

Tribology of polymer composites

Citation for published version (APA):

Krop, S., Breemen, van, L. C. A., & Meijer, H. E. H. (2012). *Tribology of polymer composites*. Poster session presented at Mate Poster Award 2012 : 17th Annual Poster Contest.

Document status and date:

Published: 01/01/2012

Document Version:

Accepted manuscript including changes made at the peer-review stage

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.

Tribology of polymer composites

Sam Krop, Lambert C.A. van Breemen, and Han E.H. Meijer



AkzoNobel

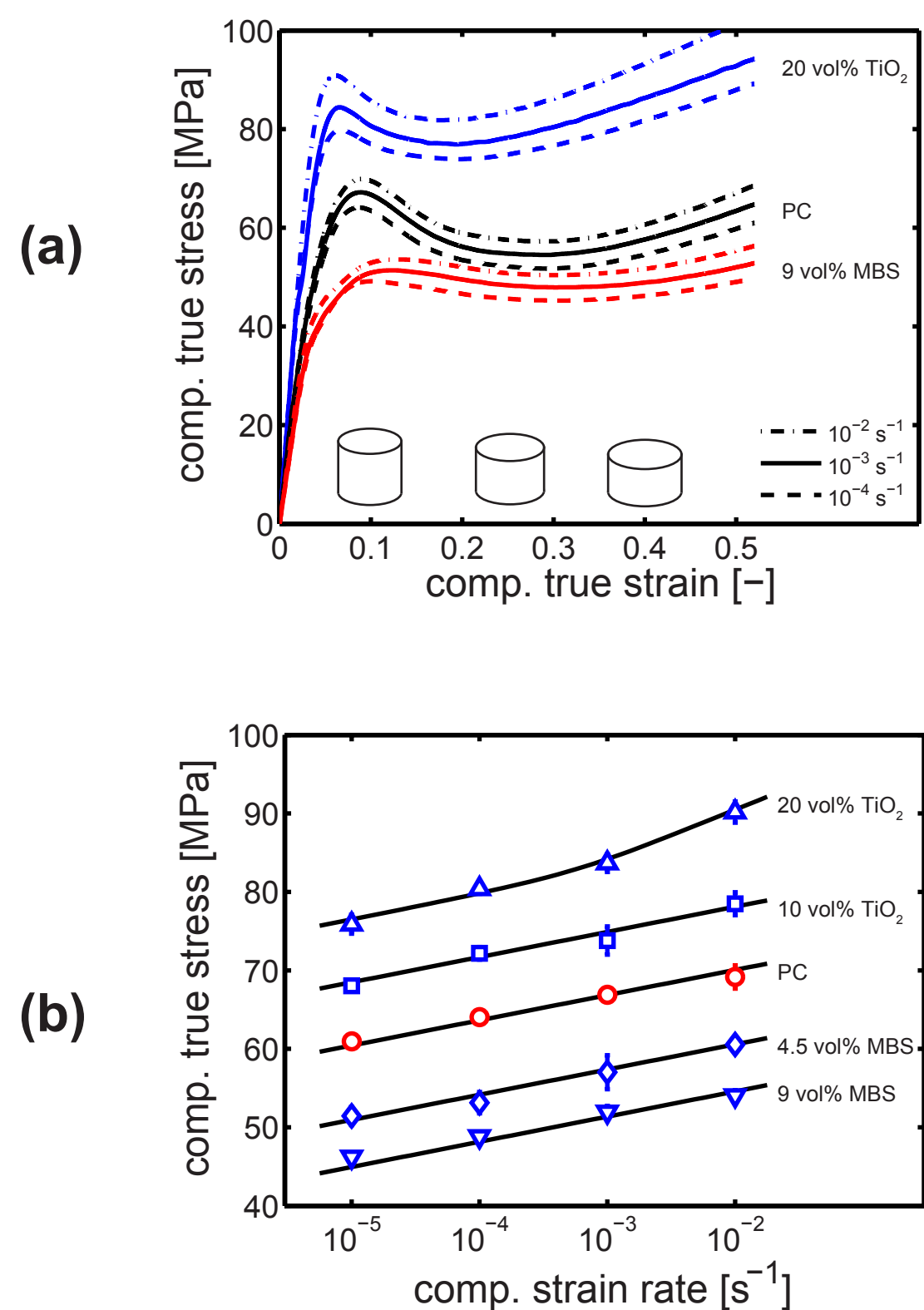


Fig. 1: Effect of filler type on intrinsic mechanical response (a) and rate-dependent yield stress (b).

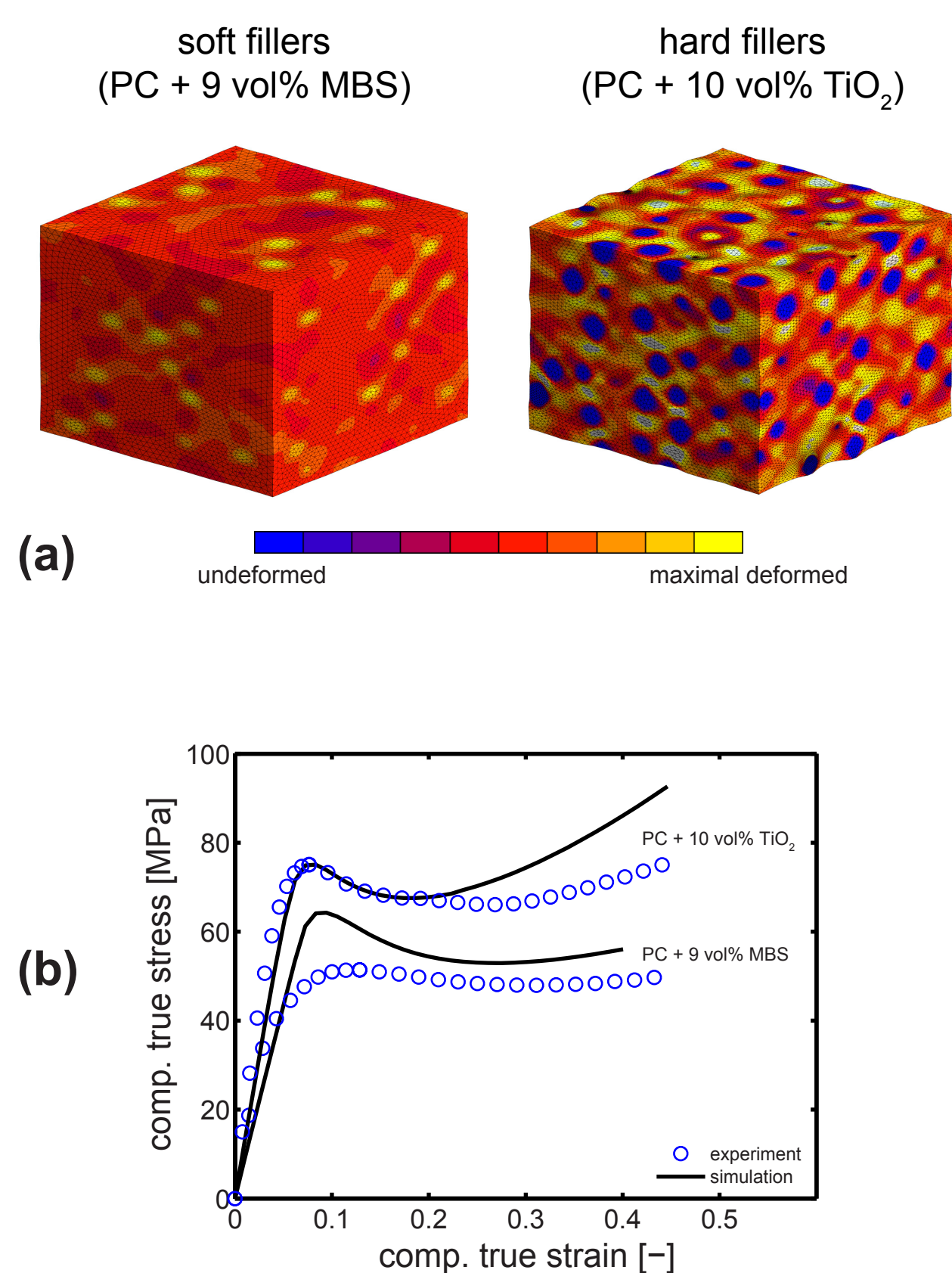


Fig. 3: Deformed RVE showing local strain level (a) and the macroscopic mechanical response (b).

Introduction

Polymers play an increasingly important role in tribological applications. The application of a hybrid experimental-numerical approach in the single-asperity scratch test proved a powerful tool in understanding the polymers' frictional response [1]. In practice, however, these polymers are filled, e.g. with colorants and impact modifiers. Therefore, this strategy is extended to heterogeneous systems.

Experiments

To characterize the effect of filler particles on the intrinsic mechanical response, model systems of PC filled with either hard (TiO₂) or soft (MBS) particles are tested in uniaxial compression, see Fig. 1a. Although the magnitude of stress changes dramatically, the rate dependence is solely determined by the matrix material, see Fig. 1b. This effect is also observed in the single-asperity scratch test; the addition of soft or hard fillers results in a change in the resistance against deformation (Fig. 2a), but the rate effect is still governed by the polymer matrix (Fig. 2b).

Simulations

It is impossible to mesh these heterogeneous materials in a scratch simulation. Therefore, representative volume elements (RVEs) are constructed, see Fig. 3a, and subjected to a macroscopic deformation. Although effects like cavitation and particle-matrix adhesion are not taken into account, simulation results show that the mechanical response is captured rather well, see Fig. 3b.

Discussion

A macroscopic material model of the heterogeneous system is constructed, which will be used in the simulation of the scratch test, see Fig. 4a. Apart from the stiffness and the yield stress, fillers also change the adhesive interaction with the indenter, which in turn changes the shape of the bow wave in front of the indenter-tip [1]. This adhesive component is the only unknown when relating the simulation to the experimentally measured total response. Imposing the local deformation from the scratch simulation on an RVE gives valuable information about the stress state in the filled system, see Fig. 4b. This enables the definition of a failure criterion that marks the onset of wear.

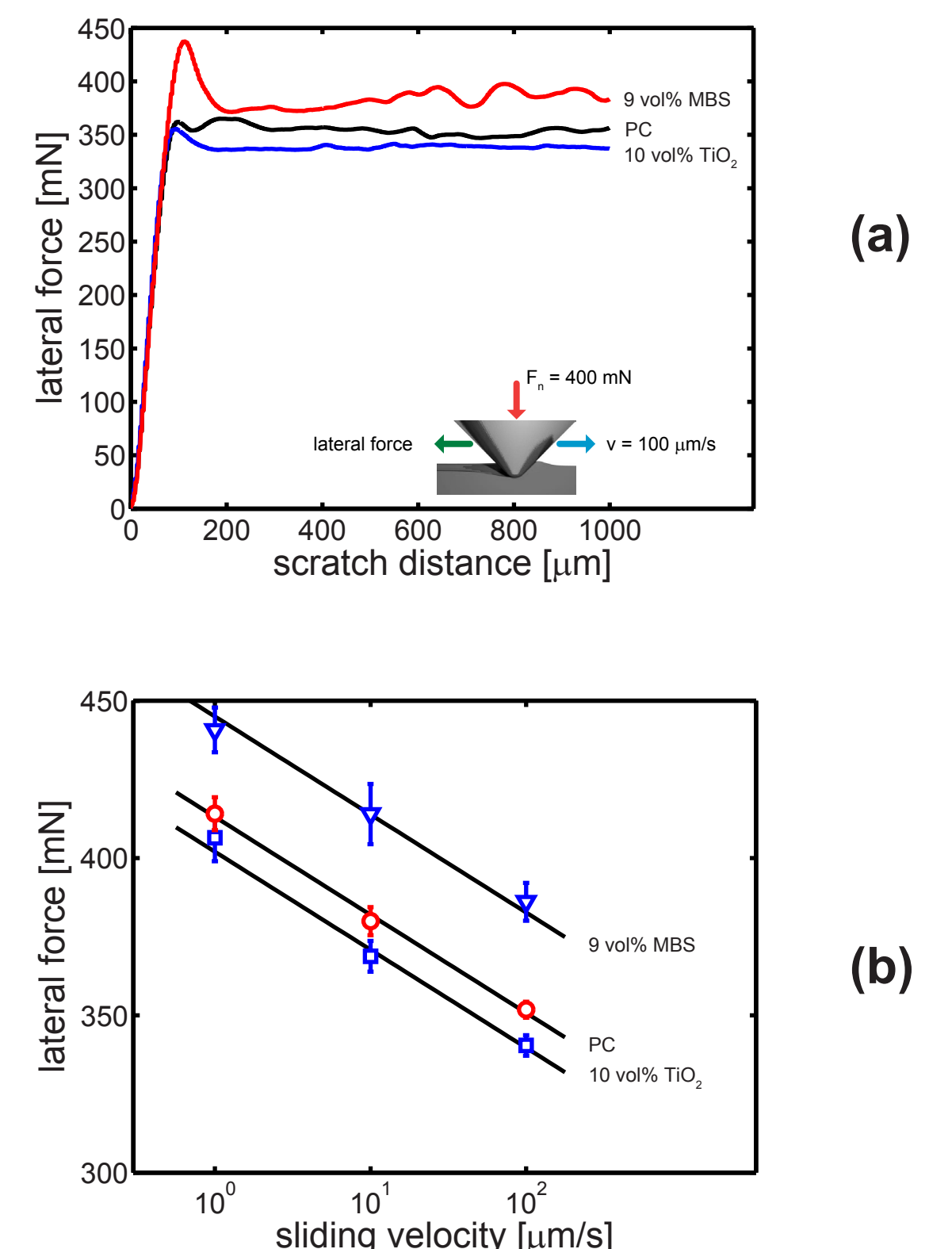


Fig. 2: Effect of filler type (a) and sliding velocity (b) on the scratch response.

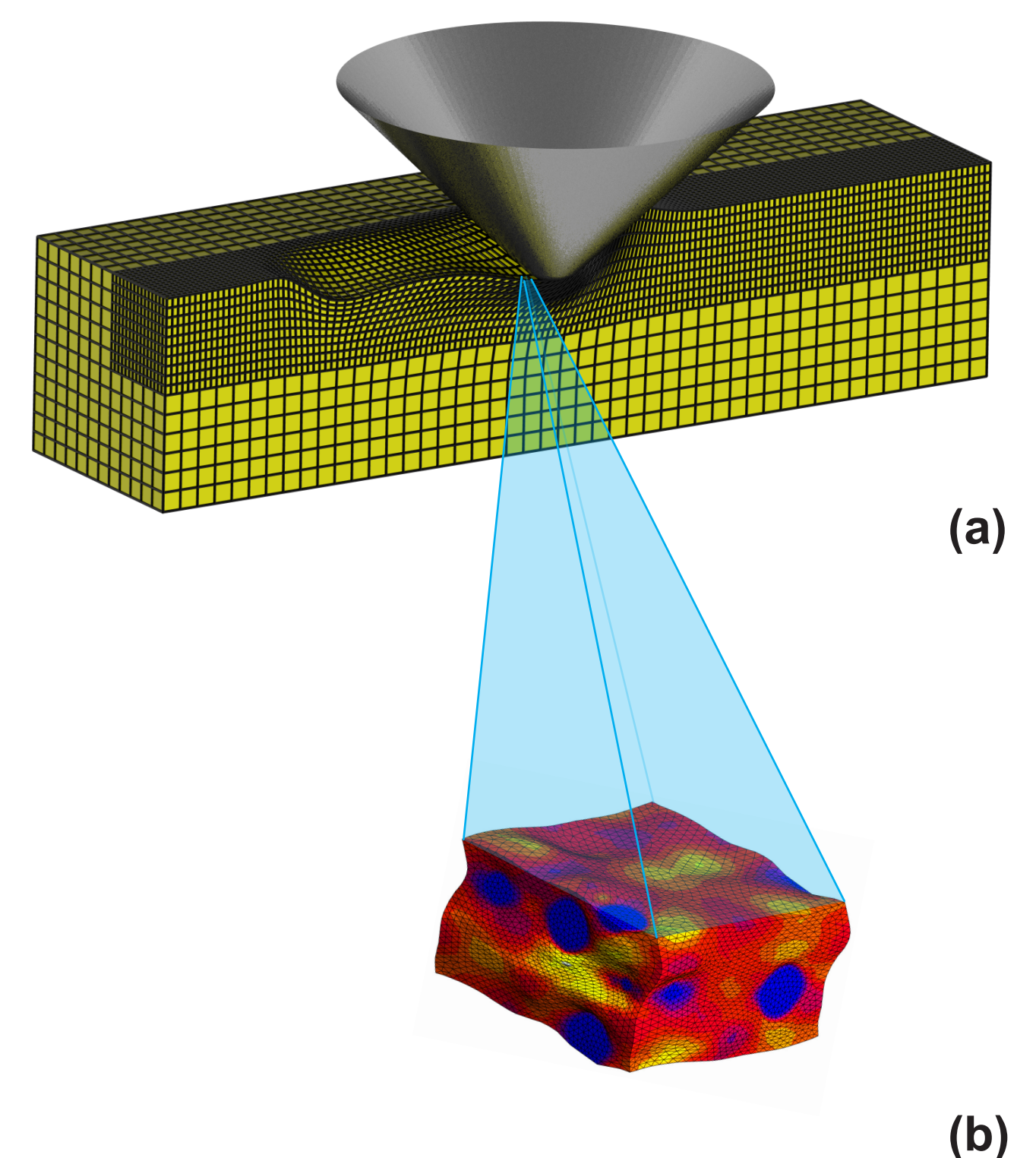


Fig. 4: Simulation of a scratch test using the macroscopic constitutive model (a) where the local deformation can be imposed on an RVE to reveal effects on smaller scale (b).

[1] Van Breemen et al., *Wear* 2012, 274-275, 238-247