

C5: Surface recovery and reconstruction after deformation

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Supervisors: H. Pelletier, R. Mülhaupt

Presentations

- 5 oral IRTG
- 5 posters IRTG
- 2 oral other
- 5 posters other
- DEPOS 24

Publications

[1] J. Lejeune, T. Chatel, H. Pelletier, C. Gauthier, R. Mülhaupt, in preparation.

[2] J. Lejeune, V. Le Houérou, H. Pelletier, C. Gauthier, R. Mülhaupt, in preparation.

[3] J. Lejeune, D. Favier, V. Le Houérou, H. Pelletier, C. Gauthier, R. Mülhaupt, in preparation.

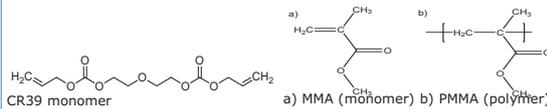
Other activities

- Organisation of a job presentation by scientific employees in academia
- Planning of a presentation by a recently recruited researcher of "Saint Gobain recherche"
- Made polymer chemistry with public during Science Day

Motivation

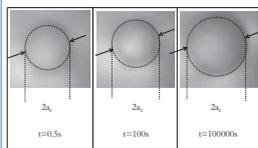
Viscoelastic properties of polymeric materials and their experimental determination have become an important area of research in the field of material science. The surge of interest in this subject stems from the increasing use of polymers for many manufactured products that covered a wide range of industrial applications.

Macromolecular chemistry

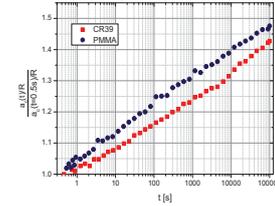


The Freiburger Material Forschungszentrum enabled me to design my polymer. Thus I could obtain transparent and filled polymers.

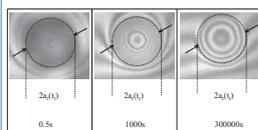
Indentation creep



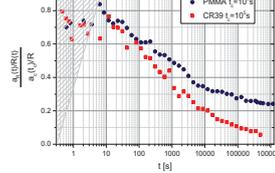
Above: Typical creep observation
Left: Normalized deformation versus creep time



Indentation recovery



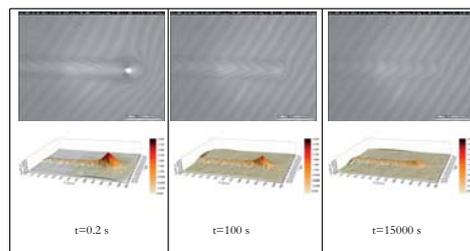
Above: typical recovery observation
Left: Normalized recovery deformation versus recovery time



The IRTG gave me the opportunity to synthesize the adequate material for the mechanical characterization. Indeed it was not possible to characterize non transparent samples.

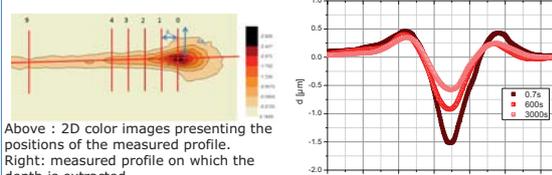
Scratch tests

Scratch surface reconstruction

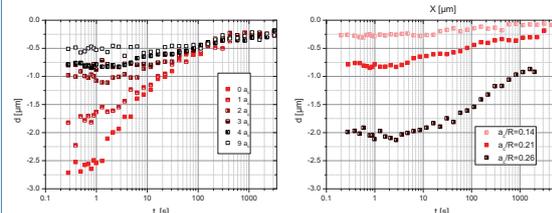


Top: images during scratch recovery ; Bottom computed surfaces

Scratch recovery depth



Above : 2D color images presenting the positions of the measured profile.
Right: measured profile on which the depth is extracted.

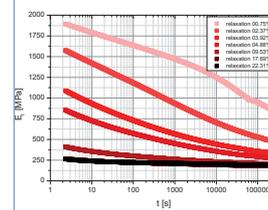


The analysis of the cross-profiles enabled us to measure the recovery depth versus time at different distances from the end of scratch (left figure the a_c distance is the reference distance where the whole mechanical cycle occurred. For the other studies (right figure example of recovery for different tip normal load) this distance is used.

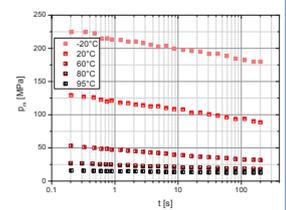
Professor Mülhaupt and his group were very interested in a way to characterize the scratch recovery versus time. They were a driving force behind this part of my thesis.

Master curves

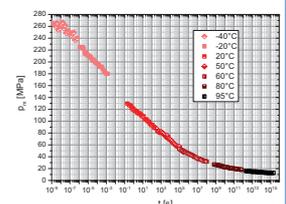
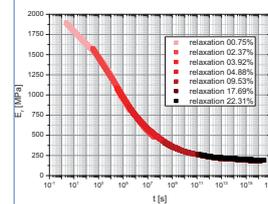
Relaxation master curves



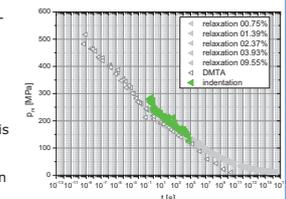
Indentation master curves



In both cases, it is possible to shift the data horizontally to obtain the master curves.



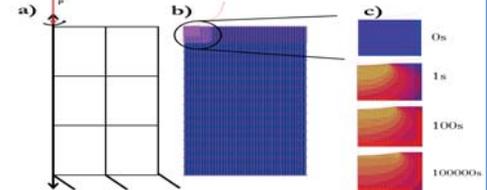
- The relaxation mastercurves are time-strain mastercurves.
- On the contrary the indentation mastercurves are **time-strain-temperature master curves**.
- As both master curves type are compatible for one material, the prediction of one, knowing the other, is possible.
- The figure on the right predict the obtained mean contact pressure for an unknown filled material.



Discussion with the IRTG members, in particular Carina Gillig and Professor Bartsch, enabled a breakthrough in the understanding of these master curves.

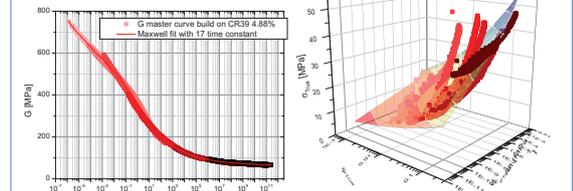
Finite element modeling

Model



a) Schematic model representation b) elements c) Von Mises stress versus time

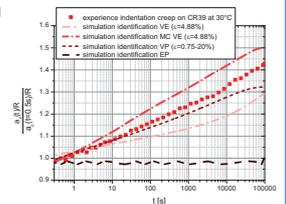
Constitutive law



Left: Master curve viscoelastic constitutive law. Right: Norton's constitutive law.

Indentation simulation

With the determined constitutive law, it is possible to simulate the mechanical behavior of the material in spherical indentation contact creep. The normalized deformation versus creep time is presented on the right. The two constitutive laws close to the experimental deformation are the master curves viscoelastic and the Viscoplastic Norton's law.



The possibility, that was given to me by the IRTG, to tune my own materials, simplified the characterization process and thus the identification of constitutive laws.

Conclusions & outlook

Thanks to the IRTG Soft Matter, I was immersed in an international group, which helped me to develop the multiple fields I was working with during my thesis.