# NANO-IMPACT TESTS ON MICRO-BLASTED COATINGS FOR ASSESSING THEIR BRITTLENESS

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## Introduction

Residual compressive stresses can be induced into a PVD film up to a certain depth from the coating surface via micro-blasting [1,2]. Depending on the micro-blasting conditions, the deformed film depth varies, thus affecting the coating's performance in different applications. A method has been already introduced for determining mechanical strength properties gradation in coatings after micro-blasting [1].

## Strength properties gradation and brittleness after micro-blasting

Considering these results, the grain penetration depth and moreover, the developed distribution of the improved film yield stress after micro-blasting versus the coating thickness are estimated. The induced coating residual stresses after micro-blasting may however simultaneously increase the film brittleness. For assessing the coatings’ brittleness, nano-impact test was employed [3,4]. In this test, an appropriate automation enables repetitive impacts at the same position on the sample surface at a set frequency. The evolution of the indentation depth, due to the progressing film damage during the repetitive impacts, is continuously monitored. Depending on the test conditions, in brittle material cases, the cracks’ formation and propagation may lead to a fast film failure.

## Nano-impact test FEM simulation and comparison between calculated and experimental results

In the described investigations, nano-impact tests were carried out on variously micro-blasted cemented carbide coated inserts by a sharp cube corner diamond indenter. In a recently developed FEM model

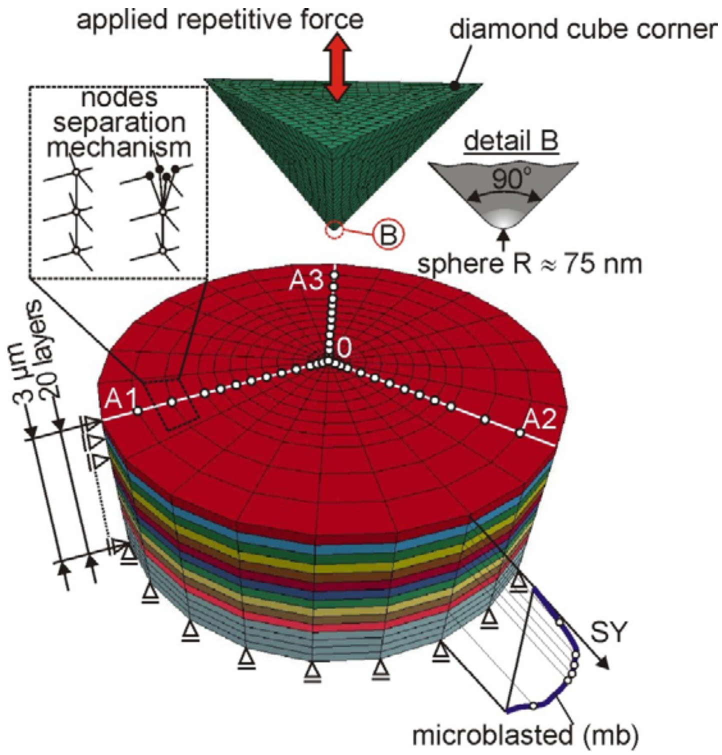


Figure 1: The developed FEM model for simulating nano-impact test on micro-blasted tools.

[4], the strength properties of the film material were uniformly distributed versus the coating thickness. Since by micro-blasting at various pressures, the attained maximum yield stress varies, depending on the depth from the coating, a new 3D-FEM model was created with a piecewise linear plasticity material law (see figure 1) [1]. Hereupon, the coating thickness was described by several material layers, with own elasto-plastic properties, developed after micro-blasting. The employed software was the LS-DYNA package. The simulation of the applied cube corner indenter geometry took place in accordance to the manufacturer specifications. The boundary conditions and the finite elements discretization network are exhibited in figure 1. The material properties and the coating thickness are variable and changeable parameters.

During the indenter penetration into the film, it is assumed that the coating at the FEM model node regions can withstand the applied load up to a maximum value, which corresponds to the coating layer rupture stress and the associated maximum plastic strain limit. Over these limits, the related nodes are disconnected from the neighboring finite elements. When all nodes of an element are disconnected, the element is released for simulating a crack formation and becomes an inactive separate entity. For minimizing the FEM calculations solving time, the nodes' ability to be disconnected is restricted to

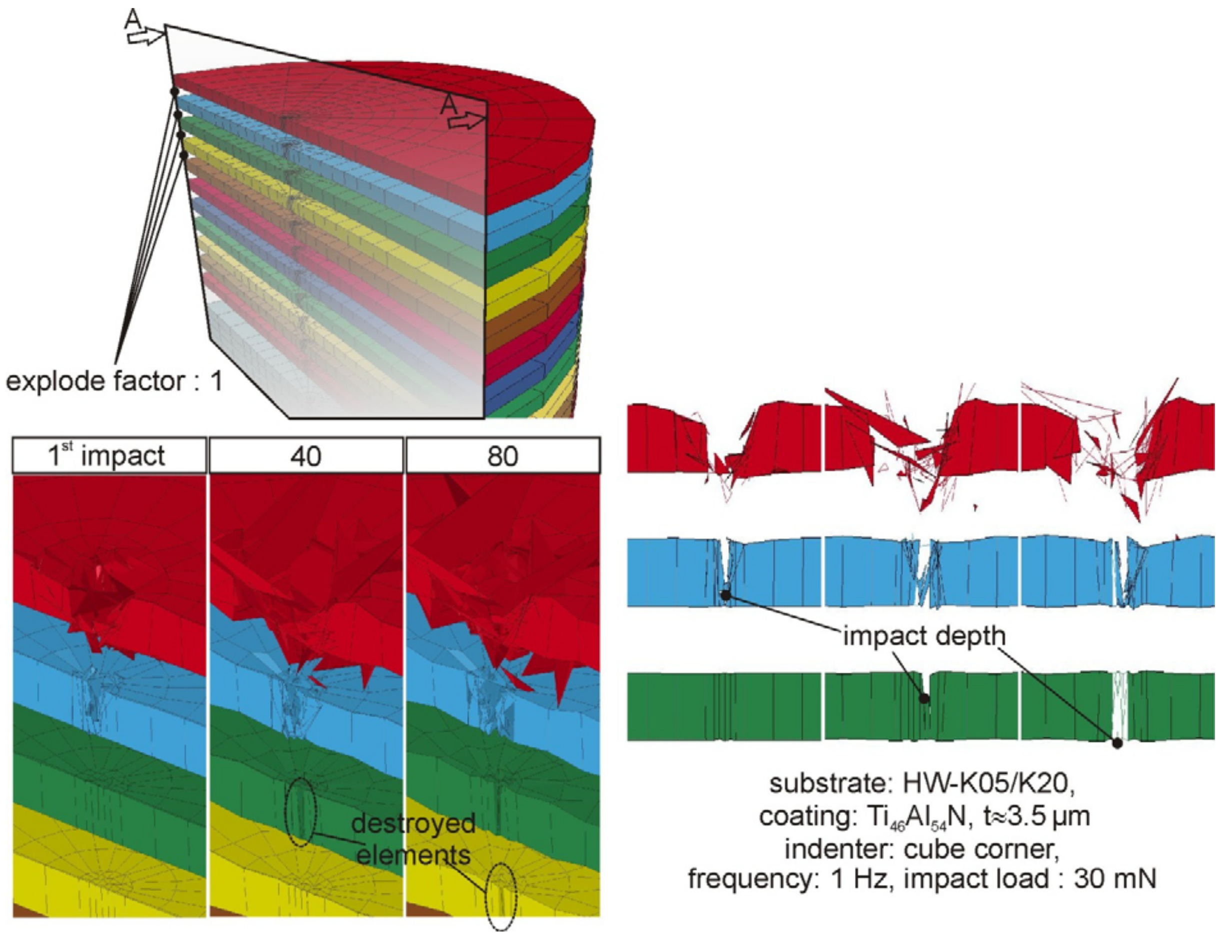


Figure 2: 3D-depiction of the crack propagation during nano-impact test on micro-blasted coatings.

those nodes, which are located on the perpendicular to the coating surface section levels OA1, OA2, OA3. The edges of the cube corner indenter lie on these levels during the indenter penetration into the film material. In this way, the stress fields developed in the coating and its fracture evolution in terms of imprint depth versus the repetitive impacts can be analytically described. A characteristic example, indicating the crack propagation and thus the impact depth versus the number of impacts is shown in figure 2. The crack propagation is implemented successively from one layer to another through the nodes' disconnections, when the developed stresses on these nodes exceed the layers' rupture stresses.

A comparison between measured and FEM calculated imprint depths on as deposited and micro-blasted coatings at impact load of 10 mN and 30 mN during the first 100 impacts is displayed in figure 3. The course of the FEM calculated imprint depths versus the number of impacts converges sufficiently with the measured results at all impact loads. In this way, micro-blasting conditions on films can be analytically optimized, for avoiding an undesired level of film brittleness.

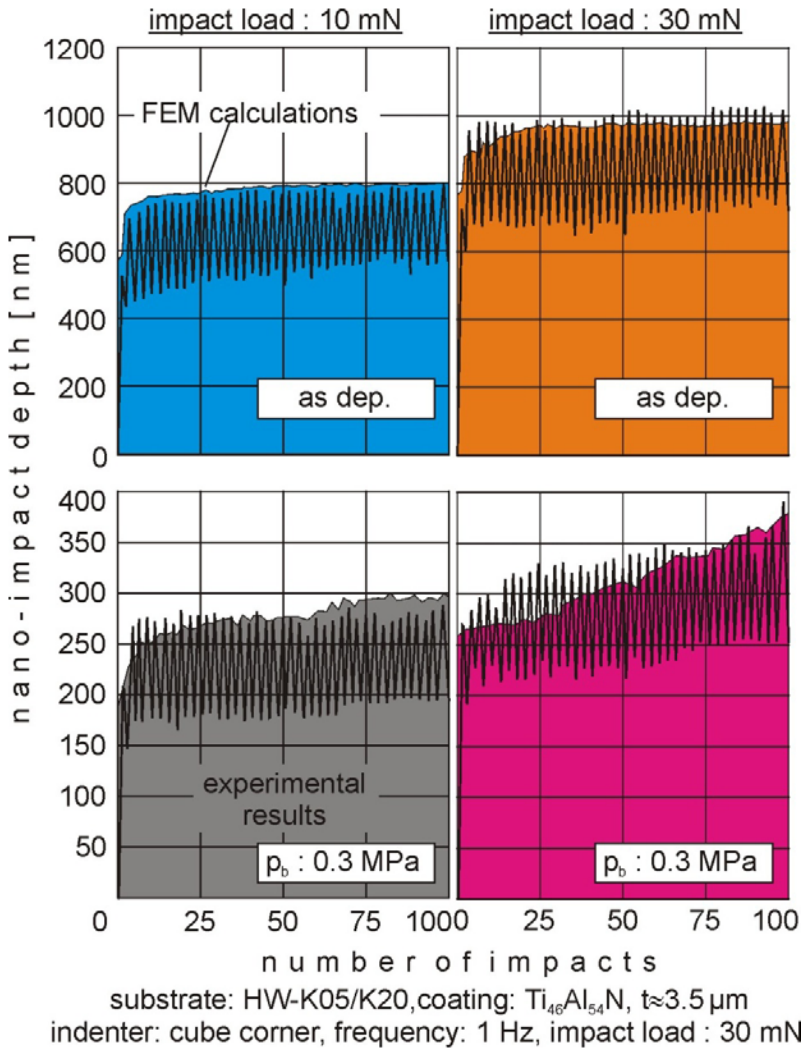


Figure 3: Comparison between experimental and FEM-calculated imprint depths versus the number of impacts

**References**

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