LENS® MATERIAL STARTER RECIPES

LENS Material Starter Recipes are time saving tools helping customers speed the development of new additive manufacturing applications. Developed by Optomec LENS application engineers and material scientists, each recipe provides detailed instructions covering powder feedstock characteristics, machine set-up, processing parameters and expected results for a variety of commercially available powders. Each recipe is also geometry specific providing time savings guidelines to produce quality results for thin wall, small volume and large volume structures. Optical and SEM images showing the microstructure and morphology of samples printed using each recipe are provided. Tensile tests conducted by an independent lab are also provided for small and large volume structures according to ASTM Standard E8.

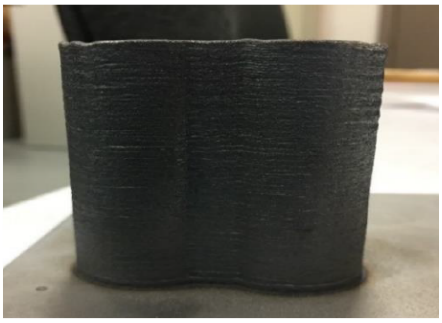

Figure 1: Single Wall Dumbbell Structure Fabricated from Stainless Steel 420LC

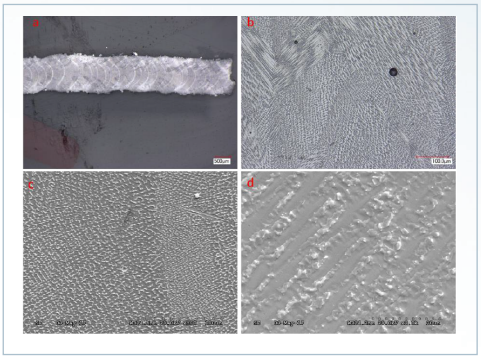

Figure 2: Optical and SEM images showing the micostructure and morphology of LENS deposited SS 420 LC

Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Reduction of Area (%)	Elongation (%)
ksi	MPa	ksi	MPa		
172.10 ± 12.99	1186.58 ± 89.56	157.16 ± 2.85	1083.58 ± 19.65	4.36 ± 0.49	0.53 ± 0.25

Table 1: Tensile Properties of LENS processed SS 420LC in open environment.

Commercially available annealed stainless steel 420 typically has ultimate tensile strength of 95 ksi or 655 MPa whereas commercially available stainless steel 420 tempered at 593°C/1100°F typically has ultimate tensile strength of 150 ksi or 1035 MPa.

KEY FEATURES

- Developed by Optomec Experts – save weeks of trial and error
- Proven – use with confidence
- Commercially Available Powders – easy to repeat results
- Geometry Specific – speed application development
- Independently Tested –assure quality results

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EXAMPLE LENS® STARTER RECIPES

For a full list of available LENS recipes, please contact sales@optomec.com

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LENS Material Starter Recipe

Revision Date: May 19, 2017

Scope: Inconel Alloy, Large
Atmosphere (OA)
Deposition Head: 4-tip LPI

Powder Information

- Material: Inconel 718
- Manufacturer: Carpen
- Powder Shape and Siz (-140+325 Mesh)

Laser and Optics Set

- Laser Fiber: 300 µm
- Collimator: 60 mm
- Focusing lens focal len
- LPE Knob Position: 0.5
- Stand-off distance: 0.3
- Estimated Laser Spot S
- Relative Spot Position: 0.247" or 6.27 mm
- Substrate Thickness: 6
- Melt Pool Sensor: Not

Powder Feeder and

- Powder Feed Rate: 16
- Powder Mass Flow Ra
- Powder Feeder Argon
- Center Purge Gas Argo

Powders with different pa characteristics. Please per The plot in Figure 2 can se

Atmosphere Settings

- Atmosphere: Open En
- Diffuser/Shield Gas: N

Print Parameters

- Layer Thickness: 0.022
- Number of layers: 45 f
- Hatch Spacing: 0.022"
- Hatch Orientation: 0°-
- Laser Power: 650W
- Laser Power Density: 1
- Print Speed/ Scan Spe hatch
- Post Processing: None

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Expected Results

- Mass Deposition Rate: Approxima
- Microstructure

Figure 3 shows the unetched cros isolated porosity can be seen in the Z isolated porosity was observed as see

Figure 3: SEM Images in the Z build directi the X, Y build direct

Figure 4 shows the microstructure an build direction in Figures 4(a) and 4 (these images, in the XY build directio the remelting of the previously depos The microstructure evolution and the was similar and the collage in Figure 5 of the Inconel 718 deposit in the XY a representative images of the Inconel

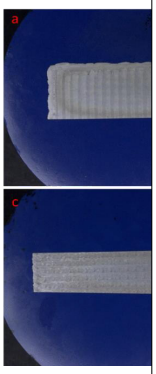

Figure 4: Optical Ima deposit in the XY build

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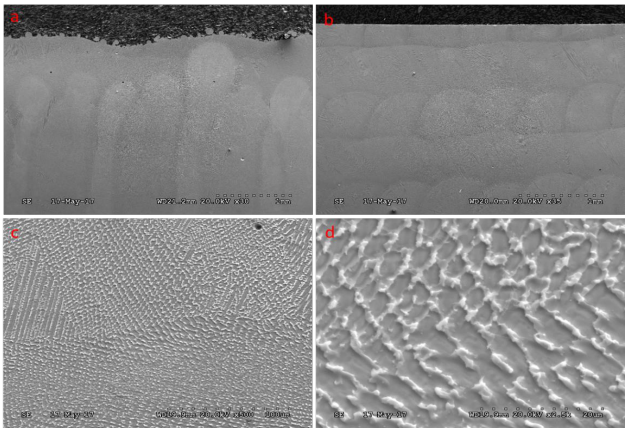

Figure 5: Optical and SEM Image of Inconel 718 at 650W: (a) Morphology in XY build direction; (b) Morphology in Z build direction and (c), (d) Higher magnification image of the morphology on the deposit.

- Tensile Properties- tensile test specimens were fabricated according to the above-mentioned process parameters and machined to ASTM Standard E8. Testing was done on the as LPE/LENS processed samples without any heat treatment, at room temperature, at an independent material testing laboratory in accordance with the above-mentioned ASTM standard. Table 1 below shows the tensile properties of the samples.

Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Reduction of Area (%)	Elongation (%)
ksi	MPa	ksi	MPa		
137.33 ± 1.38	946.85 ± 9.51	81.6 ± 0.95	562.61 ± 6.55	30.33± 1.79	26.06 ± 0.64

Table 1: Tensile Properties of LPE processed Inconel 718 at 650W in open environment.

Commercially available Inconel 718 alloy typically has ultimate tensile strength of 140-190 ksi or 965.26-1310 MPa depending upon the heat treatment given and the testing temperature.

Comments

For lasers sources or optics that produce a different spot size, the aim should be to achieve the laser power density as close to the energy density mentioned above. Application specific process development is advised for complex designs, powders with different particle size distribution and different grades of Inconel alloys.

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ABOUT OPTOMEC

Optomec® is a privately-held, rapidly growing supplier of Additive Manufacturing systems. Optomec's patented Aerosol Jet Systems for printed electronics and LENS 3D Printers for metal components are used by industry to reduce product cost and improve performance. Together, these unique printing solutions work with the broadest spectrum of functional materials, ranging from electronic inks to structural metals and even biological matter. Optomec has more than 300 marquee customers around the world, targeting production applications in the Electronics, Energy, Life Sciences and Aerospace industries. For more information about Optomec, visit http://www.optomec.com.

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