Surface Topography Corrected Analysis of Scratch Tests on Thin Films

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Motivation

- goal: **knowledge-based surface optimization**

✔ saves a lot of time and money for application-oriented design/optimization of arbitrarily structured surfaces

✔ abolishes trial-and-error testing

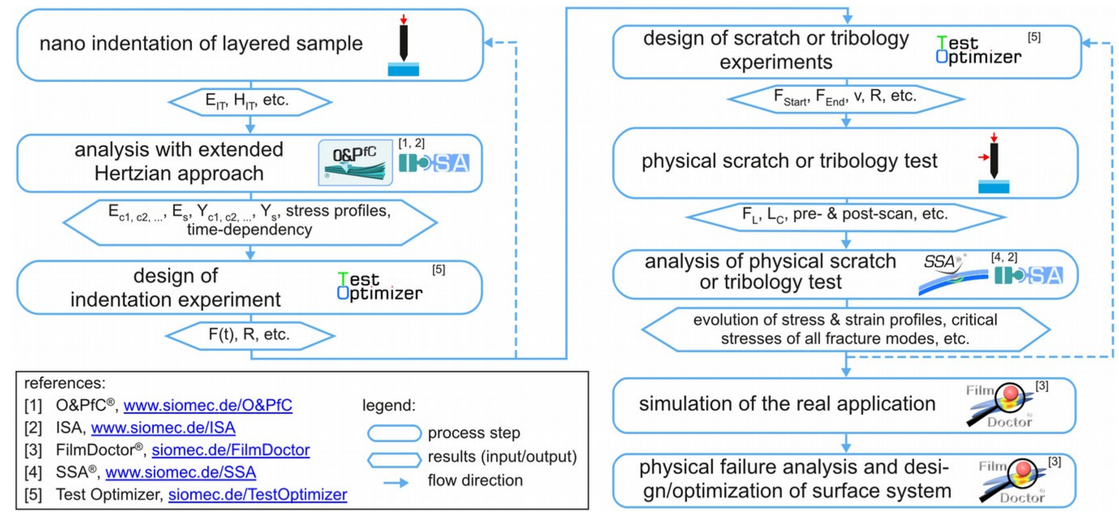
✔ sharply reduces necessary prototyping

✔ abolishes numerical modeling (FEM, BEM, MDS, etc.)

→ SIO OptiCycle [1, 5, 6]

- requires physical analysis to determine physical material parameters
- accurate analysis of experiments (also scratch tests) is necessary

→ **surface topography must be taken into account**



Design of Scratch Test

- different physical material parameters (tensile strength, shear strength, physical adhesion, tear strength) can be determined be by scratch testing
- require different failure mechanisms to be triggered
- scratch test needs to be designed properly

→ softwares Test Optimizer [2] or FilmDoctor [3]

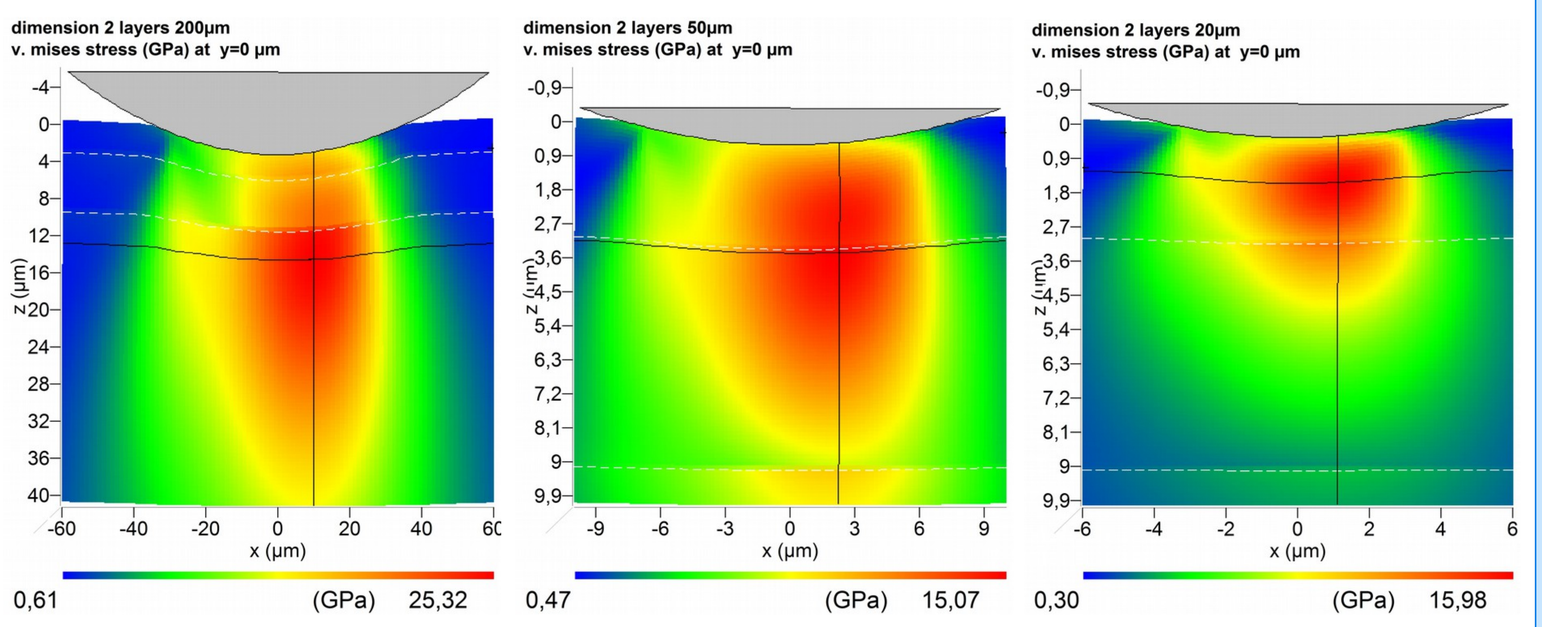
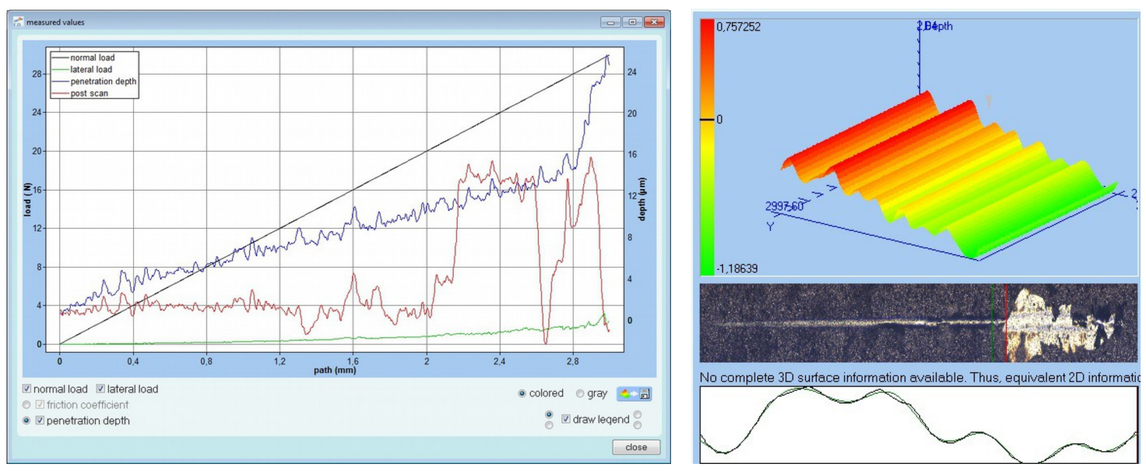
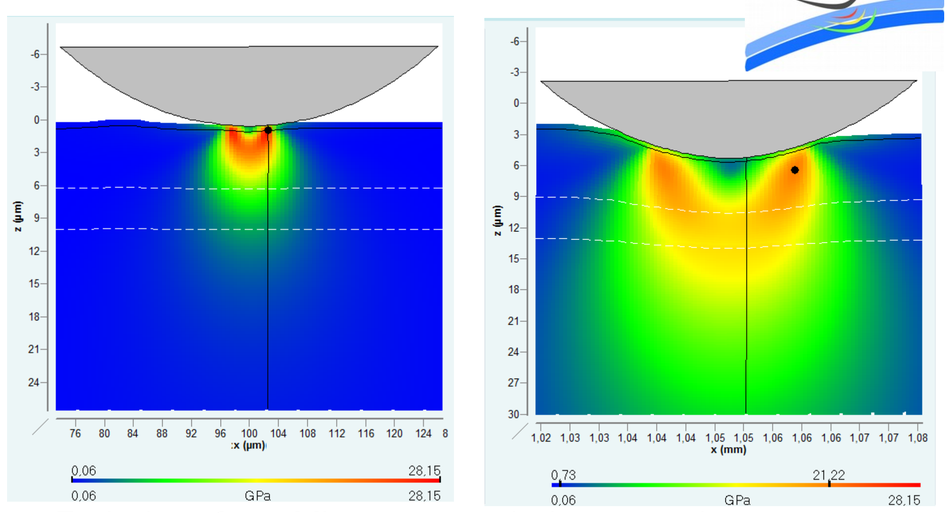


Fig. 1: This figure shows differently designed scratch tests in order to investigate different constituents of the surface: the substrate (a) with a normal load of 60 N and a sphere of 200 μm radius, the interface between first and second layer (b) with 2.5 N and 50 μm radius, and the top layer (c) with 0.5 N and 20 μm.

Physical Analysis of Scratch Test Using a 2D Pre-Scan



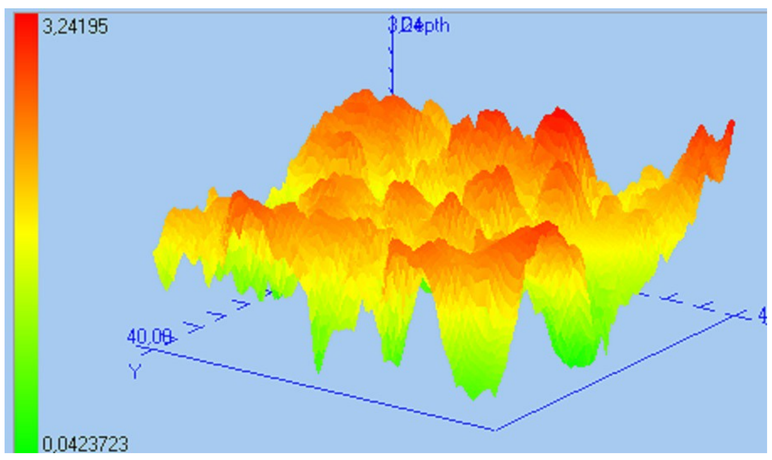
calculation of contact field evolving during scratch by SSA



In order to analyze a scratch test physically taking the surface topography into account, a tool is necessary which offers not only importing the 2D/3D topography, but also solving the contact problem completely and calculating all relevant components of the contact field.

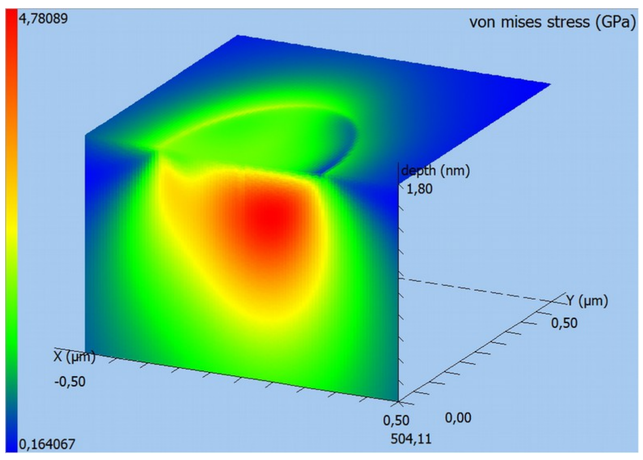
Evolution of von Mises stress during scratch test as one component of the contact field calculated by SSA [4].

Physical Analysis of Scratch Test Using a 3D Topography from AFM or WLI



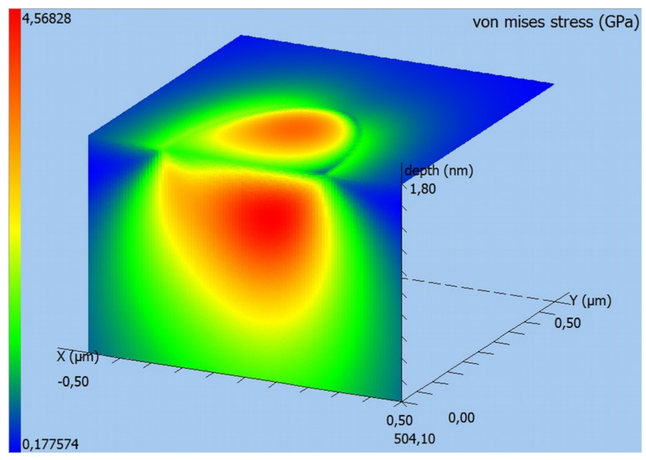
import a real topography (e.g. from AFM or WLI)

calculation of contact field evolving during scratch by SSA



only lateral and tilting load in x-direction taking 2D pre-scan

vs.



lateral and tilting load in x- and y-direction taking 3D topography

Conclusions

✔ proper physical analysis of scratch tests

✔ indentification of physical material properties

✔ appropriate design of scratch tests

✔ reproducing and understanding real-life failure mechanisms

✔ gives hints for improvement of coating structure

References

[1] SIO OptiCycle, www.siomec.de/OptiCycle.
[2] Software Test Optimizer, www.siomec.de/TestOptimizer.
[3] Software FilmDoctor, www.siomec.de/FilmDoctor.
[4] Software SSA, www.siomec.de/SSA.
[5] Schwarzer et al., Surface & Coatings Technology 206 (2011) 6.
[6] Schwarzer, Coatings 4 (2014) 2.

www.siomec.de