Exploring the plasticity of CVD Al_2O_3/TiCN multilayer coatings during nanoindentation

INDUSTRIAL PILOT PROJECT

THE INDUSTRIAL CHALLENGE

Growing demands for high production rates in the metal cutting industry requires the development of wear resistant cutting tool and coating materials. Possibilities to conduct a detailed in-situ characterization of the mechanical behaviour and structural evolution of thin coating layers during load would allow Seco to obtain deeper knowledge that can be used to design and optimize coating materials with enhanced properties to achieve a predictable performance in metal machining.

WHY USING A LARGE SCALE FACILITY

Characterization methods with a good spatial and temporal resolution are required to resolve local changes of the mechanical state of thin coating layers in situ.

HOW THE WORK WAS DONE

Thin lamella samples of CVD Al_2O_3/Ti(C,N) coated carbide tools with approximate thicknesses around 300 μm were cut from cutting tool inserts by a low speed diamond saw. The specimens were further thinned down to a "lamella" with a thickness of around 40 μm using FEI Versa 3D focused ion beam-scanning electron microscope (FIB SEM) at Chalmers University.

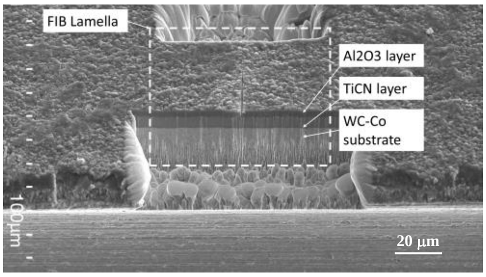

Figure 1. FIB-SEM cross section of the CVD Al_2O_3/Ti(C,N) coated tool.

The coating in the remaining 40 μm wide lamella was indented from the top using a 50 μm long diamond wedge (wider than the lamella width) nano indenter aligned with the X-ray beam of the NanoMAX beamline of MAX IV. Three lamellae with different crystal orientation of the Al_2O_3 layer were subjected to controlled loading conditions of wedge indentation (up to 0.3 N) while synchrotron X-ray nano diffraction data was collected at high spatial resolution (down to 100 nm scale) in an area of approximately 7x7 μm^2. Diffraction patterns were recorded in transmission using the Pilatus 1M detector at a photon energy of 14 keV. During acquisition of each map, the applied load was held constant (force control mode). Maps were acquired at different load levels as well as before and after indentation.

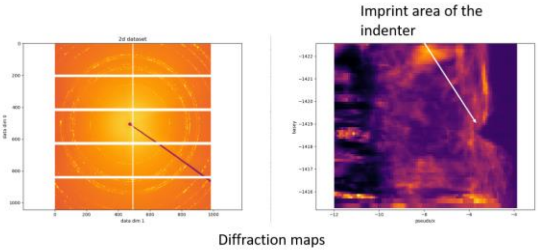

Figure 2. Typical diffraction patterns obtained in the indented CVD coating.

THE RESULTS AND EXPECTED IMPACT

The set-up allowed the evolution of elastic strains and related internal stresses in the individual coating layers to be determined with a reasonably good accuracy and a dependence of the elastic strain/stress on crystal orientation and applied load could be established. Complementary studies of the indented coating specimens were also initiated at Lund University to study the structural changes in the layers with high resolution transmission electron microscopy (TEM). This combined knowledge will be used for designing future experiments to further explore the coating material behaviour during indentation for other coating architecture, compositions, and surface treatment in the extent to optimize the coating materials for the cutting tool.

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