# In-Situ Manufacturing of ODS FeCrAl Alloy via Selective Laser Melting

Saereh Mirzababaei[1,2], Milad Ghayoor[1,2], Somayeh Pasebani[1,2]

[1] School of Mechanical, Industrial, and Manufacturing Engineering, Oregon State University, [2] Advanced Technology and Manufacturing Institute (ATAMI)

## Abstract

Oxide dispersion strengthened (ODS) FeCrAl alloys are promising candidates for aggressive environments and accident tolerant fuel cladding application due to their high strength and oxidation resistance at elevated temperatures. Conventionally, mechanical alloying of FeCrAl with yttria nanoparticle followed by hot consolidation was used to manufacture ODS FeCrAl alloy.

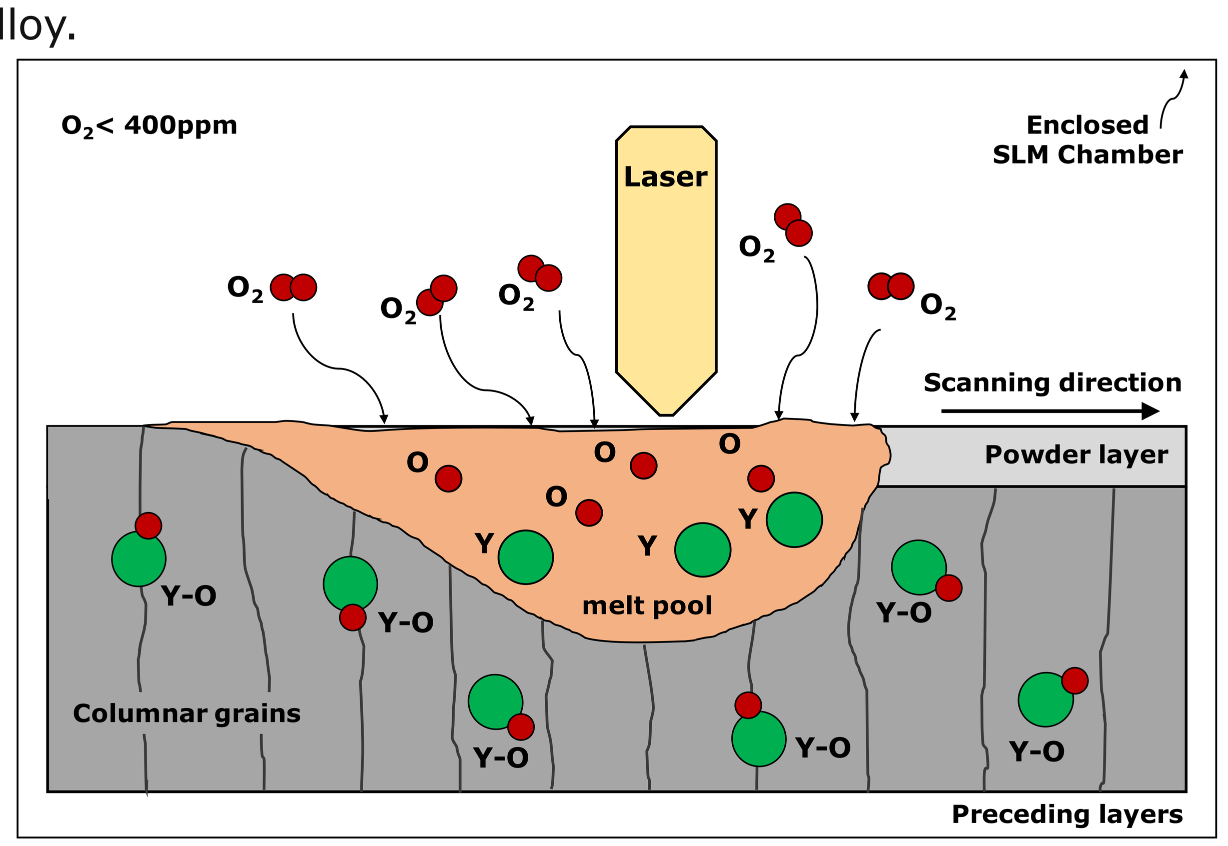


**Figure1. Schematic of In-Situ Manufacturing of ODS FeCrAlY in SLM**

This work aimed to adopt 3D printing/additive manufacturing, in particular, selective laser melting (SLM) to investigate the feasibility of in-situ manufacturing ODS FeCrAl alloys via SLM through the internal oxidation. FeCrAlY powder was used in presence of the residual oxygen inside the SLM chamber with no additional need for mechanical alloying with yttria nanoparticles.

## Motivation: Why In-Situ via SLM?

- Conventional methods for manufacturing of ODS alloys involve:
  - Too many costly and time-consuming steps
  - Contamination during mechanical alloying
  - Heterogeneous distribution of nanoparticles
- Formation of nano-sized oxide precipitates (Al-O and Y-O) during SLM process provides enhanced high temperature strength

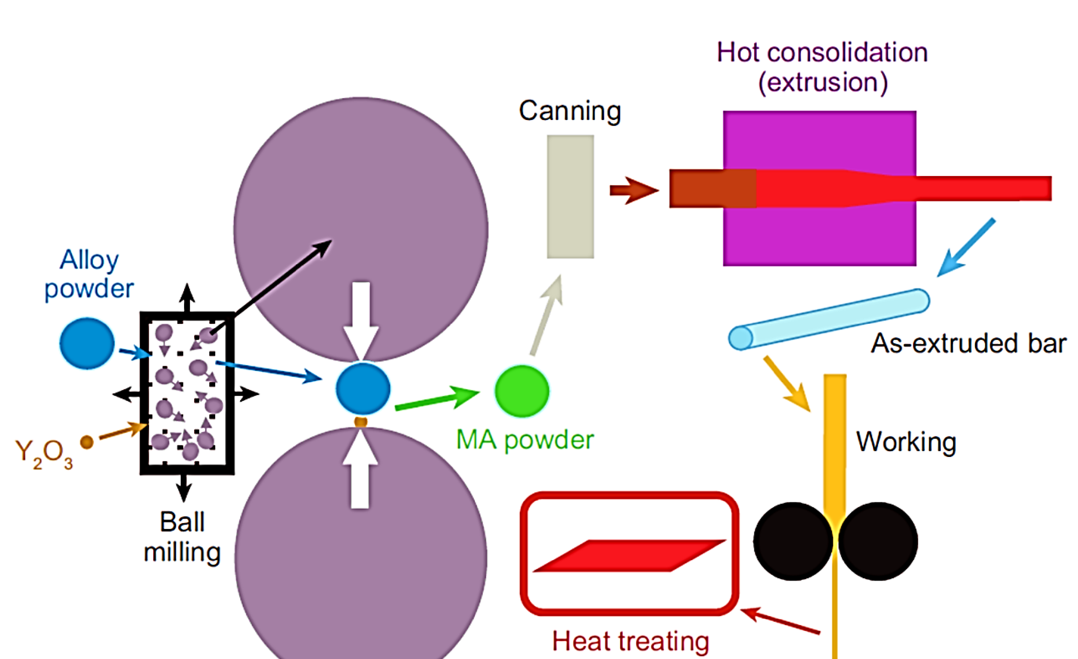


**Figure2. Conventional manufacturing of ODS alloys [1]**

## Experimental

Gas-atomized Fe–24Cr–8Al–0.5Y (wt.%) powder was procured from Orlikon Metco (D50=33μm), and used in SLM printer (OR Creator). The SLM parameters include Laser power; 100 W, Laser scan speed; 50-600 mm/s, Layer thickness; 30 μm and hatch spacing; 50 μm

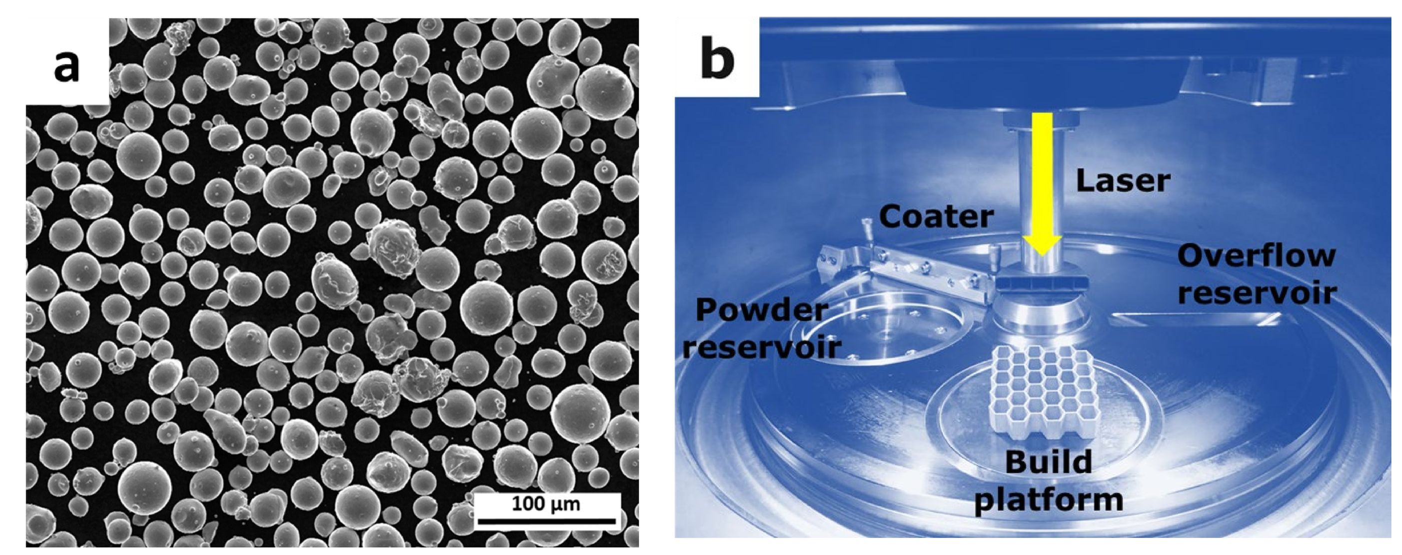


**Figure 3. a) SEM Micrograph of FeCrAlY powder, b) OR Creator SLM chamber**

## Results and Discussion

Figure 4 reveals precipitation of fine and spherical nanoparticles in the range of 20-100 nm. Formation of spherical nanoparticles implied that Y and Al precipitated in-situ within the matrix during solidification of SLM.

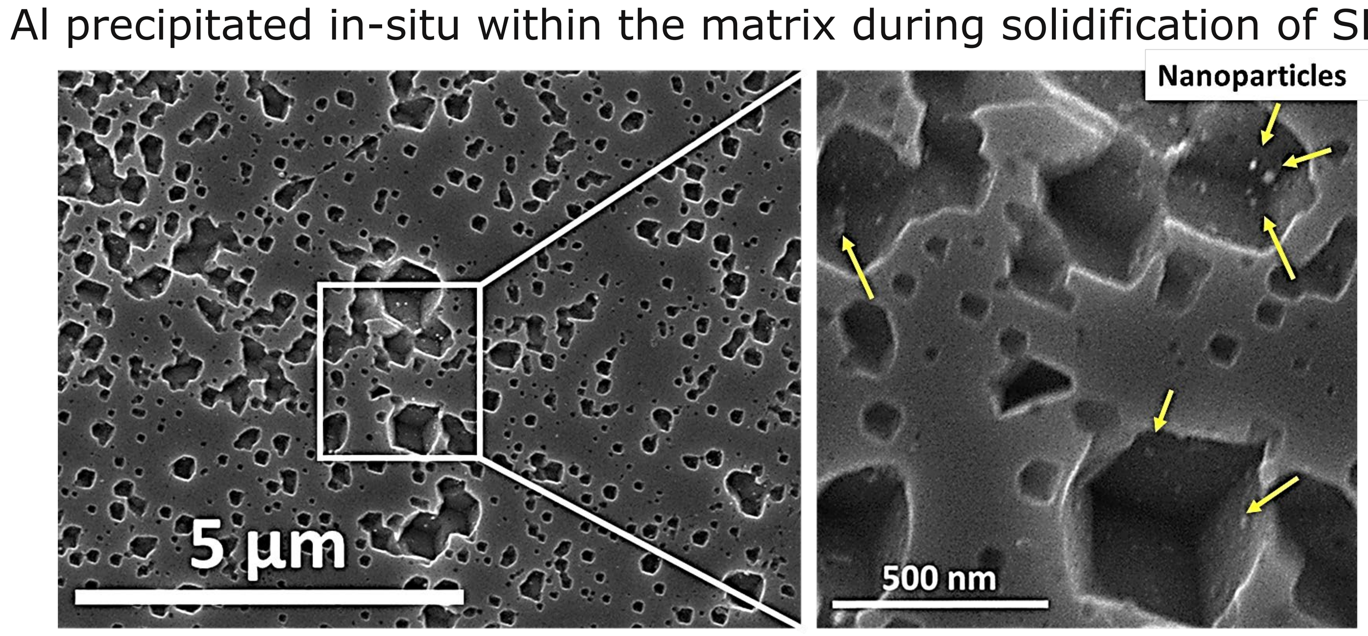


**Figure 4. SEM micrograph of ODS FeCrAlY showing precipitation of nanoparticles within the matrix**

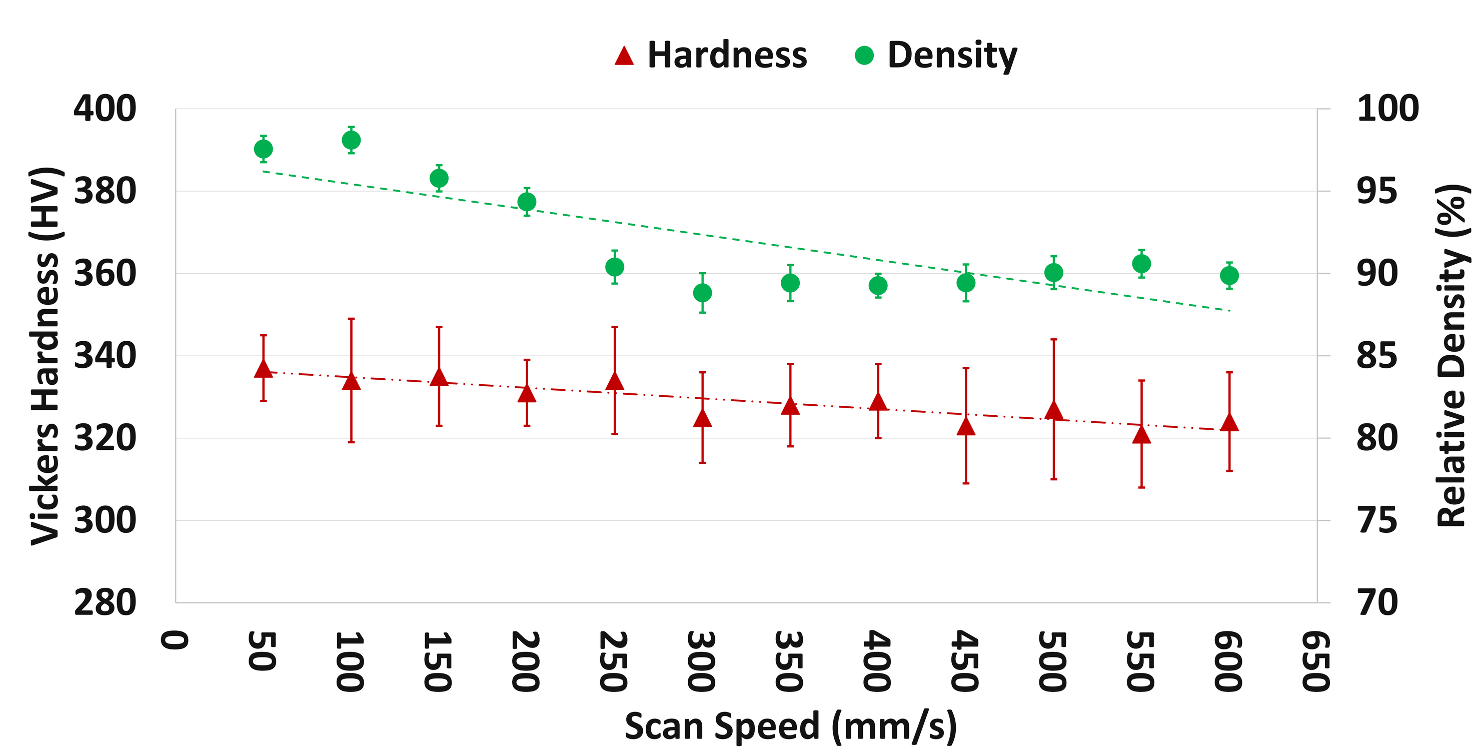


**Figure 5. Microhardness and relative density of SLM FeCrAlY parts at different scan speed**

Figure 5 displays that relative density decreased with increase of scan speed; however hardness of SLM FeCrAlY remained unchanged at different scan speeds. The highest density of 98%±0.4 was obtained for the sample printed at scan speed 100 mm/s with hardness of 335±8 HV.

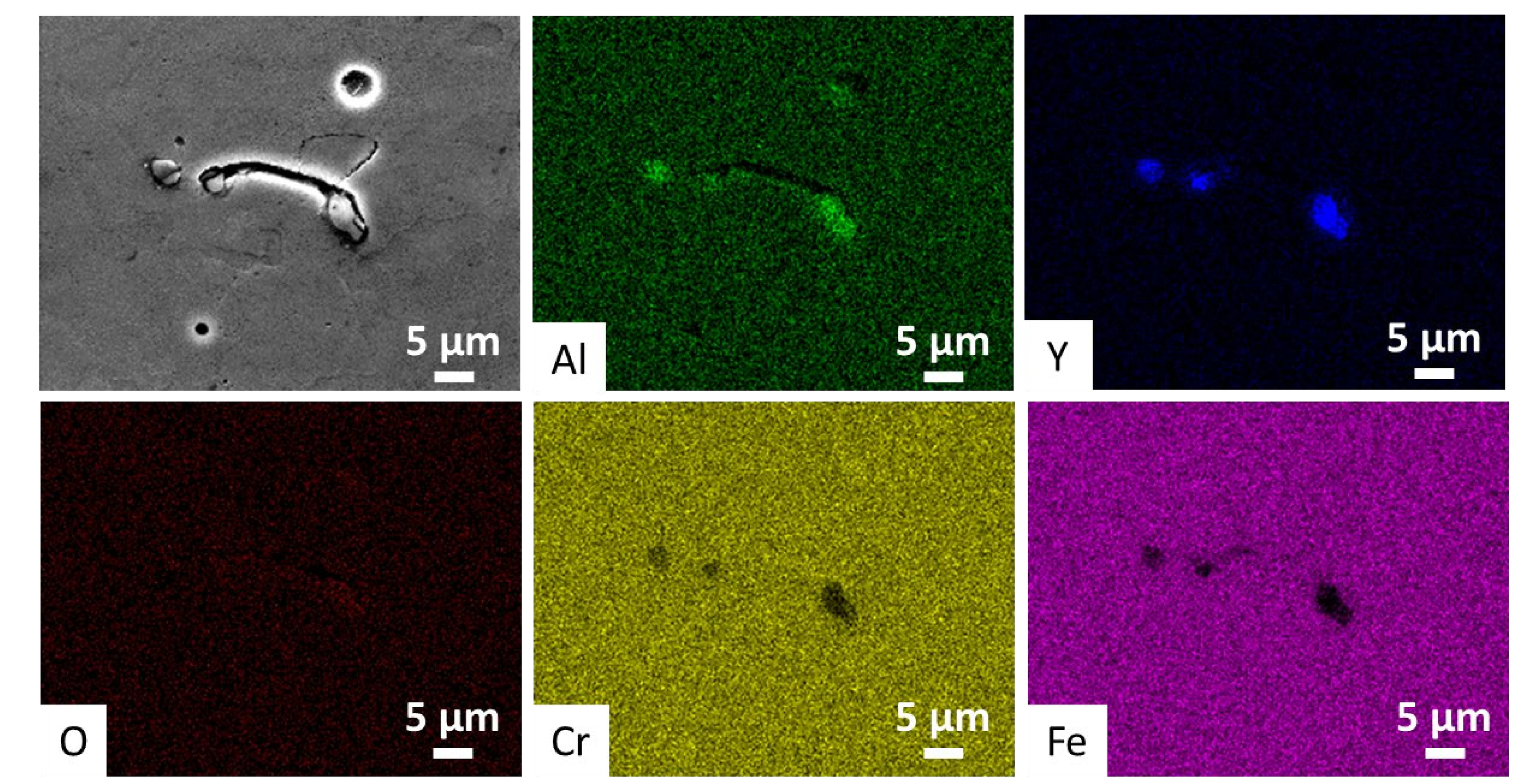


**Figure 6. HAADF micrograph and corresponding EDS elemental map of SLM FeCrAlY, identifying the agglomerated particles of yttrium, Aluminum, and oxygen**

Figure 6 presents the high-angle annular dark-field (HAADF) image and the corresponding energy dispersive X-ray spectroscopy (EDS) maps. According to the EDS analysis, Y and Al, in addition to precipitation, agglomerated in some regions and impeded achieving full density in SLM process.

## Conclusions

This study showed that by using SLM process, an ODS FeCrAlY was additively in-situ manufactured with less steps and time. Room temperature mechanical properties (e.g. hardness) of SLM FeCrAlY (335±8 HV) was acceptable compared to the closet available composition of conventionally manufactured FeCrAl alloy (Fe-15Cr-5Al-0.5$ZrO_2$-0.5$Y_2O_3$) with 388±7 HV hardness.

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## References

1. Annual Review of Materials Research, Vol.38, 2008, 471-503

ATAMI Advanced Technology and Manufacturing Institute
Oregon State University