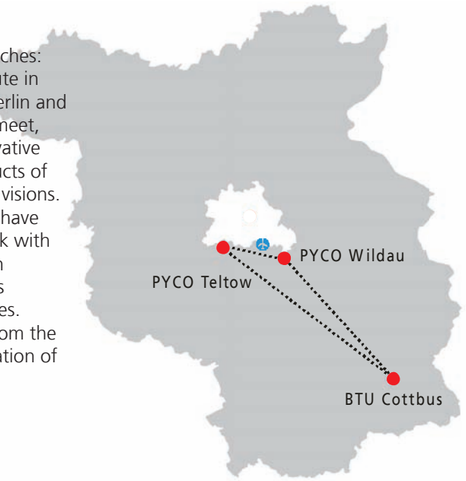
***8** Influence of adhesive fracture toughness on the dependence of lap shear strength on bond thickness*



***9** Relationship between fracture toughness and glass transition temperature for a selection of toughened thermoset resins developed by Fraunhofer PYCO*

Location Berlin-Brandenburg

New solutions require new approaches: The location of the research institute in Teltow, where the metropolis of Berlin and the federal state of Brandenburg meet, offers optimal conditions for innovative scientific research. Here, the products of tomorrow emerge from ideas and visions. Therefore, the institute's scientists have formed a creative research network with renowned universities, well-known large-scale enterprises, and various innovative medium-sized companies. Additionally, new synergy arises from the integration in the third largest location of aerospace industry in Germany.



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Prices and processing time on request.

***10** Main building*

Fraunhofer PYCO

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