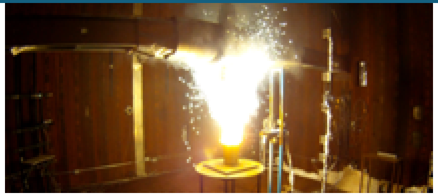
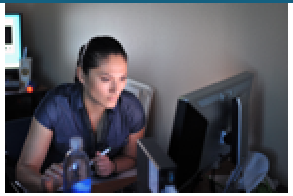
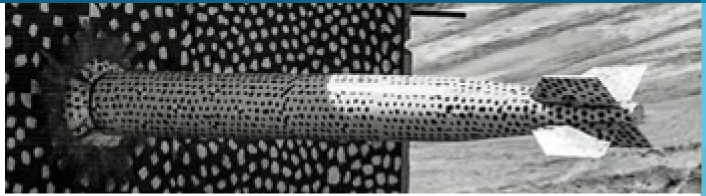
SAND2022-0735C

Sandia National Laboratories

Developing and Characterizing Ceramic Feedstock for DLP Additive Manufacturing

Dale Cillessen

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Presenter Introduction

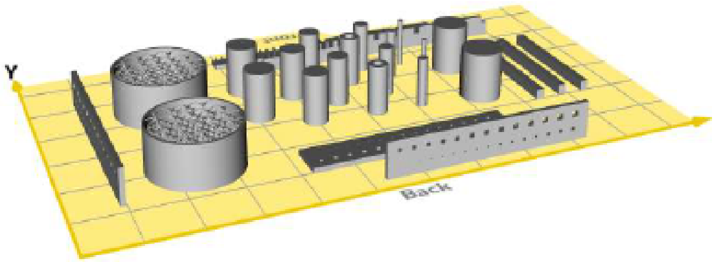
Dale Cillessen, P.E.

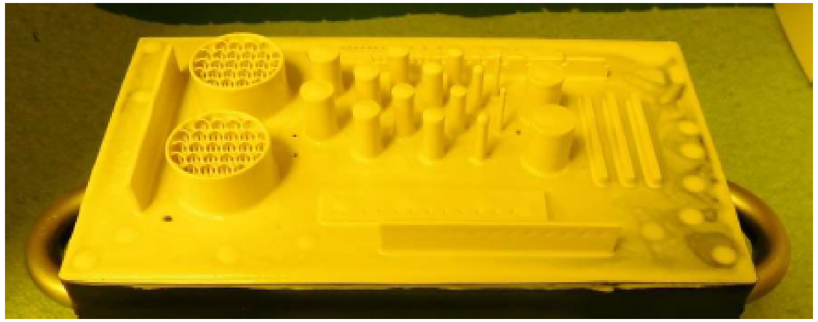
A Senior Member of the Technical Staff in the Applied Science Technology Maturation Department at Sandia National Laboratories in Albuquerque, NM. Dale is the engineering operational lead of Sandia’s metal and ceramic printing facility. His research focuses on developing accurate, repeatable, structurally sound advanced manufactured components.

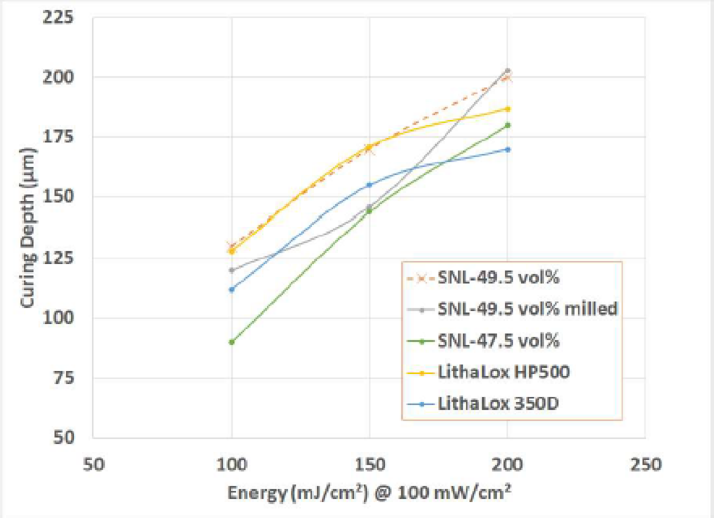
Developing Feedstock

Development and characterization of glass-bonded alumina (94% Al_2O_3, 1.5% MgO, 1.2% CaO, 3% SiO_2). The addition of Silica allows for processing at lower temperatures compared to pure Al_2O_3.

In 2018, Lithoz America successfully combined SNL's glass-bonded alumina with photocurable resin and established the initial processing parameters.



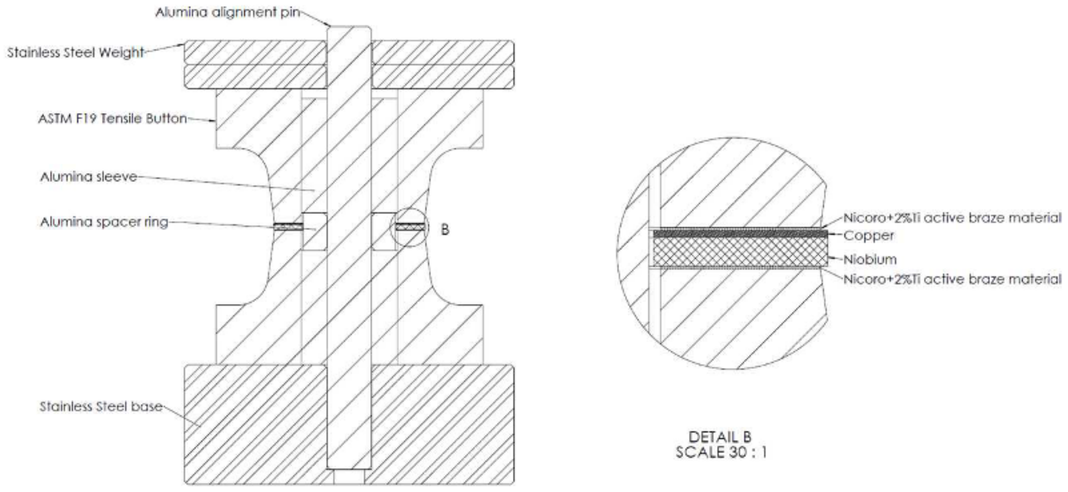




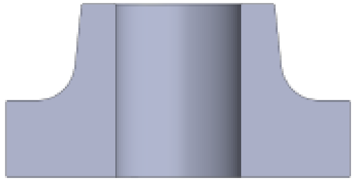
Parameter	*Standard Value*	*Range*	*Influencing parameters*
Geometry			
Layer thickness [µm]	25	15 – 50	Resolution vs. printing speed
Support structure thickness [µm]		240-360	Mass of the part & support design
Geometry corrections			
Contour offset [µm]	-40	0/-20/-40	Tolerances
Pixel alignment	Yes	Yes	Tolerances
Lateral (XY) shrinking compensation	1.203		Tolerances
Build direction (Z) shrinking compensation	1.353		Tolerances
Z curing depth compensation	Yes	No/Yes	Lateral channels/holes
Z curing depth compensation layers	1	0 - 3	Tolerances

Initial printed component characterization

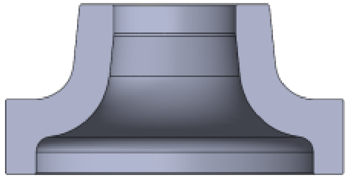
ASTM F19-11 tensile buttons evaluation. Tensile buttons were evaluated in computer tomography and proved to be challenging to manufacture for the DLP printing technology.



Standard Test Profile Cross Section

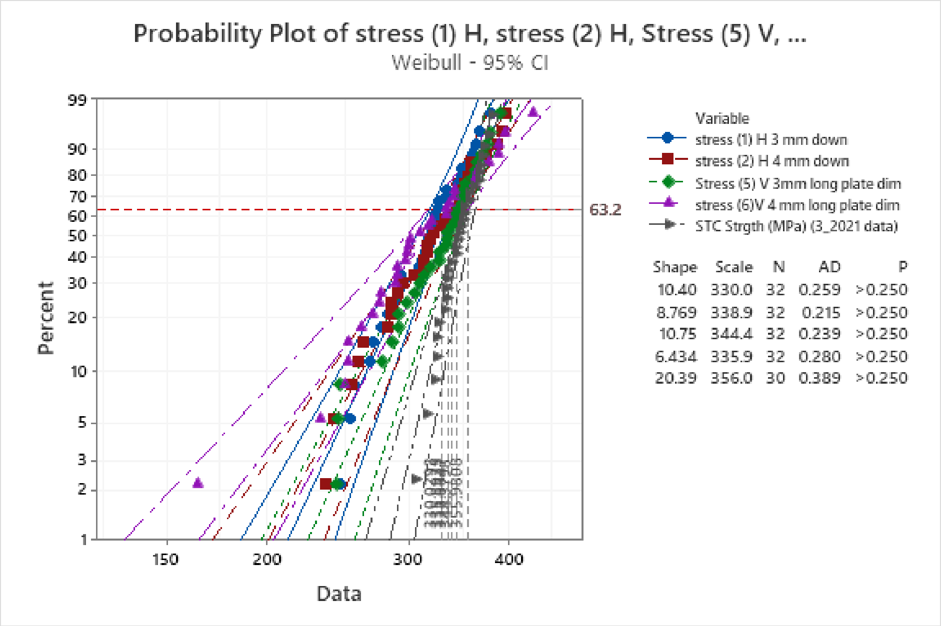


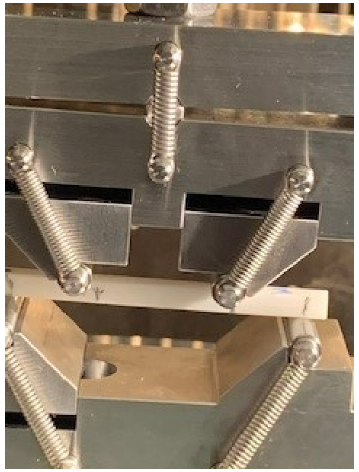
Lithoz Test Profile Cross Section

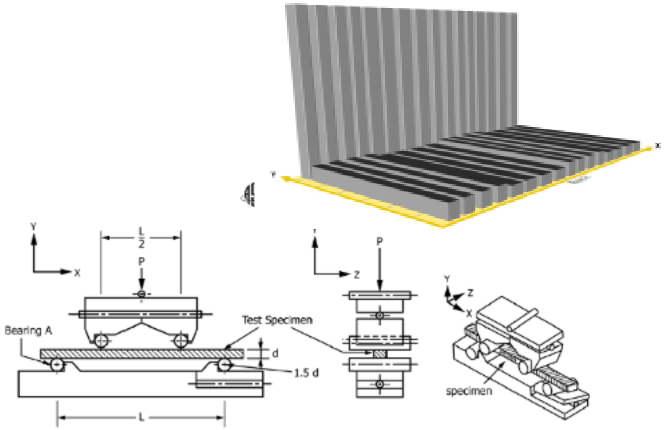


Additional mechanical Characterization

Flexural Bend Testing





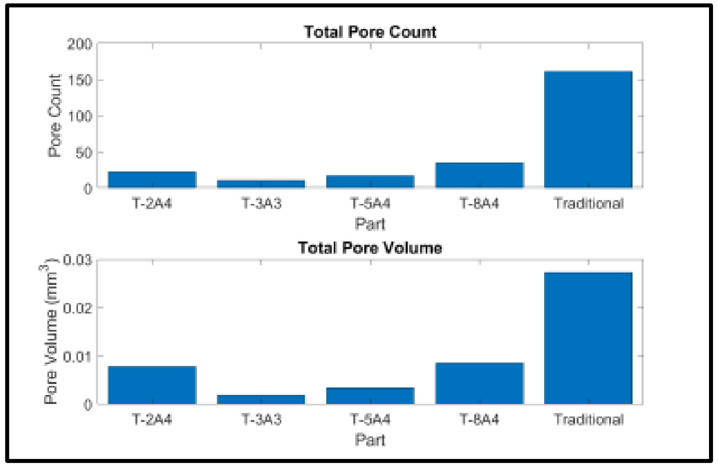


Archimedes Density

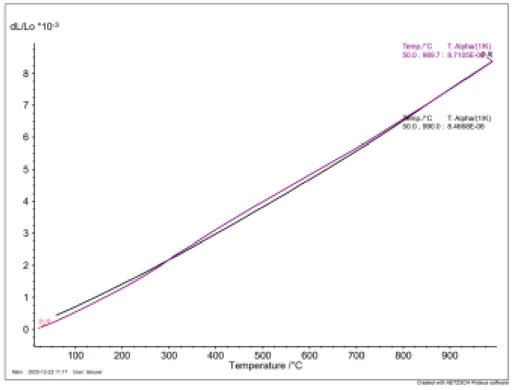
Sample ID	Dry Weight (g)	Suspended Weight (g)	Saturated Weight (g)	Bulk Density (g/cc)**	Open Porosity (%)
4 - TRADITIONAL	1.06	0.777	1.062	3.719	0.702
T5A2	1.074	0.788	1.077	3.716	1.038
T2A3	1.408	1.033	1.409	3.745	0.266
T3A2	1.192	0.875	1.196	3.713	1.246
T8A2	1.059	0.778	1.06	3.755	0.355

AM

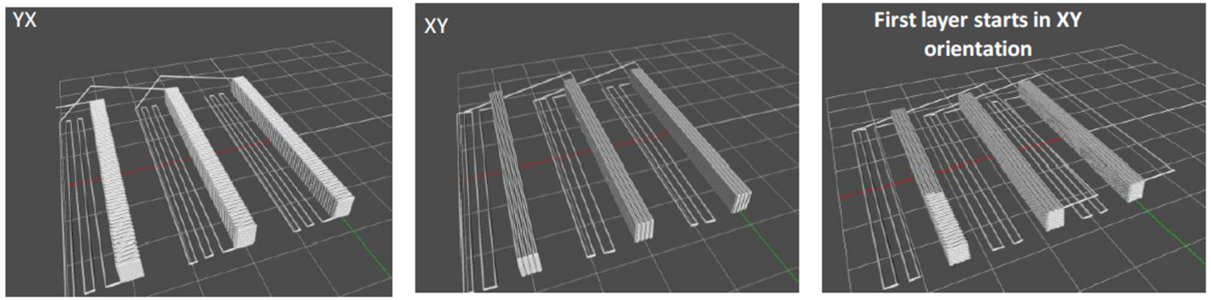
CT Analysis for Pore Evaluation

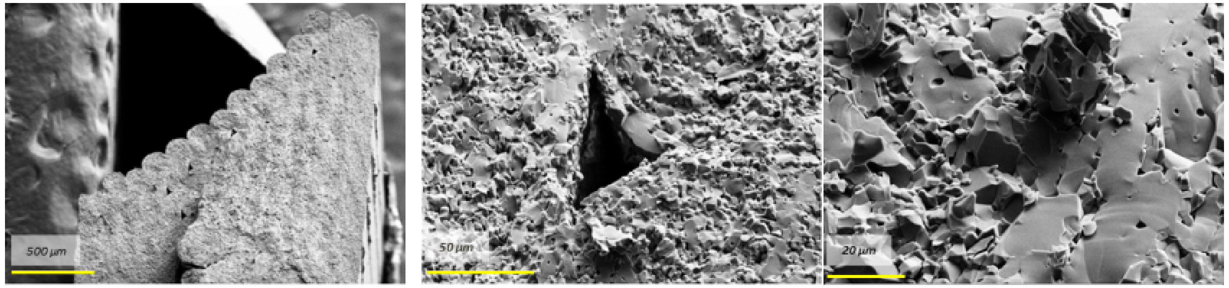


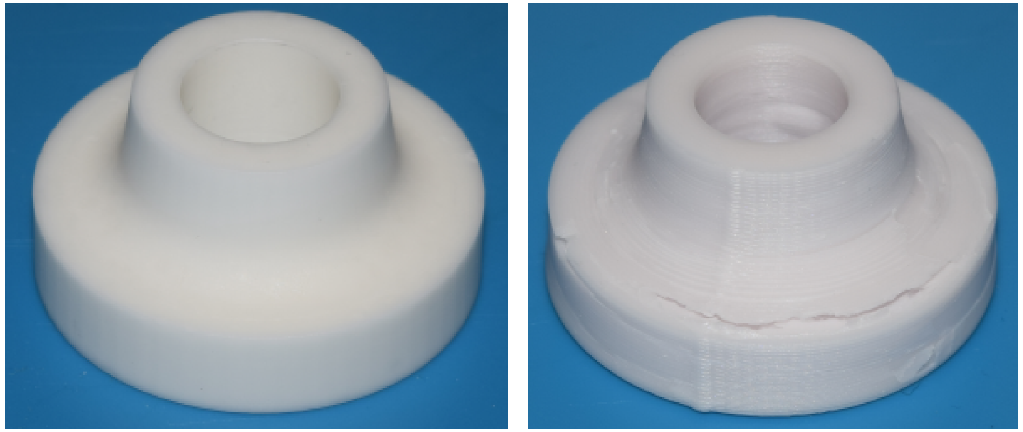
Coefficient of Thermal Expansion



Comparing DLP and DIW







Al_2O_3	char strength (Mpa)	modulus
Conventional 94ND10	356	20.4
LCM 94ND10	330-344	6.4-10.8
LCM 94ND10 + wet H_2	376	14.2
*DW Al_2O_3	160-210	7.1-13.1

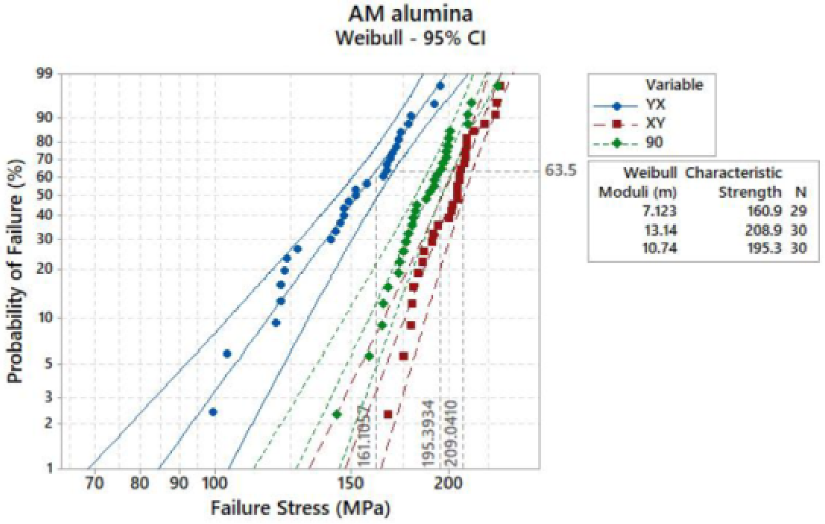


Figure 4.10 Weibull fits of three build orientations for Direct Write printing of Alumina tensile bars.

A. Cook, C. Diantonio, et al. Pacific Rim Conference on Ceramic and Glass Technology, May 21-26, 2017
A. Roach, et al. SAND2018-11244

Collaborators

Special thanks to the following contributors:

Dr. Daniel Kammler

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Will Davidson

James Christopher

Elizabeth Larkin

Julie Gibson

THANK YOU!

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