INDUSTRIAL DEVLOPMENT PROJECTS

Studying surface chemical mechanisms during chemical vapor deposition of hard nitride coatings using APXPS at MAX IV

THE INDUSTRIAL CHALLENGE

Hard coatings are used to prolong the lifetime and performance of cutting tools. The few micrometres thin coatings are often deposited by chemical vapor deposition (CVD) where the coating material is formed by chemical reactions in the gas phase and on the surface of the tool. A key to control the properties and quality of the coatings is to control these chemical reactions, which in turn requires understanding on which reactions are dominating. The chemical reactions taking place on the surface are especially hard to study.

WHY USING A LARGE-SCALE FACILITY

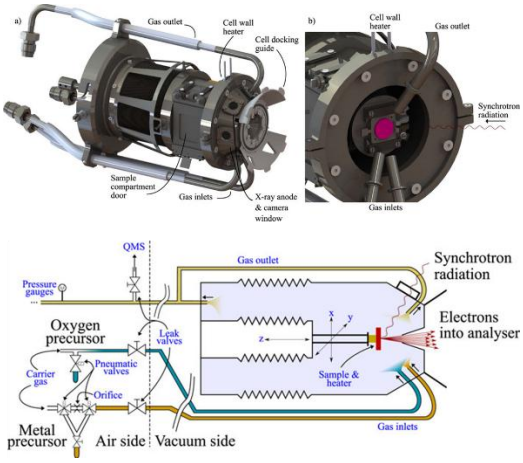
The working principle of x-ray photoelectron spectroscopy (XPS) is that an x-ray beam directed onto the surface knocks out electrons from the surface and their energy is analyzed. From this, one can calculate from which atom the electrons came from, and which chemical bonds that atom has formed. While there are plenty of lab scale XPS equipment available, they require that the measurements are done at extremely low pressures, at about a billionth of the atmospheric pressure. The more powerful x-rays at a synchrotron, like MAX IV, supplies more photons which allows for the experiments to be done at ambient pressure – about a thousandth of atmospheric pressure. With ambient pressure XPS (APXPS) we can let the molecules from the CVD process interact with the surface while measuring. The high intensity of the synchrotron beam allows for more measurements per unit time, hence time-resolved measurements with the possibility to see new chemical bonds form on the surface in real time.

HOW THE WORK WAS DONE

We used the APXPS capability at the SPECIES beam line at the MAX IV laboratory, also using their special cell that allows for surface chemical studies when molecules interact with surfaces. We introduced precursor molecules for Al, Ti, and N in sequential pulses while recording the XPS spectra for the elements in the coating material, ligands, and the substrate. Measurements were conducted on both silicon and cemented carbide from Seco's production. We had great help from the beamline scientist Esko Kokkonen and Professor Joachim Schnadt at MAX IV.

THE RESULTS AND EXPECTED IMPACT

From our measurements we can now better understand how the common coating material TiN is deposited by CVD. We have also data that is not yet fully analyzed on how the new generation coating $Al_{1-x}Ti_xN$ is deposited by CVD. With this information Seco is now set to tune their CVD processes to allow for new and improved products.



The heart of the experimental setup built by scientists at MAX-labb to study surface chemical reactions with APXPS.

"Now we can understand surface chemistry in CVD much better"
Tommy Larsson, Seco Tool

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Vinnova's project No: 2023-02815 **Duration:** November 2023 -- December 2025

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.