Particle reinforcement of CoCrFeNi by targeted powder synthesis and selective laser melting

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Particle strengthened Compositionally Complex Alloys
interlinking powder synthesis, additive manufacturing, microstructure evolution and deformation mechanisms
Project course

Dr. Uhlenwinkel
WP1 Powder fabrication

Dr. Jägle
WP2 Additive manufacturing

Prof. Dehm
WP3 Characterization

Time

CoCrFeNi
4 - Elements

AlCoCrFeNi
5 - Elements

AlMnCoCrFeNi
6 - Elements
Gas atomization

Actual flowability

Desired flowability

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Adjusting flowability

\[ \text{SAC} = \frac{A_{\text{Nano particle}}}{S_{\text{Metal particle}}} \]

- \( w_{\text{SiO}_2} = 0 \text{ Ma.-%} \)
- \( w_{\text{SiO}_2} = 0.004 \text{ Ma.-%} \)
- \( w_{\text{SiO}_2} = 0.008 \text{ Ma.-%} \)
- \( w_{\text{SiO}_2} = 0.028 \text{ Ma.-%} \)

SAC = 0 %
SAC = 1.1 %
SAC = 1.7 %
SAC = 5.8 %
SLM parameters

- SLM process parameters:
  - Power [W]: Various
  - Scan speed [m/s]: Various
  - Layer thickness [µm]: 70
  - Height [µm]: 90
  - Diameter [µm]: 90

Graph showing the relationship between scan speed [m/s] and power [W].
Characterization

XRD

Single phase A1
Characterization

STEM – LAADF
High dislocation density

EDS

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Correct composition & Homogeneous distribution

Desired elemental concentration 25 at. %

**Cr**
24.9 ± 2.6 at. %

**Co**
25.3 ± 2.4 at. %

**Fe**
24.4 ± 2.5 at. %

**Ni**
25.4 ± 2.7 at. %
Single phase and homogeneous composition at nanoscale.

Fe

Ni

20 nm

Co

Cr

ZA [110]
Nitriding

1. During atomization

N$_2$ purging into melt

2. During atomization

N$_2$ atmosphere during process
1. During atomization

- Purging rod (N₂ supply)
- Crucible with cast ingot
Nitriding during atomization

N\textsubscript{2} atmosphere during process

STEM - HAADF

ca. 50 nm particles

80 µm

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Conclusion & Outlook

- Atomization & SLM optimized
- Single phase HEA
- High dislocation density
- Nitriding works

Deformation behavior by in-situ SEM & in-situ TEM deformation
"Coming together is a beginning. Keeping together is progress. Working together is success." – Henry Ford