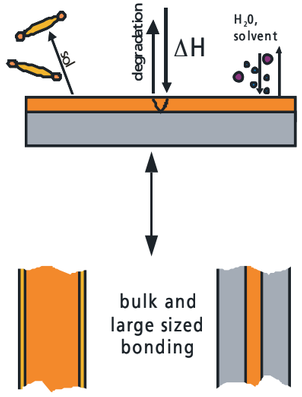
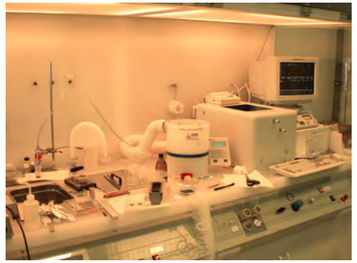
Motivation for Investigating Thin Films

- Applications of polymer in nanometer scale have increased
- Polymer properties and polymer formation respectively may be size-dependent
  - Thin films stabilize faster with the environment (e.g. regarding humidity and solvents)
  - Components evaporate during polymer formation (monomer, sol)
  - When thermally degrading, the process zone is in the magnitude of the polymer size
- Some polymers only exist in thin-layer form (e.g. CVD layers, plasma polymer coatings)
- Accelerated investigation of the aging of polymers at moderate temperatures possible
- Accelerated investigation of water uptake, determination of absorption and adsorption isotherms



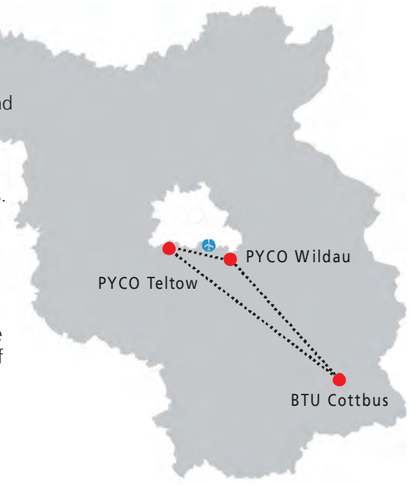
9 *Additional processes have to be considered for polymers in thin film state compared to bulk state*



10 *Lab for the preparation of thin polymer layers*

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.



Fraunhofer Research Institution for Polymeric Materials and Composites PYCO

Application Lab for the Thermophysical Characterization of Thin Transparent Films
Dr. Olaf Kahle
Kantstrasse 55
14513 Teltow, Germany
Phone +49 3328 330-276
Fax +49 3328 330-282
olaf.kahle@pyco.fraunhofer.de
www.pyco.fraunhofer.de

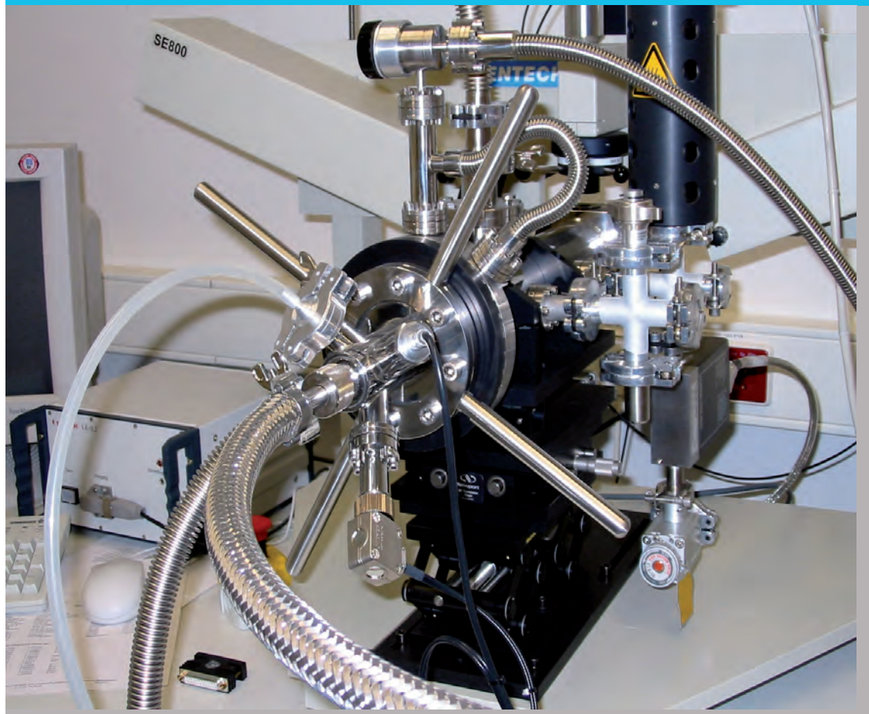
Prices and processing time on request.

11 *Main building*

Fraunhofer PYCO

FRAUNHOFER RESEARCH INSTITUTION FOR POLYMERIC MATERIALS AND COMPOSITES PYCO

Application Lab for the Thermophysical Characterization of Thin Transparent Films - Nano-TMA/TGA/DVS



Application Lab - Nano-TMA/TGA/DVS

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.

Today the research work is principally concerned with lightweight composites and micro- and optoelectronics.

PYCO is developing polymer systems along the whole supply chain beginning with the monomers up to the finished part which is unique with any material research center in Germany.

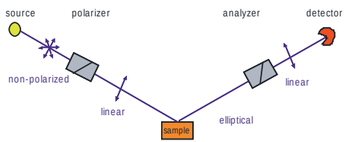
The Application Lab for Thermophysical Characterization of Thin Transparent Films - Nano-TMA/TGA/DVS extends classical, thermophysical examination methods for the characterization of bulk polymeric materials by temperature and humidity-dependent ellipsometry in order to investigate thin transparent polymer layers.

Apparatus

For the examinations, two separate modules (temperature/humidity cell and vacuum cell respectively) for a commercialized ellipsometer (Sentech 850) have been developed and integrated into ellipsometer software.

Equipment

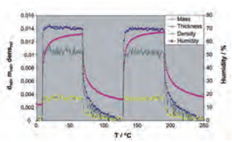
- Concept: Ellipsometer extended by temperature/humididty cell or vacuum cell respectively
- Layer thickness range: 70 up to 2.000 nm, layers transparent and planar
- Temperature range: Room temperature up to 350 °C
- Relative humidity: 5 up to 90%, vacuum
- Substrate: Silicon wafer



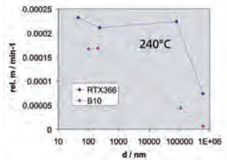
1 *Concept of ellipsometry*

Applications

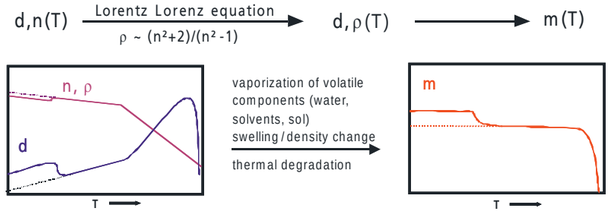
- Determination of the linear Coefficient of Thermal Expansion (CTE) in z-direction (from the changes in layer thickness) as well as for the Coefficient of Volume Expansion (from the changes in the refractive index
- Determination of glass transition temperature (T_g)
- Investigation of mass loss processes
  - Evaporation of volatile components such as sol or residual solvents (irreversible)
  - Water uptake (reversible)
  - Distinction between change of thickness and change of density
- Investigations regarding thermal degradation
  - In dependence of layer thickness (in combination with classical TGA)
  - Changes in the refractive index (chemical reactions)
- Investigations regarding curing behavior (T_g)
- Determination of degree of curing (indirectly via T_g)



2 *Kinetics of water uptake when humidity is changed incrementally*



4 *Thickness-dependent investigations give informations about the effective layer thickness where degradation mostly takes place, e.g. isothermal Nano-TMA and TGA of two cyanates*

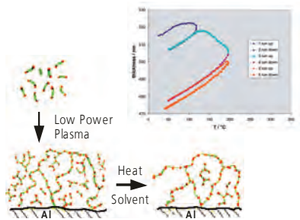


3 *Separation of effects related to thickness or mass*

APPLICATION LAB - NANO-TMA/TGA/DVS

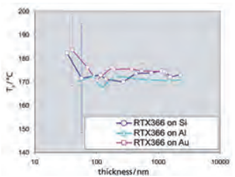
Structure Investigation

Thermal expansion can be used as a tool for structure investigations.



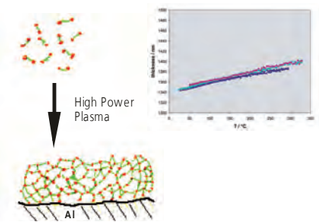
5 *Low Crosslink Density*

- High sol content (i.e., high content of volatiles)
- Low stability in liquids and at higher temperatures
- High swelling by water and solvents
- Low modulus (flexible coating)
- High thermal expansion



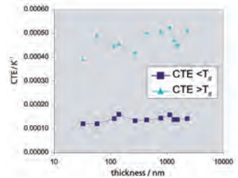
6 *Thickness dependence of glass transition temperature (T_g) on PMMA*

Example: Plasma polymer coatings made of HMDSO under different plasma conditions.



7 *High Crosslink Density*

- Low sol content (i.e., no volatiles)
- High stability in liquids and at higher temperatures
- Low swelling by water and solvents ("sealing function")
- High modulus (stiff coating)
- Low thermal expansion



8 *Thickness dependence of the Coefficient of Thermal Expansion (CTE) on PMMA*