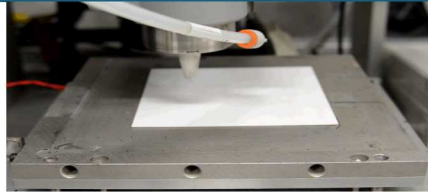SAND2018-8602C

Evaluating Parameters and Performance of a Metallized Spray-Deposition Process

Authors

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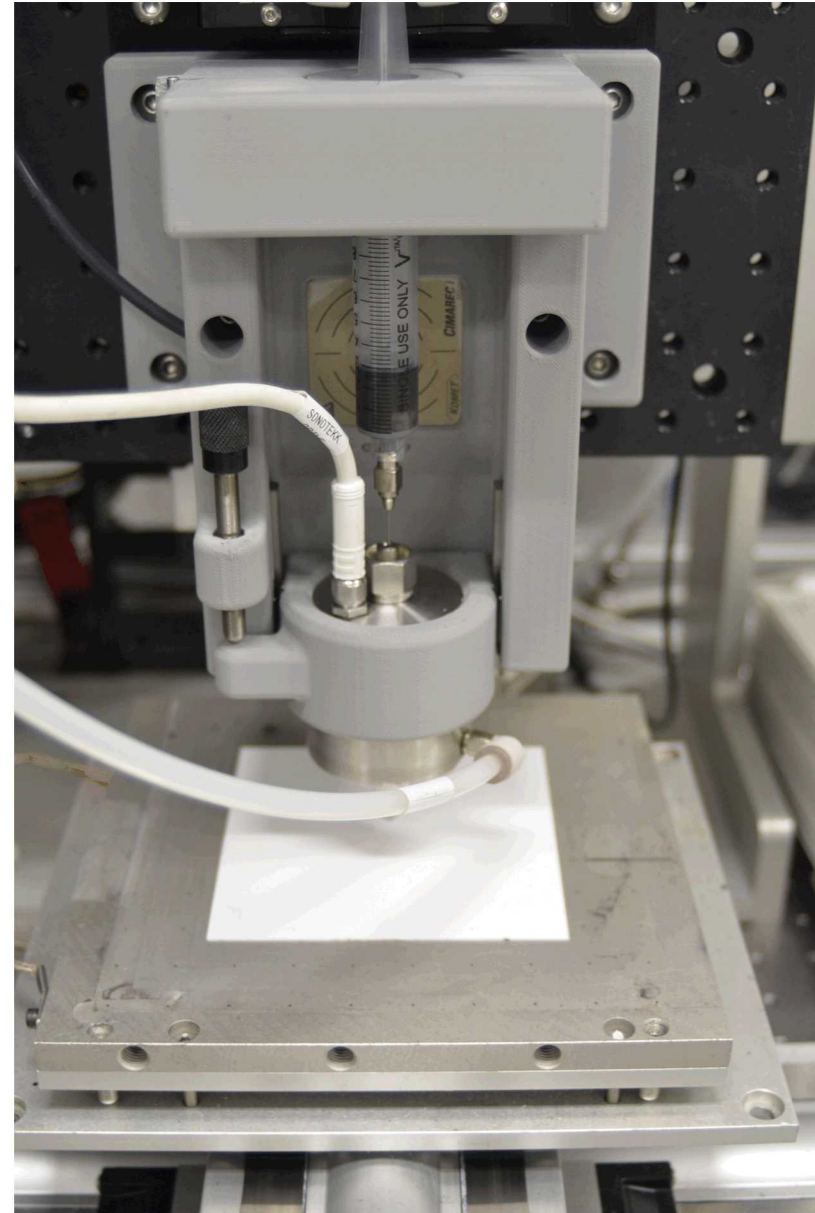29th Annual Solid Freeform Fabrication Symposium, Austin, USA

August 13, 2018

Outline

- Purpose

- The Direct-Write System

- Setting Up Baseline

- What Impacts Line Width?

- Case Study: Needle Depth

- Thinking about the Bigger Picture

Purpose

Explore the capability of a new tool with the ultimate goal of creating a Design Guide
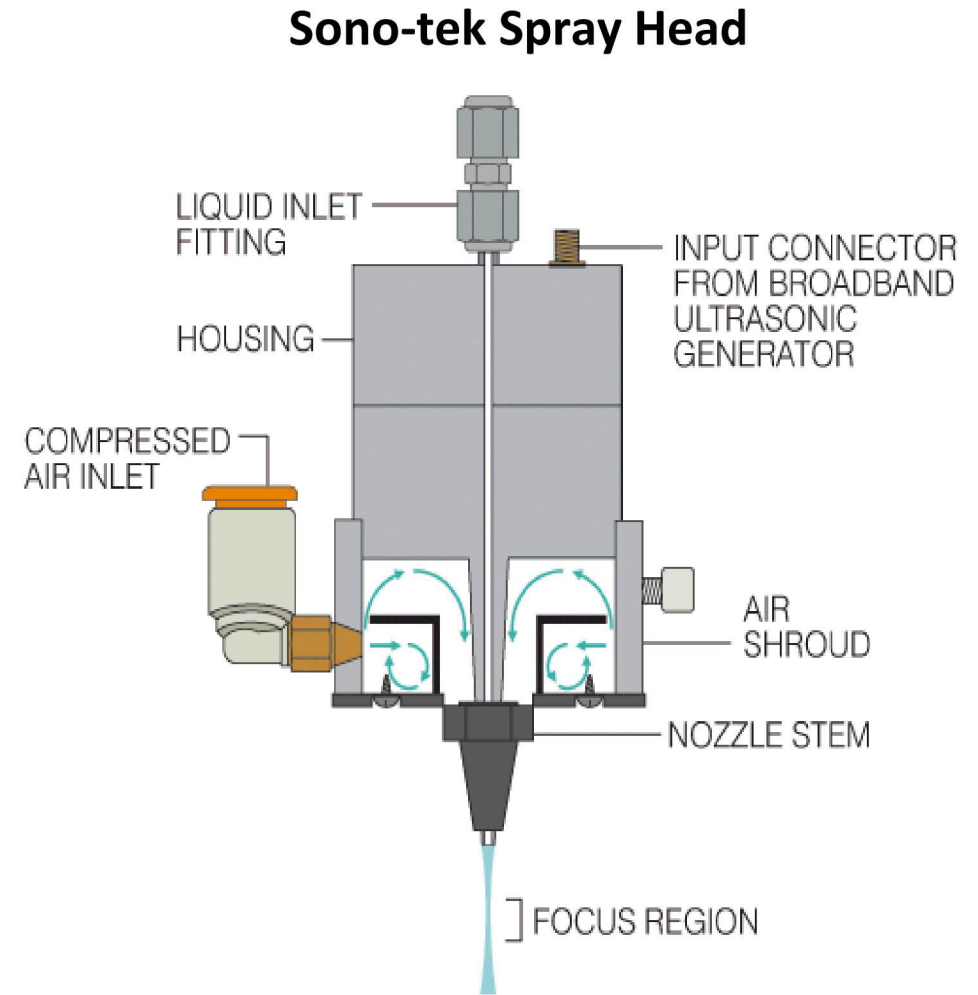
What is the Tool?

Overview

- Direct-Write System

- Additive manufacturing techniques

- Automates coating processes

How it Works

1. Mixture is loaded into a syringe

2. Sono-tek head aerosolizes mixture

3. FlashCut 6 interfaced with multi-stage platform

4. Material spray-deposited onto substrate

Sono-tek Spray Head

LIQUID INLET FITTING

HOUSING

COMPRESSED AIR INLET

INPUT CONNECTOR FROM BROADBAND ULTRASONIC GENERATOR

AIR SHROUD

NOZZLE STEM

FOCUS REGION

www.sono-tek.com

The Direct-Write System

Features and Impact

- Minimize overspray

- Integrated mixer

- Micrometer head to measure needle depth
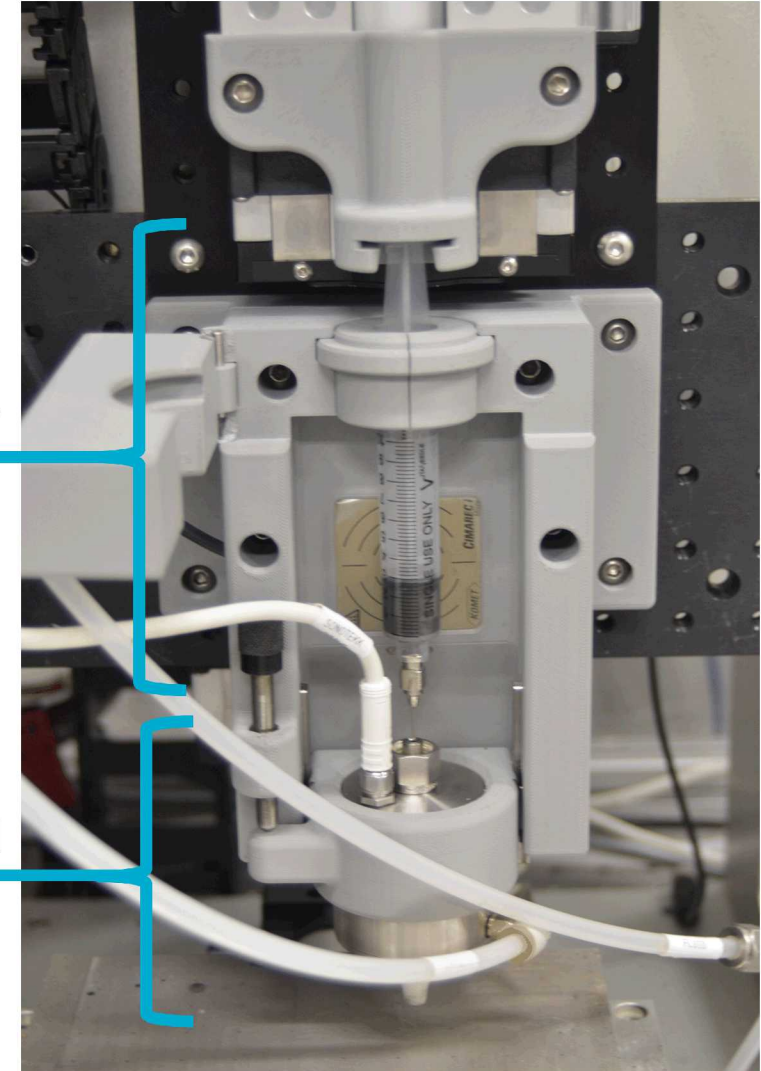
- Parts 3D printed in-house for customization

Syringe with Stir Bar in Water
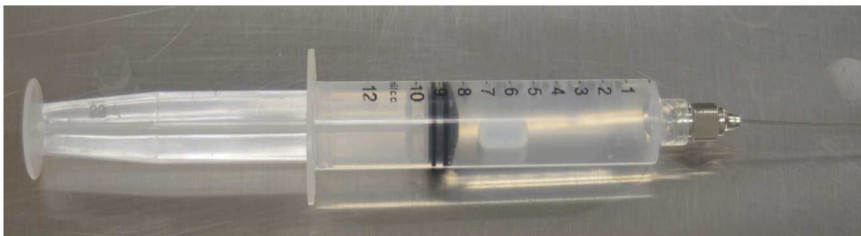
Direct-Write System

Plastic 10mL Syringe and Integrated Stirrer

Sono-tek Spray Head

Program Constraints:

- Metallized ink of Ti/Mn in 1-butanol
- Sheath gas (nitrogen, 10psi)

Constants:

- Al_2O_3 ceramic plates
- Material solids loading (20% by weight)
- Stir speed
- Stage movement speed
- Needle gage size

Variables

- Sono-tek Power (%)
- Needle depth (mm)
- Z Height/Distance from substrate (inches)
- Deposition (µL/35mm travel)
- Line width (mm)

Common Issues

- Error alarms from Sono-tek controller

- Z height <.5" discontinuous lines

- High deposition flow can leave excess material on the pathway (non-uniform)

- Clogging or bleeding of material
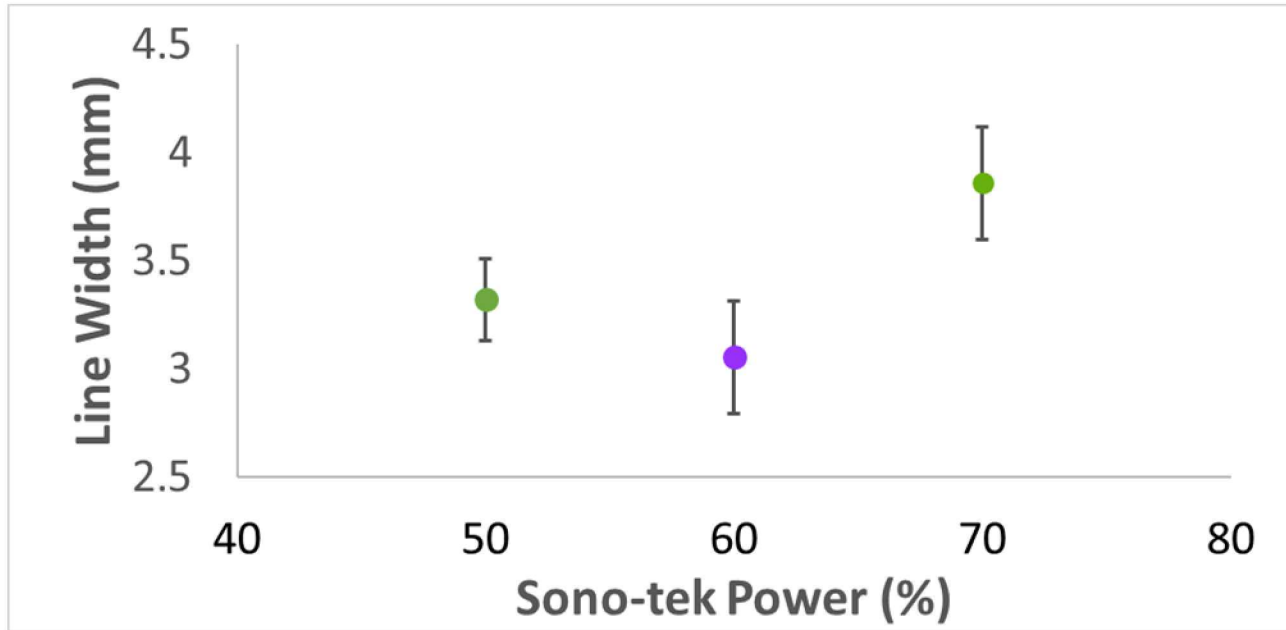
- G-Code pathing

Baseline Settings

- Sono-tek Power: 60%

- Z Height: .5"

- Deposition: 5µL/35mm travel

- Needle depth from spray head: .5mm

Proposed Experiment

- 12 Trials
  - Sono-tek Power (3 Trials)
  - Z Height (3 Trials)
  - Deposition (3 Trials)
  - Needle Depth (3 Trials)
- 3 Replicates
- Line Width
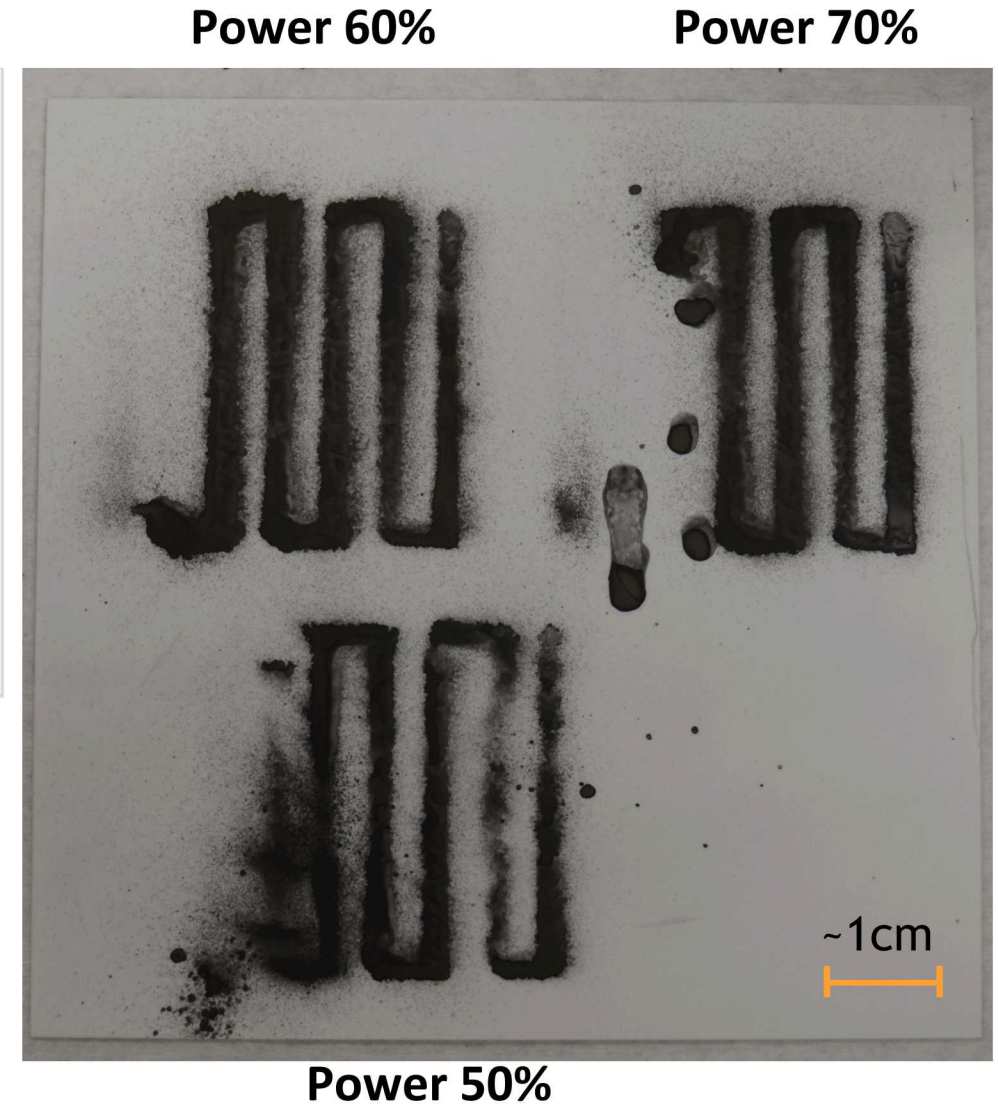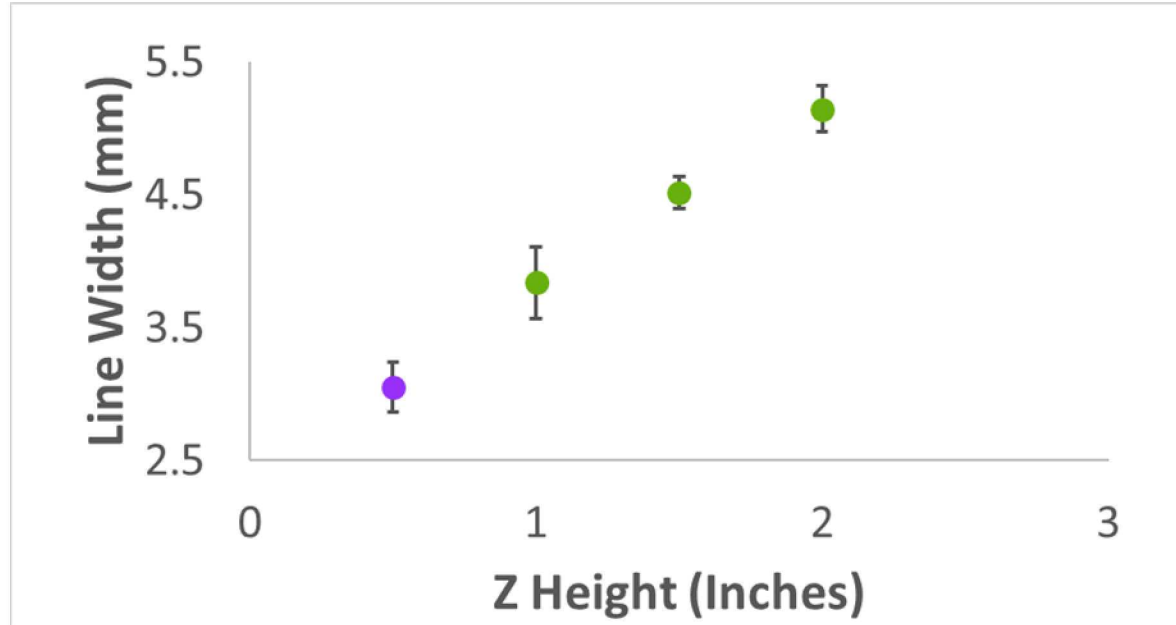 - Why it matters
  - How it was measured

Travel Pathway

X (6mm)

Y (35mm)
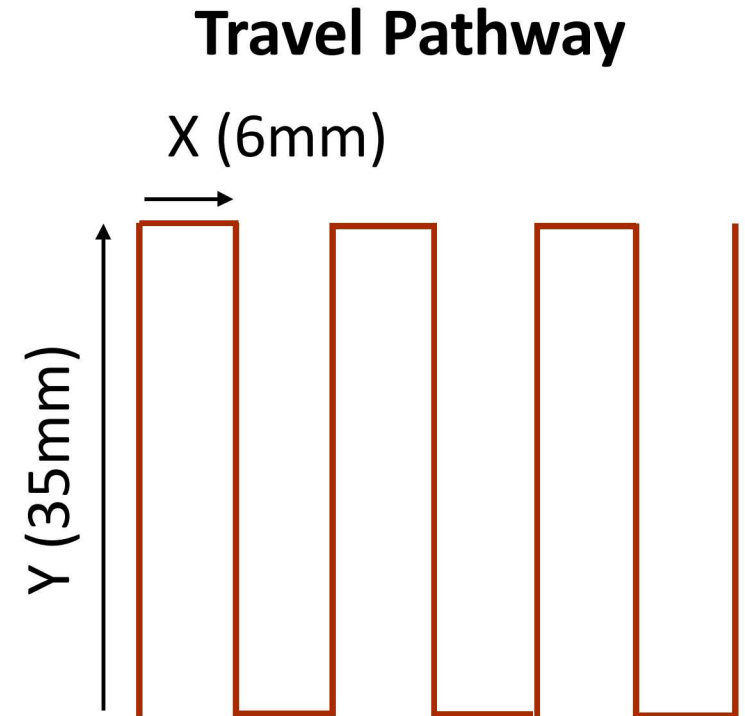
Sono-tek Power Aerosolizes Material

- The "Power 60%" trial involves all baseline settings

Print Impact: Low

Power 60%   **Power 70%**
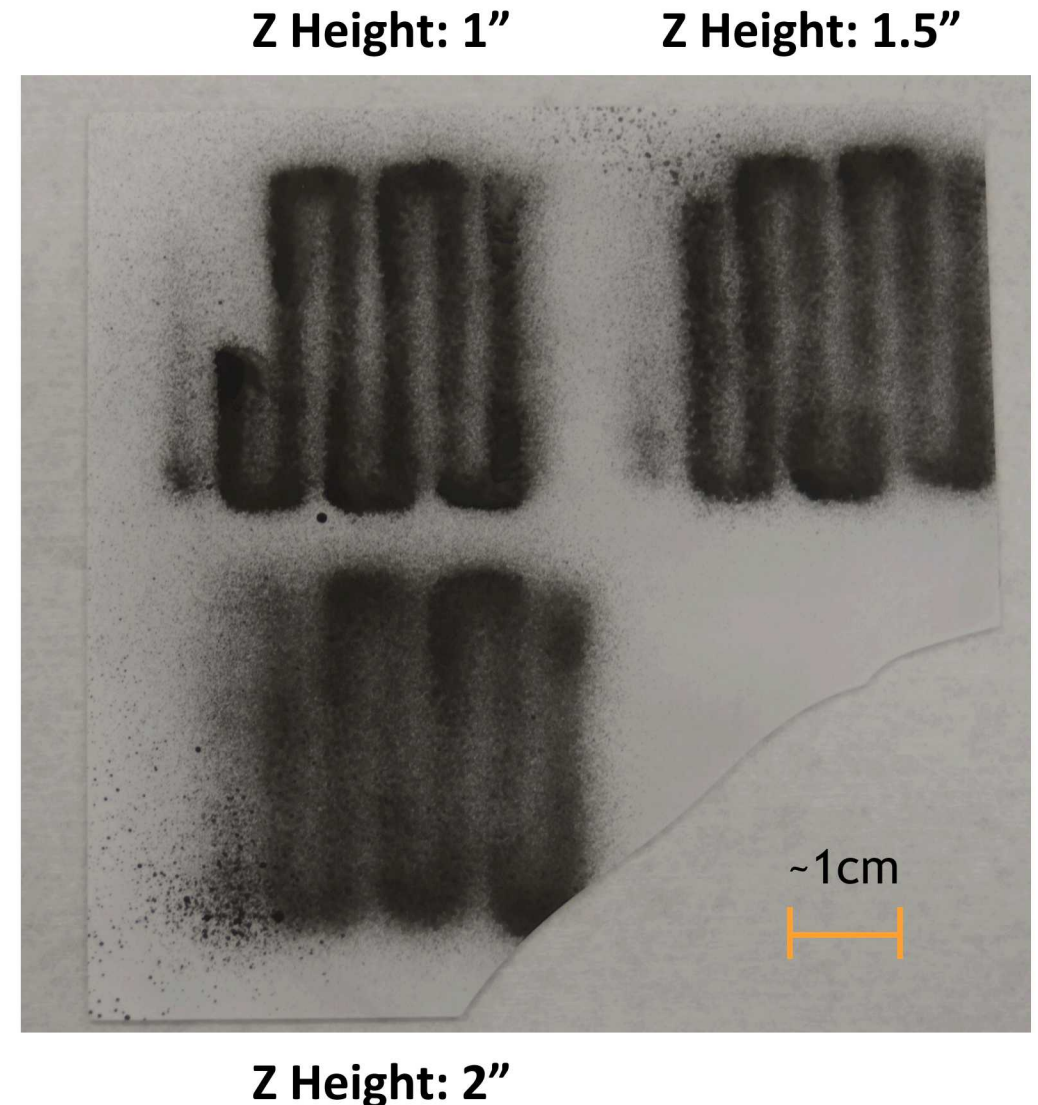

~1cm
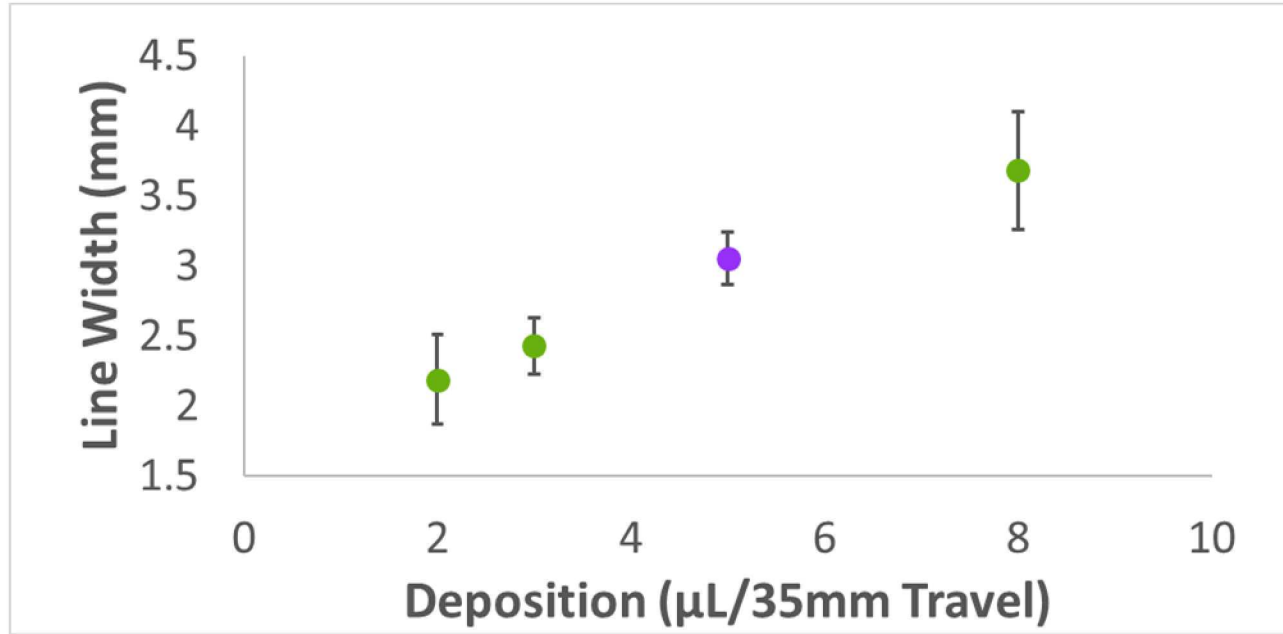
Power 50%

Increasing Z Height Increases Line Width

- Largest line widths of chosen variables

- Measuring line width for larger Z heights became difficult to differentiate
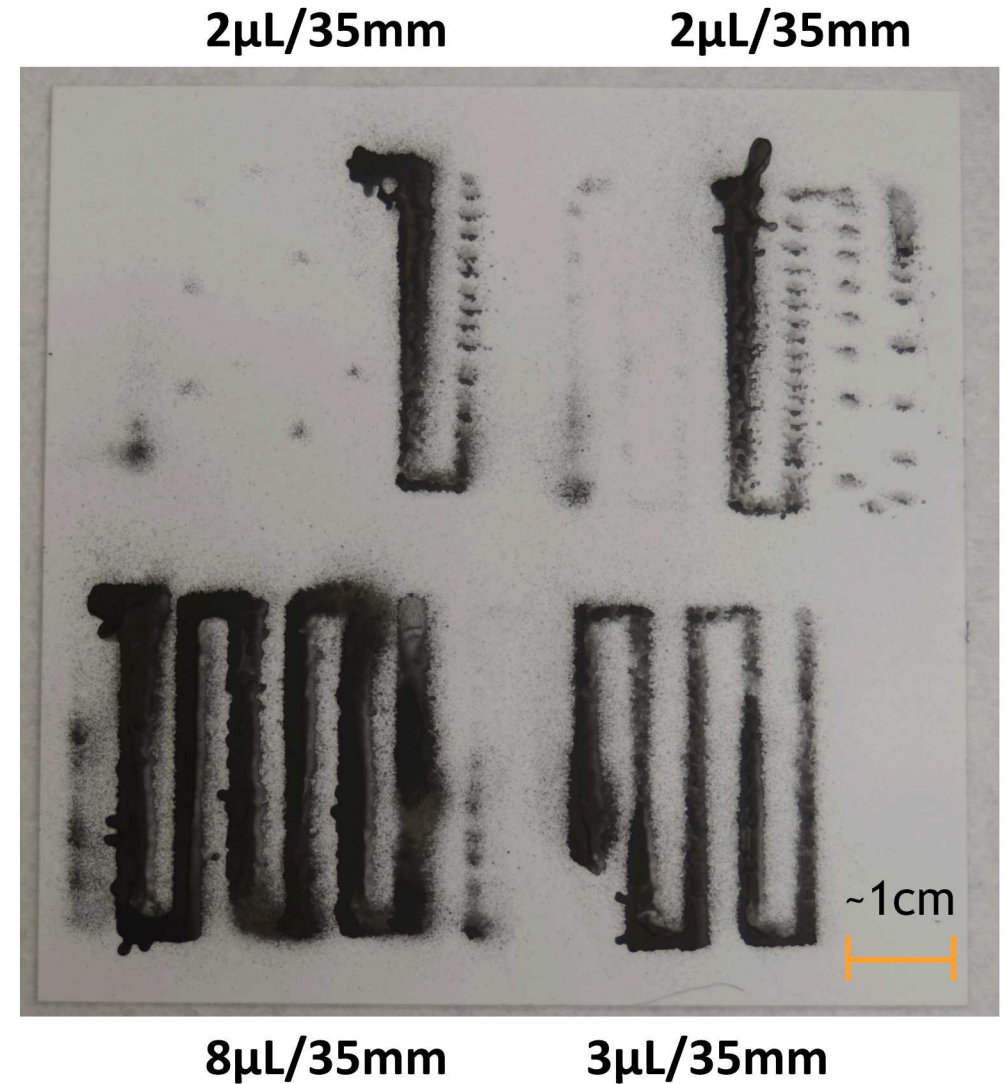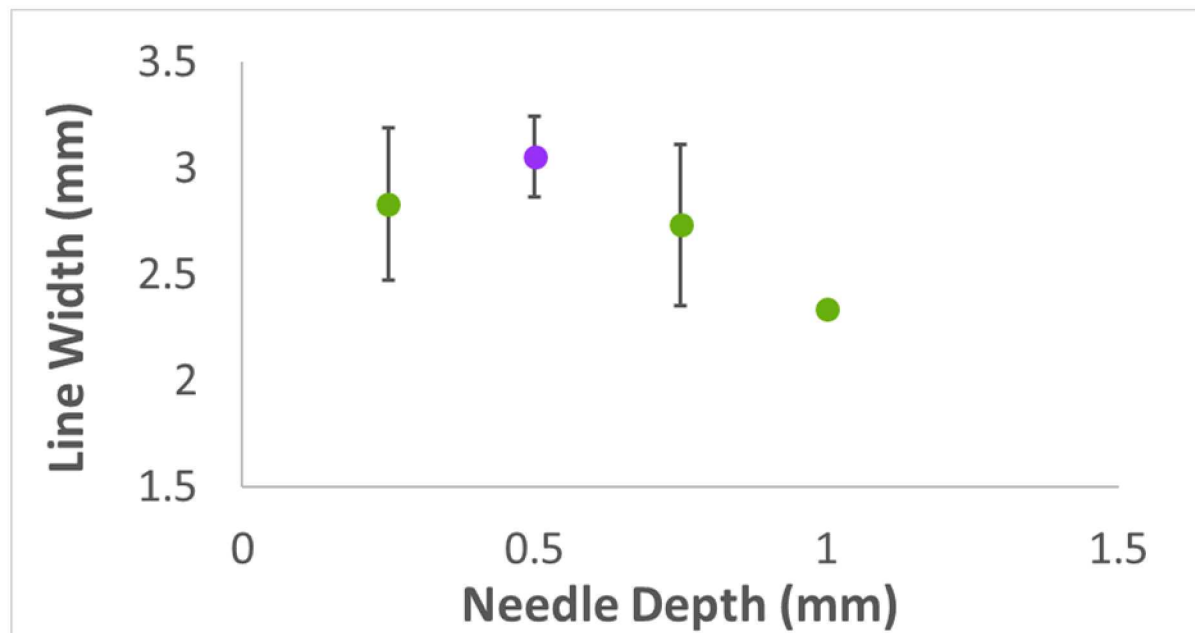
Print Impact: Moderate

Z Height: 1"   **Z Height: 1.5"**

~1cm

Z Height: 2"

Sheath Gas Influences Deposition

- Discontinuous lines caused by sheath gas

Print Impact: High

2μL/35mm   2μL/35mm

~1cm

8μL/35mm   3μL/35mm

Needle Depth Must Remain Low

.25mm .75mm

- High needle depth had trouble aerosolizing

Print Impact: High

~1cm

1mm .75mm

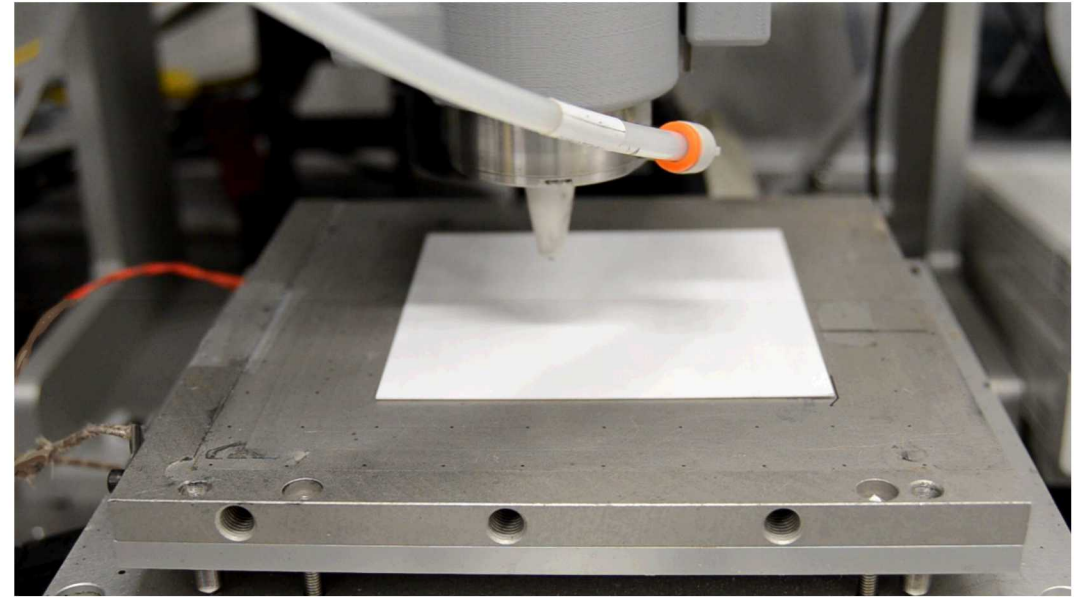# Settings Case Study: Needle Depth
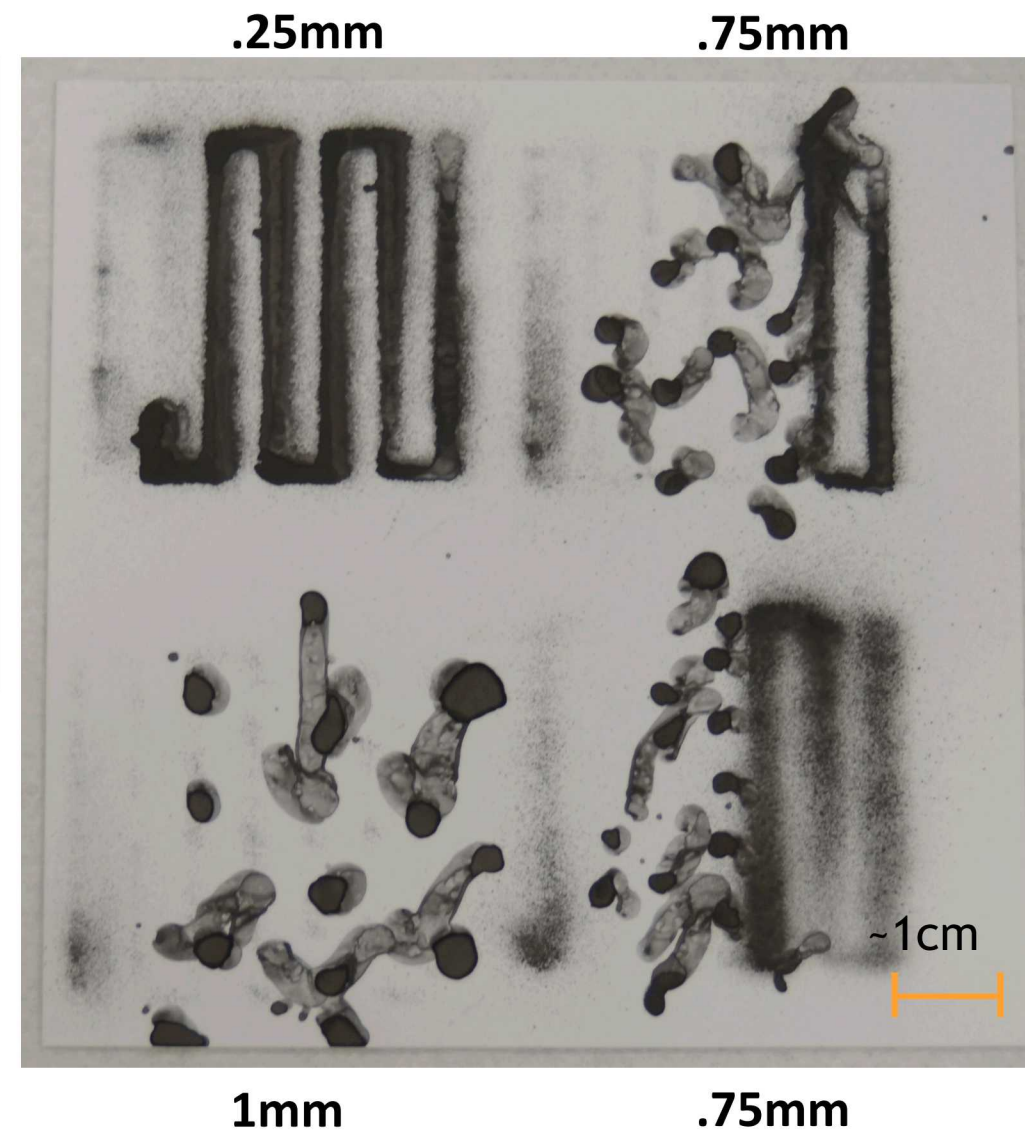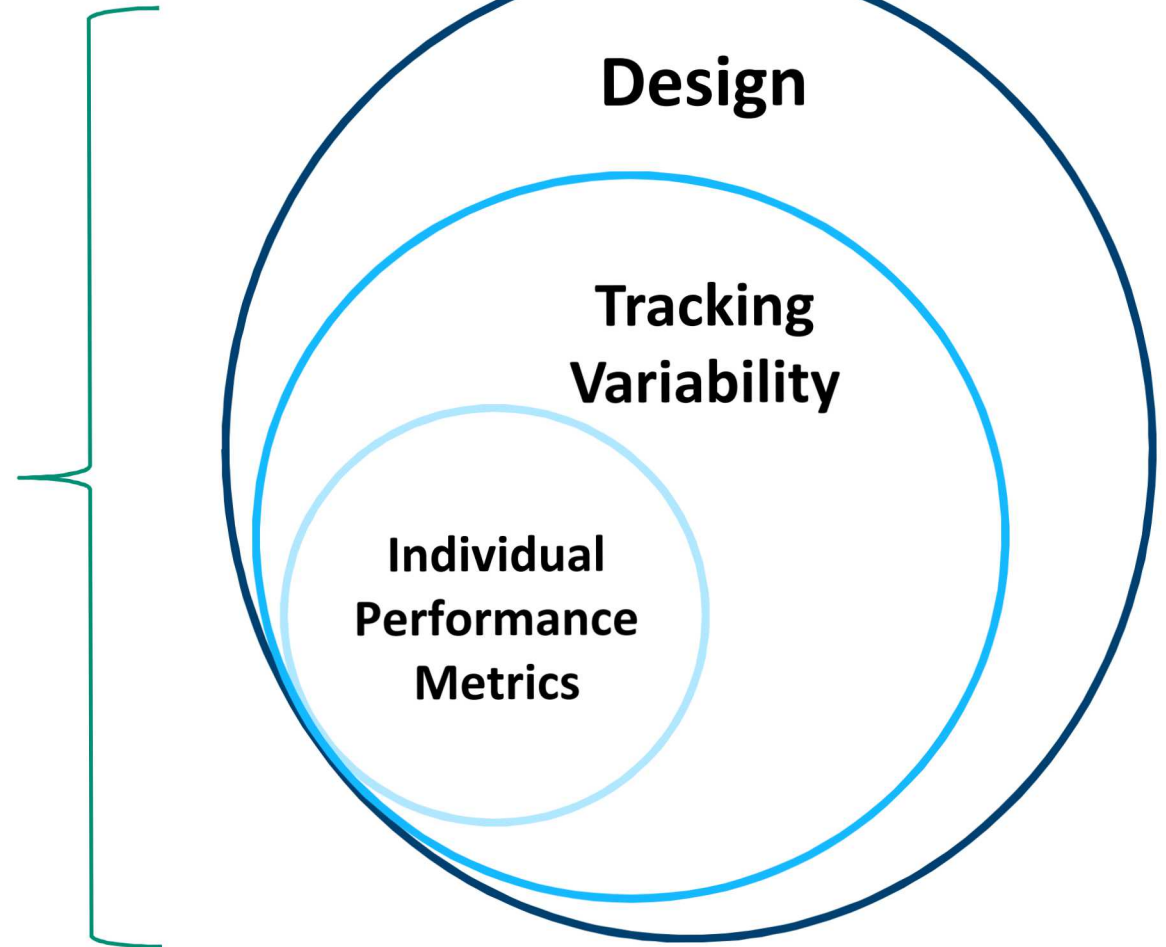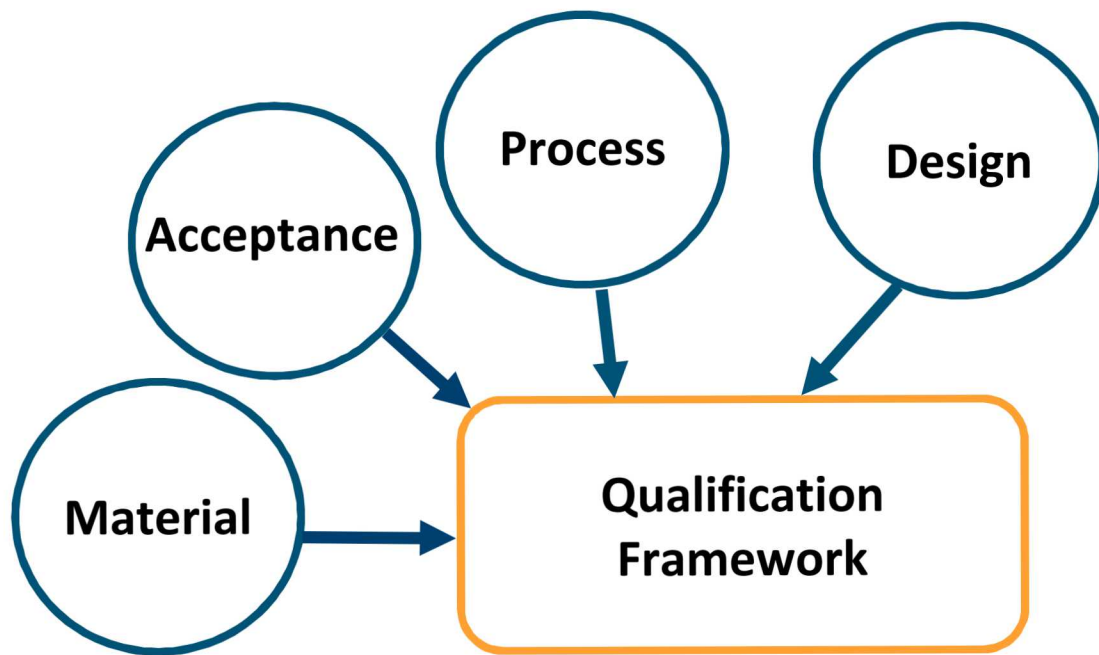
Nominal Needle Depth (.5mm)
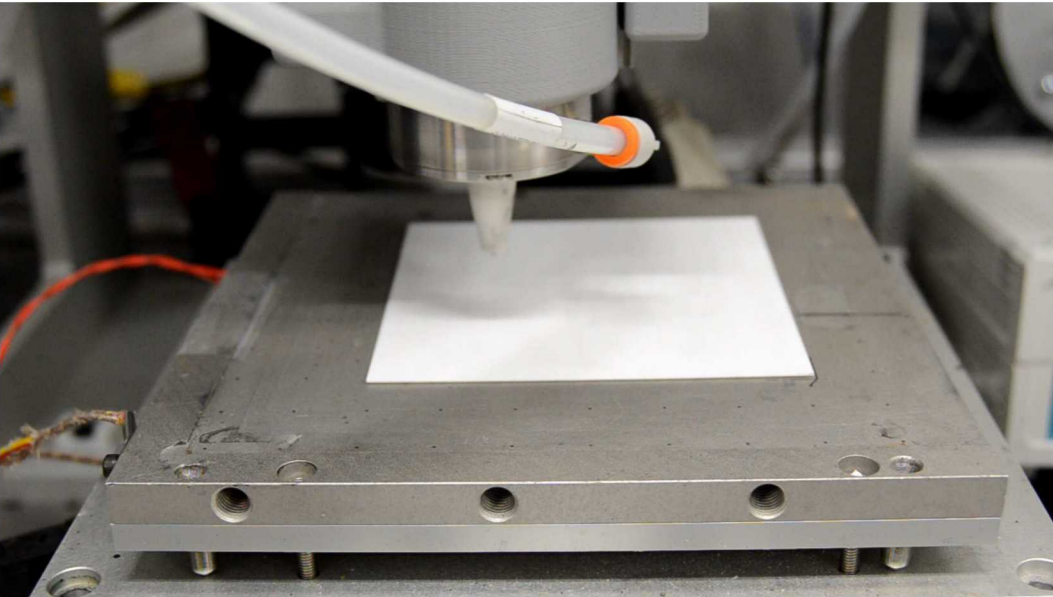
High Needle Depth (1.5mm)

Upcoming Work

- Explore relationship between sheath gas and material deposition

- Start changing variables previously held as constants

- Look into uniformity between prints, where spray tends to aggregate, etc.

What is a Design Guide?

• Freezes process for production

• Provides margin information

• Addresses performance

Acceptance

Process

Design

Material

Qualification Framework

Design

Tracking Variability

Individual Performance Metrics

A Large "Thank you!" to:

Sita Mani, Judi Lavin, Shaun Whetten, Kristin Wilde,

Lauren Gartner, Nathan Acree, David Keicher,

Dan Kammler, Shawn Dirk, and Collin Donohoue

Questions?

Z. Stephens, SFF 2017

- Introduced direct-write hardware

- DOE: Uniformity and Pick-up Weight
  - Defect counts
  - Print Speed
  - Z Height

Previous Direct-Write System

Plastic 10mL Syringe

Magnetic Stirrer

Sono-tek Spray Head