The Practical Side of the Project WnM

"verschleißbeständige Werkstoffe nach Maß"

customized wear-resistant materials:

designed by computer-aided materials simulation,

and manufacted by laser welding

Dr.-Ing. Jürgen Röthig, IRAtec GmbH, Magdeburg

Collaboration partner of the project WnM

- ***Köthener Spezialdichtungen GmbH (KSD), poject leader, generator of the project, Köthen, Federal State of Saxony-Anhalt***
- ***Institut für Rohrleitungs- und Apparatetechnik GmbH (IRAtec), Magdeburg, Federal State of Saxony-Anhalt***
- ***Gesellschaft für Technische Thermodynamik und –physik mbH (GTT), Aachen, Federal State of North Rhine-Westphalia***
- ***Hochschule Osnabrück, Osnabrück, Federal State of Lower Saxony***

About us

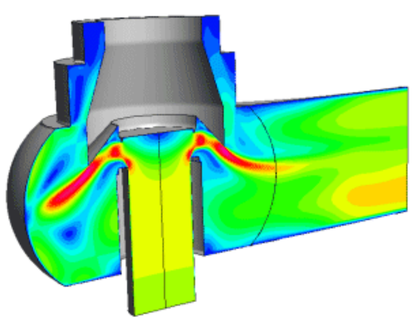
IRAtec GmbH

is an engineering service provider in

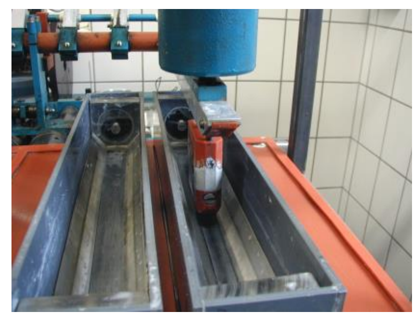
Fluid mechanics

Tribo mechanics

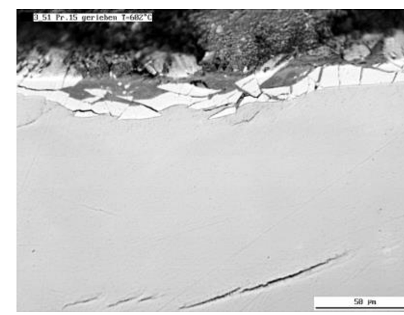
Test stand for Valves



CFD-calculation



Abrasive wear test stand



Metallographic examination

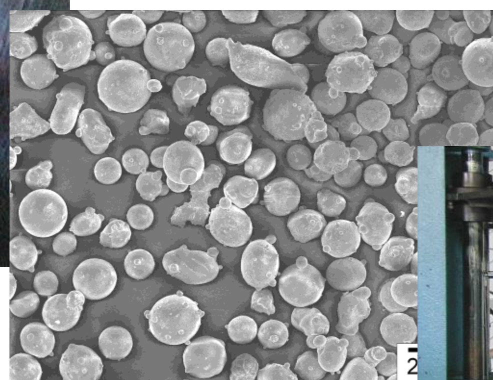
and creat innovative solutions for componies

Design of tribological-stressed components

Damage analysis

Damage pattern
Damage cause

Material development

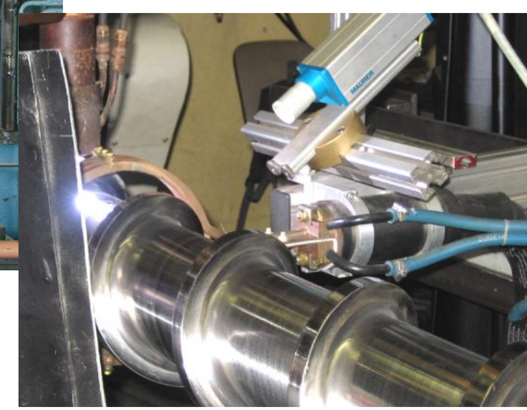


Iron hard alloy
Weld filler material

Laboratory experiments

Material properties
friction, wear

Field test



Extruder screw

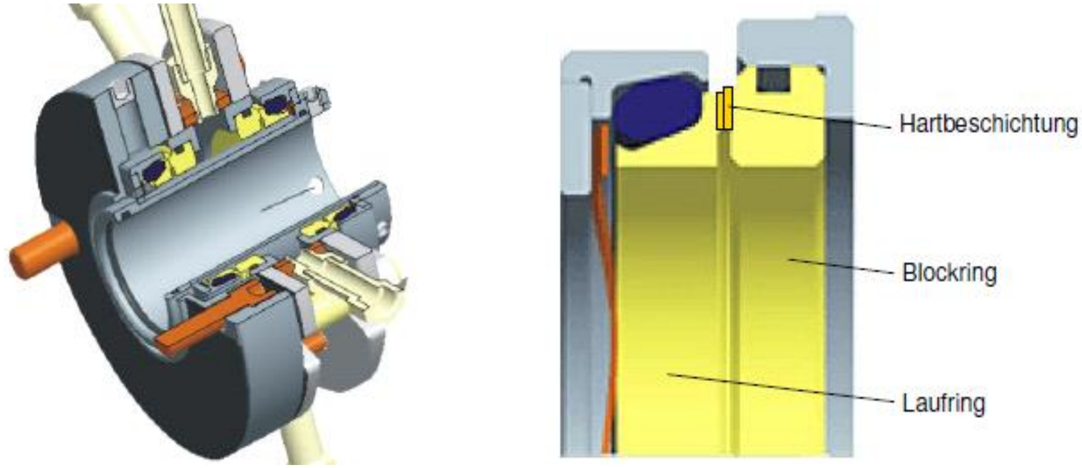
Background of the Project WnM

The competition forces (coating) companies to improve the quality and economy of their products, services and processes.

The KSD GmbH had reacted and has developed the

Rapid Laser Materials Manufacturing (R:LM²) - technology

to create customized wear resistant coatings in high quality by laser welding for using e.g. in mechanically seals



TARGO sealing module for Bitumen pumps, KSD GmbH

Hard facing of sliding ring seals by Laser cladding

After Lasercladding

sliding ring (Blockring), coated

sliding ring (Laufring), coated

sliding ring (Laufring), lapped

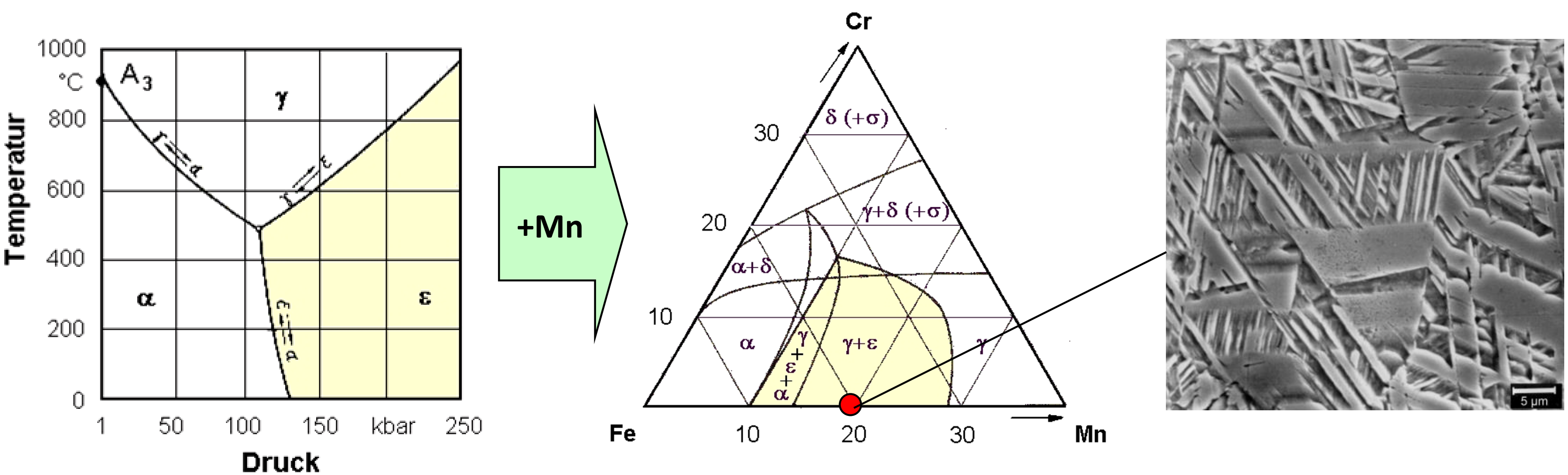
Demands on wear-resistant coatings

- high strength (high-temperature), fatigue resistance and hardness (≥55HRC)
- good thermal conductivity and low expansion, high thermal shock resistance
- low friction coefficient
- good wear resistance (low adhesion tendency)
- adequate corrosion resistance
- good weldability (plasma powder welding, laser beam technique)
- adequate machineability (grounding)
- small material and processing costs

⇒ **hard alloys with Fe-Mn-Cr-metal matrix**

Materials concept of the Project WnM

Iron base alloys, especially from the system Fe-Mn-Cr, are economical, efficient and environment-friendly. In that system it is possible to stabilize all phases of the iron solid solution at atmospheric conditions – a nessesary condition to creat customized **iron composite materials**

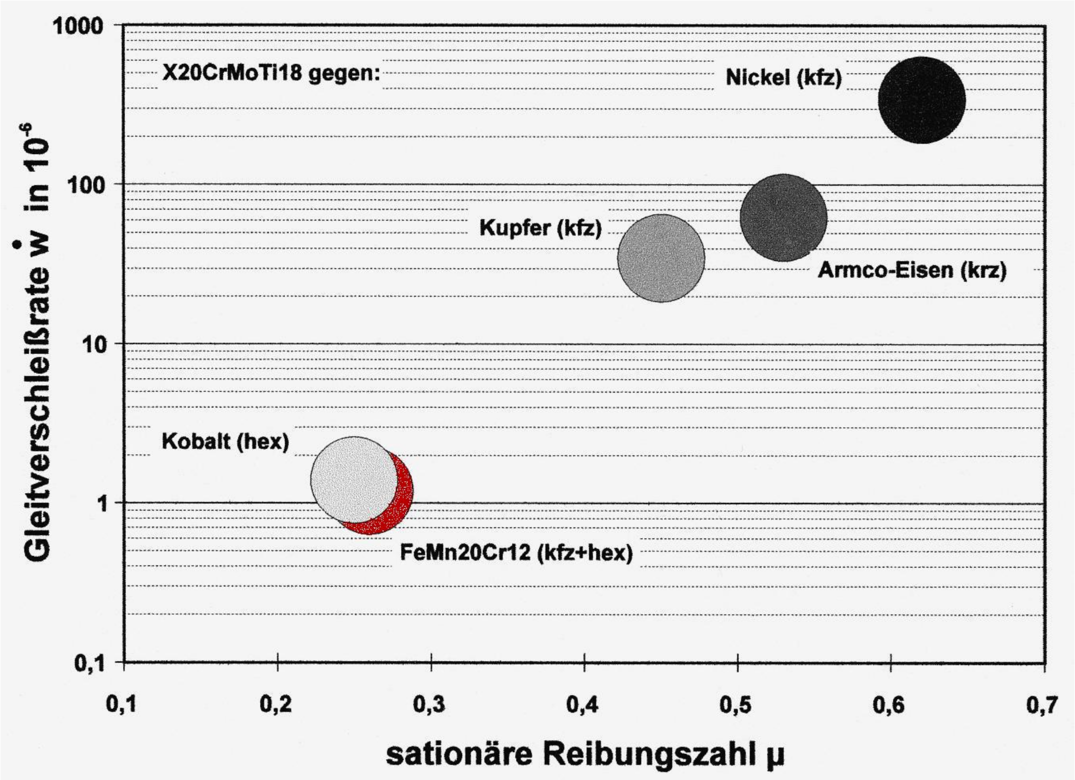


iron-pressure-diagram

Fe-Cr-Mn-diagram, C=0,05%, T=20°C

X5Mn20, T=20°C
γ-austenite, ε-martensite

Friction and wear of metastable austenitic FeMn-alloys



C ≤ 0,05%

Friction and Wear behavior (dry sliding friction, 200 friction cycles, room temperature)

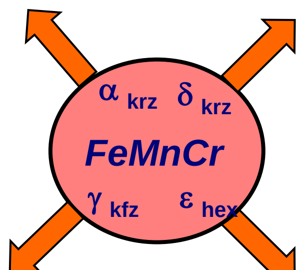
Fields for applications for FeMnCr-alloys

Martensitic hard alloys

microstructure
matrix: α-martensite (+ retained austenite)
hard phases: carbides, borides
properties
hardness ↑↑, ductility ↓,
high-temperature strength ↓↑
friction↑↑, abrasion resistance↑↑
application (T≤500°C)
farming (maschine knives)
mining (bucket teeth)

Stable austenitic hard alloys

microstructure
matrix: γ-Austenit, (intermetallic phases)
hard phases: carbides, nitrides, borides
properties
hardness ↓, ductility ↑, fatigue strength ↑,
warm and creep strength↑↑, high temperature wear stability ↑
friction ↓↑, abrasion resistance ↓↑ corrosion resistance↑
application (T≤850°C)
process engineering (high temperature area)
power plants (pumps, armatures, slide ways)
thermal mechanical engineering (valve seats)



Ferritic-austenitic hard alloys

microstructure
matrix: δ-ferrite+ γ-austenite (Duplex)
hard phases: carbides, nitrides borides
properties
hardness ↓↑, Ductilityt ↓↑,friction ↑
Abrasion- and sliding wear resistence ↓↑
Corrosion resistence ↓↑
application (T≤500°C)
mechanical engineering, Offshore, pumps

Metastable austenitic hard alloys

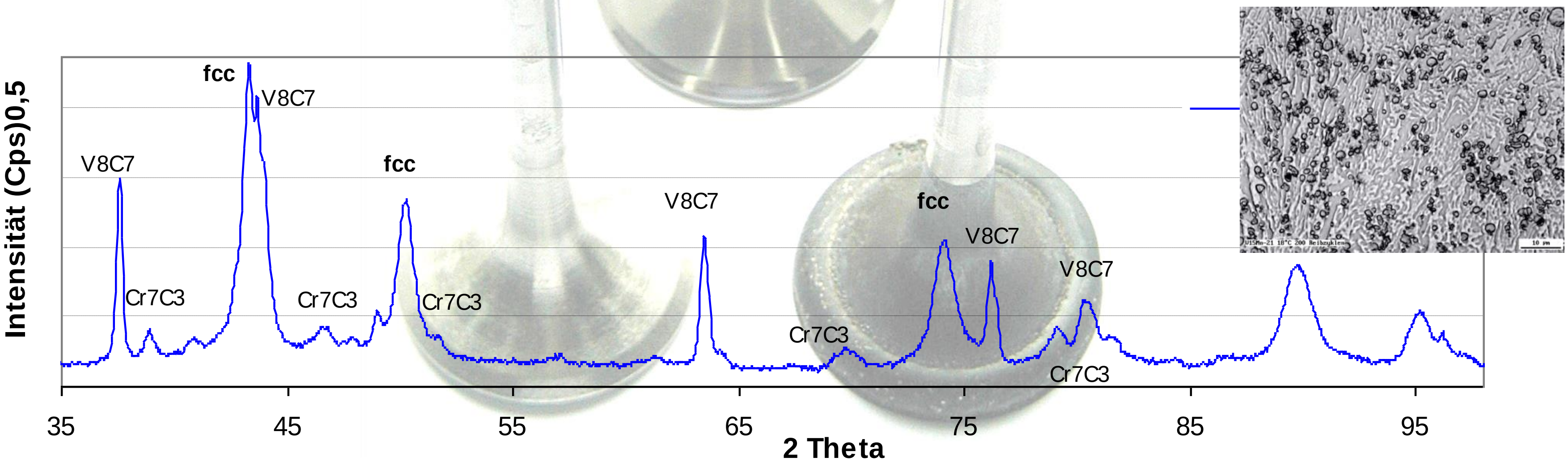
microstructure
matrix: metastabile γ-austenite + hexagonaler ε-martensite
hard phases: borides, (carbides, nitrides)
properties
hardness ↑↓, ductility ↑↑, friction ↓
fatigue wear a. sliding wear resistance ↑ corrosion resistance ↑
application (T≤150°C)
process engineering (low temperature range)
power plants (pumps, armatures, slide ways)
mechanical engineering (valve seats, maschine knives,
jaw crusher)

CMS – creation of a iron hard alloy by PTA-cladding – Example

Development of a high-temperature wear-resisting weld coating

The hard alloy FeMnCrVC-V2 is a composite material, consisting of primery carbidic hard phases (VC) and a eutectic of secondary hard phases and austenitic solid solutions.

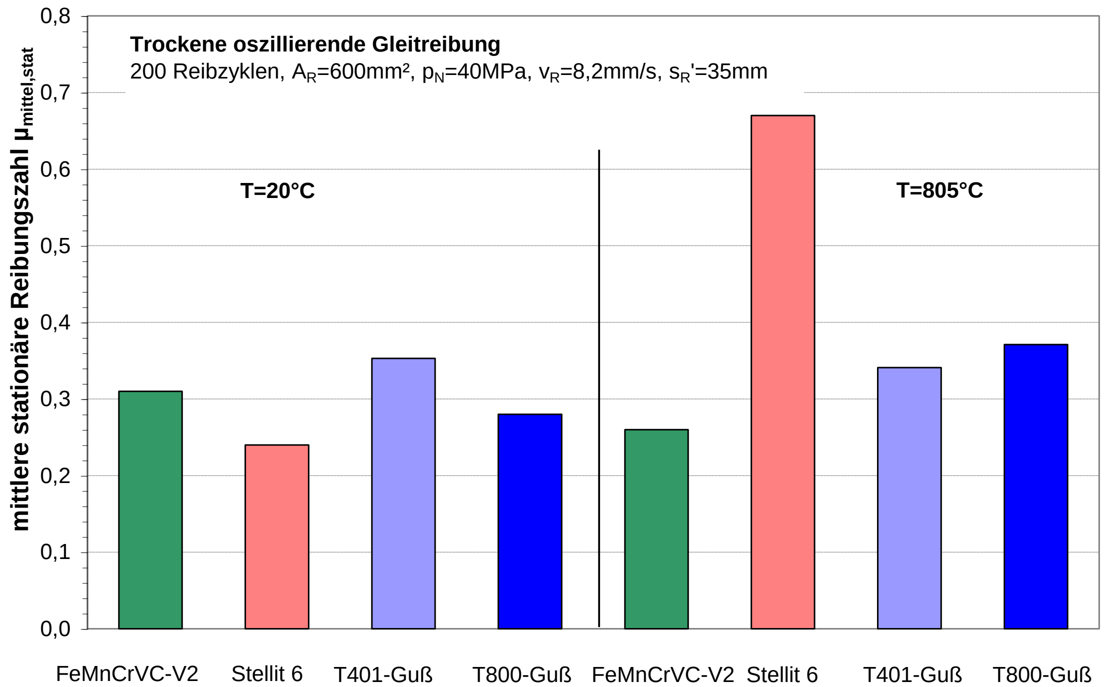
gas atomized powder (wt%)	C	Si	Mn	Cr	Ni	Mo	V	W	Co	Fe
FeMnCrVC-V2 PTA, 688HV30	4,5	0,9	16,2	17,2		1,8	14,8			44,6



CMS *– creation of a iron hard alloy by PTA-cladding –* ***Example***

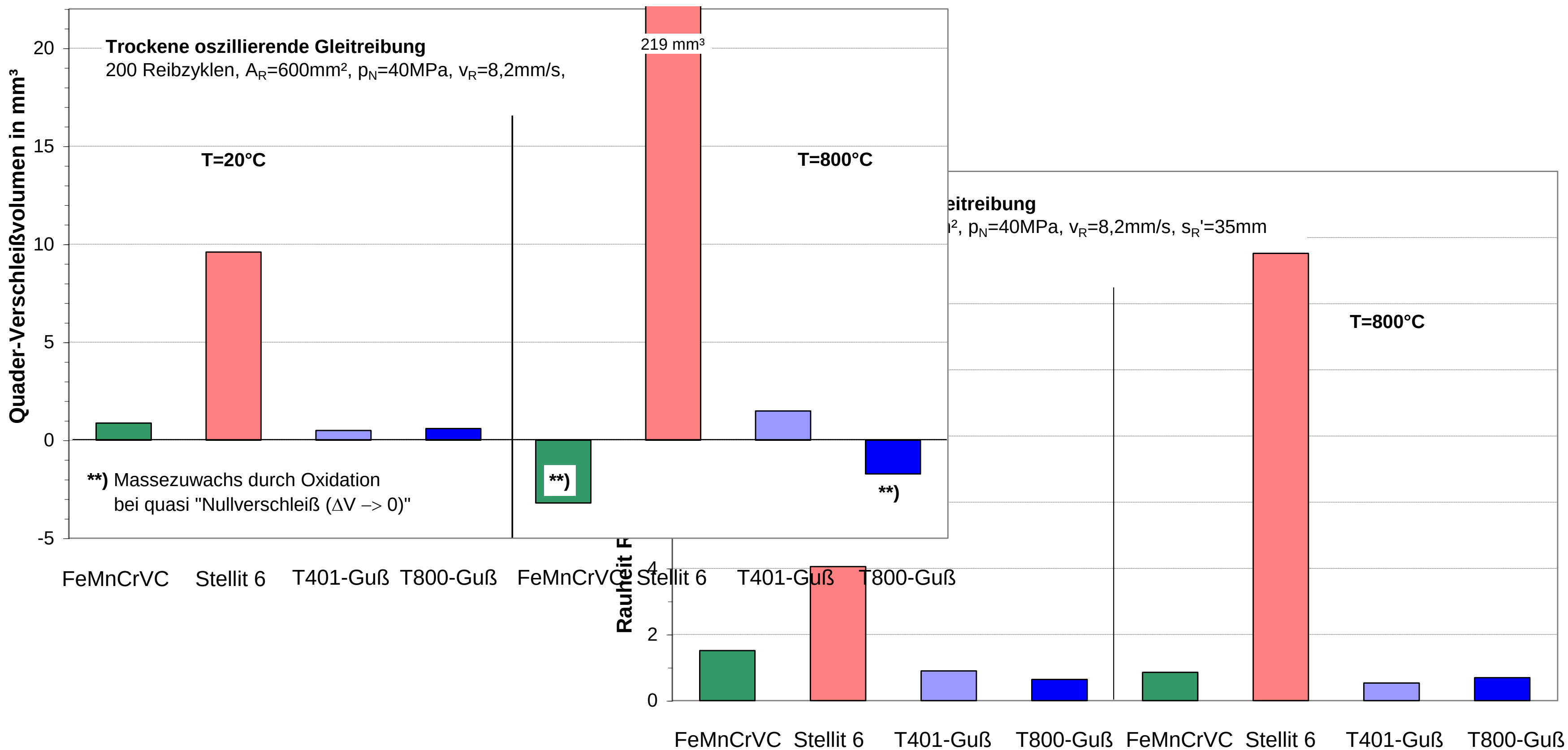
Friction behaviour

FeMnCrVC-V2 shows under dry sliding friction and temperatures up to 800°C a good friction and wear behaviour, compared to Tribaloy® T- 800

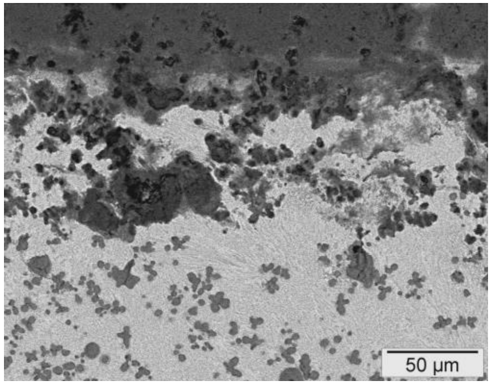


CMS – creation of a iron hard alloy by PTA-cladding – Example

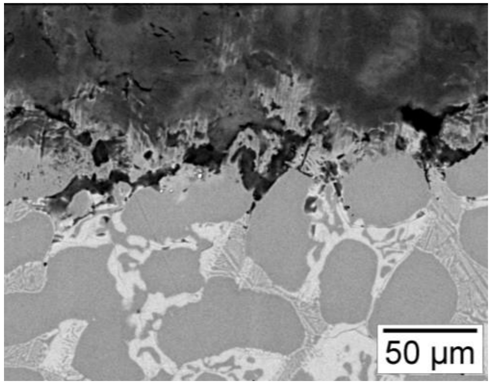
Wear behaviour and the roughness of stressed surface



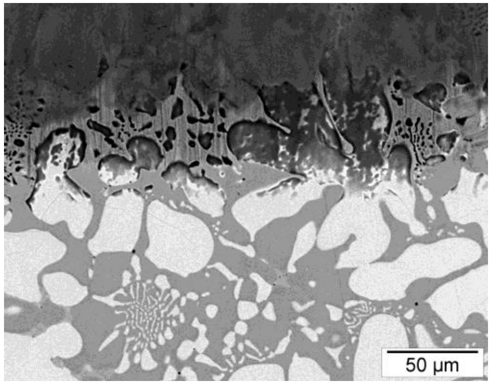
7°-Cross-grinding of the stressed sliding surface of the hard alloys



FeMnCrVC, V2



Tribaloy® T-401



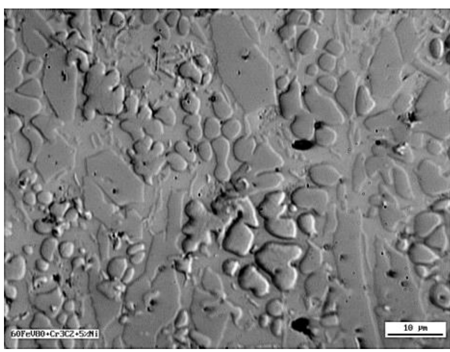
Tribaloy® T-800

T_R=800°C, p_N=40 MPa, v_R=8,2 mm/s, 200 Reibzyklen

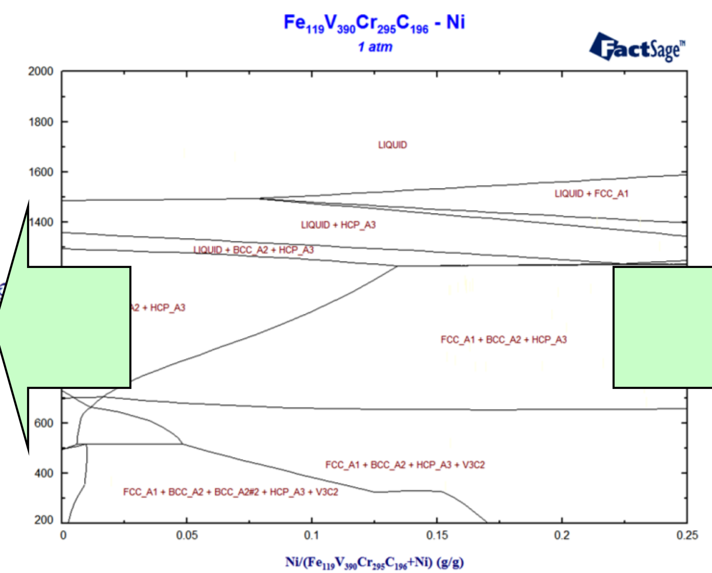
Aim of the Project WnM

Integration of the computional aided materials simulation into *R:LM²*

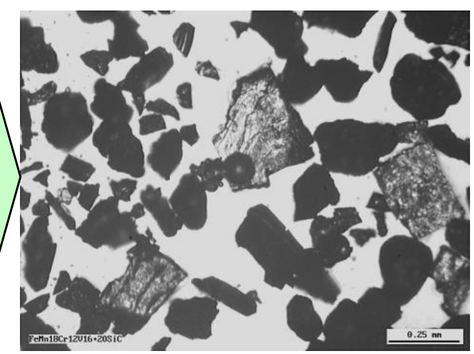
- calculation of the phase composition of coatings or
- calculation of the alloying elements for welding powder



weld metal
(microstructure)



Calculated phase diagram

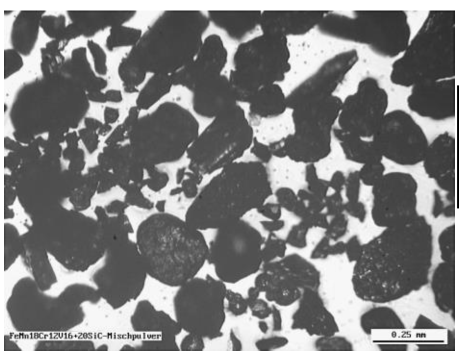


welding powder
(Ferroalloy mixture)

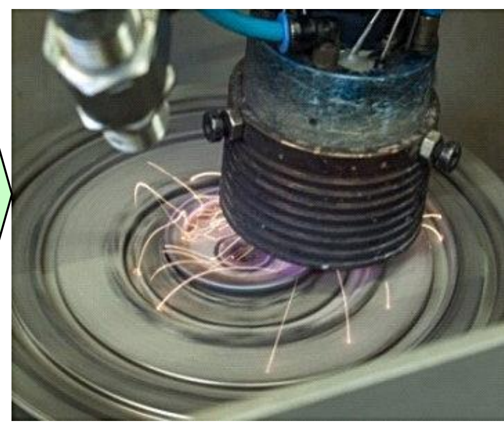
Aim of the Project WnM

Using the laser weld pool as a mini metallurgical furnace to produce high-quality Coatings from low-cost ferroalloys mixtures

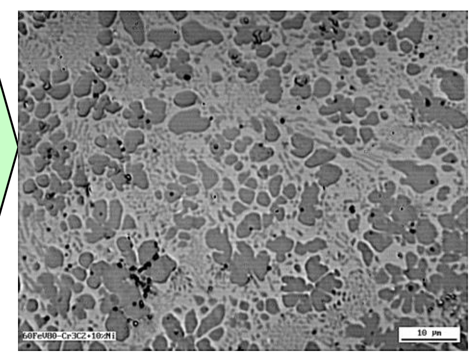
FeV80 + Cr_3C_2 + Ni → Metall-Matrix (bcc, fcc) + V2C + $(Cr,V)_3C_2$



welding powder



laser welding



weld metal

CMS *– creation of a hard alloy by laser cladding –* ***Example***

Welding powders 60FeV-40Cr3C2 + nickel for laser cladding

mixture	Components of mixed powder		
5Ni	60g FeV75	40g Cr3C2	5g Nickel
10Ni	60g FeV75	40g Cr3C2	10g Nickel
15Ni	60g FeV75	40g Cr3C2	15g Nickel
20Ni	60g FeV75	40g Cr3C2	20g Nickel
25Ni	60g FeV75	40g Cr3C2	25g Nickel

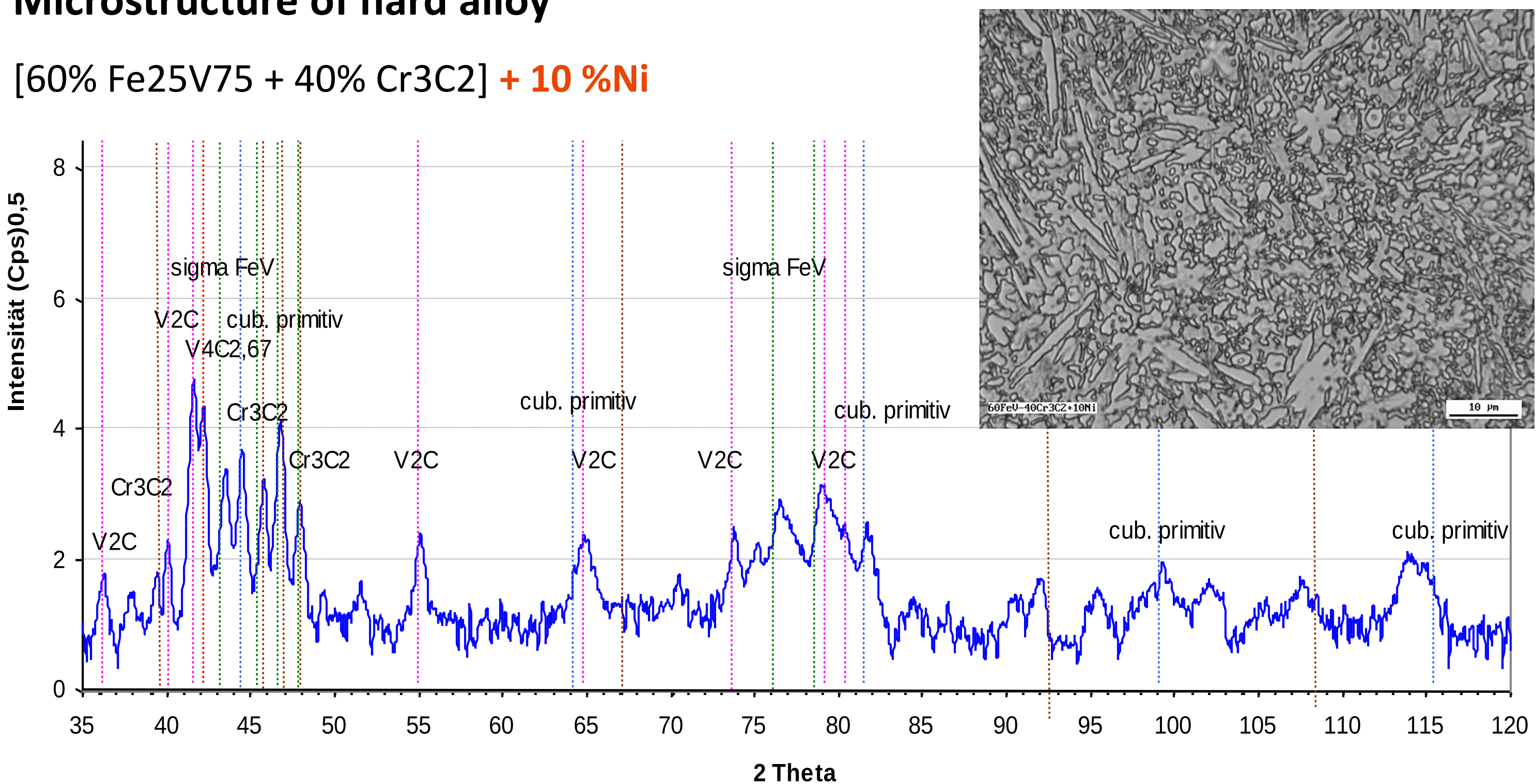
FeV80 –> 25 wt-% Fe + 75 wt-% V –>

Cr3C2 –> 86,6 wt-% Cr + 13,4 wt-% C

CMS – X-ray-diffraction diagram of a welded layer – Example

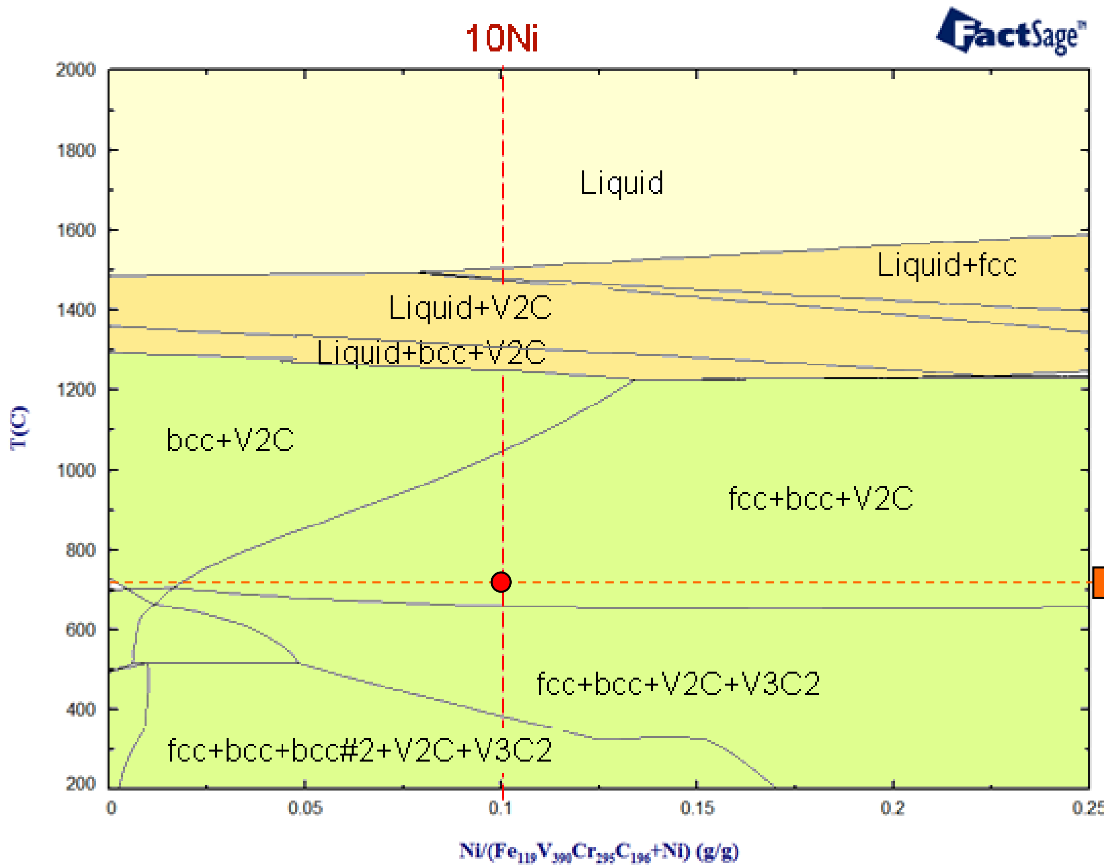
Microstructure of hard alloy

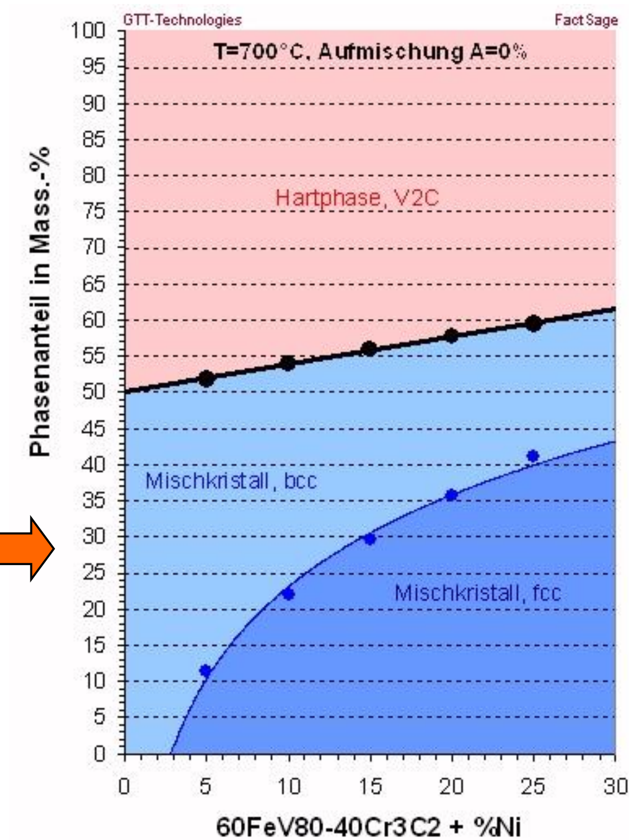
[60% Fe25V75 + 40% Cr3C2] **+ 10 %Ni**



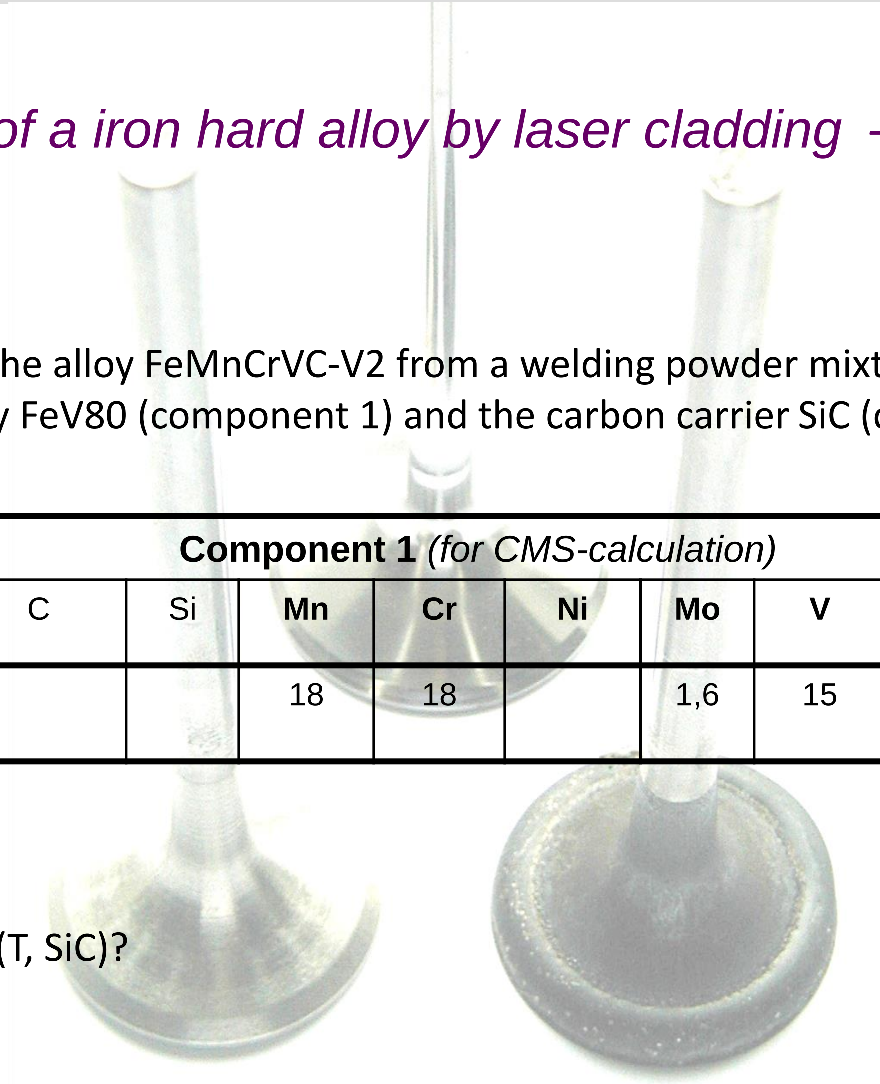
CMS – *Phase simulation of a hard alloy* – ***Example***

T-x-phase calculation of (1-x)*[60% Fe25V75 + 40% Cr3C2] + x Ni





CMS – creation of a iron hard alloy by laser cladding – **Example**



Objective

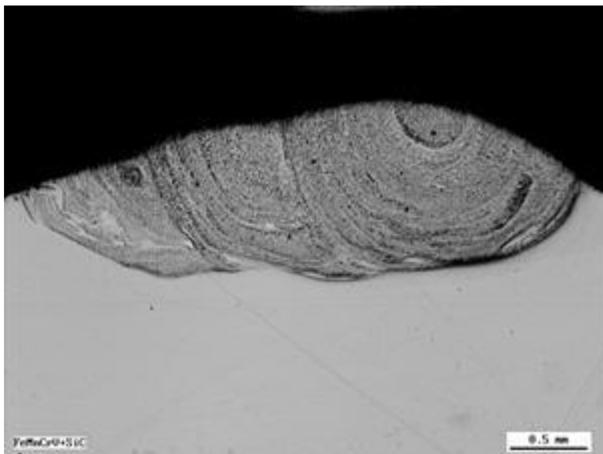
Is it possible to creat the alloy FeMnCrVC-V2 from a welding powder mixture of the pure metalls Fe, Mn, Cr, the ferro-alloy FeV80 (component 1) and the carbon carrier SiC (component 2) by laser?

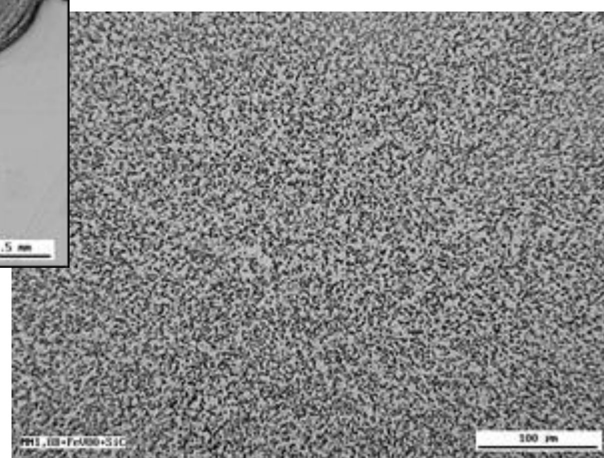
	Component 1 *(for CMS-calculation)*								**Component 2**	
wt%	C	Si	**Mn**	**Cr**	**Ni**	**Mo**	**V**	**Fe**	**+**	**SiC**
FeMnCrVC-V2 PTA, 688HV30			18	18		1,6	15	47,4		≤20

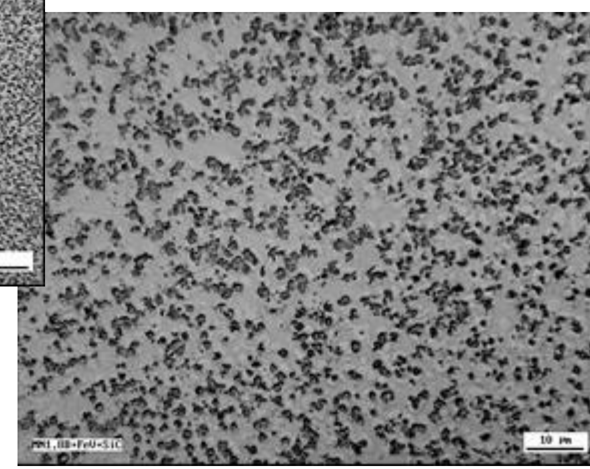
Questions

Phase composition = f (T, SiC)?

Microstructure of the weld metal (857±26 HV0,05)



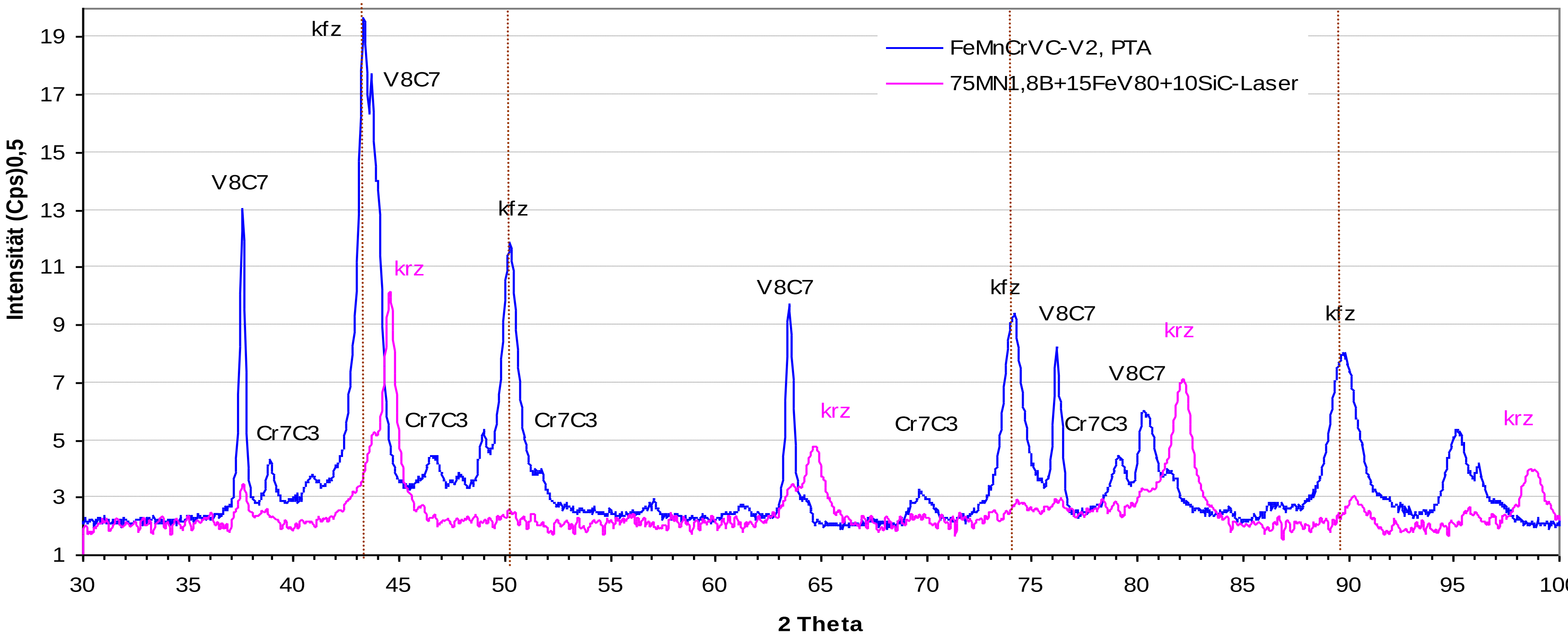




<u>Lasercladding</u>

75MN1,8B+15FeV80+10SiC on sliding ring 1.4301

X ray diffraction diagram – after deposition welding



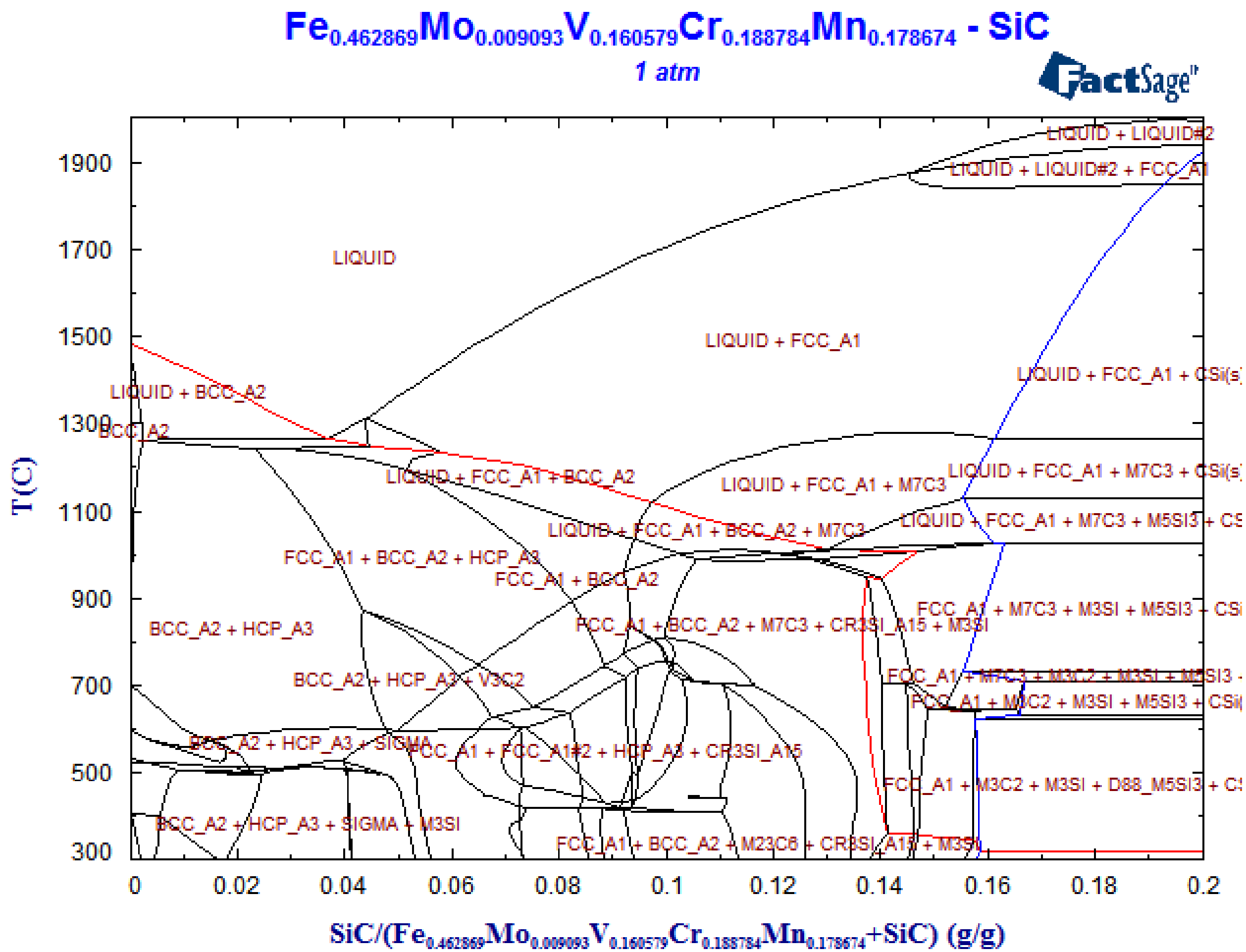
powder (wt%)	C	Si	Mn	Cr	Ni	Mo	V	B	Co	Fe
75MN1,8B+15FeV80+15SiC Laser, 857HV0,05	3,34	7,93	13,43	16,88			12	1,25		44,96
FeMnCrVC-V2 PTA, 688HV30	4,5	0,9	16,2	17,2		1,8	14,8			44,6

CMS *– creation of a iron hard alloy by laser cladding –* ***Example***

Application calculation for WnM Project

- *A quasi-binary system is set up*
- *Component 1 is a five component ferro-vanadium alloy (in wt%): 47.4 Fe, 1.6 Mo, 15 V, 18 Cr, 18 Mn*
- *Component 2 is stoichiometric SiC*
- *Calculations are carried out for (1-A)*Component 1 + (A)*Component 2*

CMS – T-x phase diagram – Example



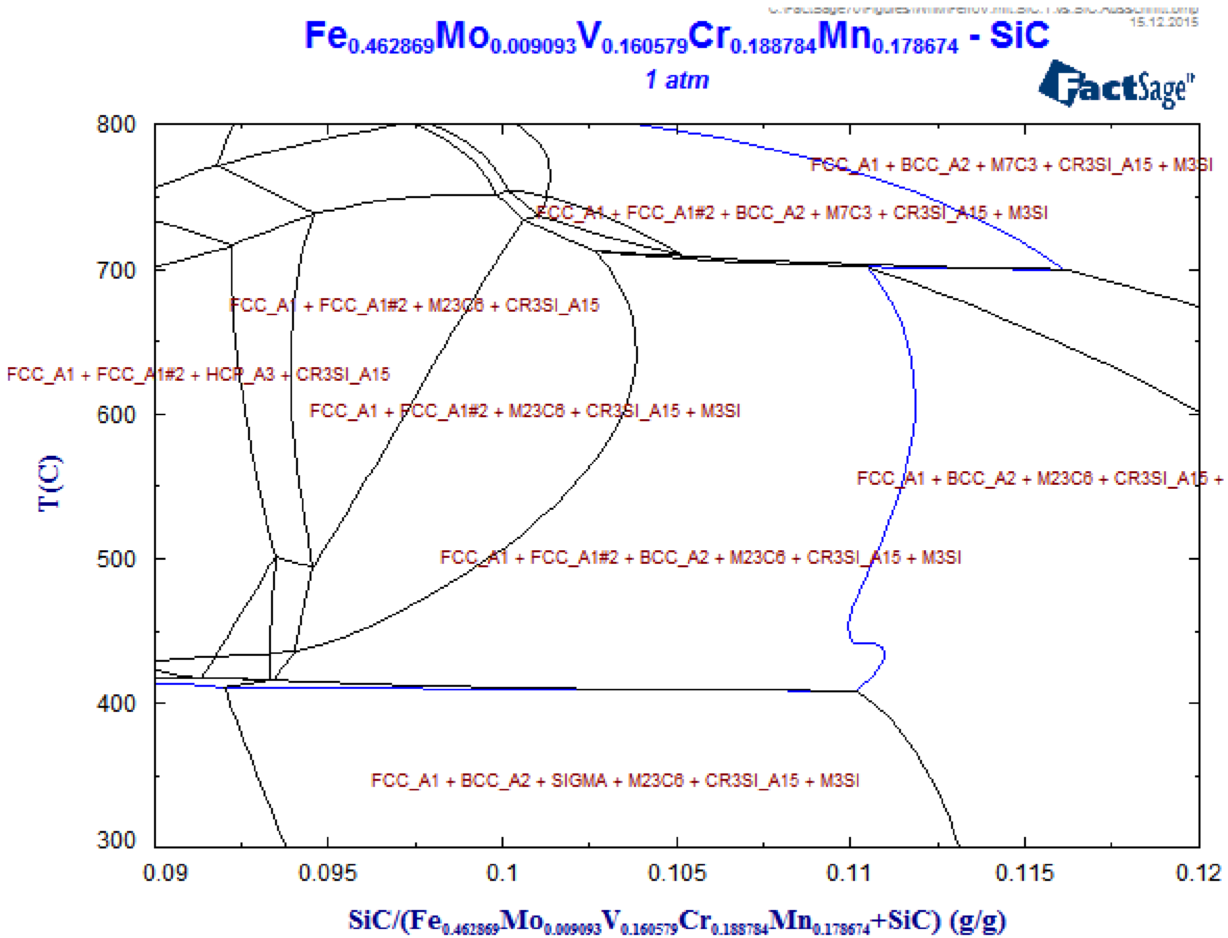
Blue: ZPF line for SiC

Red: ZPF line for BCC

FCC = Austenite

FCC#2 = „VC“

CMS – T-x phase diagram, enlarged center section – Example



Blue: ZPF line „VC“

Note: little nose is artefact of calculation

Conclusion

We stand at the beginning our project but the steps, we have made, go in the right direction. That show us the first results, which we have recived.

Thank you for your attention !