SANDVIK

Ongoing and future materials research for sustainability within Sandvik

Susanne Norgren,
Head of Sandvik Scientific Council

WISE

28 January 2025

Our number 1 priority

Safety first

- Emergency exit
- Assembly point
- Protective equipment
- Emergency number
- First aid kit
- In case of emergency
- Psychological safety
- Health and well-being
- Cyber security

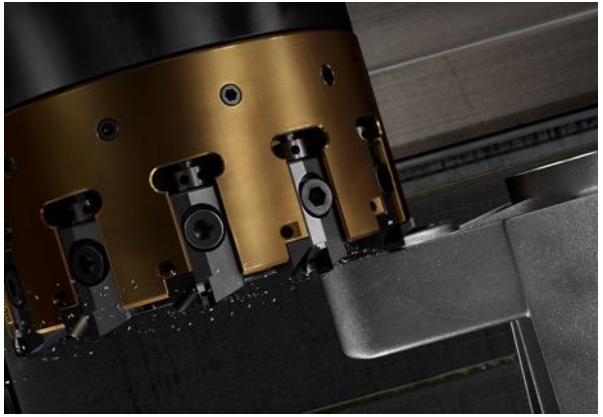
Business areas – our portfolio with technology leadership

Sandvik Mining and Rock Solutions

Share of revenue 2023	52%
Share of adjusted EBITA	53%

Sandvik Rock Processing Solutions

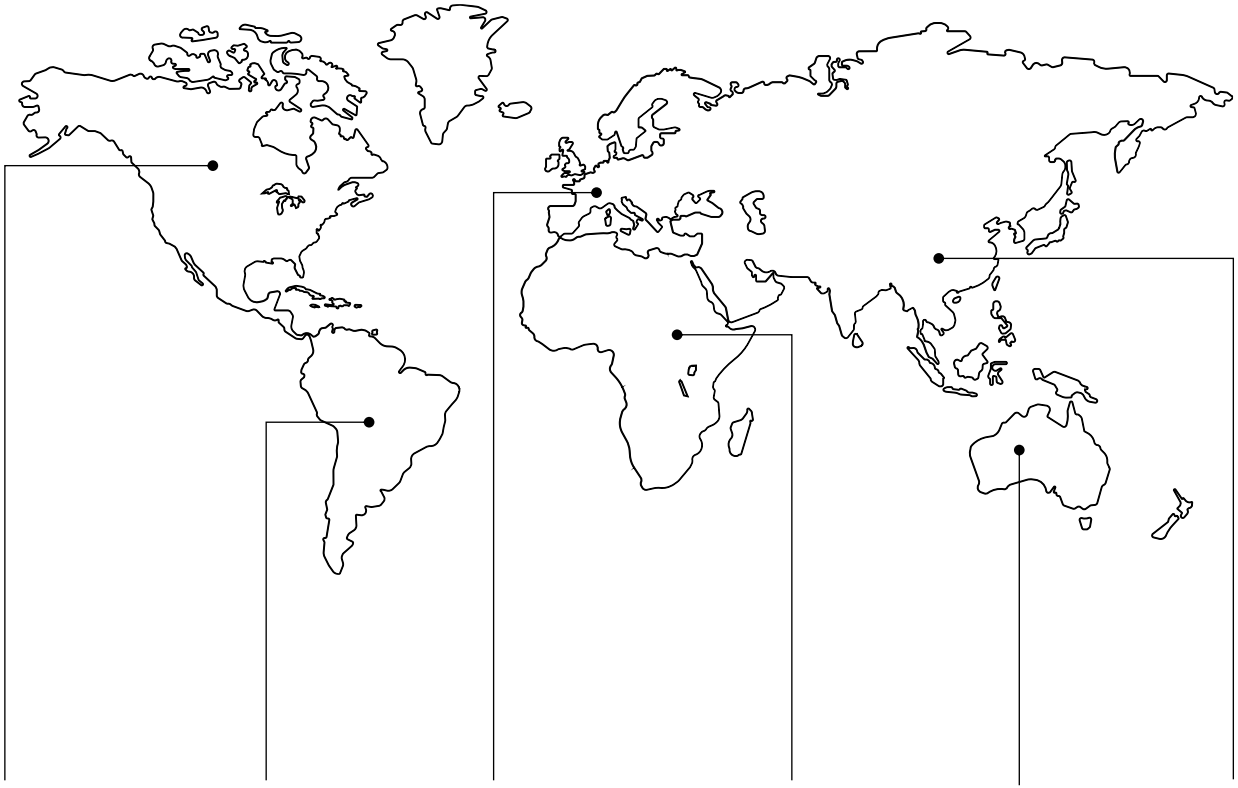
Share of revenue 2023	9%
Share of adjusted EBITA	6%



Sandvik Manufacturing and Machining Solutions

Share of revenue 2023	39%
Share of adjusted EBITA	41%

Revenues by market area



North America
25%

South America
7%

Europe
26%

Africa/Middle East
12%

Australia
13%

Asia
17%

Sales countries around the globe

170

Active patents

6,921

BSEK in revenues

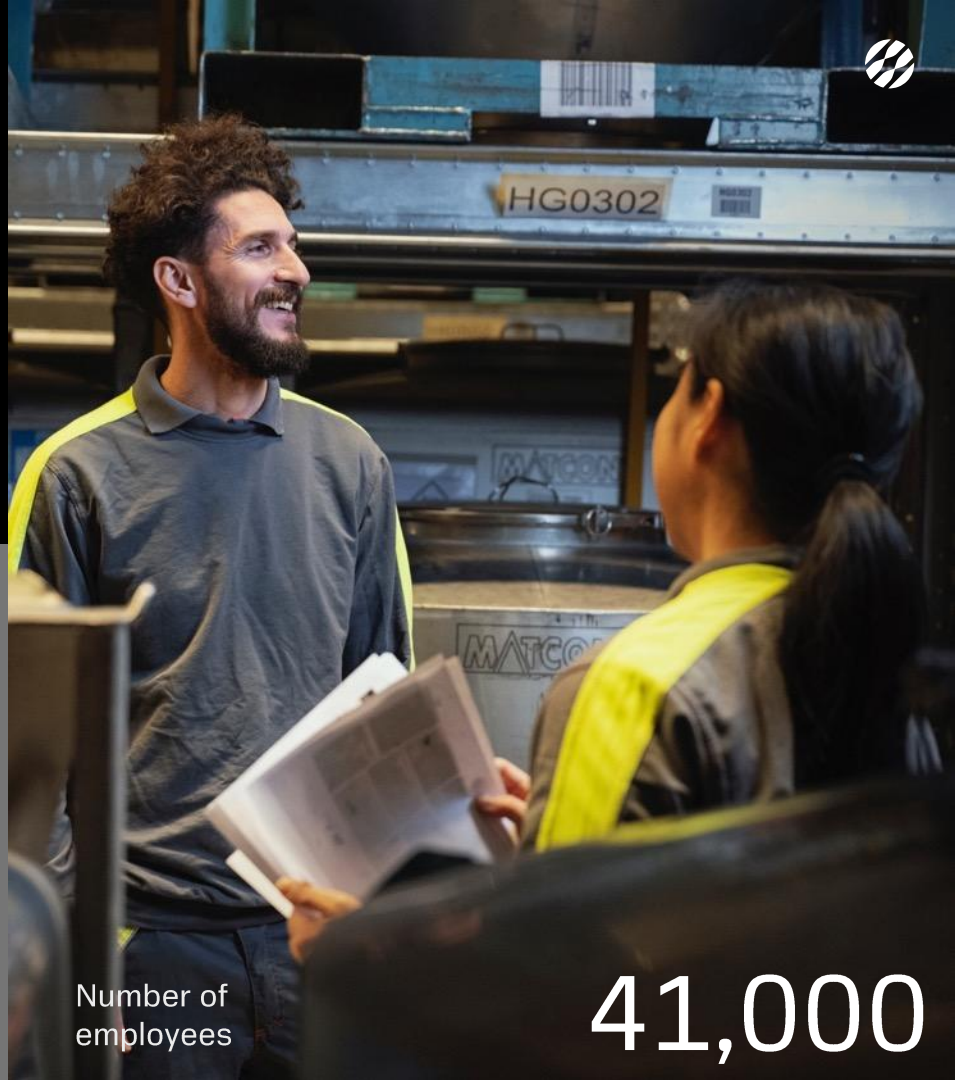
127

R&D centers globally

68

Annual R&D investments, BSEK

4.8



Number of employees

41,000

Machining and Rock Drilling

– Indstrial product to front end Research

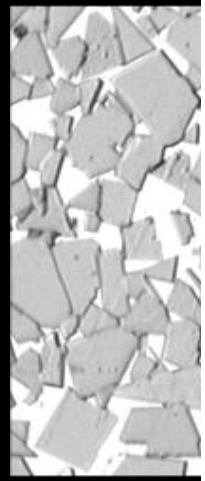
Cemented Carbides (Hardmetals)

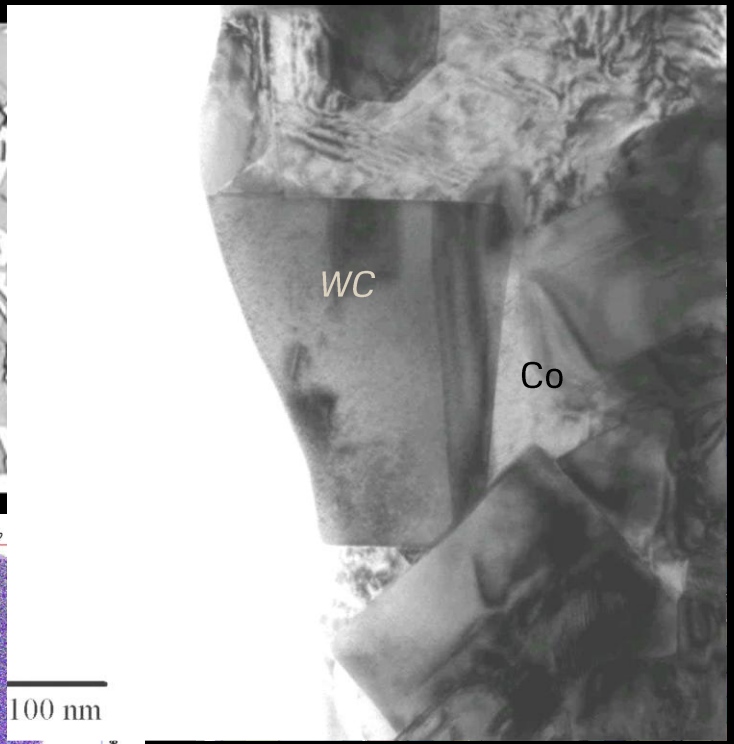
Composite material

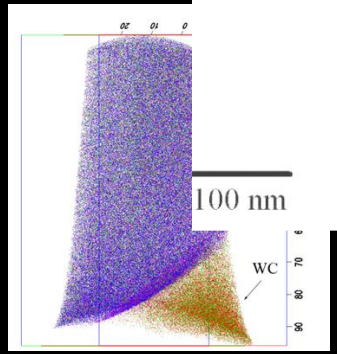
Tungstencarbide (WC) and Cobalt

– Hard - can machine metal
– Wear - resistant can break rock
– Can operate at high temperatures
– High Compressive strength
– “Coatable”

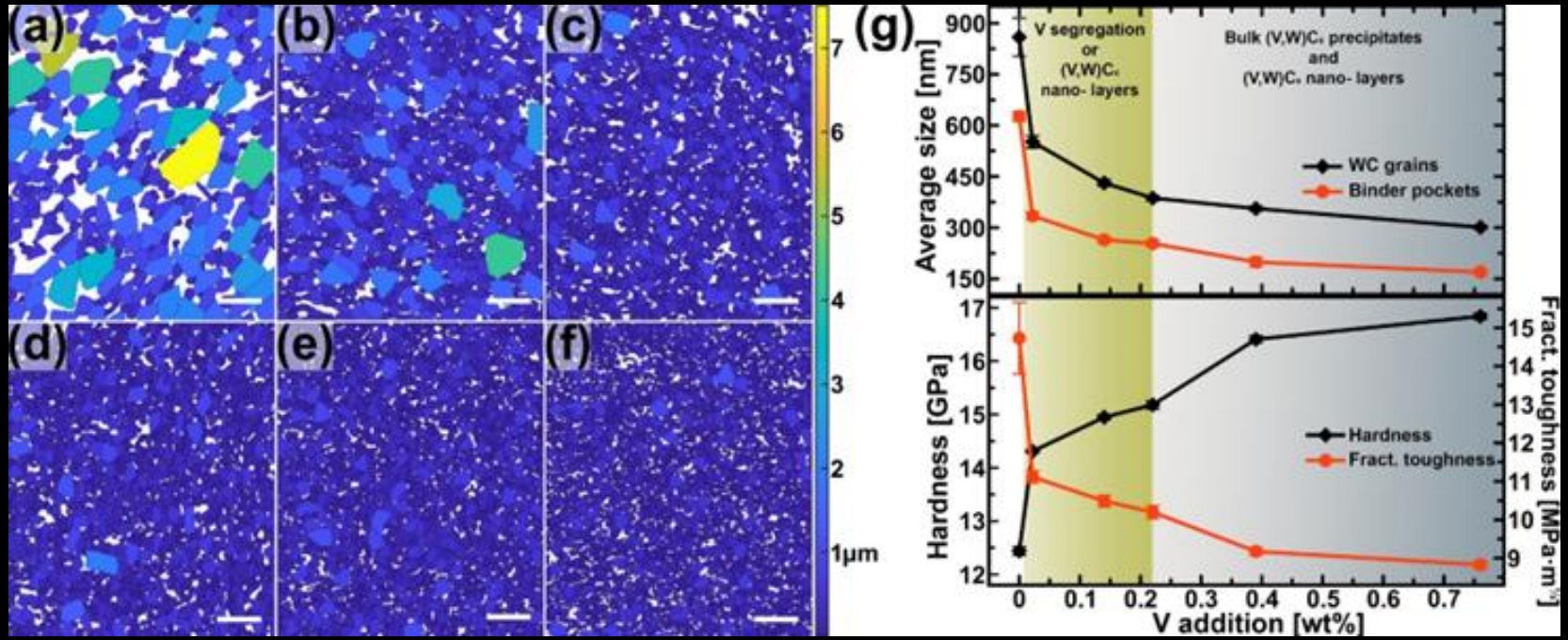
Most important WC grain size and the interfaces!







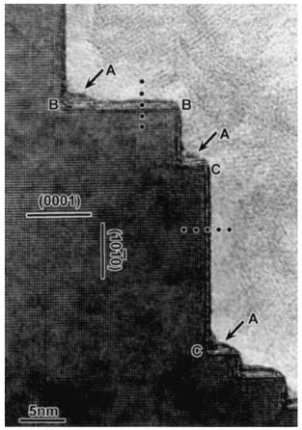
Reducing WC grainsize by V addition



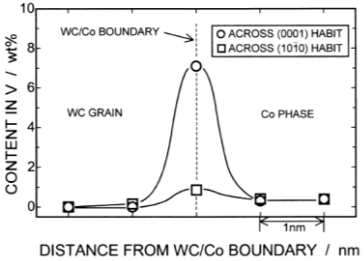
Yildiz et al, Quantification of nano-scale interface structures to guide mechanistic modelling of WC grain coarsening inhibition in V-doped hard metals, Materials & Design 207 (2021)
Investigations of the precipitation microstructure in alloys, hard metal composites and powders using SANS V. Ryukhtin et al, Acta Cryst. (2021).

Effect of V addition to Co-WC -Mechanism of the grain growth control ?

Segregation of V to steps at WC/Co interfaces

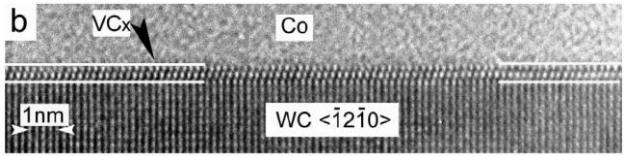


V profile



T. Yamamoto *et al.*, Sci. Technol. Adv. Mater. **1**, 97 (2000).

Thin cubic carbide layer at the WC/Co interface

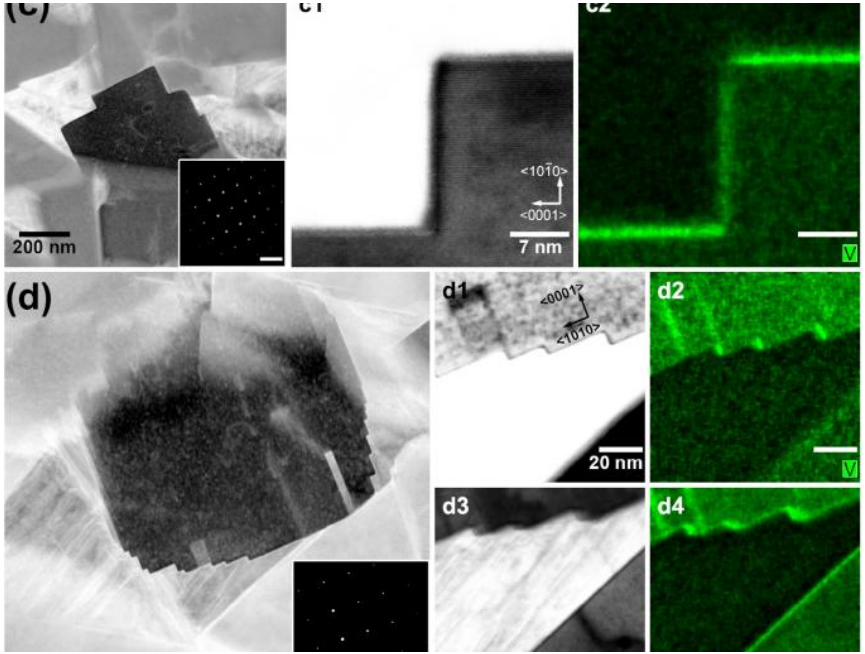


S. Lay *et al.*, Adv. Eng. Mater. **6**, 811 (2004).

Can these thin films exist at high temperature liquid phase sintering conditions where a large part of the grain growth occurs?

At these temperatures and relevant doping conditions (below solubility limit) VC_x is thermodynamically unstable.

Complexions/
Thin film formation – or segregation ?



Following the work by A computational study of thin cubic carbide films in WC/Co interfaces, S.Johansson and G. Wahnström Acta Materialia 59, 1, 2011,

a Chalmers, KTH, SANDVIK collaboration Including 4 Ph.D students funded by VR

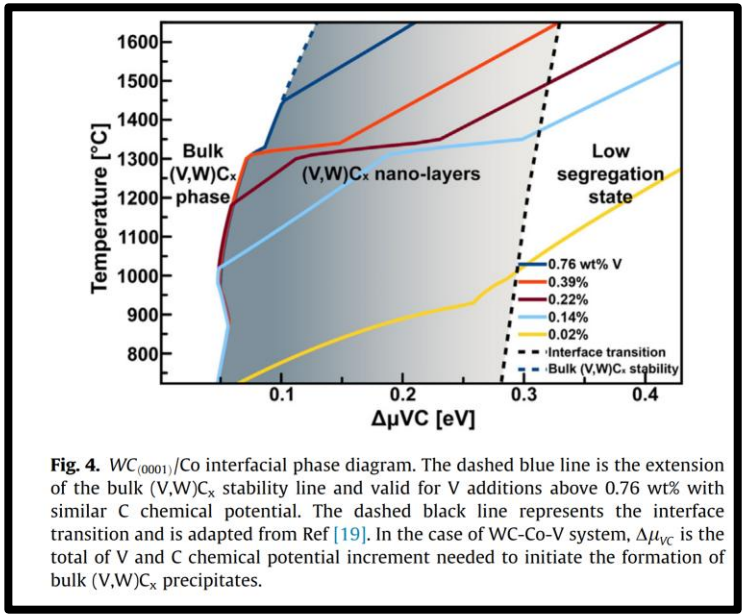


Fig. 4. $WC_{(0001)}$/Co interfacial phase diagram. The dashed blue line is the extension of the bulk $(V,W)C_x$ stability line and valid for V additions above 0.76 wt% with similar C chemical potential. The dashed black line represents the interface transition and is adapted from Ref [19]. In the case of WC-Co-V system, $\Delta\mu_{VC}$ is the total of V and C chemical potential increment needed to initiate the formation of bulk $(V,W)C_x$ precipitates.

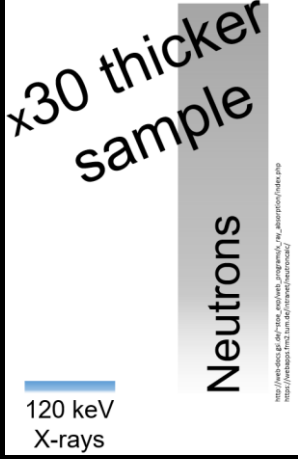
Interfacial phase diagram – Ab initio & thermodynamics

Quantification of nano-scale interface structures to guide mechanistic modelling of WC grain coarsening inhibition in V-doped hard metals, Yildiz, Babu, Bonvalet-Rolland. Busch, Ryukhtin, Weidow, Norgren, Hedström, Materials & Design 207 (2021) 109825

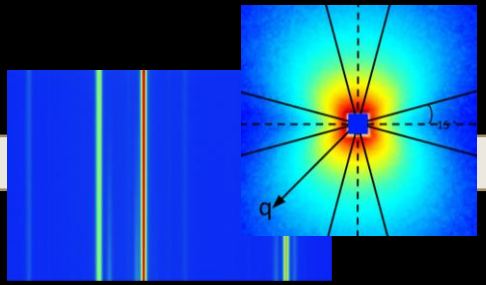
We need neutrons !

Bulk-scale characterization and *In-situ* investigations at high temperatures

- Non-destructive
- Real-time processing insights
- Transmission bulk probe enabing in-situ real-time studies
- Magnetic scattering of Co

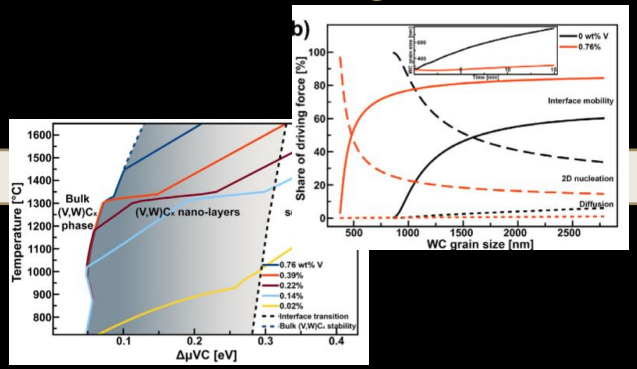


Simulated industrial processing

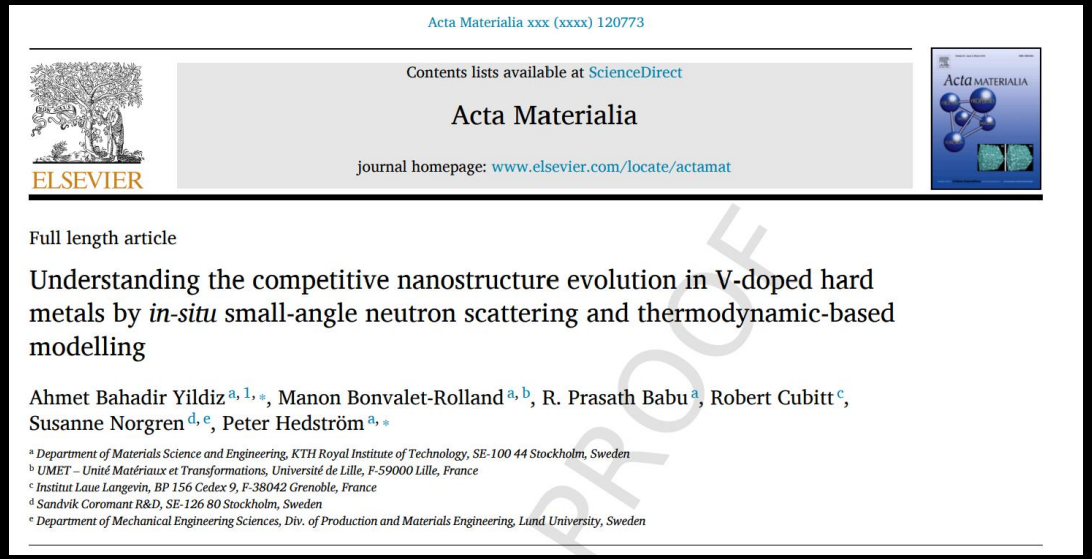


Real-time diffraction/scattering

Modelling



Now we know – layers/Complexions….



Acta Materialia xxx (xxxx) 120773

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journal homepage: www.elsevier.com/locate/actamat

Full length article

Understanding the competitive nanostructure evolution in V-doped hard metals by *in-situ* small-angle neutron scattering and thermodynamic-based modelling

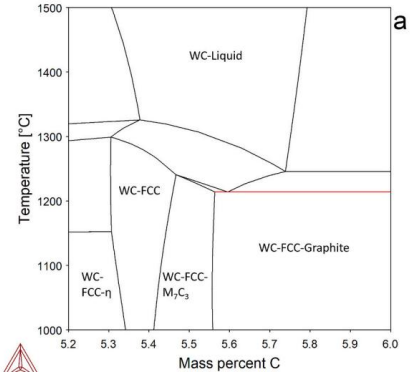
Ahmet Bahadir Yildiz [a, 1, *], Manon Bonvalet-Rolland [a, b], R. Prasath Babu [a], Robert Cubitt [c], Susanne Norgren [d, e], Peter Hedström [a, *]

[a] Department of Materials Science and Engineering, KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden
[b] UMET – Unité Matériaux et Transformations, Université de Lille, F-59000 Lille, France
[c] Institut Laue Langevin, BP 156 Cedex 9, F-38042 Grenoble, France
[d] Sandvik Coromant R&D, SE-126 80 Stockholm, Sweden
[e] Department of Mechanical Engineering Sciences, Div. of Production and Materials Engineering, Lund University, Sweden

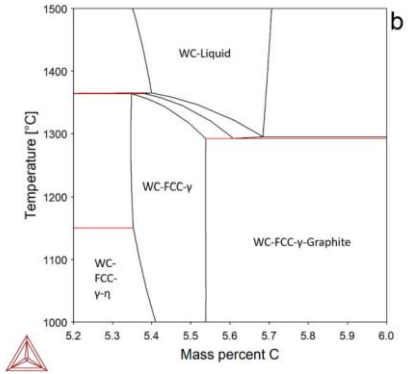
In the present work , we have provided the first in -situ experiment al evidence on the presence of (V,W)C_x complexions at liquid sintering temperatures in hard metals.

Is it important ????

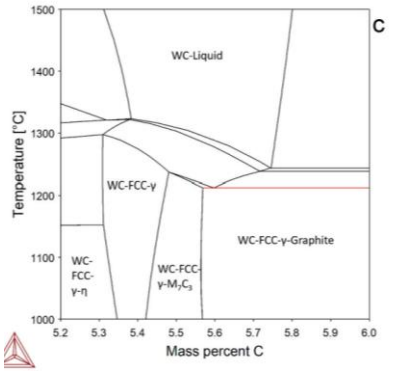
Modelling compositional space



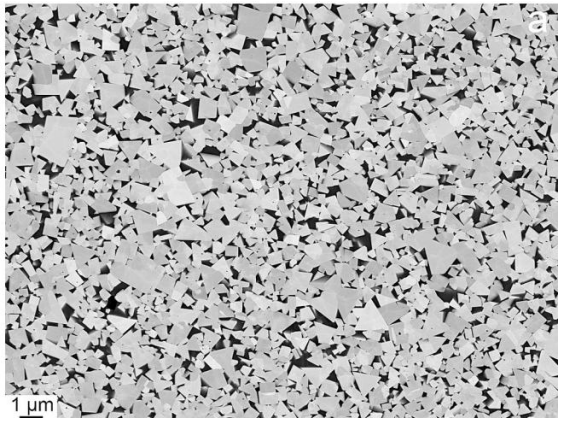
Industrial Ph.D
Equilibrium aspects of Cr-alloyed cemented carbides.
B. Kaplan



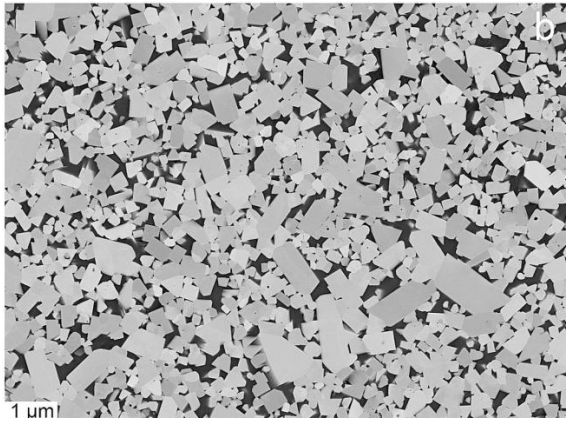
Industrial Ph.D
Transition Metals and their Carbides, Nitrides and Carbonitrides
F. Haglöf



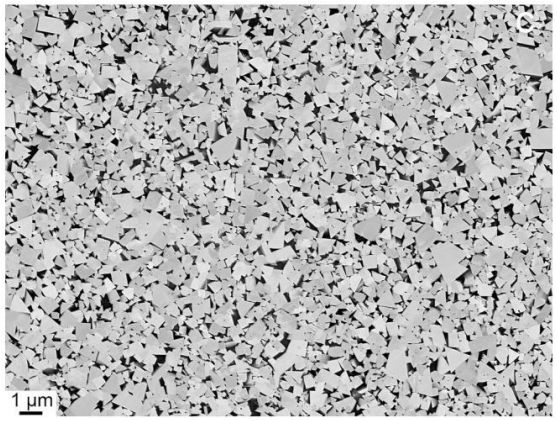
WC+Co+Cr



WC+Co+Ti



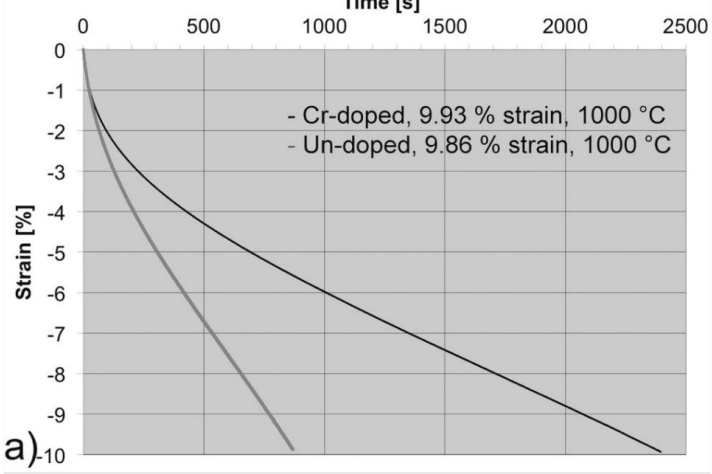
WC+Co+Cr+Ti

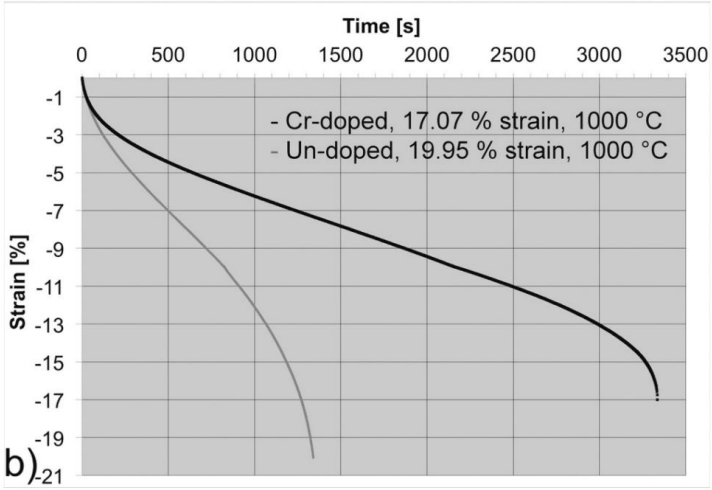


Weidow et al, International Journal of Refractory Metals and Hard Materials 128 (2025) 107005

High Temperature Creep

- a) 9.9%
- b) 17.1% and 19.9% strain.

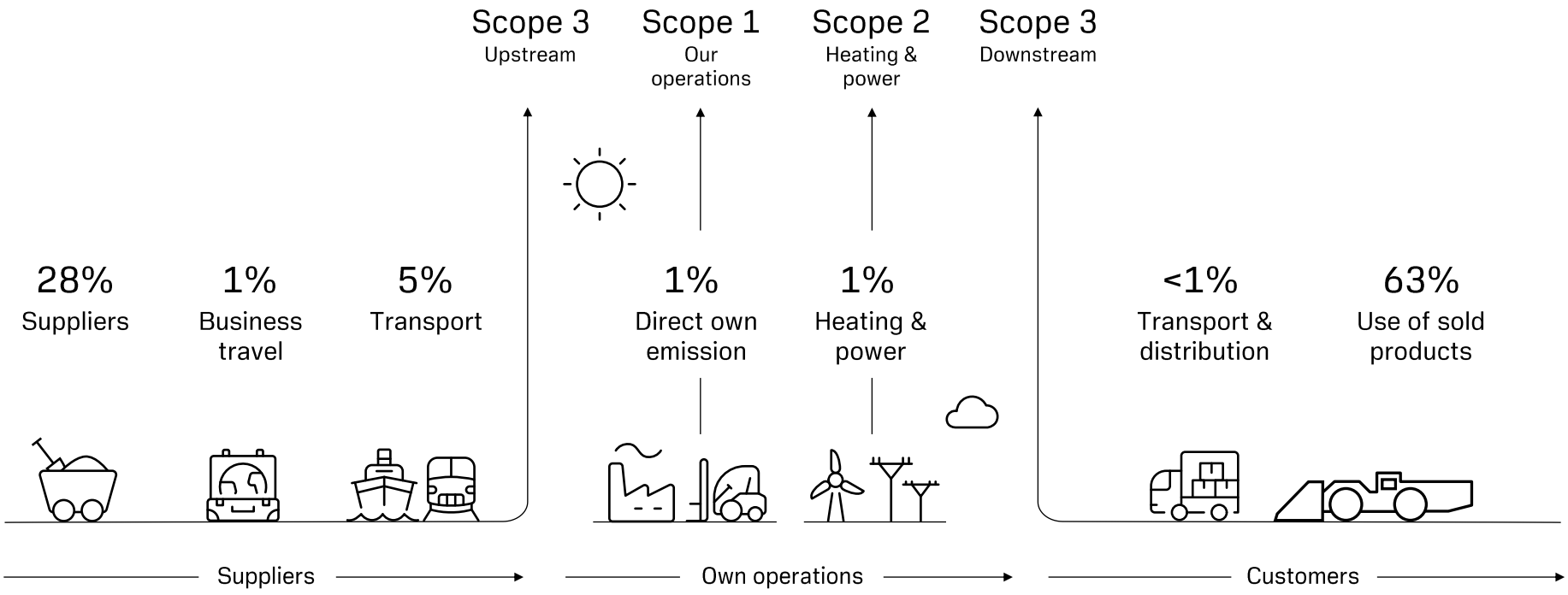




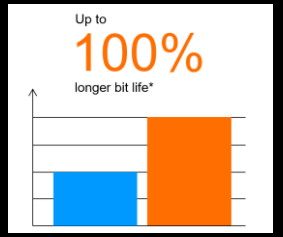
Nordgren, A. Ekmarker, S. Norgren,
Patent EP 3 274 482 B1 (2016), US 10,895,001 B2, 2021.

Creep of un-doped and Cr-doped WC-Co at high temperature and high load, Yousfi , Nordgren , Norgren, Weidow, Andrén, Falk, International Journal of Refractory Metals and Hard Materials 117 (2023) 106417; [47]

The largest climate impact is when customers use our products



A SAFER CHOICE



Changing drill bit is a safety hazard

Bits with longer bit life improve the safety underground

50 M	25.000 M	5 Jumbos
Grinding Interval on standard bits	Monthly drill meters per jumbo	Drill fleet in mine development

11.250

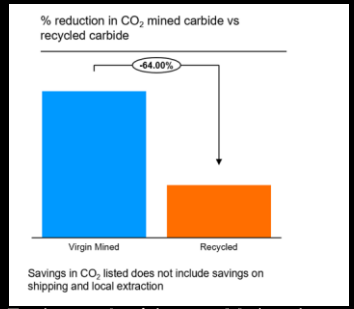
LESS BIT CHANGES PER YEAR*

https://www.rocktechnology.sandvik/en/campaigns/powercarbide-gc81-and-sh70/

Going from products made of Virgin to Recycled Material raw materials

Making tools from recycled carbide:

Requires	means
70%	40%
less energy	less CO_2 is emitted



Furberg, Arvidsson, Molander, Journal of Cleaner Production 209 (2019)

Recycled material - Contains small amount of other ”unwanted elements” giving unwanted effects if not governed.

Consequences on interfaces, material properties and performance ?

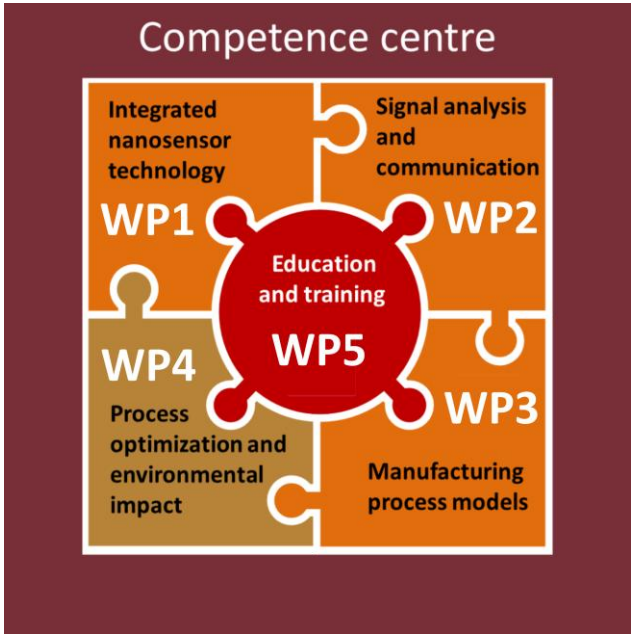
- Here there is an urgent need for more research!

Examples

SENTIO: Integrated Sensors and Adaptive Technology for Sustainable Products and Manufacturing

Combine excellence across disciplines, TRL levels and industrial sectors.

Areas of impact, examples:
160 million plate heat exchangers &
40 million machine tools in use
daily



Funded by Vinnova, Swedish industry, and Academia

ALFA LAVAL
SANDVIK COROMANT
Tetra Pak®
Seco
VOLVO
MODIG MACHINE TOOL SWEDEN
elitkomposit
ACCU-SVENSKA AB Minimum Quantity Lubrication Systems
AUTOMOTIVE COMPONENTS FLOBY
LUND UNIVERSITY
RI. SE
IUC
REGION SKÅNE

Strategic research

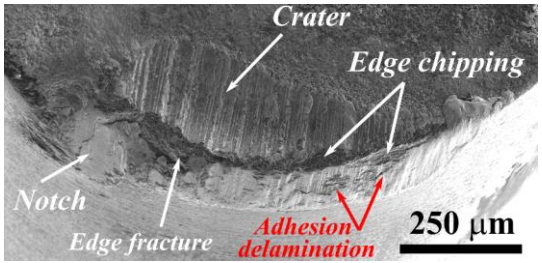
- understanding the customers and our needs for tomorrow

Industry- Academia NEXT Competence centre- 2024-2029 105MSEK

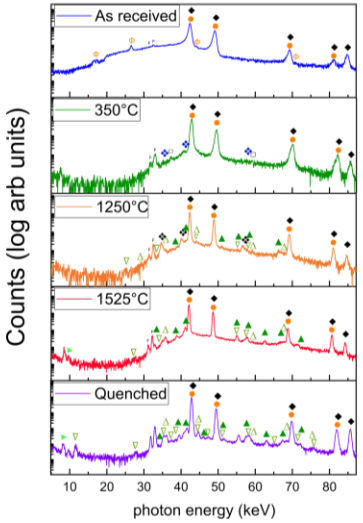
Degradation of Polycrystalline Cubic Boron Nitride

Tool material failure and protection for new material design

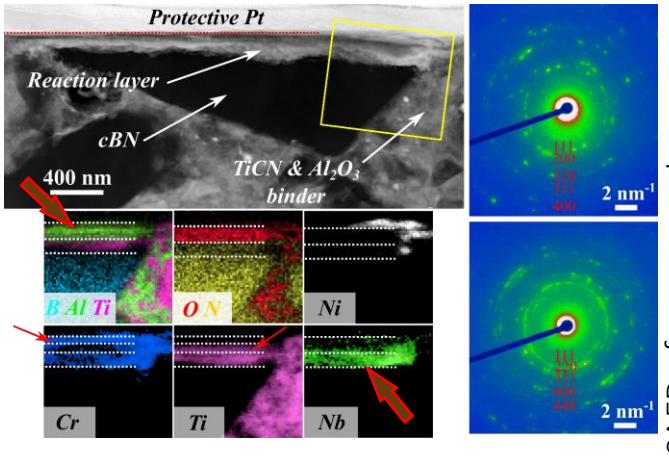
PcBN wear scar at v_c = 400 m/min



Results of *in-situ* chemical interaction under HPHT synchrotron beamline at SOLEIL

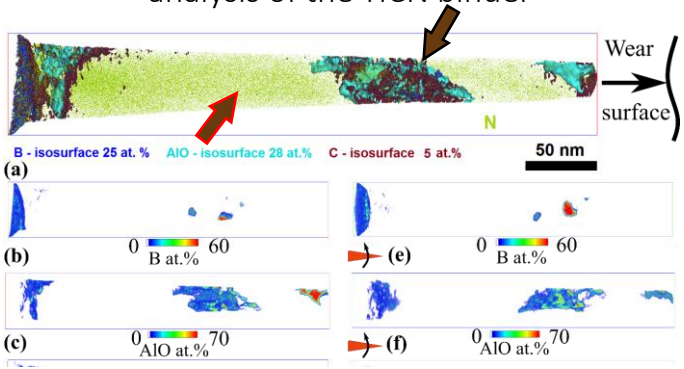


Scanning TEM (STEM-HAADF) image of crater lamella



and SAED of γ-Al_2O_3 (Ti,Cr,Nb)N

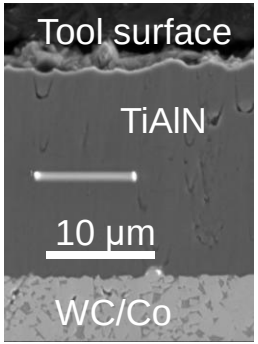
Atom Probe Tomography (APT) analysis of the TiCN binder

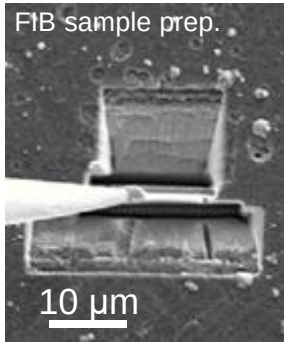


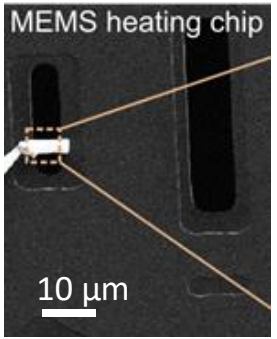
- Diffusional dissolution of superhard cBN
- Preferential dissolution of nitrogen (C) from the binder
- Optimized Ti(C,N) binder balancing diffusion and oxidation
- *In-operando* formation of Tool Protection Layer (TPL) of (Ti,Cr,Nb)N and Al_2O_3

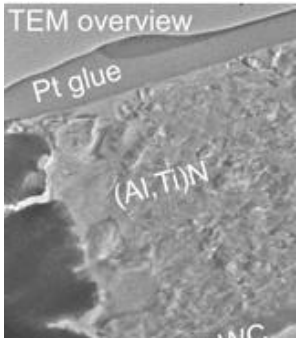
New CVD TiAlN coating for machining

In–situ Environmental TEM study from 600-1000°C

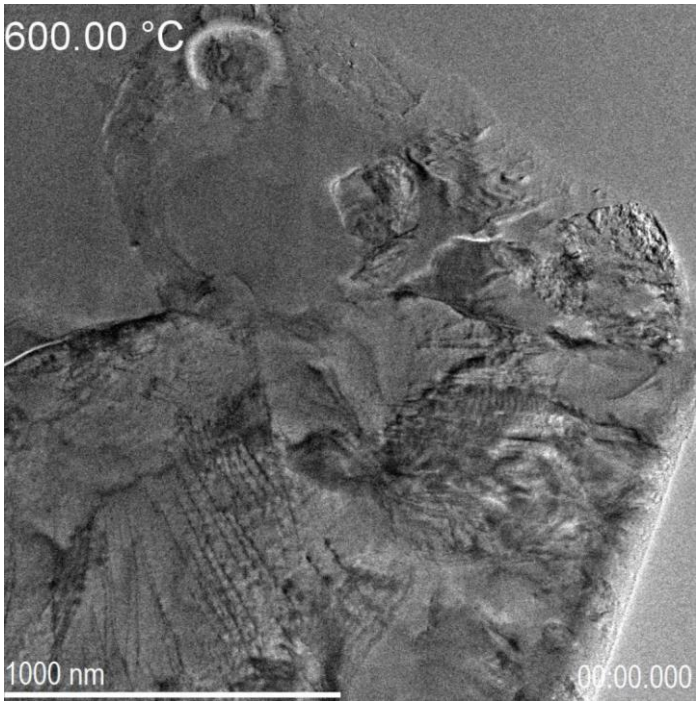






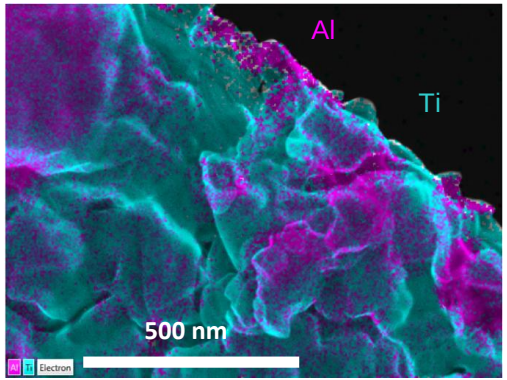


In situ nanoscale structural characterization



ETEM2 under planning
WISE RTP!

Complementary compositional analysis



Example: $Ti_{0.56}Al_{0.44}N$

Heated from 600 to 1000 °C in O_2

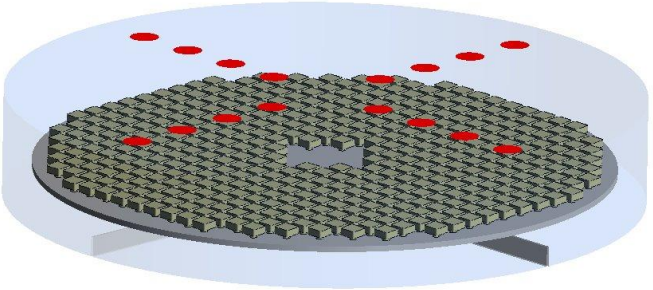
Ofentse A. Makgae et al.
Visualising Microstructural Dynamics of Titanium Aluminium Nitride Coatings Under Variable-Temperature Oxidation
Appl. Surf. Sci. **618** (2023) 156625

Working on our processes here Chemical Vapour deposition

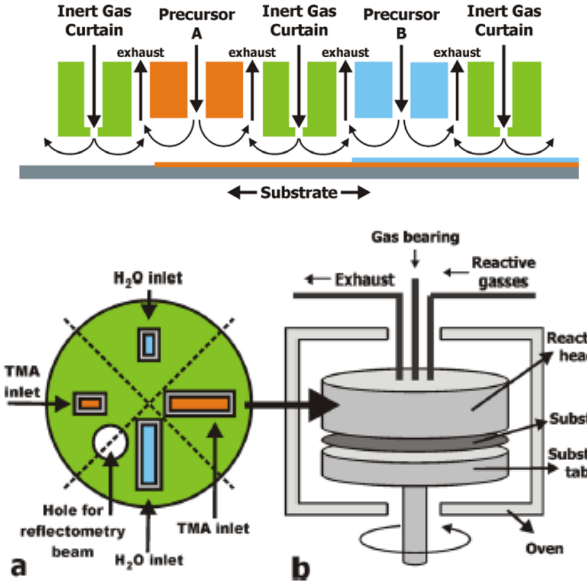
- New Reactor design for sustainability

- Low vacuum volume
- Low thermal budget
- Gas recirculation or capture

In silico design by CFD
Single plate inline reactor



With inspiration from spatial-ALD



Collaboration with

SANDVIK Coromant

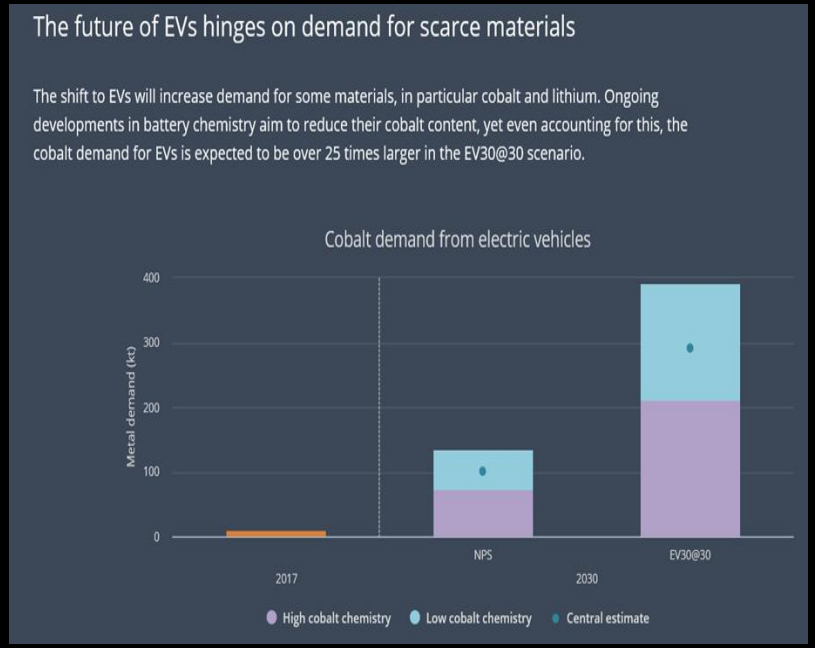
Seco

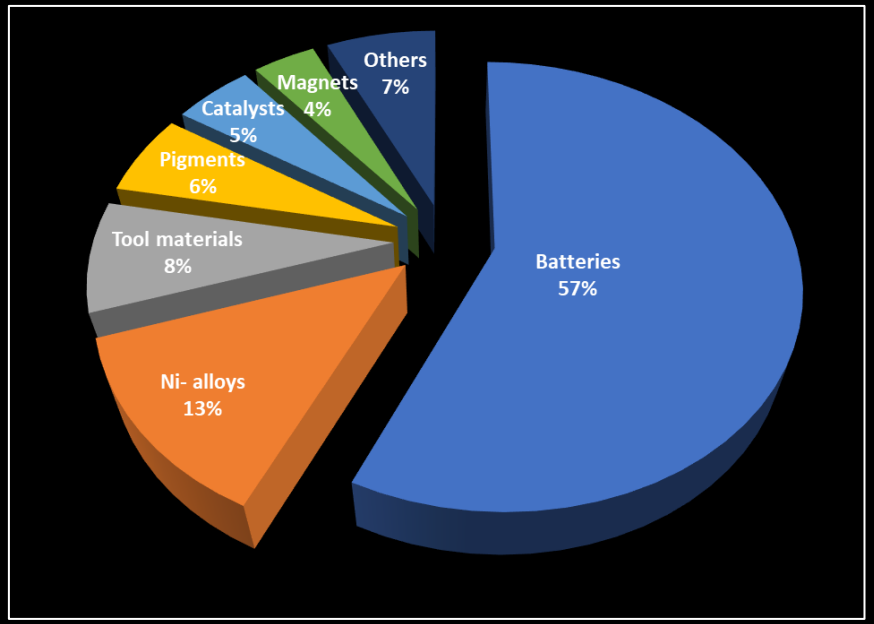
Veeco

henrik.pedersen@liu.se

Sustainability

Electric veichles - demand for Cobalt

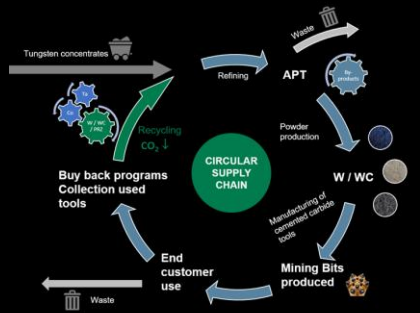


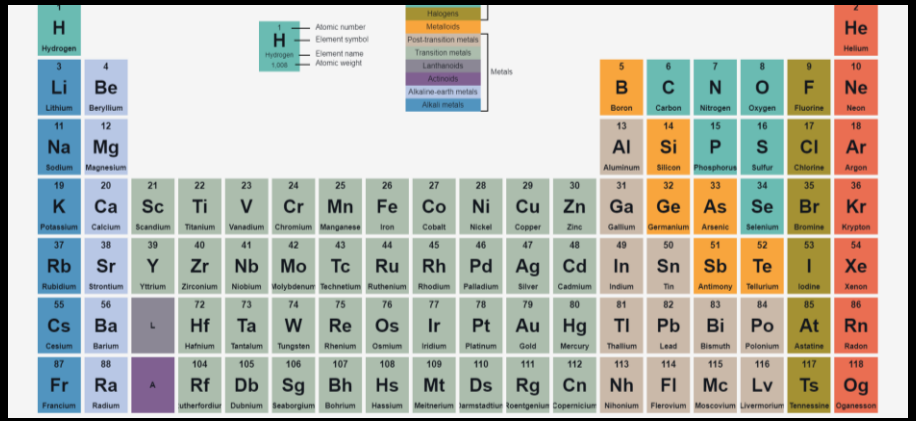


Source: OECD/International Energy Agency

COBALT: CONSUMPTION 101,5 kt

Solutions
(re-use, re-grind, re-make….)

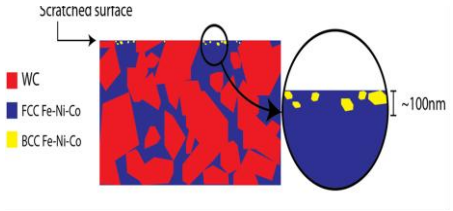




Substitution + Recycling

KTH ROYAL INSTITUTE OF TECHNOLOGY

New material systems – modelling



L. Toller-Nordström et al

International Journal of Refractory Metals and Hard Materials, Volume 128, April 2025,

L Toller-Nordström, et al Materials Characterization 155, 2019

LUND UNIVERSITY

SANDVIK

NPL National Physical Laboratory

UPPSALA UNIVERSITET

Germany-France- Spain- Sweden- Portugal

AIM-NEXT
doctoral network; goal:*competence reassurance*

SMR-Material modelling of non Co binders in Rock Drill bits
SecoTools Machining using recycled carbide

Granted EU project - 10 Ph.Ds

This project has received funding from the Horizon Europe Framework Programme (HORIZON) under the Marie Skłodowska-Curie Action grant agreement No.101119897

Funded by the European Union

RESQTOOL Sustainability & Traceability

Recommendation to the EU for a marking and tracability standard for maching and mining products based on hardmetals, and critical raw materials.

Granted EU project

This project has received funding from the Horizon Europe Framework Programme (HORIZON) under the Marie Skłodowska-Curie Action grant agreement No.101119897

Funded by the European Union

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Front Global front end research – are brought in automatically
and necessarily when working with a multinational Industrial company –like SANDVIK

Rachid M´Saoubi

Industry- Academia- collaboratins

Trust ad mutual respect

Focus on taregeted areas and applications
Speed
Internal reserach
Engineering – intelligent guesses
- Patents

Understanding phenomena based fundamental science
Building digital models and tools based on fundamentals
Education and competence development
- Publications

Industrial Post.Doc
Employed by industry

Co-funded Collaborations, National and international Comptentence Centra, EU projects, and more

Ph.D co funded by academia
employed by academia,
with clear industrial engagement

Industrial Ph.D
Employed by industry

Ph.D co funded by industry and academia,
employed by academia

Master thesis students

Thank You for listening

– advancing the world through engineering

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