Table of contents

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Poster Exhibition 2026

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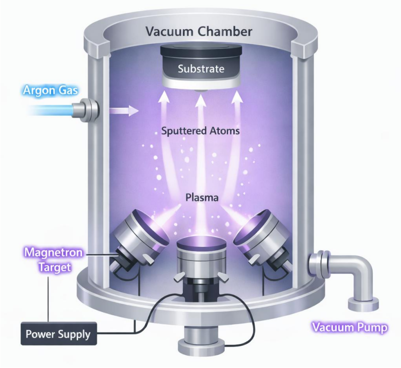
High-throughput deposition and characterisation of hard coatings

Christian Doppler Laboratory for Sustainable Hard Coatings

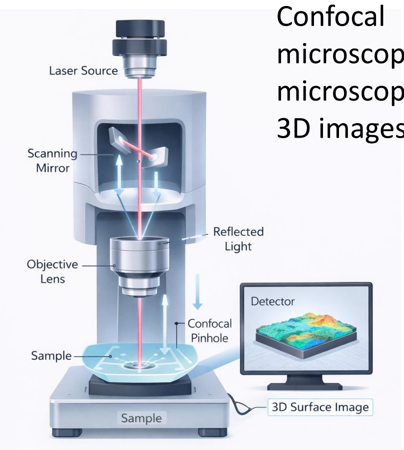
ECO
ARMOR

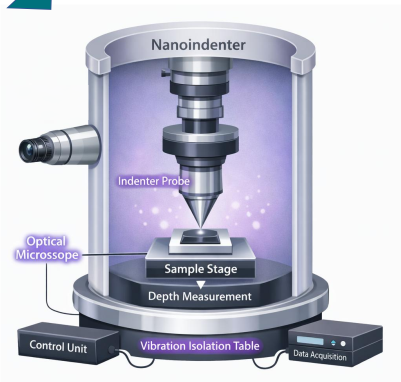
Hard coatings are extremely thin protective layers applied to cutting tools such as drills. They help industries produce components with higher precision and lower material waste.

Magnetron sputtering: Creates thin coatings by sublimating atoms from a material and depositing them onto a surface

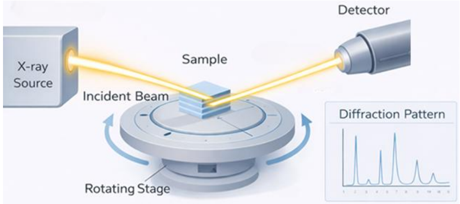


Confocal laser scanning microscopy: A laser-based microscope that produces 3D images of a surface



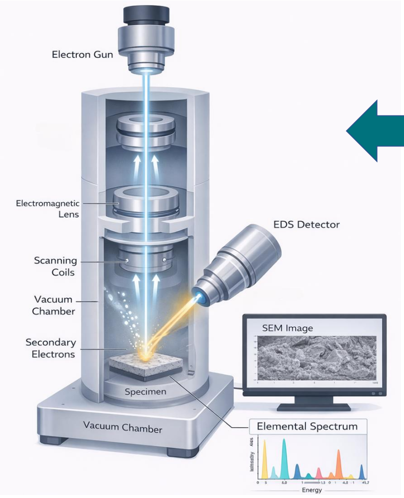


Nanoindentation: A tiny tip is pressed into a material to measure how hard and resistant it is to deformation



X-ray diffraction: X-rays are used to determine how atoms are arranged inside a material

Scanning electron microscopy: Surfaces are imaged at very high magnification while simultaneously the chemical composition of the material is determined



Our mission

We are working to make hard coatings more sustainable and resource-efficient. Our goal is to develop new coating concepts that:

- Reduce energy consumption
- Lower CO_2 emissions
- Use more sustainable materials
- Increase the lifetime of cutting tools

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materials

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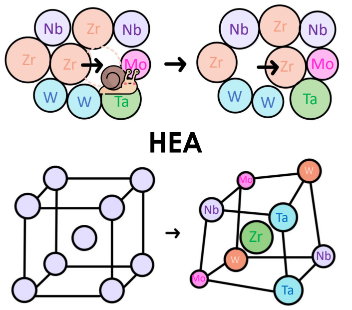
CERATIZIT GROUP

Protective High Entropy Alloy Coatings Against Hydrogen Damage in Steel

Magdalena Kirchmair*, Stefan Zeiler, Verena Maier-Kiener, Nina Schalk

Motivation

Hydrogen (H) is considered as a key energy carrier for a sustainable future because it enables clean and efficient energy storage and transport. However, H can also cause problems when it enters steel, making the material brittle and leading to cracks or loss of strength. To enable safe H-technologies, new material solutions are required. One promising approach is the use of hydrogen permeation barriers (HPBs), protective coatings that reduce H ingress into metals. In our research, we therefore investigate high entropy alloys (HEAs) which are promising materials for HPB coatings due to their complex multicomponent chemistry and tunable microstructure.



Deposition

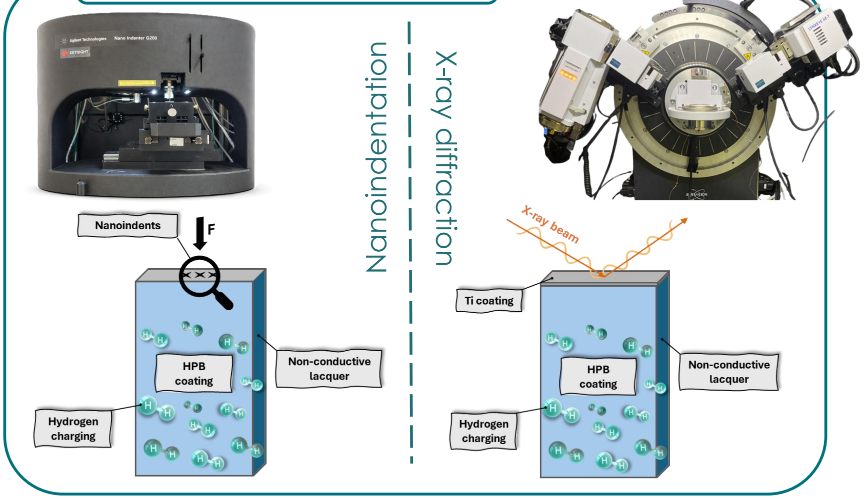
Metallic & nitride MoNbTaWZr coatings were synthesized on steel substrates by physical vapor deposition:

→ Direct Current Magnetron Sputtering (DCMS)

→ High Power Impulse Magnetron Sputtering (HiPIMS)

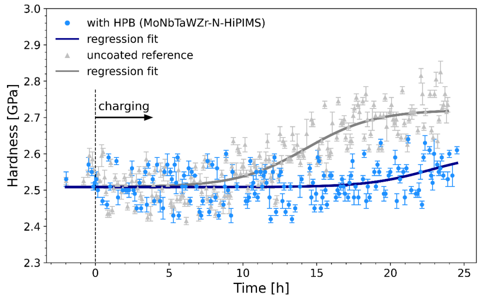

©H. Tauderer

In situ HPB testing



Results

In situ nanoindentation



Info

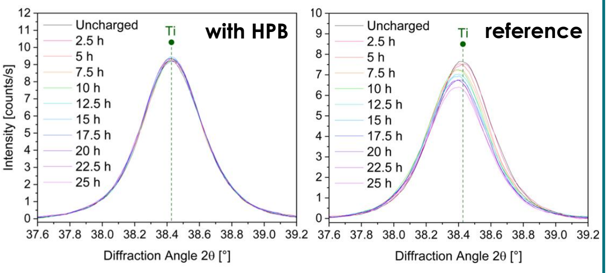
Hardness increase:

→ H-dislocation interactions reduce dislocation mobility

Ti-peak shift to lower 2θ:

→ H incorporation causes Ti-lattice expansion

In situ X-ray diffraction



The dense nitride HEA coating deposited by HiPIMS exhibits excellent resistance to H-induced degradation. *In situ* nanoindentation and *in situ* XRD measurements demonstrate a strong suppression of H ingress, highlighting the potential of nitride HEA coatings as effective HPBs.

Dipl.-Ing^{in}.
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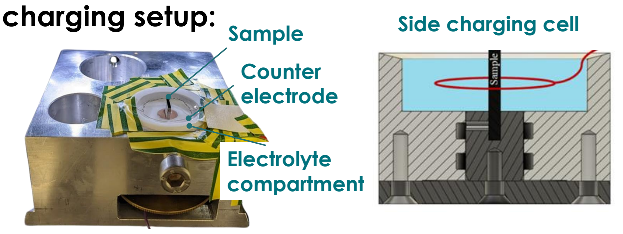
Electrochemical hydrogen charging setup:



Side charging: S. Zeiler et al., Acta Mater. 276 (2024) 120113.

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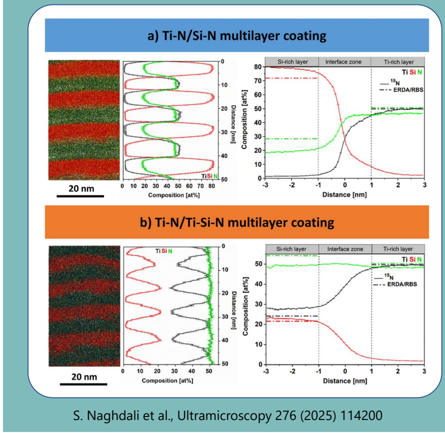
Atom Probe Tomography

What if you could see and identify every atom in a material? Atom Probe Tomography makes this possible by field-evaporating ions from a sharp tip, enabling three-dimensional imaging with near-atomic resolution and quantitative chemical analysis. *Scan the QR code to explore the atomic world!*

Isotopic substitution for SiN-based coatings

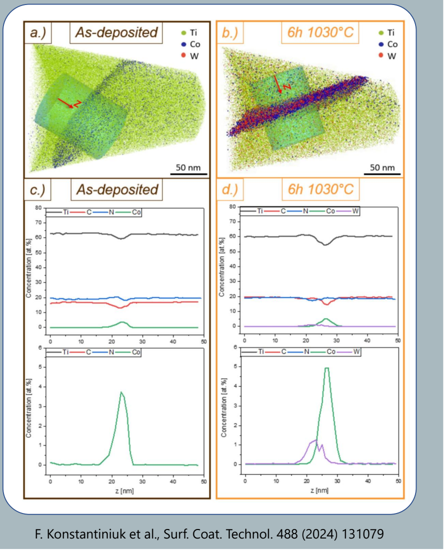
Overlapping nitrogen and silicon signals in atom probe tomography make the analysis of Si-containing nitrides challenging. Using isotopically substituted nitrogen (^{15}N) resolves this overlap and enables reliable compositional analysis of magnetron-sputtered thin films.



S. Naghdali et al., Ultramicroscopy 276 (2025) 114200

Co und W diffusion in hard coatings

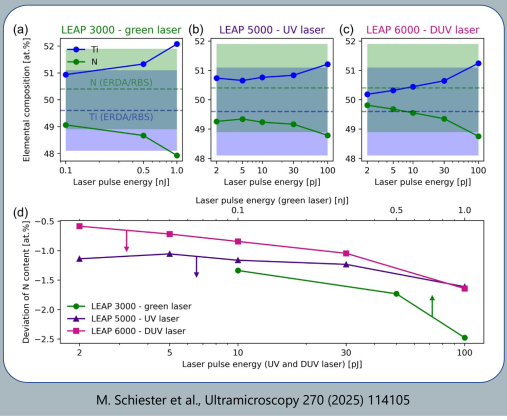
In Al_2O_3–TiC hard coatings, cobalt and tungsten diffuse along grain boundaries, affecting the mechanical properties of the coating. Atom probe analysis allows these diffusion pathways to be quantified, providing insight into how local compositional changes influence hardness and wear resistance.



F. Konstantiniuk et al., Surf. Coat. Technol. 488 (2024) 131079

Laser-dependent evaporation behavior

The evaporation behavior of TiN coatings was studied across three generations of atom probes with different laser wavelengths. Shorter wavelengths enable higher laser densities, resulting in increased elemental accuracy.

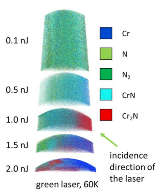


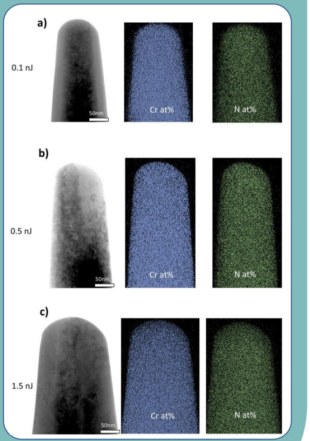
M. Schiester et al., Ultramicroscopy 270 (2025) 114105

Laser-induced decomposition of CrN

Laser-assisted atom probe tomography can alter the measured composition of metastable materials.

In CrN coatings, increasing laser pulse energy causes nitrogen loss and decomposition into Cr_2N and Cr. Thus, careful selection of laser parameters is crucial to obtain accurate, reliable compositional data.





H. Waldl et al., Ultramicroscopy 246 (2023) 113673

Atom Probe Tomography for Functional Materials

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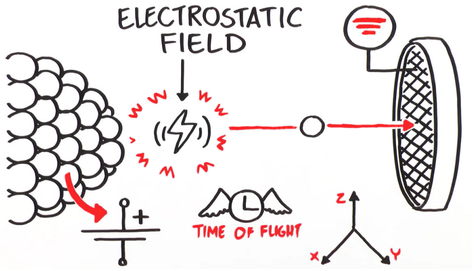

SCAN ME

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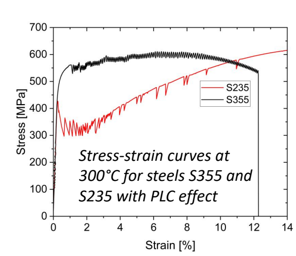
Advanced Mechanical Testing

Universal Testing Across Scales and Conditions

Quasistatic Testing

- Quasi-static mechanical testing with load capacities from 5 to 250 kN
- High-temperature testing up to 1000 °C
- Analysis of Portevin-Le-Chatelier effects



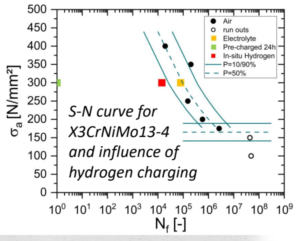
Stress-strain curves at 300°C for steels S355 and S235 with PLC effect

Fatigue Testing

- Fatigue testing under tension-compression loading up to 100 kN

  Rotational bending fatigue testing for cyclic loading conditions

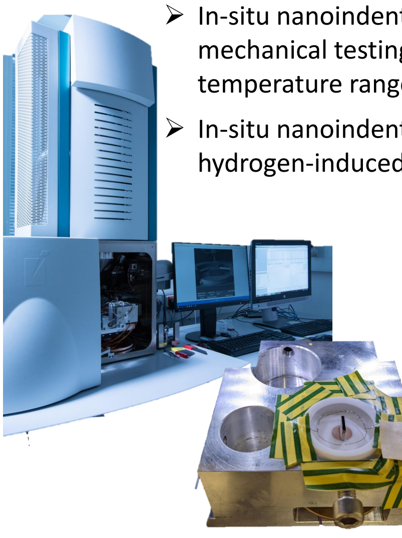
  Determination of S-N curves for fatigue life assessment

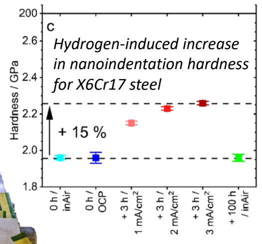


S-N curve for X3CrNiMo13-4 and influence of hydrogen charging

Scale-bridging Methods

- In-situ nanoindentation and micro-mechanical testing across a wide temperature range (−150 °C to 1000 °C)
- In-situ nanoindentation to capture hydrogen-induced material changes

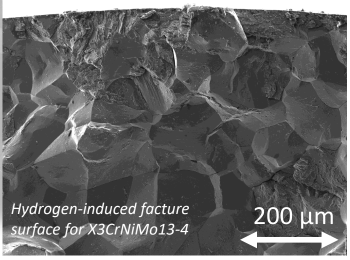




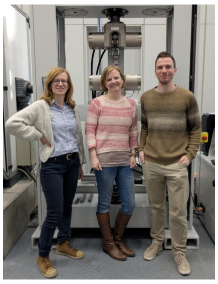
Hydrogen-induced increase in nanoindentation hardness for X6Cr17 steel

Operando Testing

- Electrochemical cell for in-situ hydrogen charging
- Salt spray testing for corrosion-assisted degradation
- Scanning electron microscopy for fracture surface analysis



Hydrogen-induced facture surface for X3CrNiMo13-4



Materials Testing under Extreme Conditions
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Research Focus

- Materials testing under extreme conditions
- High-temperature and environmental effects
- In-situ and operando characterization