A physical scratch test analysis for coated materials

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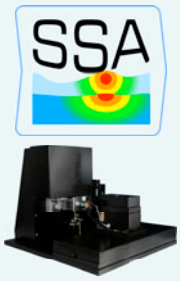
Introduction to the Scratch-Stress Analyser (SSA)

The SIO developed a special software solution (SSA), on the one hand, for the automatic physical analysis of your scratch tests and, on the other hand, to extract more mechanical parameters of the coating. Therefore, it is based on the extended Hertzian theory [1] and involves the Oliver&Pharr for coatings method [2] allowing a completely analytical mathematical approach. This software will be available in 4 different standard versions and customer optimized ultimate versions. For more information about the different features please visit www.siomec.de/SSA.

The following example, which shows you the physical analysis of a scratch test, is based on a nano-scratch measurement of Micro Materials Ltd using their sophisticated NanoTest™ [3]. The sample consists of a hard nanocomposite TiN/Si_3N_4 coating (h=780nm, E=490GPa, ν=0.2), which has been deposited on a Si-substrate by dual ion beam assisted deposition (IBAD).

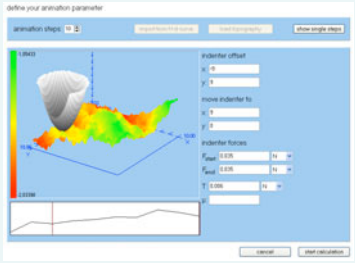


Step 1: Define your sample properties

Firstly, define the material properties of your sample. You can either input the poisson's ratio and young's modulus or choose the values from our database for layers and substrate. In the SSA ultimate version you can define up to 100 layers and gradient layers, optionally with (graded) intrinsic stresses.

Step 2: Obtain surface topography

Secondly, you can import the topography of your sample. It can be obtained from a linear tactile pre-scan using a no-load (profilometers) or, better, as an 3D topography from AFM or other methods.

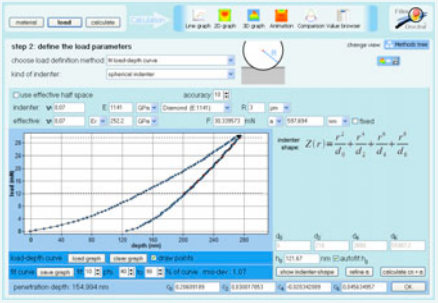


Step 3: Scratch measurement dimensioning

With the special SIO-scan procedures (see flyer) you have control over the contact area at every position of your probe. This also allows the application of the “concept of the effectively shaped indenter” (see figure) or even the continuous stiffness method with the full power of the extended Oliver&Pharr method for coatings (see poster PO2009 and booth #32). Hence, you can simultaneously determine so far unknown mechanical parameters of your sample (e.g. Young's modulus of a intermediate layer) with the measurement data of your scratch test.

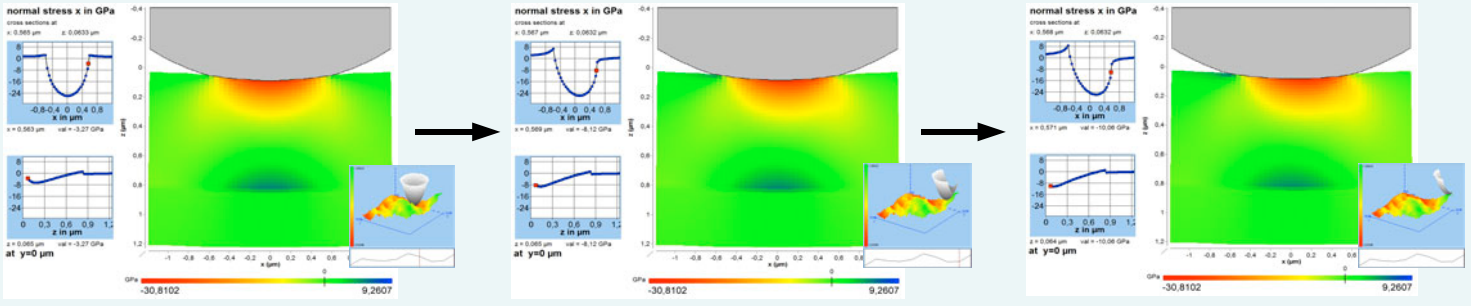
Alternatively: Scratch parameter definition

If you would like to simulate a virtual scratch measurement, you can specify the load settings (or fit the effective indenter to one of your scratch tips as shown in the figure) and scratch parameters directly. Thus, the number of time-consuming but necessary real scratch tests can be reduced dramatically.



Step 4: Animate the scratch test

After calculating the complete stress field you can see the results as an animated scratch test. There are up to 28 different field components available. You can see which parameters exceed their critical values as well as where and when these limits are reached.



Benefits:

- ✔ Gain more physical information out of your scratch tests
- ✔ Get more mechanical information about your sample structure
- ✔ Avoid expensive and time consuming trial-and-error tests
- ✔ Find and avoid failure sources
- ✔ Ward off unjustified customer complaints

References:

[1] N. Schwarzer: "The extended Hertzian theory and its uses in analysing indentation experiments", Phil. Mag. 86(33-35) 21 Nov - 11 Dec 2006 5153 – 5767, Special Issue: “Instrumented Indentation Testing in Materials Research and Development”

[2] N. Schwarzer: "An Extension of the Oliver and Pharr Method to Ultra-Thin Structures, Coatings, Functionally Graded Coatings and Multilayer Systems", online archives of the Saxonian Institute of Surface Mechanics www.siomec.de/pub/2007/010

[3] B. Beake, V. Vishnyakov, R. Valizadeh, J. Colligon: „Influence of mechanical properties on the nanoscratch behaviour of hard nanocomposite TiN/Si_3N_4 coatings on Si“, J. Phys. D: Appl. Phys. 39 (2006) 1392–1397

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More about the Poly-Scan Scratch methods.