Multi-scale modelling of oriented polymer foils

Citation for published version (APA):

Document status and date:
Published: 01/01/2013

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
Multi-scale modelling of oriented polymer foils

M. Poluektov, J.A.W. van Dommelen, L.E. Govaert and M.G.D. Geers
Eindhoven University of Technology, P.O. Box 513, 5600MB Eindhoven

Objective
The project aim is to understand and predict the effects of time, stress, temperature and humidity on the mechanical response of thin semicrystalline polymer foils during lithographic processing and handling. A multi-scale modelling tool is developed capable to predict dimensional stability of flexible substrates, in particular PEN and PET foils. These foils are used to manufacture plastic electronics, for instance, a plastic memory for RFID or the backplane of a flexible display (figure 1).

Modelling approach
The composite inclusion model is a material point model, relating the macroscopic stress and the deformation gradient (figure 2), in which these macroscopic quantities are obtained by volume averaging of local quantities. The microscopic scale is represented by layered domains, which are linked by a hybrid interaction law (between parallel and serial connection of domains). Multi-scale modelling approach is used to obtain a structure-property relationship for oriented material.

Results
Experimental macroscopic characterisation of short-term and long-term behaviour of the oriented foil was performed establishing degrees of anisotropy and inhomogeneity. Initial parameter identification was performed on isotropic samples, with more precise characterisation obtained using experimental data for orientated foil. Figure 3 demonstrates the ability of the model to simulate the large-strain anisotropic behaviour of PET in the strain rate controlled regime.

Creep master curves, which were constructed using time-temperature superposition, show a difference in dimensional stability of the foil in the machine direction (MD) and the transverse direction (TD), resulting from the orientation of the crystalline phase created by the production process. If internal anisotropic stresses in the non-crystalline phase (also a result of the manufacturing) are incorporated in the micromechanical model, the long-term behaviour of PET can be predicted, figure 4.

Conclusions
The short-term and long-term macroscopic behaviour at different conditions can be predicted with the composite inclusion model using information about the underlying microstructure. Parameters of the constitutive laws describing the different constituent phases at the microscopic level can be identified from the experimental data.