Previous Research Experience

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Table of Contents

- **Master thesis**
  RWTH Uni. IBF & MPIE

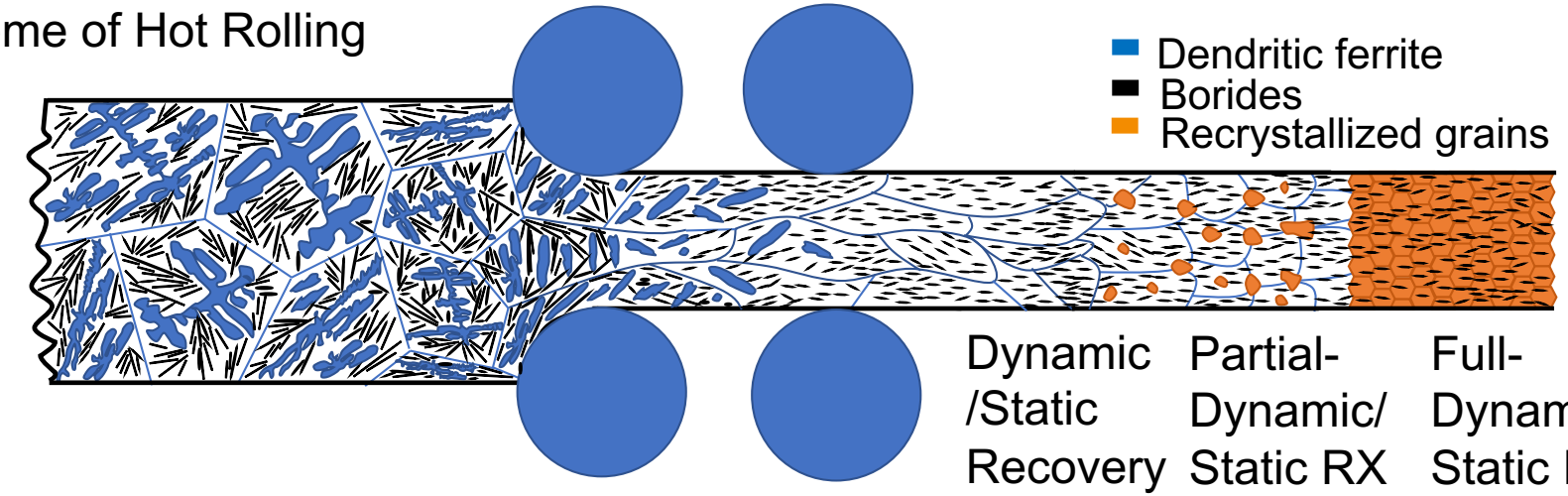
Master thesis

- **Topic:** Combinatorial study on the thermo-mechanical treatment(TMT) of in-situ metal matrix composite (MMC) Fe-Cr-B

- **Motivation:** Low ductility and toughness due to brittle particles
  → Can these be improved by TMT?

- **Challenge:** Simultaneous microstructural change
  Fragmentation of borides ↔ Softening of Fe-matrix,
  Phase transformation (α – γ)

Scheme of Hot Rolling



Master thesis

- **Objectives**
  - ▷Finding Guidelines of TMT for in-situ MMC
  - ▷Investigating the microstructural damage behaviors of in-situ MMC

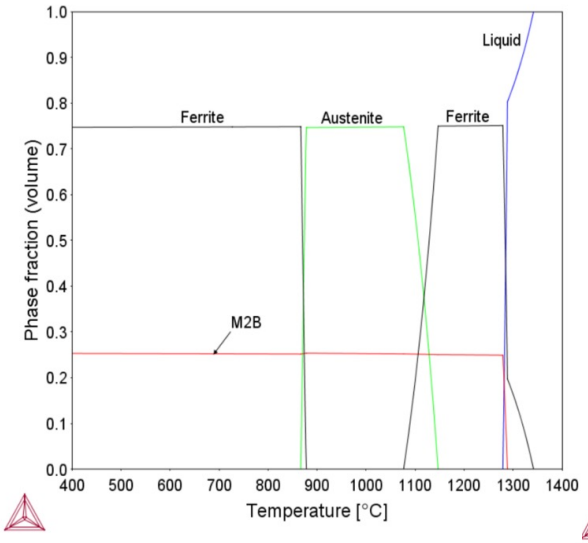
- **Materials**
  - ▷ Fe-18Cr-1.6B for 14-17 vol.% of $(Cr,Fe)_2B$

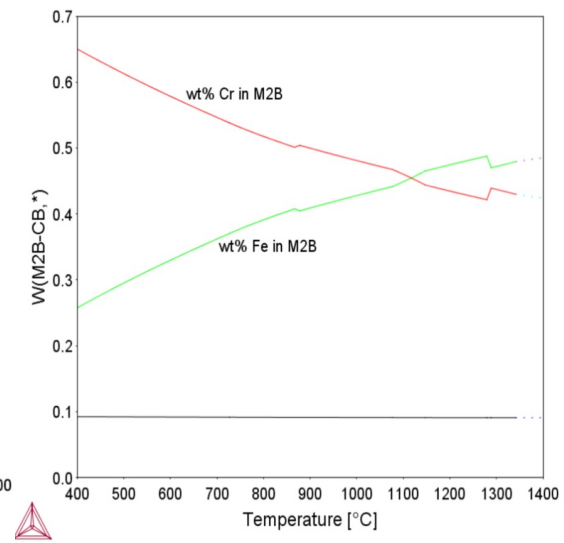
- **Experimental Procedure**
  - ▷ Hot Rolling
    Variables: Temperature, Total Reduction, Number of Passes
    (1000-1200 ºC) (30-85%) (10-40 %)
  - ▷ Cold Rolling
    Variables: Annealing Temperature
    (400-1200 ºC)
  - ▷ Uniaxial tensile test & Vickers hardness test
  - ▷ SEM measurement (BSE images, EDS Analysis)
    Microstructure, Elemental analysis
  - ▷ EBSD measurement (Image Quality, IPF , KAM)
    Microstructure, GB misorientation

Results & Discussions

CALPHAD modeling

Determination of hot rolling temp.





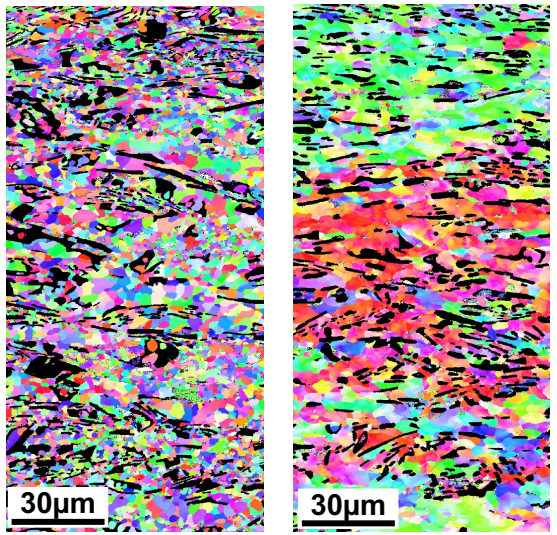
- Most efficient grain refinement

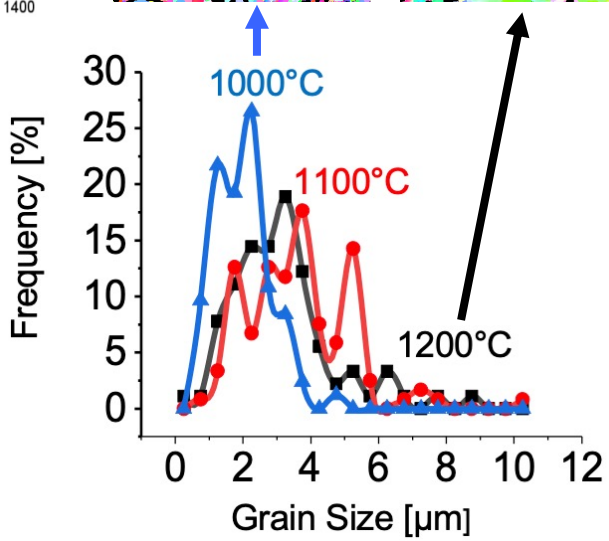
  (1-2 mm ➡ 1.970 µm)

  1000 °C / 70% red./ 2 passes

  Dynamic Strain Induced Transformation

  (γ-α)



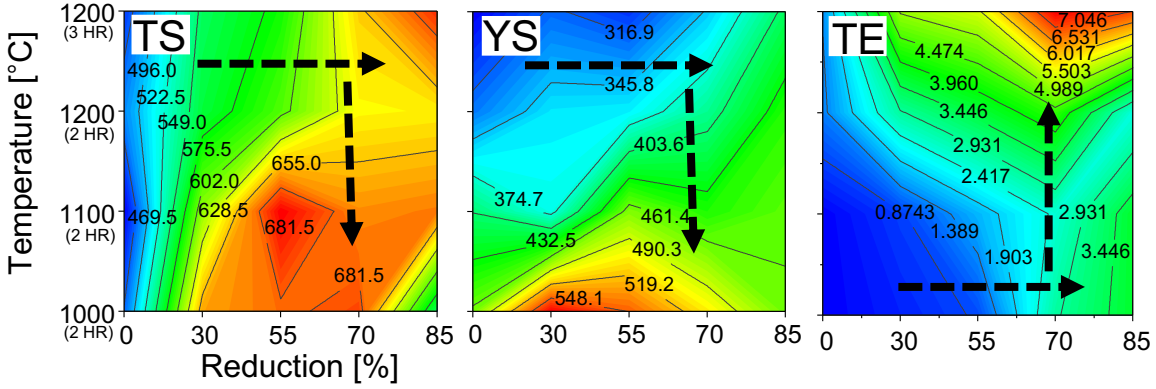


Master thesis

► Results & Discussions

▷ Hot Rolling

	Red.	Temp.	Passes	Microstructure
Strength (TS,YS)	↑	↓	↓	GS of ferrite ↓ Borides Size ↓
Ductility (TE)	↑	↑	↑	RX-ferrite ↑ Decluster ↑ Less fracture ↑
Rolling Defects	↓	↑	↑	N/A



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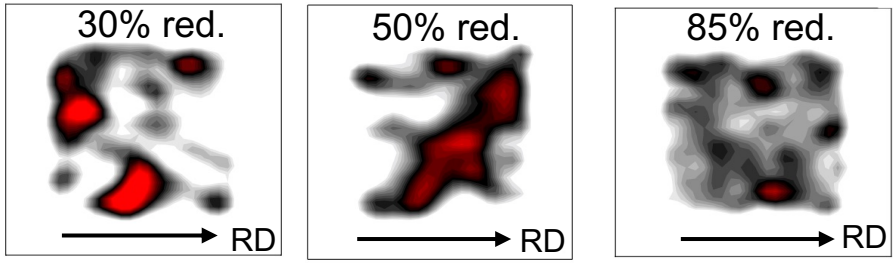
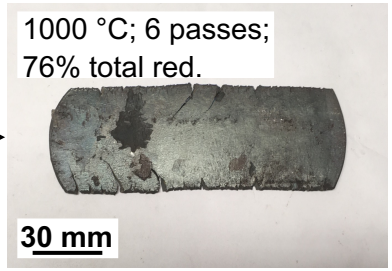
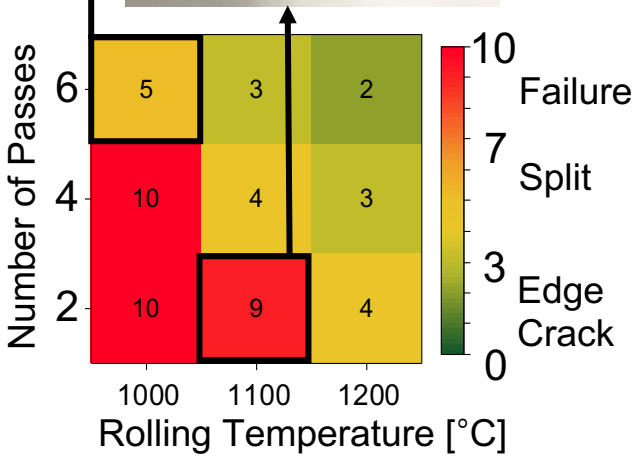


Edge Cracking



Split in the center

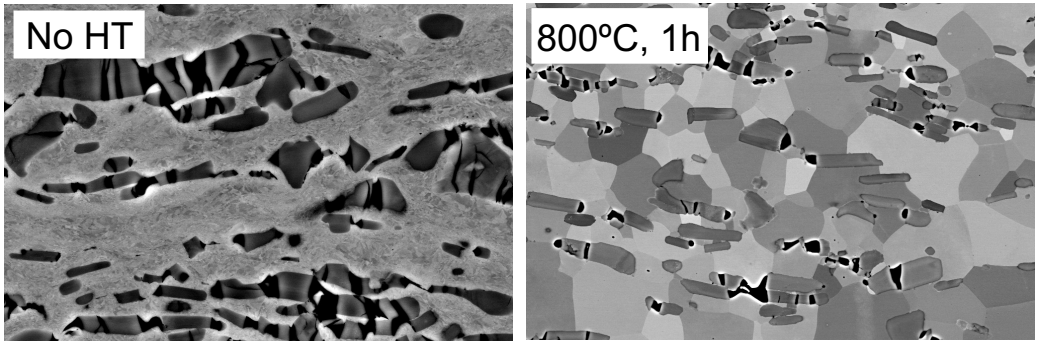


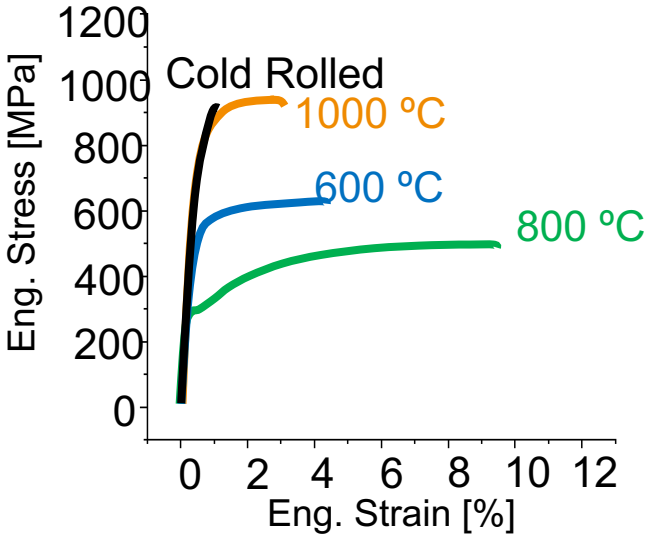
Master thesis

▶ Results & Discussions

▷ Cold Rolling with Annealing

RX temp. in range between 600-800°C

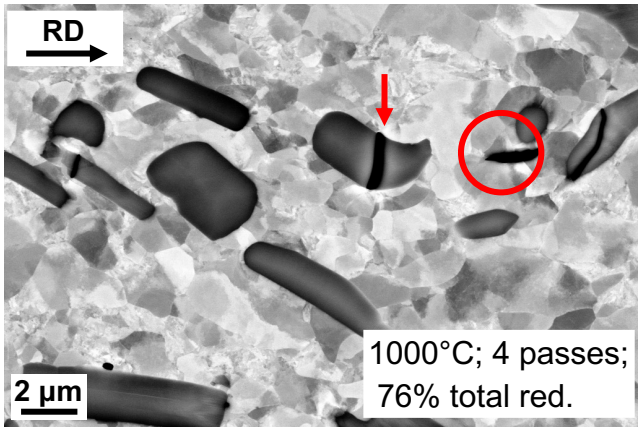




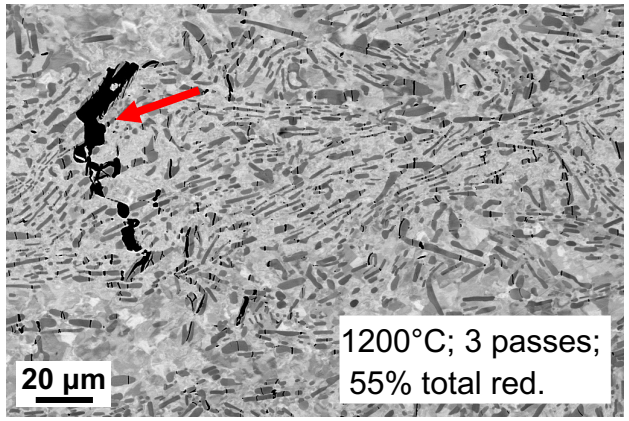
▷ Damage Behavior

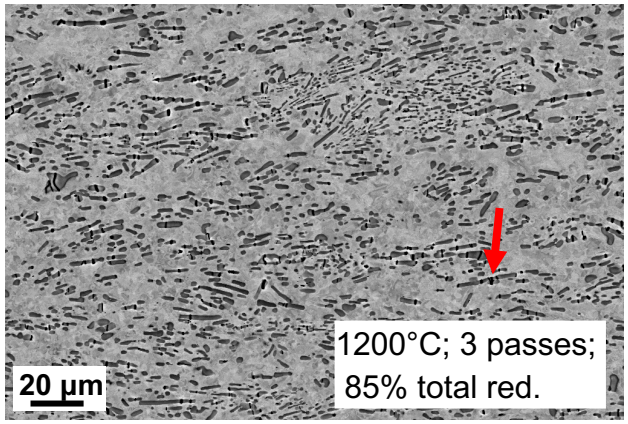
(a) Damage initiation - Fracture of borides

(b) Damage propagation - Clustered borides



(a) Damage initiation





(b) Damage propagation

▶ Research exchange program

Tohoku Uni, Sendai, Japan

Research Internship

- **Topic:** Ordering and magnetic transition temperature of $(Ni,Cu)_2AlMn$ Heusler Alloys

- **Motivation:** Magnetic field controlled ferromagnetic shape memory (SM) alloy with $L2_1$ Heusler structure

	Advantages	Disadvantages
CuAlMn	1. Low cost 2. High electrical thermal conductivities 3. High Curie temp. (640K)	High brittleness
NiAlMn	High martensite temperature → High temp. SM alloys	Low Curie temp. (323K)

- **Objectives:**
  - To find the best optimal composition between Cu and Ni for CuAlMnNi alloys
  - To research the influence of Ni composition on magnetization

Research Internship

Experimental Procedure:

- Sample Production
  Induction melting → Hot Rolling → Heat Treatment

- Heat Treatment
  800℃ 1day : as solid solution → WQ → 400℃ 3days : as annealing → furnace cooling

- DSC measurement
  Determination of B2-$L2_1$ order-disorder transition temp.

- XRD measurement
  Determination of lattice constants of $L2_1$ phase.

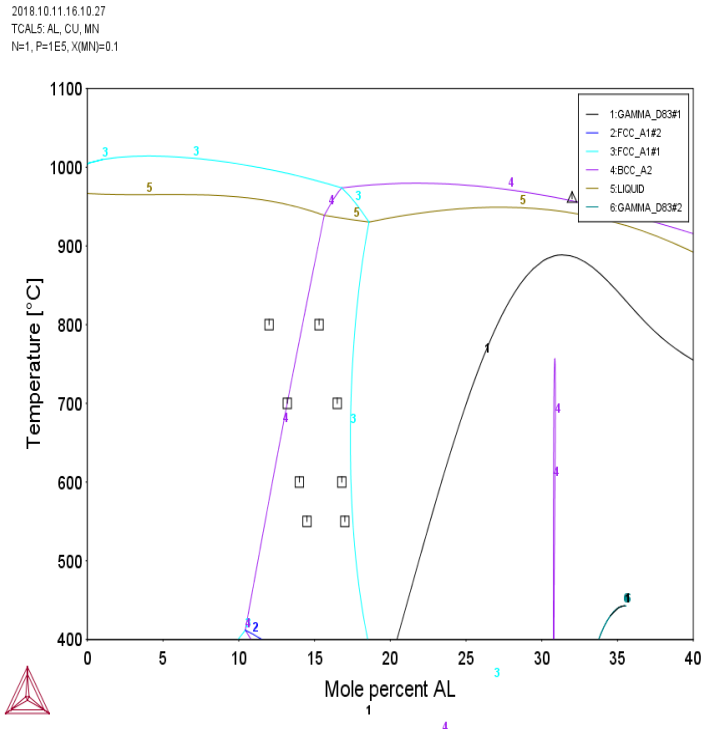
- VSM & SQUID measurement
  Magnetism measurement in different temp.

Research Internship

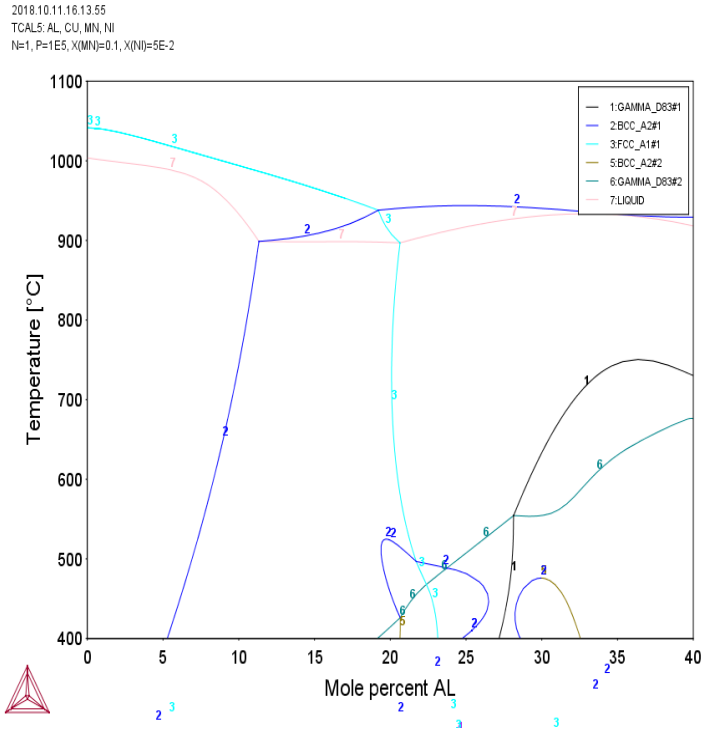
Results & Discussions:

CALPHAD modeling

Influence of Ni content



(a) Cu-Al-Mn



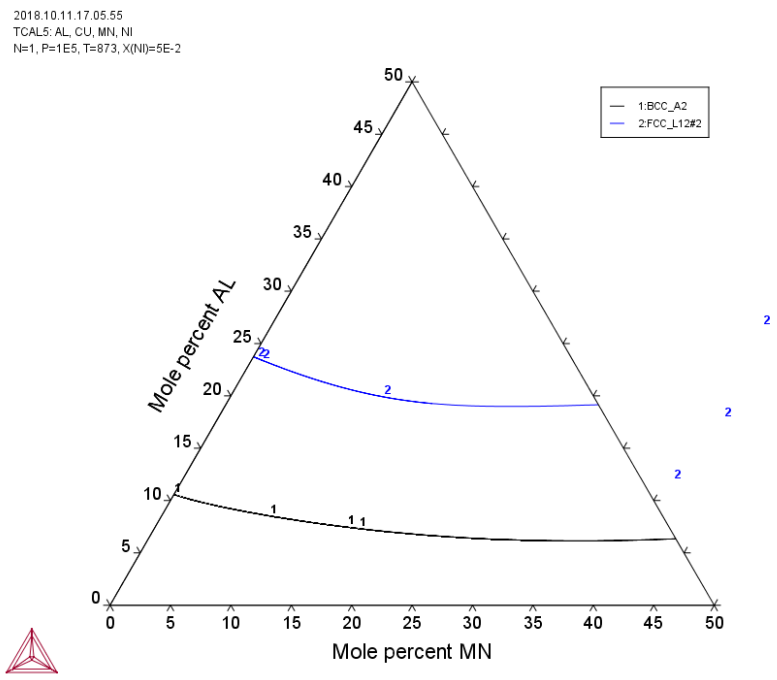
(b) Cu-Al-Mn-5Ni

Research Internship

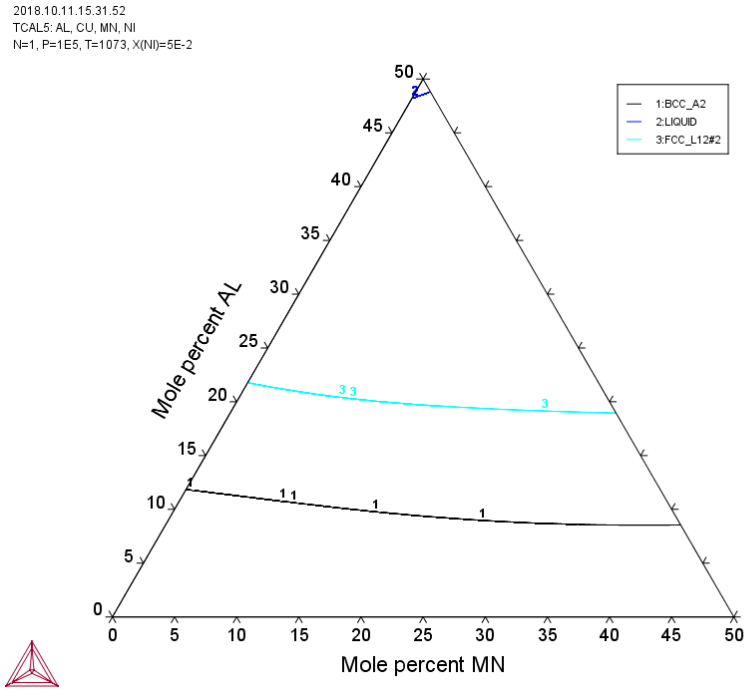
Results & Discussions:

CALPHAD modeling

Isotermal Section at 600 & 800 ºC of Cu-Al-Mn-5Ni



(a) Isothermal Section at 600 ºC

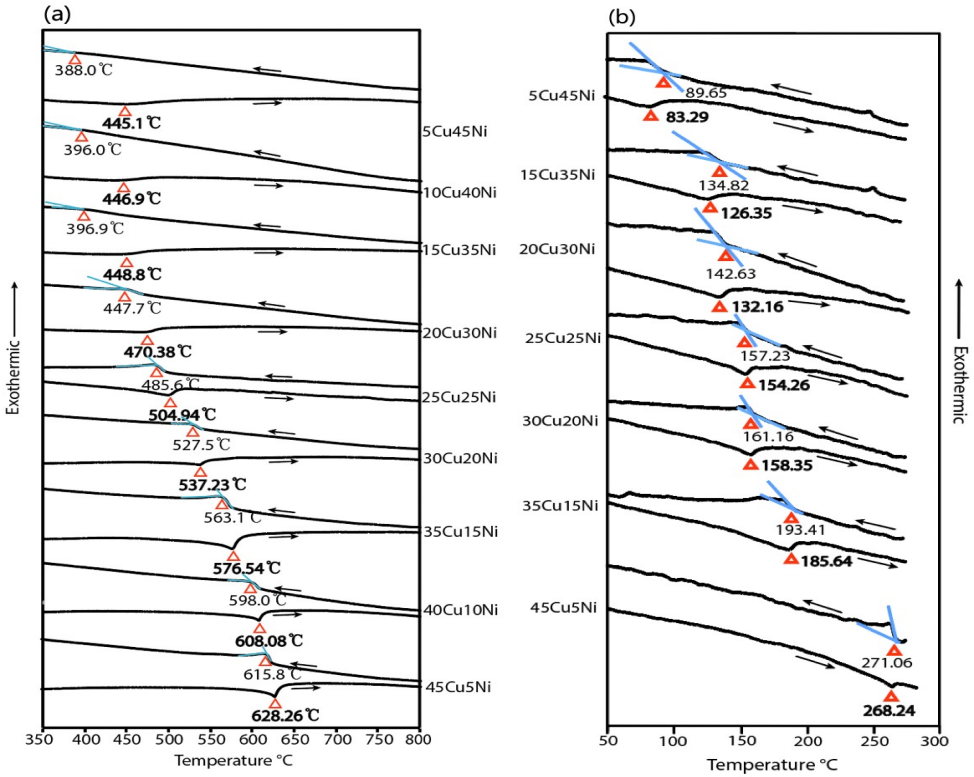


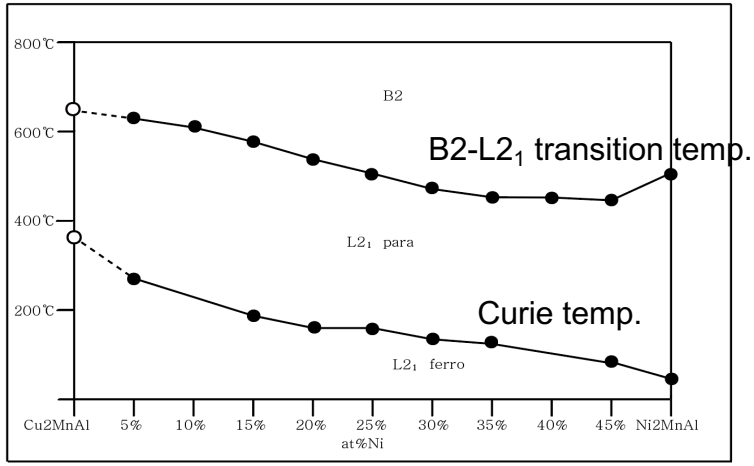
(a) Isothermal Section at 800 ºC

► Research Internship

► Results & Discussions:

▷ B2-$L2_1$ order-disorder transition temp. & Curie temp.





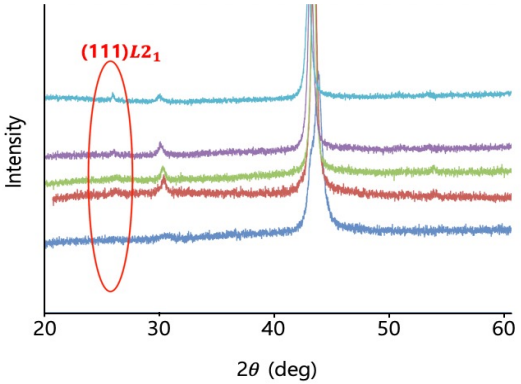
(a) High temp. mode of DSC with 10K/min (b) Low temp. mode of DSC with 10K/min

Research Internship

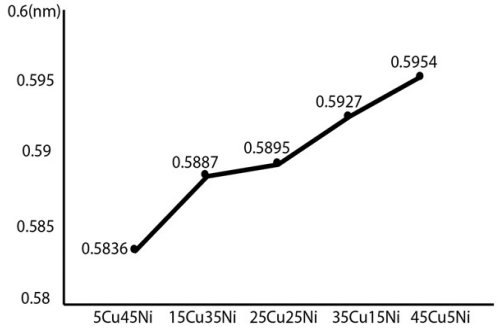
Results & Discussions:

B2-$L2_1$ order-disorder transition temp. & Curie temp.

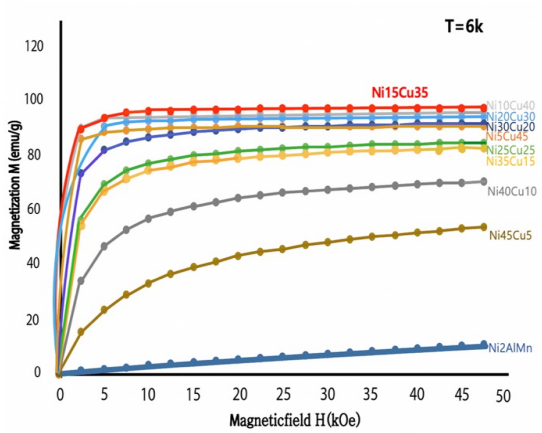
(a) XRD diffraction peak of $L2_1$



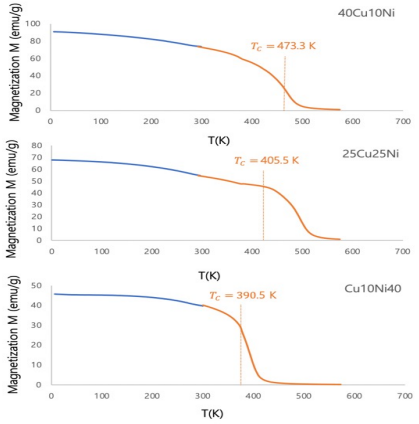
(b) Lattice constants



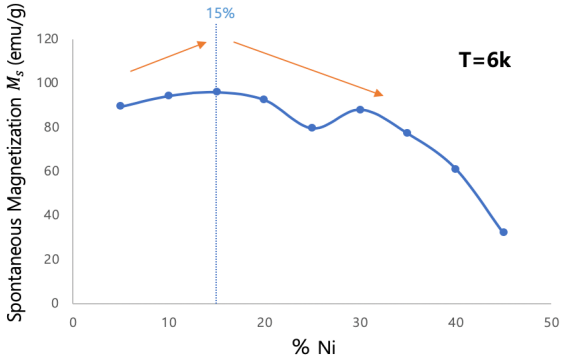
(a) M-H (Magnetization- Magnetic Field)



(b) M-H (Magnetization- Temperature)



(c) Spontaneous Magnetization M_S



▶ Research internship
Fraunhofer EMI, Freiburg

Research internship

- **Topic:** Process optimization and heat treatment of WHA (Tungsten Heavy alloy) manufactured by SLM

- **Motivation:** SLM as a new processing method for WHA, demand of investigation about process optimization and heat treatment.

- **Materials:** Maraging Steel(EOS MS1; Fe-19Ni-9.5Co-5.2Mo-0.8Ti-0.15Al-0.5Cr-C-Mn-Si) with Tungsten particles(TEKMATTM W-45)

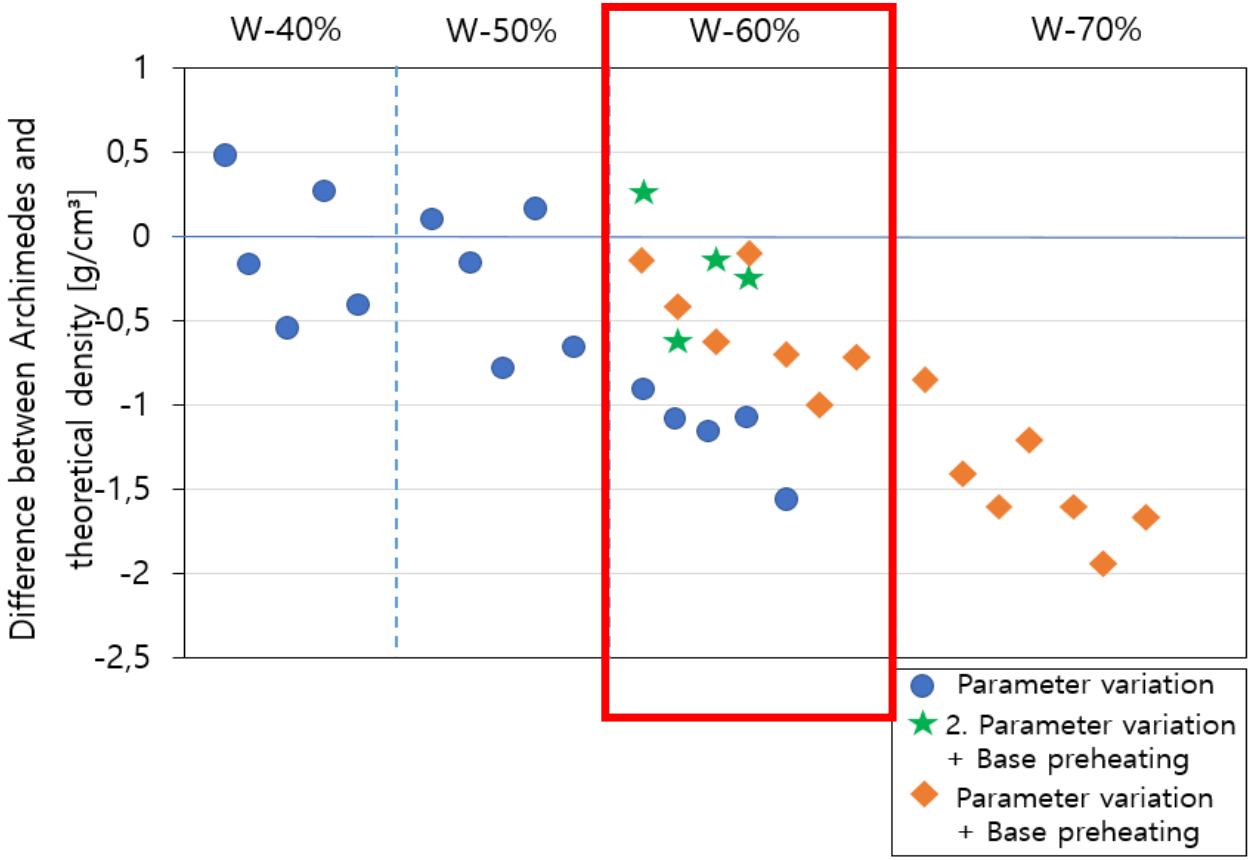
- **Experimental Procedure**
  - Archimedes density measurement
    Find ideal volume fraction of Tungsten(40-70%)
  - Variation of SLM process parameters
    Scanning speed, Laser Power, Hatch distance
    (400 - 500mm/s), (90 - 110W), (0.07 - 0.09mm)
  - Annealing process
    (460-1200ºC)
  - LOM, SEM (BSE, EDS Analysis)
    Microstructure, Fractography, Elemental analysis

► Research internship

► Results & Discussions

▷ Archimedes density measurement

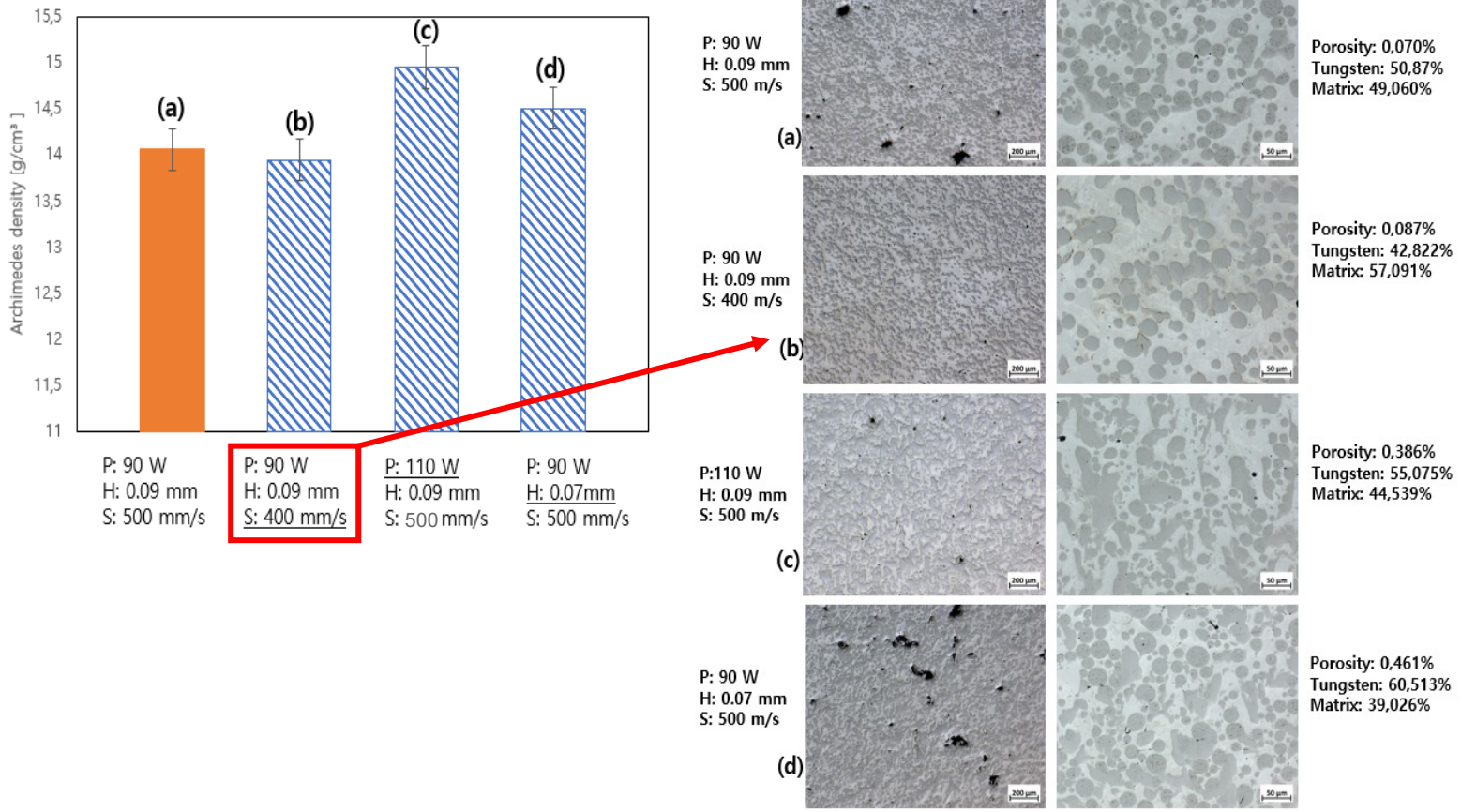
60 vol. % of tungsten was determined



► Research internship

► Results & Discussions

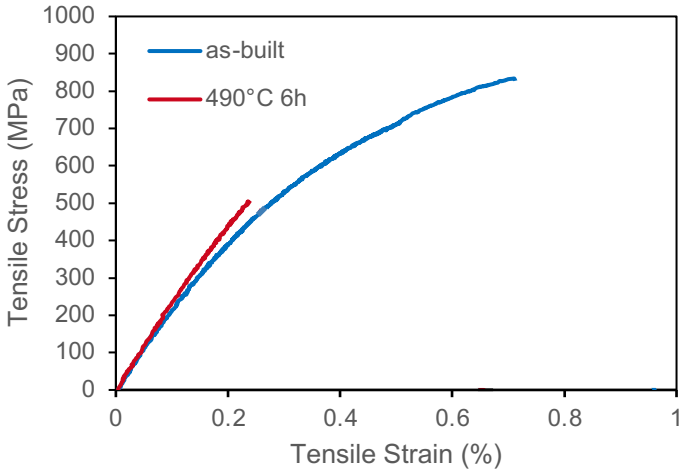
▷ Optimization SLM process parameter

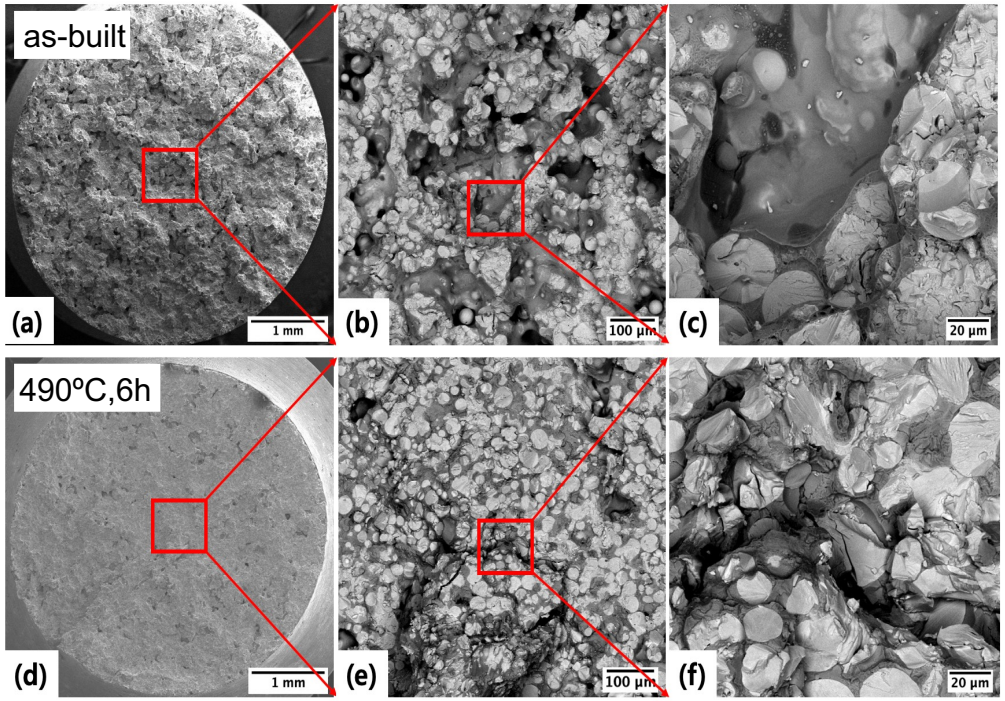


Research internship

Results & Discussions

Influence of annealing process

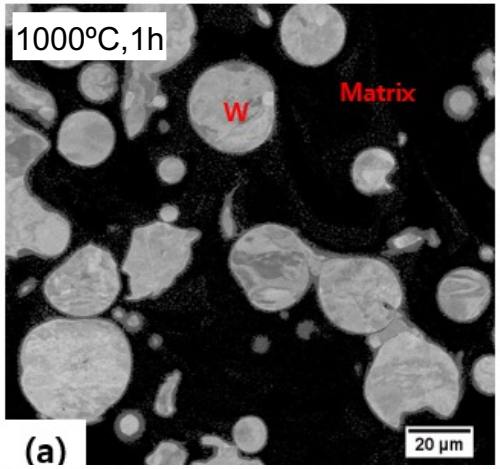


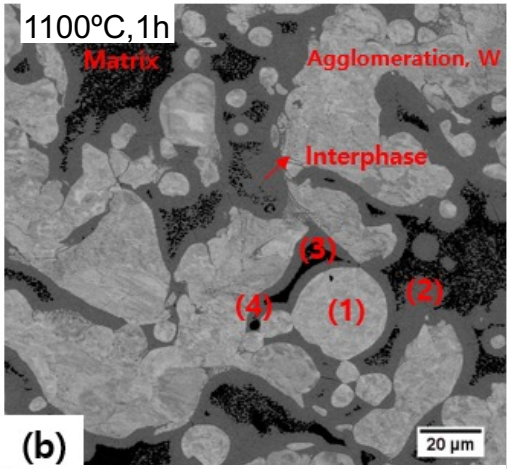


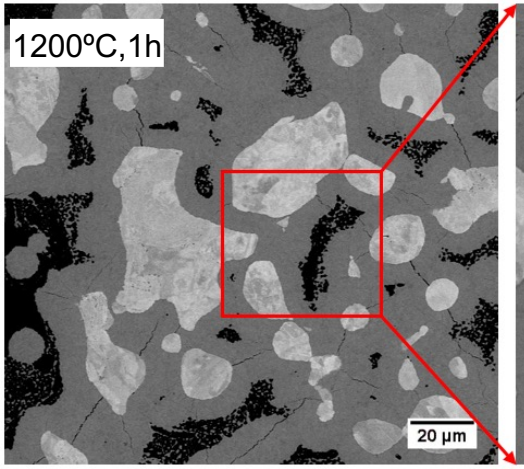
► Research internship

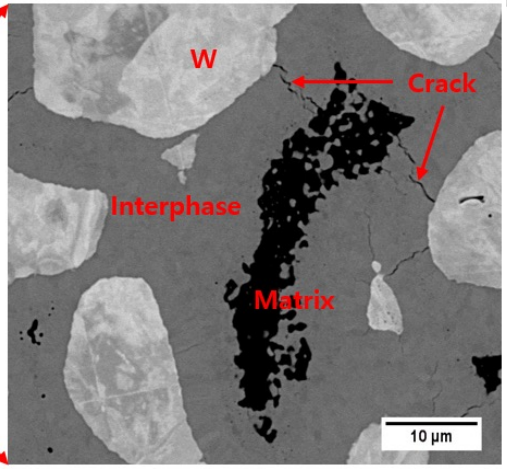
► Results & Discussions

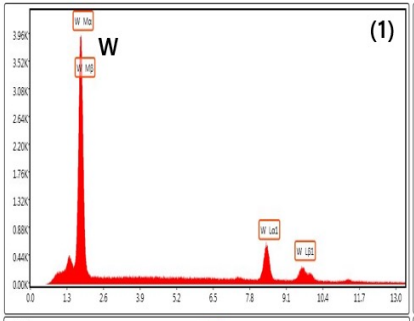
▷ Influence of annealing process

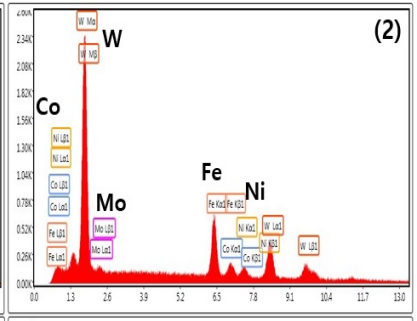


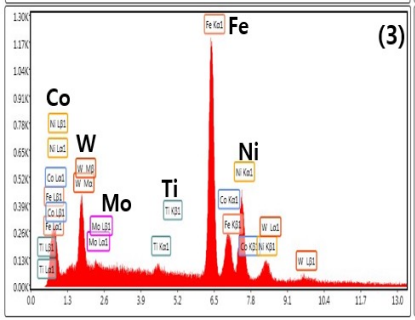


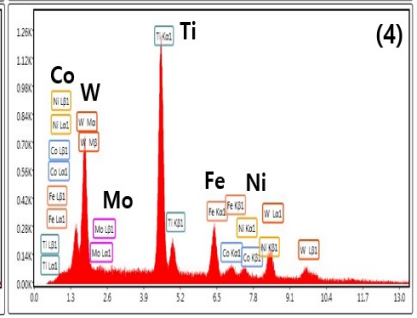












► Mini thesis
Fraunhofer ILT, Aachen

Mini thesis

- **Topic:** Influence of scanning speed and laser beam diameters on microstructure of ODS alloy in Laser Metal Deposition

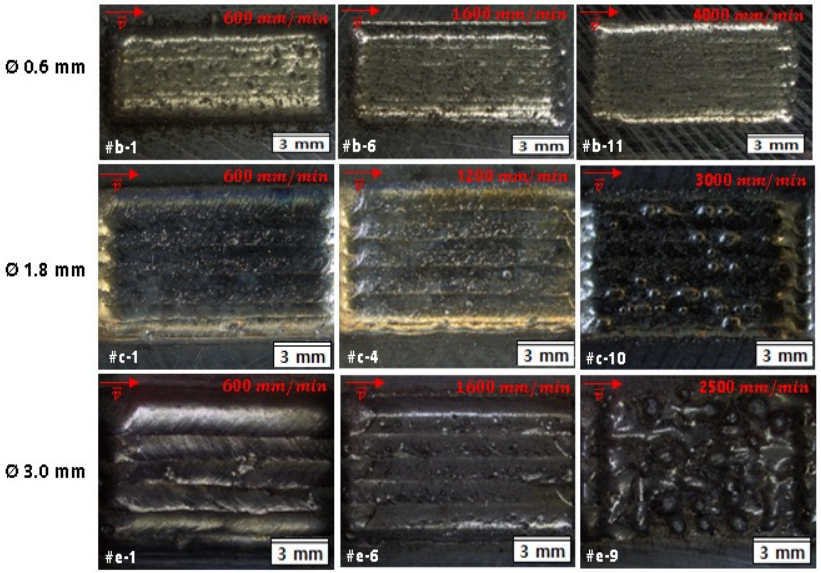
- **Motivation:** Lack of microstructural study according to the different parameters of Laser Metal Deposition (LMD)

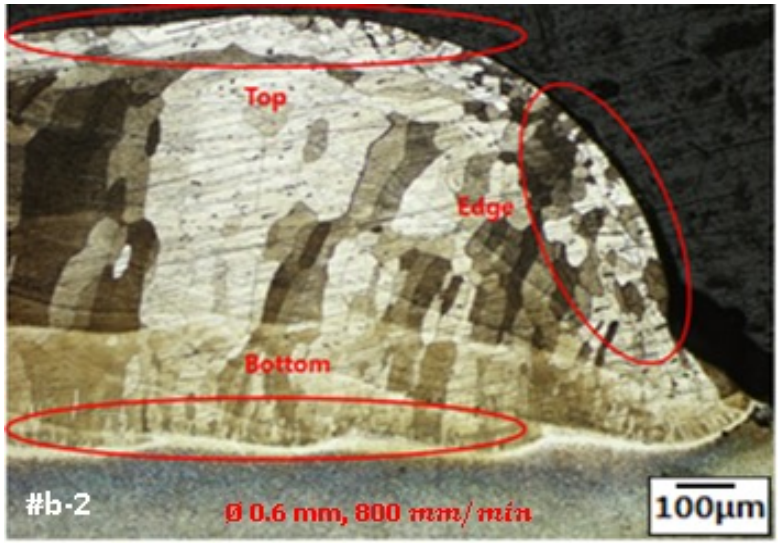
- **Materials**
  - Powder material: Fe-20Cr-4.5Al-0.5Ti (PM 2000)
  - Substrate material: hot-working steel 32CrMoV12-28 (1.2365)

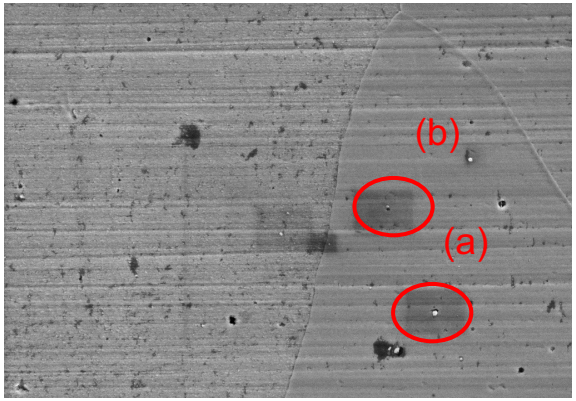
- **Experimental Procedure**
  - Mechanical alloying of powder materials
  - Variation of LMD process parameters
    Scanning speed, Laser beam diameter
    (600-2500 mm/min) (0.6-3.0mm)
  - LOM, SEM, EDS Analysis
    Microsturcture, Elemental analysis

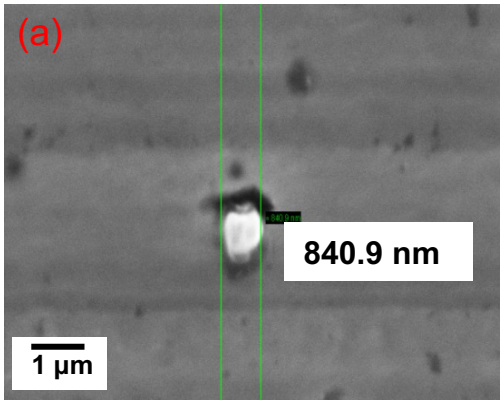
► Mini thesis

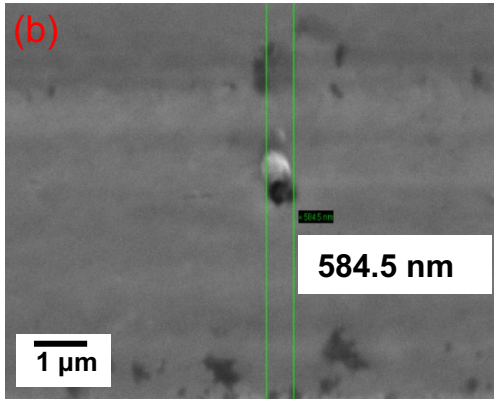
► Results & Discussions











Thank you for your attention