Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

HiBarSens® - OUTSTANDING FOR ULTRA BARRIER MATERIAL TESTING

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CHALLENGE

The demands of organic electronics with respect to the barrier properties of the encapsulation materials are constantly increasing. Hence the measuring technology for the reliable highly sensitive Water Vapour Transmission Rate (WVTR) determination of flexible barrier samples has accordingly to be improved.

TECHNOLOGY

To answer these demands a highly precise but also rugged and smart permeation measurement system using a laser diode spectroscopic sensor has been developed for quantifying WVTRs of ultra barrier materials down to 10^{-6} g m^{-2} d^{-1} and better. Different measuring modes are implemented in one setup to select the best test conditions in dependence on the sample properties and performance.

HIBARSENS® AT A GLANCE

- Setup
  - carrier gas mode
  - diffusion controlled mode
  - accumulation mode
  - simple sample handling
  - holder for large area samples
- Laser spectroscopic gas sensor (LDS):
  - sensitivity in the ppb range
  - selective and long-term stable
  - no sensor drift or damage caused by saturation or overdrying
  - minimal maintenance
  - measurement under typical application conditions (pressure, temperature, moisture)
- Active sample sealing
  - suppression of any interferences by the ambient humidity
  - zero blank value
  - gentle sample mounting

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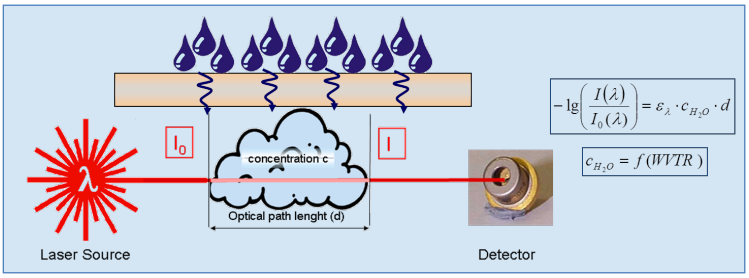
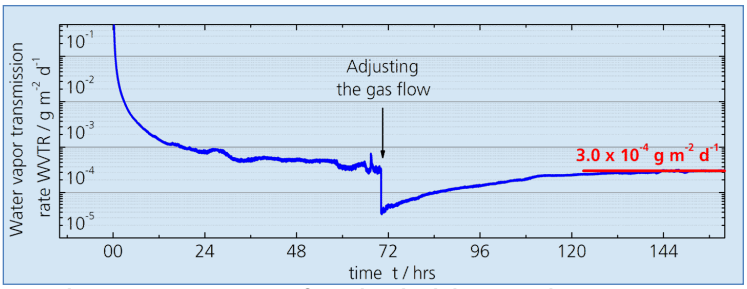
Permeation measurement at it's best!

PRINCIPLE



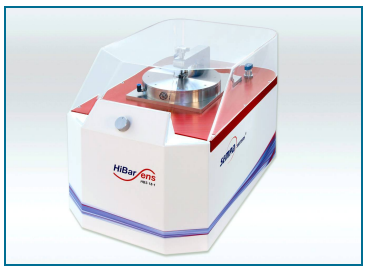
RESULTS

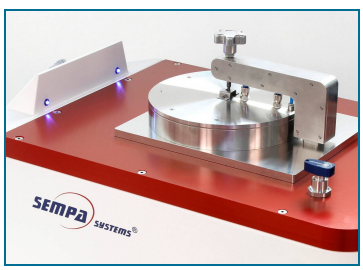


Typical WVTR measurement of an ultra-high barrier substrate (Fraunhofer POLO®)

SPECIFICATION

permeate:	H_2O
measurement range:	**WVTR: 10^{-7}... 10^{-6} - 10 g m^{-2} d^{-1}**
sensor:	tunable diode laser absorption spectrometer (TDLAS)
temperature range:	10 °C - 50 °C ± 0.05 °C
rel. humidity range:	60 % - 95 % ± 2 %, 100 %
sample size (total):	Ø 200 mm
active sample area:	134 cm^2
sample thickness:	20 µm - 5 mm
dimension:	550 x 350 x 380 mm





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HiBarSens® - DIFFUSIVE MODE THE ACCESS TO THE 10^{-6} g m^{-2} d^{-1} LEVEL

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CHALLENGE

The limit of detection and the reliability of the classical carrier gas methods for permeation rate testing strongly depend on the precision of the carrier gas flow control and the limit of detection of the used sensor. To overcome these hurdles new measuring concepts are needed.

TECHNOLOGY

The transport of the permeate has been realized by a diffusion controlled flow. The diffusive flow is much lower than any classical carrier gas flow and can be described by 1st FICK's law. The steady state condition (isocapnic condition) in the measurement cell will be achieved at much higher moisture concentrations. The WVTR of the sample can be calculated using the measured concentration and the known geometrical parameters of the diffusion path (diameter and length of the narrow pipe).

THEORY

The basic idea: The quantity of the permeated moisture must be the same as the transported moisture in the steady state condition.

Fick's law

$$J = -D \cdot \frac{\Delta c}{\Delta x}$$

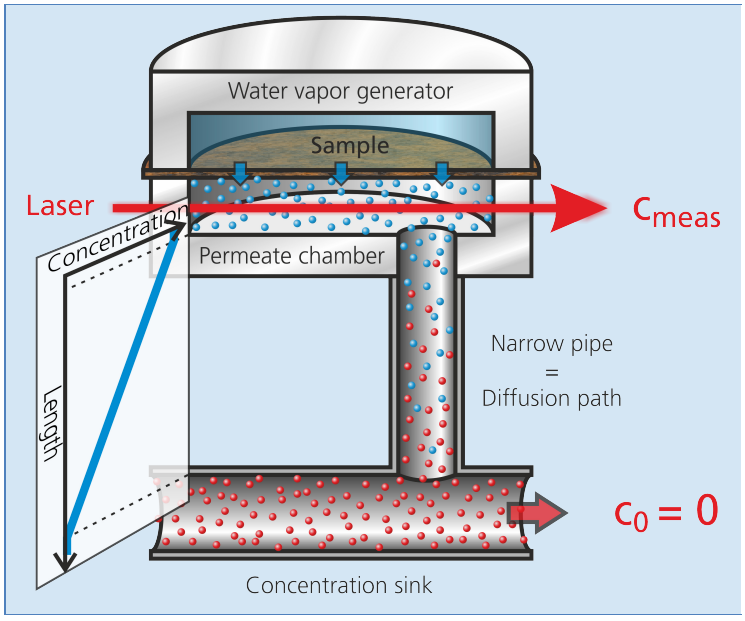
J ... Diffusion flux
D_{H2O} ... Diffusion coefficient of water vapor = 2.60E-05 m^2/s

$$WVTR_{sample} \cdot A_{sample} = J(H_2O)_{pipe} \cdot A_{pipe}$$

$$WVTR = -D \cdot \frac{\Delta c}{\Delta x} \cdot \frac{A_{pipe}}{A_{sample}}$$

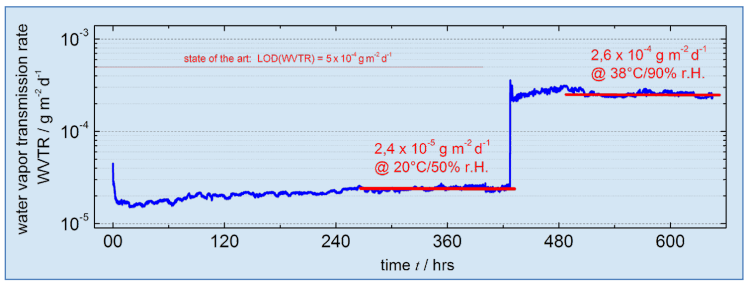
Δx ... pipe length ; $\Delta c = (c_{measured} - c_0)$

PRINCIPLE



Principle of the diffusive setup for WVTR measurement of ultra-high barrier samples implemented in HiBarSens®

RESULTS



Typical HiBarSens® diffusive WVTR measurement at different measuring conditions of an ultra-high barrier sample (Fraunhofer POLO®)

SUMMARY

The diffusive measurement mode opens the simple but reliable access to the WVTR-level of 10^{-6} g m^{-2} d^{-1} and lower. The proof of principle has been checked using already well-examined ultra-high barrier samples (Fraunhofer POLO®).

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HiBarSens® - COMBINATION MODE THE ACCESS TO THE 10^{-6} g m^{-2} d^{-1} LEVEL

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CHALLENGE

The limit of detection and the reliability of the classical carrier gas methods for permeation rate testing strongly depend on the precision of the carrier gas flow control and the limit of detection of the used sensor. To overcome these hurdles new measuring concepts are needed.

TECHNOLOGY

The hermetically closing of the permeate chamber results in an increase of the water vapour concentration inside the cell caused by permeation. The continuously monitoring of the water vapour concentration inside the permeation cell enables a sequentially opening and closing of the cell at dedicated water vapour concentration values. In case of the opened cell the water vapour has been purged out the cell, in case of the closed cell the water vapour has been accumulated inside the cell. The concentration monitoring during the purge phase enables the calculation of the purged mass of water vapour which is accumulated during the time of a whole cycle consists of accumulation and purging. The WVTR of the sample can be calculated using the integral of all measured concentration values during the purge phase and the total cycle time.

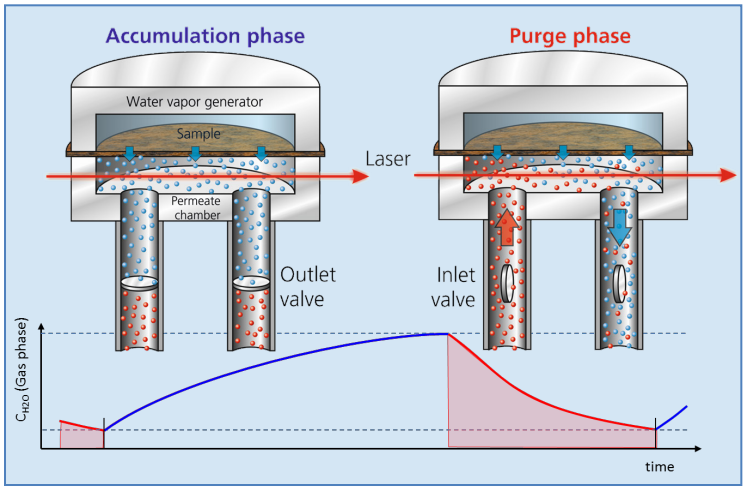
THEORY

The basic idea: The method considers all permeated water molecules for the calculation of the WVTR: the water vapour in the gas phase as well as the water molecules sticking on the wall during the water vapour accumulation process.

$$WVTR_{combination} = \frac{M_{H_2O} \cdot p}{A_{sample} \cdot R \cdot T} \cdot \frac{\int (c(t) \cdot \dot{V}) dt}{t_{total}}$$

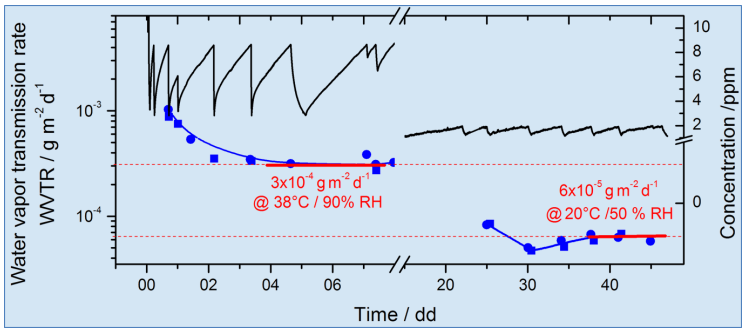
V ... purge flow; $t_{total} = t_{Accumulation} + t_{purge}$

PRINCIPLE



Principle of the combination mode setup for WVTR measurement of ultra-high barrier samples, implemented in HiBarSens®

RESULTS



Typical HiBarSens® WVTR measurement of an ultra-high barrier sample (Fraunhofer POLO®) using the combination mode at different measuring conditions (38°C/90% RH; 20°C/50% RH).

SUMMARY

The combination measurement mode opens the simple but reliable access to the WVTR-level of 10^{-6} g m^{-2} d^{-1} and lower. The proof of principle has been checked using already well-examined ultra-high barrier samples (Fraunhofer POLO®).

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