Indirect Selective Laser Sintering of Nuclear Cermets

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Outline

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- Indirect Selective Laser Sintering
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- I-SLS Cermet Design Guidelines
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Project Motivation

- We must first understand how advanced manufacturing can impact nuclear technology to understand how it could affect proliferation

- Cylindrical uranium oxide (UO_2) has advantages but also has some disadvantages for advanced reactor design
  → High melting point (positive)
  → Simple shape is not optimized for heat transfer or fission gas escape (negative)
  → Low thermal conductivity (negative)
  → Low uranium density (negative)

- Indirect SLS can address these issues without fully sacrificing the benefits

Figure 1: Cylindrical Heat Exchanger produced via AM [1]

Selective Laser Sintering

- SLS is an industrial additive manufacturing process used for polymer components

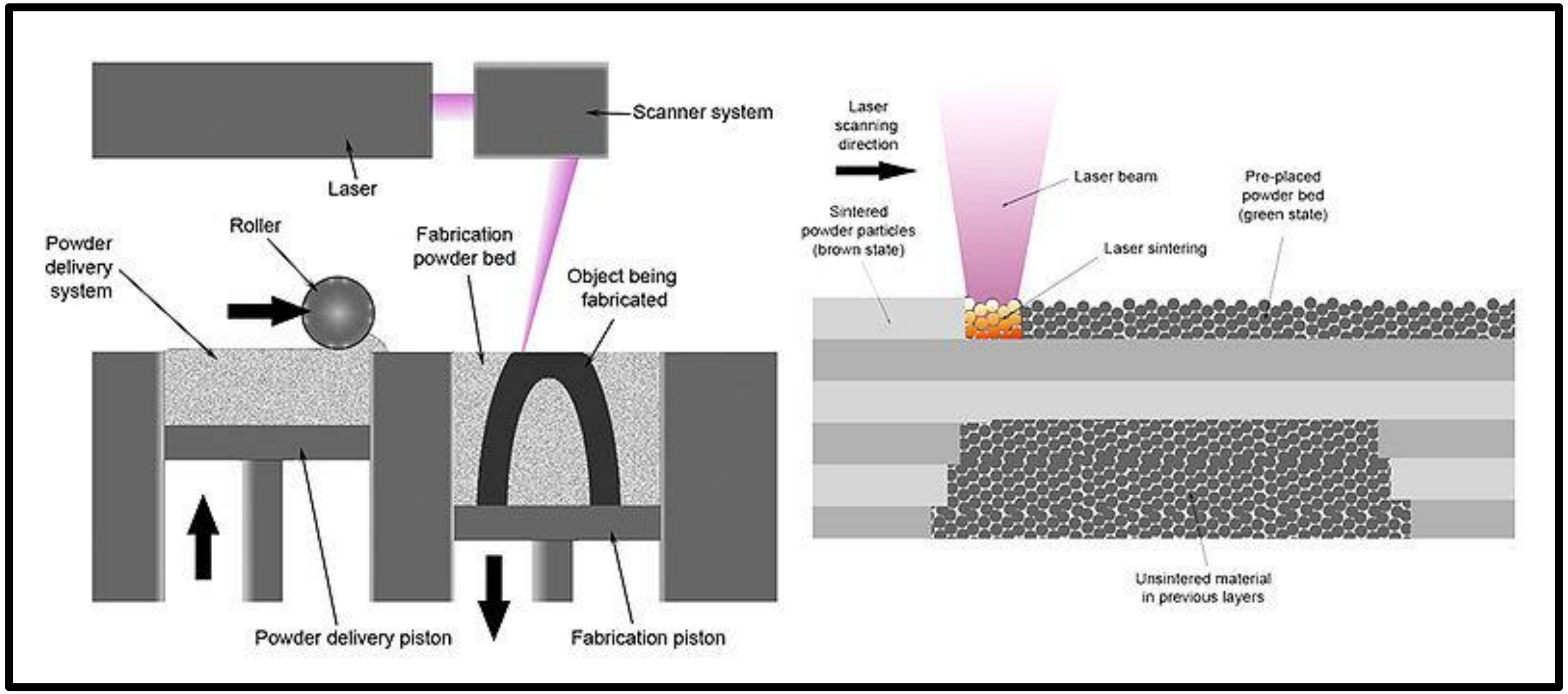

Figure 2: Overview of Selective Laser Sintering [2]

Indirect Selective Laser Sintering (I-SLS)

- The SLS process can be modified to print complex ceramic structures
  → These porous structures can be infiltrated with metal to create complex cermets

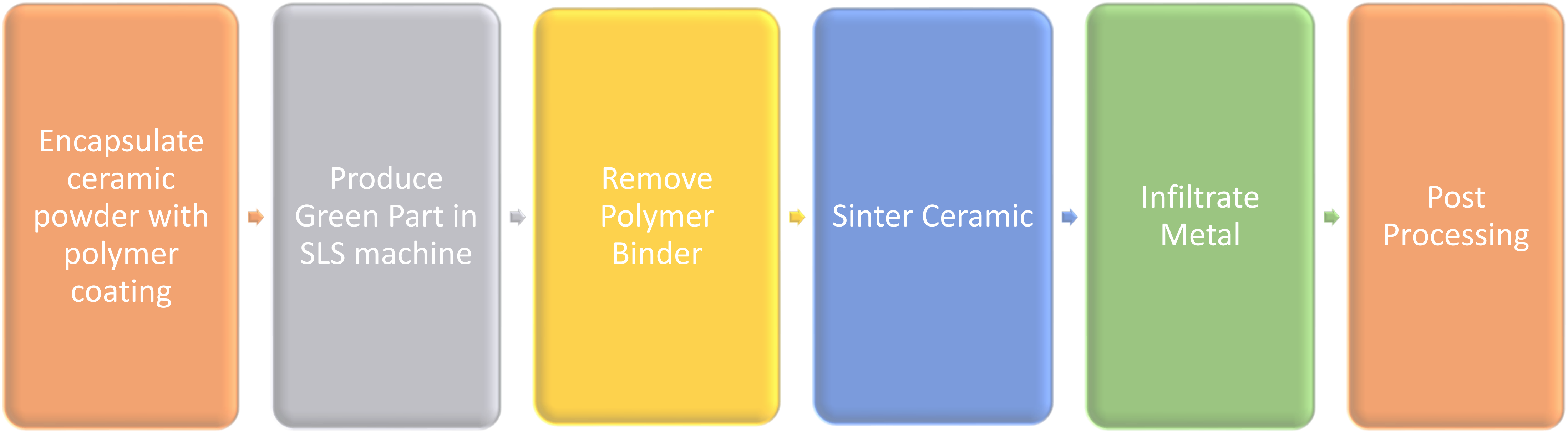

Figure 3: Proposed I-SLS Process

Predicting Cermet Material Properties

- Currently there is no material property data for cermets produced via I-SLS
  - →Yield Strength (if applicable) and UTS
  - → Thermal Conductivity and Expansion
  - → Max Operation Temperature (Creep)

- The Voigt (Iso-strain) and Reuss (Iso-stress) models provide boundaries the properties must fall within.
  - → The average of the two is a reasonable place to expect the true value

- Test specimens with different ceramic volume fractions will be manufactured and tested to model the properties as a function of ceramic volume fraction

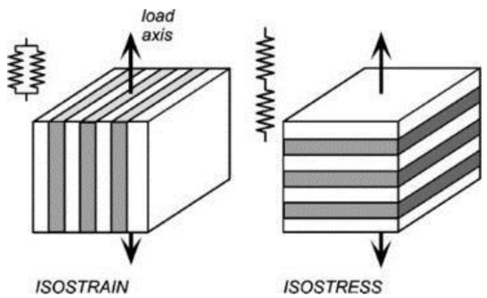

Figure 4: Composite Property Models [3]

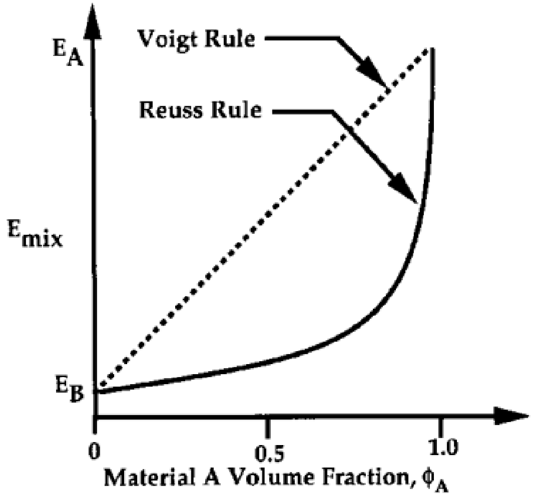

Figure 5: Plot of Voigt and Reuss Models [4]

Design Guidelines for I-SLS Cermets

- To complete the engineering design loop, we must evaluate what geometries are capable of being printed.
- Metrology parts will be printed to see what geometries survive the I-SLS process
- These studies will provide design guidelines for future engineers to use with nuclear applications utilizing complex cermets

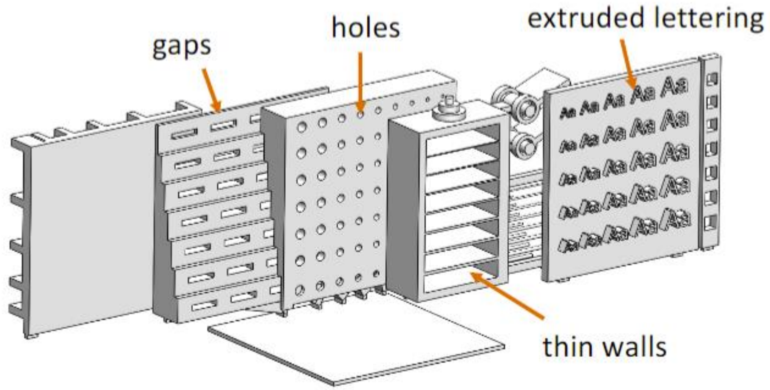

Figure 6: Metrology Piece for Design Guidance [5]

	Holes						
	Hole Diameter (mm)						
Wall Thickness (mm)	2.0	1.8	1.6	1.4	1.2	1.0	0.8
1.0	0.96	0.95	0.94	0.92	0.85	0.76	0.69
2.5	0.91	0.88	0.86	0.78	0.7	0.57	0.41
4.0	0.83	0.8	0.69	0.6	0.49	0.35	0.23
5.5	0.68	0.6	0.55	0.43	0.35	0.24	0.05
7.0	0.58	0.51	0.43	0.36	0.22	0.13	0.04
8.5	0.5	0.43	0.37	0.26	0.16	0.07	0.04
10.0	0.5	0.4	0.32	0.17	0.08	0.06	0.04

Figure 7: Example of Established Design Guideline [5]

ACKNOWLEDGEMENTS

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Questions and Remarks

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Thank you!

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