

IWPK

**MONTAN
UNIVERSITÄT**

Prüfmethoden Kunststoffe

G. Pinter

Institut für Werkstoffkunde und Prüfung der Kunststoffe
Montanuniversität Leoben
Polymer Competence Center Leoben GmbH

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Professoren der Kunststofftechnik

Wolfgang Kern
Chemie der Kunststoffe

Clemens Holzer
Kunststoffverarbeitung

Gerald Pinter *
Werkstoffkunde und
Prüfung der Kunststoffe

Rudolf Wörndl
Konstruieren mit
Kunst- und Verbundstoffen

Neu ab Wintersemester 2010 / 2011:

- 1 Professur für Spritzgießen von Kunststoffen
- 1 Professur für Verarbeitung von Faserverbundstoffen

* interim. Institutsleiter

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Neues Kunststoffzentrum Leoben

6 600 m², Bezug ab März 2010

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Comet K1 Zentrum PCCL: 2010 -2016

Area 1
Chemistry of Polymeric Materials

Area 2
Advanced Technologies in Polymer Processing

Area 3
Polymeric Materials and Material Systems for Structural Applications

Area 4
Functional Surfaces and Interfaces in Polymer Technology

Polymers

Forschungsvolumen 2010-2013:
€ 20 Millionen

COMET
Competence Centers for Excellent Technologies

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IWPK: Major fields of research

Material structure	Testing and property characterization	Material models and material laws
<ul style="list-style-type: none"> Microscopy (LM, SEM, TEM, AFM) Spectroscopy (IR, UV/VIS/NIR, Raman) Scattering (SAXS, WAXS) 	<ul style="list-style-type: none"> Standardized and non-standardized methods Method development Accelerated test methods Advanced data reduction 	<ul style="list-style-type: none"> Mechanical, thermal, optical and electrical properties and property functions Advanced material laws and failure criteria

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IWPK: Major fields of research

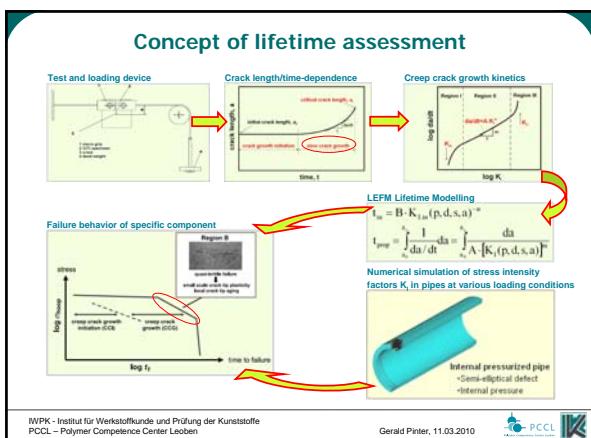
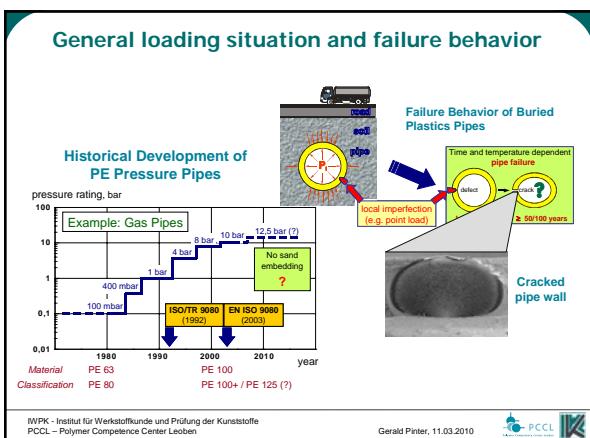
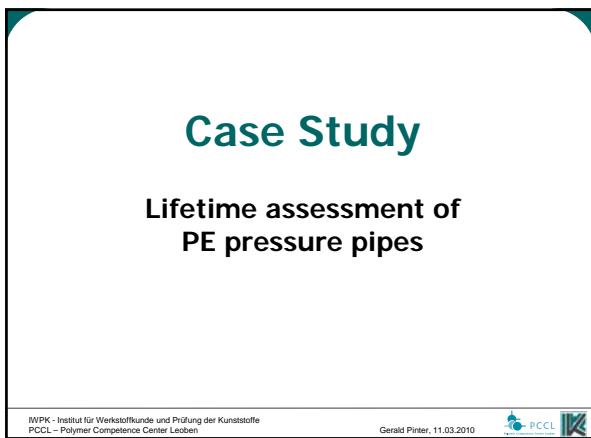
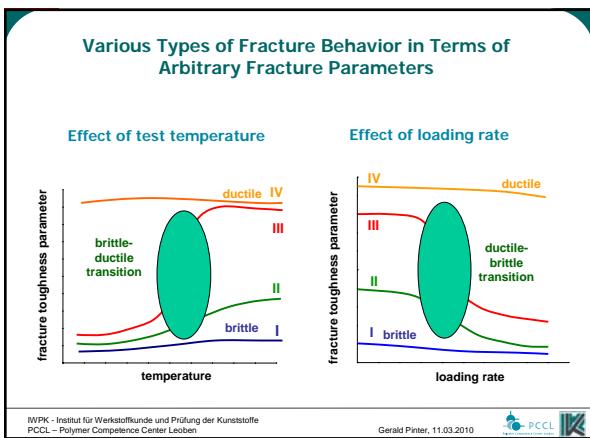
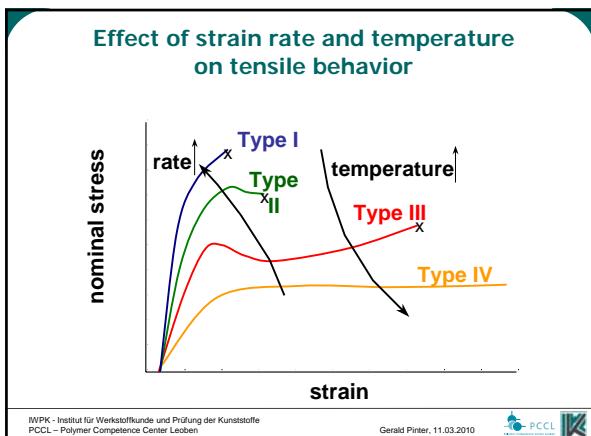
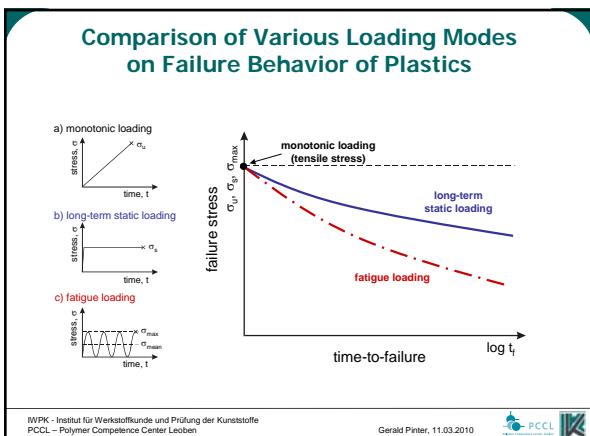
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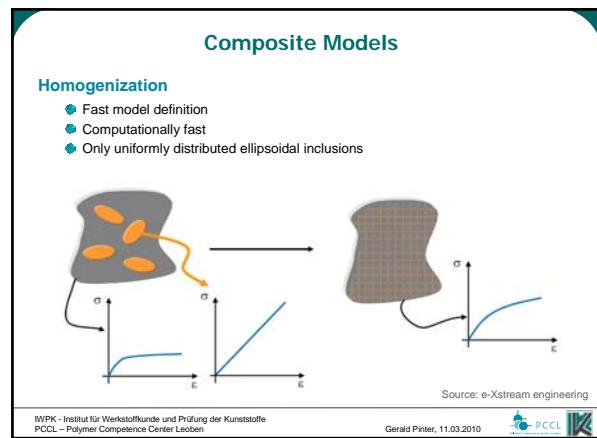
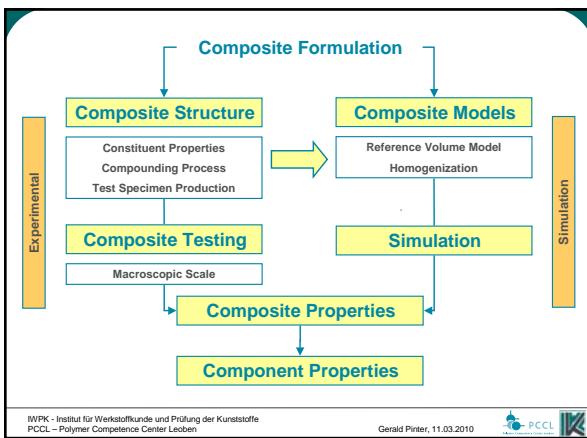
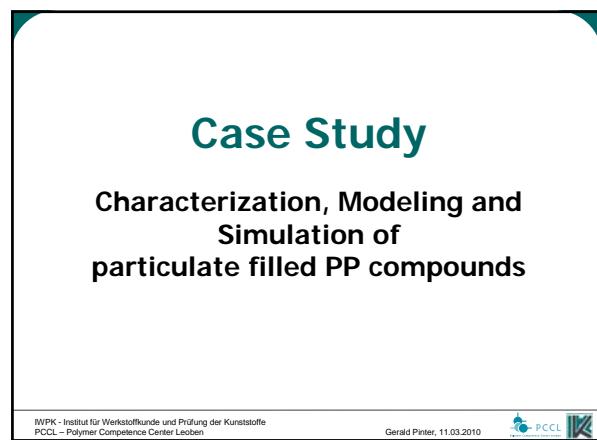
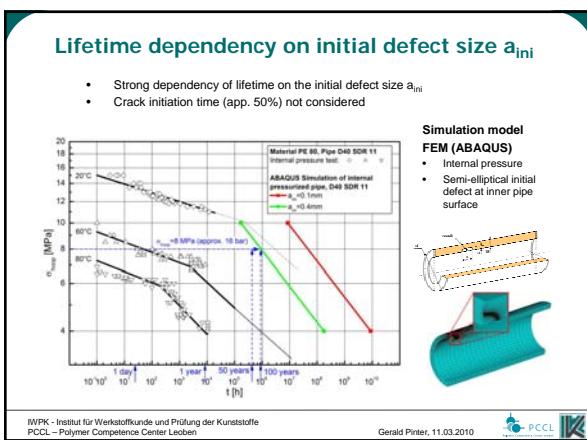
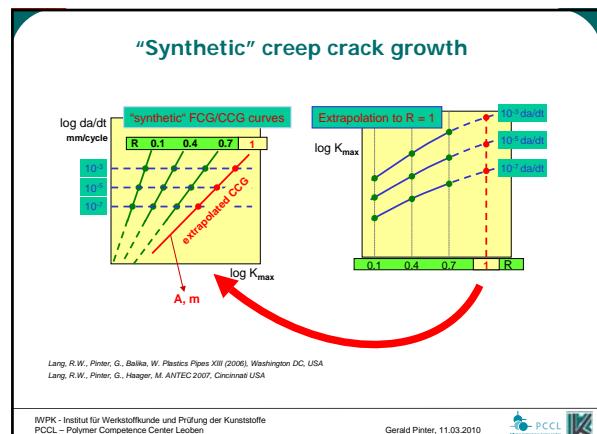
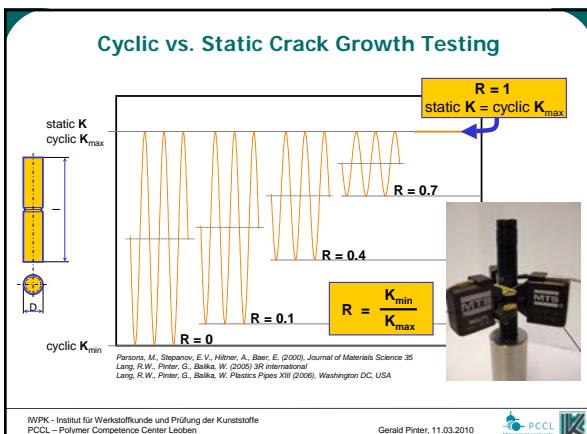
General Research Objectives

- Structure-property-performance relationships on all size scales (molecular-nano-micro-meso-macro)
→ **Material development**
- Structural and functional performance modeling and prediction
→ **Part/component design and optimization**

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Composite Models

Reference Volume Element (RVE)

- Microscale Information
- Complex inclusion shapes
- Inclusion distribution (clustering; percolation)
- Elaborate RVE definition
- CPU intensive

Spherical inclusions

Short fiber reinforced materials

Source: e-Xstream engineering

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Compression Test Configurations

Stress State

uniaxial – plane strain – multiaxial

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Experimental setup of the confined compression test

Steel loading pins

Confining Cylinder

Specimen

Strain gauge

- Cylinders made of polypropylene or steel
- Different thicknesses to vary the multiaxial stress state

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Experimental setup for compression tests

guiding bars in ball linings for alignment

LVDT

Testing machine
Instron 5500

compression plate

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Optical strain measurement

- Full field strain measurement
- Transverse and longitudinal strain

Thermal field measurement

- Full field surface temperature measurement

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Compound Simulation

Simulation of multi-phase compound:
elastomeric phase for toughness, mineral phase for strength

Separate dispersion of the filler particles

Partial dispersion and partial embedding

Embedded structure → coated particles

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Compound Simulation

Multi phase systems

- Simulation with Digimat MF
- Influence of the embedding of hard particles in various phases
- Due to the embedding, the matrix cannot "see" the filler, only the elastomer
- Stiffness does not increase with filler content
- DIGIMAT's multi level homogenization method is able to simulate the embedding effect with good accuracy.

Source: Moczo and Pukanszky, 2008

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Case Study

Rapid Gas Decompression

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Rapid Gas Decompression

- Specimen**
 - Cylinder height 8 mm diameter 8 mm
 - Seal cord thickness 5,33 mm inner diameter 37,47 mm

Test Setup

Test with "unconstrained" specimen	Test with "constrained" specimen
<ul style="list-style-type: none"> The geometric change of the specimen is measured by a camera system (height $h(t)$ and diameter $d(t)$) The volumetric change is calculated $\Delta V(t)$ 	<ul style="list-style-type: none"> Change of the force is detected ($F(t)$) The stress can be calculated ($\sigma(t)$)

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Unconstrained Test Set Up

ECONOMOS®

Test Parameter

- 10h CO₂, unconstrained
- 60°C, 150 bar
- decompression rate 22,5 bar/min

Measured values

- temperature, T
- pressure, p
- diameter d, height h

$$V_0 = \frac{d_0^2 \pi}{4} \cdot h_0 \quad V_p = \frac{d_p^2 \pi}{4} \cdot h_p$$

$$\Delta V = \frac{V_p - V_0}{V_0} \cdot 100\%$$

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Unconstrained HNBR CO₂ 150 bar

Compression

Decompression

COMPRESSION

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Quelle: Klaus Ledermann
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Constrained Test Set Up

Material- and Component behavior under "constrained"- condition

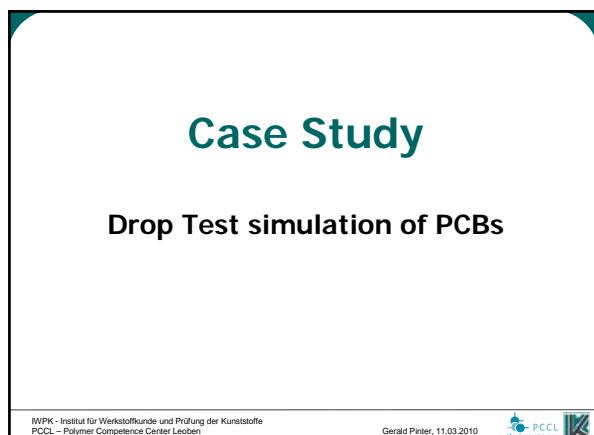
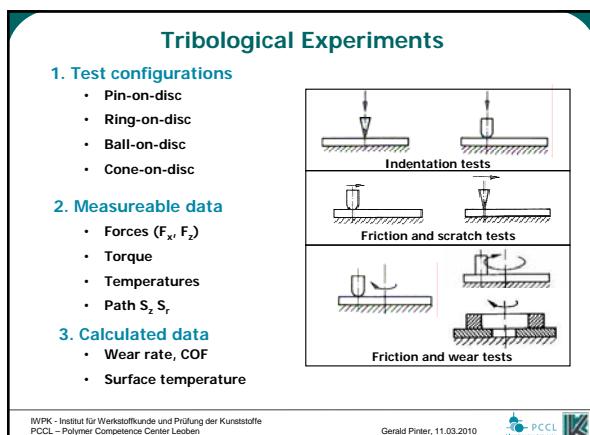
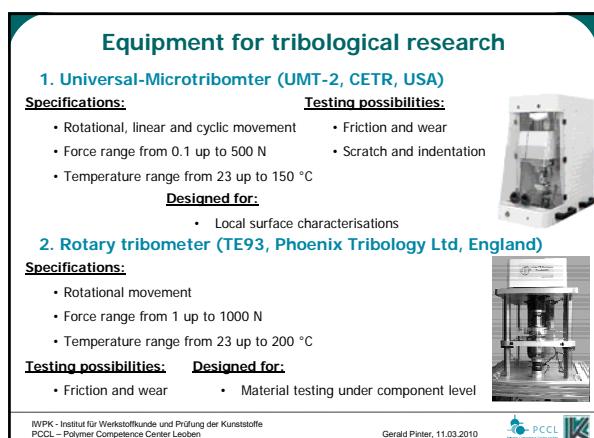
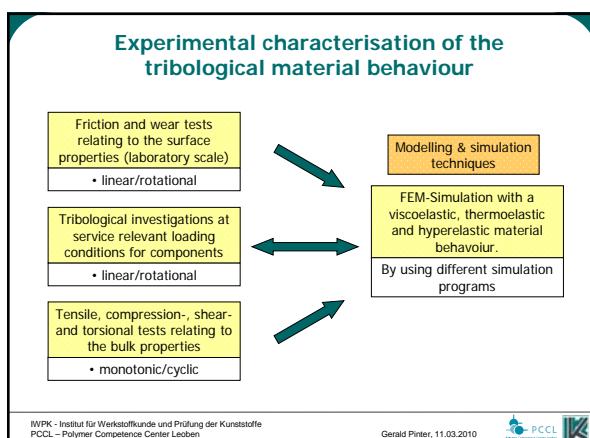
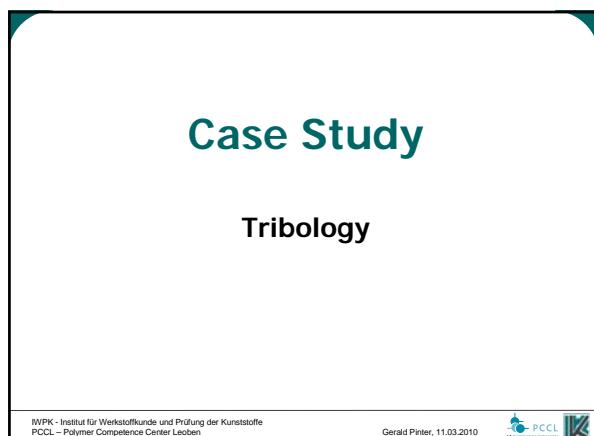
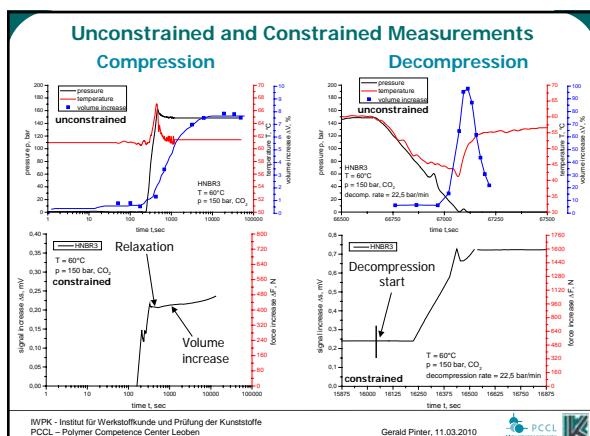
DMS instrumented loadcell (wireless connection to controller)

specimen (cylindrical or seal)

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Instrumented Drop Test

Analysis of the standardized Drop Test for PCBs to determine the loading conditions and the material response.

- high speed camera,
- strain gauges and an acceleration sensor

were used for measurements.

Drop Test (1500 g in 1ms)

High Speed Camera Video

Oscillogramm

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Instrumented Drop Test

Strain Gauges

Acceleration Sensor

Acceleration Signal

Strain Envelope

Frequency Development

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Material Characterization

Dynamic Mechanical Analysis (DMA)

A DMA with loading conditions in step with actual bending loads was used to characterize the material.

Electrodynamic Testing Machine
BOSE 3450, BOSE Co, MN, USA

Bending Fixture (in-house development)

Temperature Range: -40 °C - 125 °C (6 temperatures)
Frequency Range: 0.01 - 10 s⁻¹ (4 points/decade)

$E'' \text{ MPa}$

frequency, s^{-1}

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Material Characterization

Material Law Generation

Taking the DMA measurement data a master-curve is generated and a prony series is fitted for the use in FEM-software.

Temperature - Time Shift

Prony Series

$E(t) = E_0 + \sum_{i=1}^n E_i \cdot e^{-\frac{t}{\tau_i}}$

$\tau_i = \eta_i / E_i$

$E'' \text{ MPa}$

time [s]

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Drop Test Simulation

Drop Test Simulation

- Good agreement for amplitude
- Good agreement for frequency evolution
- Discrepancy regarding frequency level
- Valuable tool for relative comparisons

Velocity Field

Constraints

Acceleration

FEM- Software: Abaqus 6.9-1 (Simulia, Providence, RI; USA)

envelope oscillation

frequency development

time [s]

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