Laboratory for Advanced Materials and Additive Manufacturing • AM[2]

Laser Powder Bed Fusion of White Cast Iron

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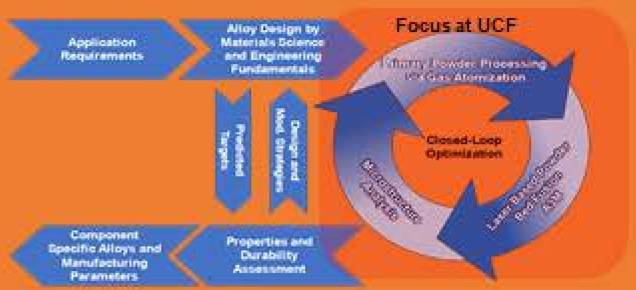
Research Objectives

- Identify the composition of Regolith via X-ray diffraction (XRD) and energy dispersive spectroscopy (EDS).
- Investigate White Cast Iron over a wide range of laser powder bed fusion (LPBF) processing parameters
- Identify the optimal combinations of processing parameters capable of producing high density, crack free parts.



Background

Regolith is a blanket of unconsolidated, loose, heterogeneous superficial deposits covering solid rock. It is important to scientists and engineers for space/planetary exploration and settlement because:

- ✓ High oxygen content
- ✓ Electrolysis process can produce oxygen from metal oxides found in the regolith
- ✓ Metals produced can be alloyed to produce structural components required on-site

White Cast Iron- Class III Type A of ASTM A532/A532M, was chosen because:

- ✓ Tough against high impact
- ✓ Excellent abrasion resistant
- ✓ Commonly used alloy

Acknowledgments

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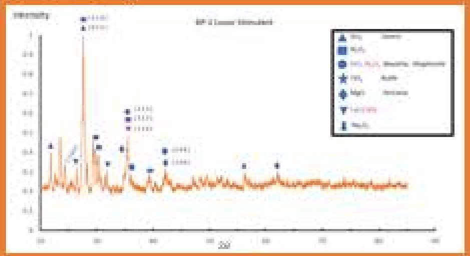
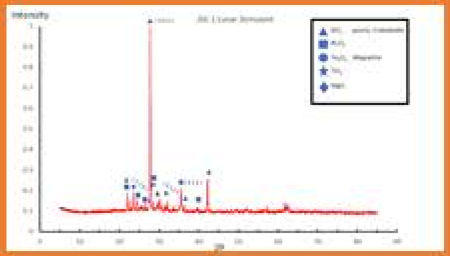
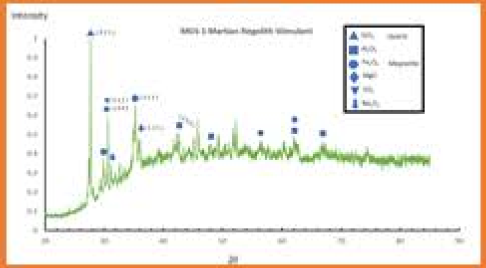
Results

X-ray Diffraction (XRD) data demonstrates that the regolith contains oxides of metals such as Fe, Si, Al, Ti, Mg and Ca.







A significant cracking (slow scan at 100 mm/s) or lack of fusion (fast scan at 600 mm/s) were observed for sample built by LPBF.

Future Work

Modification of alloy composition based on regolith constituents such as Fe, Si, Al and Mg should be explored to develop metallic alloy composition suitable for additive manufacturing of engineering components, on-demand and on-site

Laser Powder Bed Fusion

Laser powder bed fusion (LPBF), the most popular additive manufacturing technology, involves selectively laser melting (SLM) and fusing of metal alloy powders, building (or printing) an engineering component, layer by layer.

LPBF has an ability to produce complex parts with little to no post-processing

Four main processing parameters which can be normalized into "energy density"

- ✓ Laser power (W)
- ✓ Scan speed (mm/s)
- ✓ Hatching distance (mm)
- ✓ Layer thickness (mm)

$$\text{Energy Density} = \frac{\text{Laser Power}}{\text{Scan Speed} * \text{Hatch Spacing} * \text{Slice Thickness}}$$

Experimental Methods

Parametric Investigation of LPBF for White Cast Iron

ID	Laser Power (W)	Scan Speed (mm/s)	Hatch Spacing (mm)	Slice Thickness (mm)	Focus (mm)	ED ([illegible])
1	300	800	0.12	0.03		104.16
2	300	1000	0.12	0.03		83.33
3	300	1200	0.12	0.03		69.44
4	300	1400	0.12	0.03		59.52
5	300	1600	0.12	0.03		52.08
6	300	1800	0.12	0.03		46.29
7	300	2000	0.12	0.03		41.66
8	300	2200	0.12	0.03		37.87
9	300	2400	0.12	0.03		34.72
10	300	2600	0.12	0.03		32.05
11	300	2800	0.12	0.03		29.76
12	50	400	0.06	0.03	2	69.44
13	50	400	0.06	0.03	4	69.44
14	50	400	0.06	0.03	6	69.44
15	50	400	0.06	0.03	8	69.44
16	50	400	0.06	0.03	10	69.44

Microstructural Analysis

Samples were metallographically prepared by sectioning them in both the XY and XZ planes with respect to the build direction. Mounted in epoxy and polished to 1 um diamond paste and observed under an optical microscope.