SIO Scan Procedures

Poly-Scan Scratches

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Introduction:

Currently used scratch methods only allow testing of your material such, that it meets certain quality requirements, but you can't determine any physical material parameters or optimize them.

SIO developed more general scan procedures and a respective software (SSA) for its automatic analysis. The idea is, that several scans are performed with different loads instead of just one main scan optionally combined with zero-load pre- and post-scans. The load of each scan within such a general method can be given as: load(n, x)=f(x)•fac(n) with n as number of scan and f(x) as arbitrary function of lateral coordinate. An extension to 2-D-scans is possible.

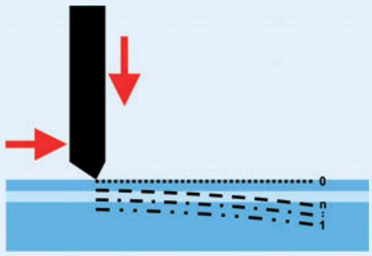
These scans result in a series of “loading unloading information” at each x-position for example allowing you to apply the classical O&P, the Continuous Stiffness Method or even the “O&P and CS for Coatings method” (O&PfC) at each x-position. It also allows direct application of the concept of the “effectively shaped indenter” with the possibility of having a “view inside the material” being investigated.

Poly-Scan Scratch$^{O\&P}$:

f(x)=x, fac(1)=0, fac(2)=const, fac(3)=const•0.95, fac(4)=const•0.9, fac(5)=const•0.85, fac(6)=const•0.8, ...

The factors 0.95, 0.9, etc. are just examples and can be adjusted with respect to the experimental needs

→ Scratch with subsequent O&P method analysis is possible



Poly-Scan Scratch$^{O\&P}$

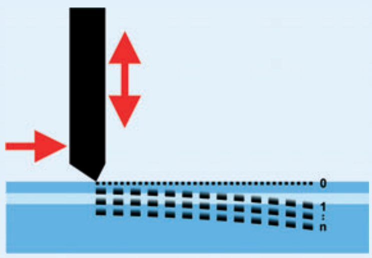
Poly-Scan Scratch^{CSM}:

f(x)=x, fac(1)=0, fac(i, j_i)=$const_i$, fac(i, j_i)=$const_i$•0.99, fac(i, j_i)=$const_i$•0.98, fac(i, j_i)=$const_i$•0.97, fac(i, j_i)=$const_i$•0.96, ...

with several i (i=0, 1, ..., n; key scans), j_i (j_i=0, 1, ..., m; sub scans) and $const_i$ (increasing from i=0 to i=n)

The factors 0.99, 0.98, etc. are just examples and can be adjusted with respect to the experimental needs

→ Scratch with Continuous Stiffness Method analysis combined



Poly-Scan Scratch^{CSM}

The big advantage of the CSM is that it is not neccessary to know the layer structure of your sample. These information can be found out during the analysis of the measurement curves.

schematic formulas for the extraction of material parameters on reverse side

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New physical scratch test for the extraction of material failure parameters

1. Finding the slope of the contact area

We find the slope around the contact point $\{x_i, y_j\}$ due to the known topography of sample Z2 and indenter Z1 and the following fitting procedure.

$Z1(x_i+x0+xstep, y_j+y0+ystep)-h-Z2(x_i+xstep, y_j+ystep) = Fit[(x-x_i)\cdot A+(y-y_j)\cdot B]$

Then we have the slope angles with Tan[alpha]=A and Tan[beta]=B

2. Surface-Fit around the contact area in order to find the local contact geometry

Introduction of new local coordinates: $X=[(x-x_i)\cdot A]$ und $Y=(y-y_j)\cdot B$ und $r=Sqrt[X^2+Y^2]$, with x_i, y_j defining the current contact point of the scratch or groove test.

Now the following fit is performed:

$Z1(x_i+x0+xstep, y_j+y0+ystep)-h-Z2(x_i+xstep, y_j+ystep) = Fit[X\cdot AA+Y\cdot BB+d0\cdot r^2+d2\cdot r^4+d4\cdot r^6+d6\cdot r^8]$

3. Evaluation of the contact forces

The forces in the contact area can be given as follows

$F=(Fz\cdot Cos[alpha]+Fx\cdot Sin[alpha])\cdot Cos[beta]$

$Tx=(Fz\cdot Sin[alpha]+Fx\cdot Cos[alpha])\cdot Cos[beta]$ $Ty=(Fz\cdot Sin[alpha]+Fx\cdot Cos[alpha])\cdot Sin[beta]$

And the tilting moments:

$Mtx=deltax\cdot 1/C+Tx\cdot theta$ (tilting in x-direction) $Mty=deltay\cdot 1/C+Ty\cdot theta$ (tilting in y-direction)

with: $deltax=ArcTan[AA]$, $deltay=ArcTan[BB]$, $C=3\cdot H\cdot s/(4\cdot a^2\cdot(1+theta^2))$,

$H=(1-ny^2)/(Pi\cdot E)$, $s=(1-2\cdot ny)/(2\cdot(1-ny))$, $theta=pi/2\cdot ln[3-4\cdot ny]$

4. Evaluation of the field beneath the indenter

Elastic case: The evaluation can be performed directly and easily with the software FilmDoctor® or the Scratch Stress Analyser (SSA). This gives important information about critical material parameters and the physical reason of material failure.

Inelastic case: In those cases where the scratch has produced inelastic material behavior, an intermediate step is required applying the effective intender concept. Then the effective field can be evaluated and gives important information about critical material parameters and the physical reason of material failure.

All evaluations are quick enough to animate whole scratch or groove tests.

An example is given at www.siomec.de/downloads/020 (This is only a draft with reduced resolution in order to minimize download time. There will be a much better version soon, also demonstrating the later standard for the FilmDoctor® and the SSA.)

Simplification for 1-D Multi-Path-Scan in x-direction

Only the differences to the method shown above are listed here.

1. $Z1(x_i+x0+xstep, y_i)-h-Z2(x_i+xstep, y_i) = Fit[(x-xi)\cdot A]$
   Then we have only the slope angle with Tan[alpha]=A
2. Introduction of new local coordinates: Y
   $Z1(xi+x0+xstep, y_j)-h-Z2(xi+xstep, y_j) = Fit[X\cdot AA+Y\cdot BB+d0\cdot r^2+d2\cdot r^4+d4\cdot r^6+d6\cdot r^8]$
3. Mty=deltay=0
4. See point 4 above.