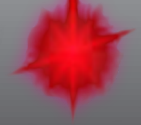
Award Number 1661146

3D METAL PRINTER

SDMAY18-05

Team Members: Jett Ptacek, Rachel Shannon, Caleb Toney, Ben Pieper, and Kevin Oran

Faculty Advisor and Client: Dr. Timothy Bigelow



IOWA STATE UNIVERSITY

College of Engineering

Iowa State University
Department of Electrical and Computer Engineering

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Center for Nondestructive Evaluation

Acknowledgement

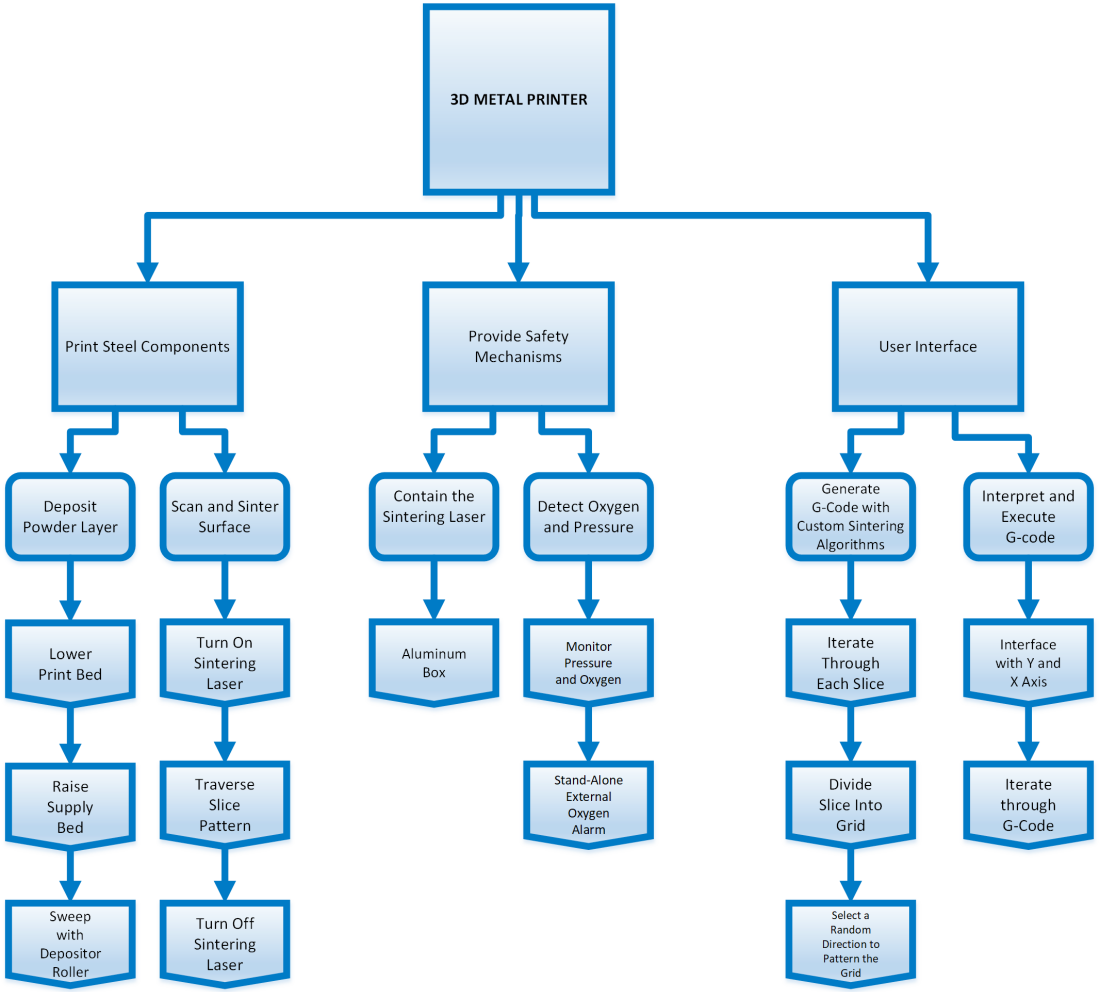
We would like to thank Dr. Timothy Bigelow, Associate Professor of Electrical and Computer Engineering at Iowa State. Dr. Bigelow serves as the faculty advisor for this project. He provides guidance, technical advice, and design constraints in each of our weekly meetings. Additionally, the majority of the funding for the project comes from a research grant obtained by Dr. Bigelow.

PROBLEM STATEMENT

“How might we design a 3D Metal printer that researchers at the Center for Nondestructive Evaluation can safely and easily use to simulataneously print and evaluate basic geometric parts?”

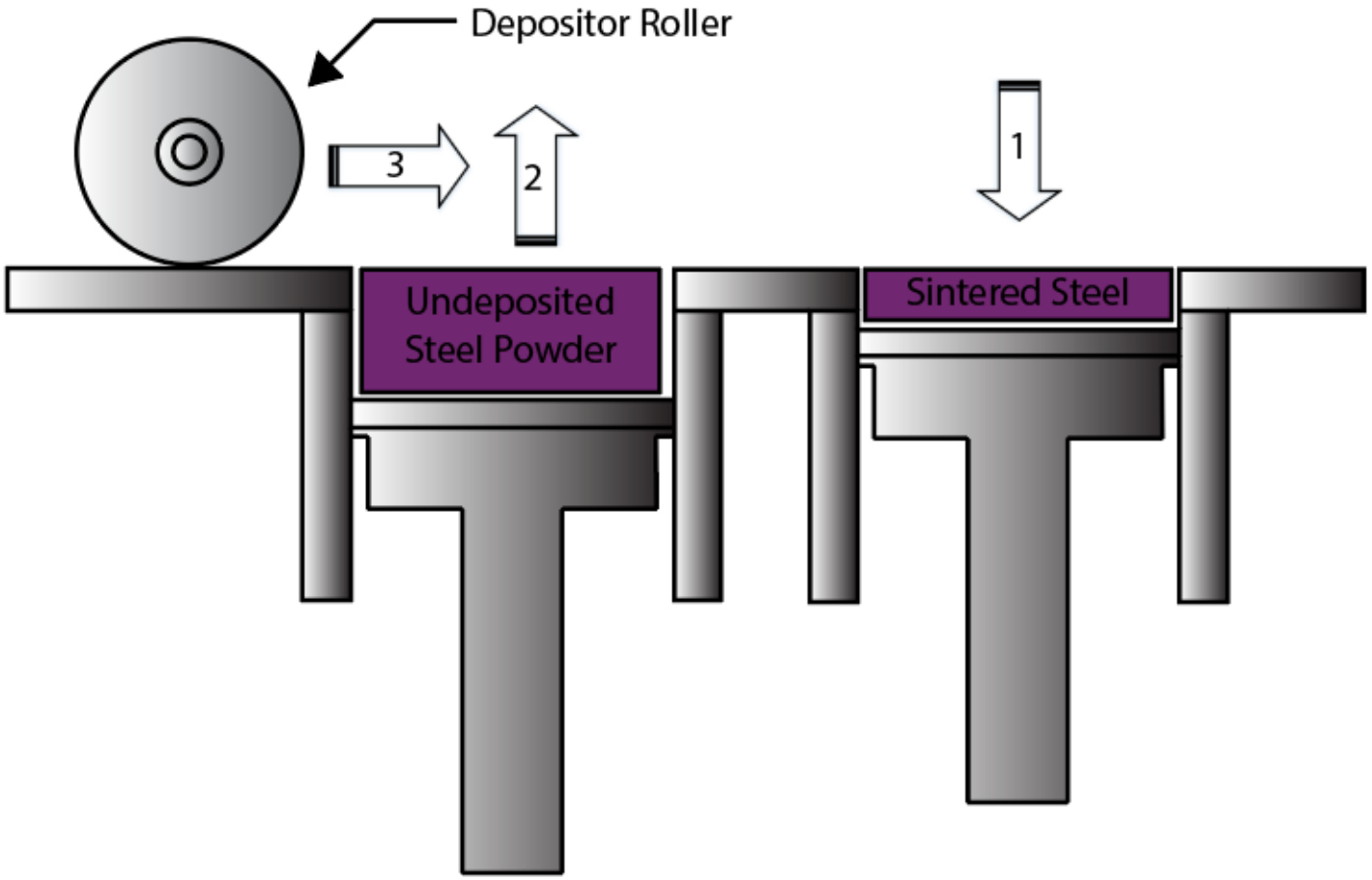
SOLUTION

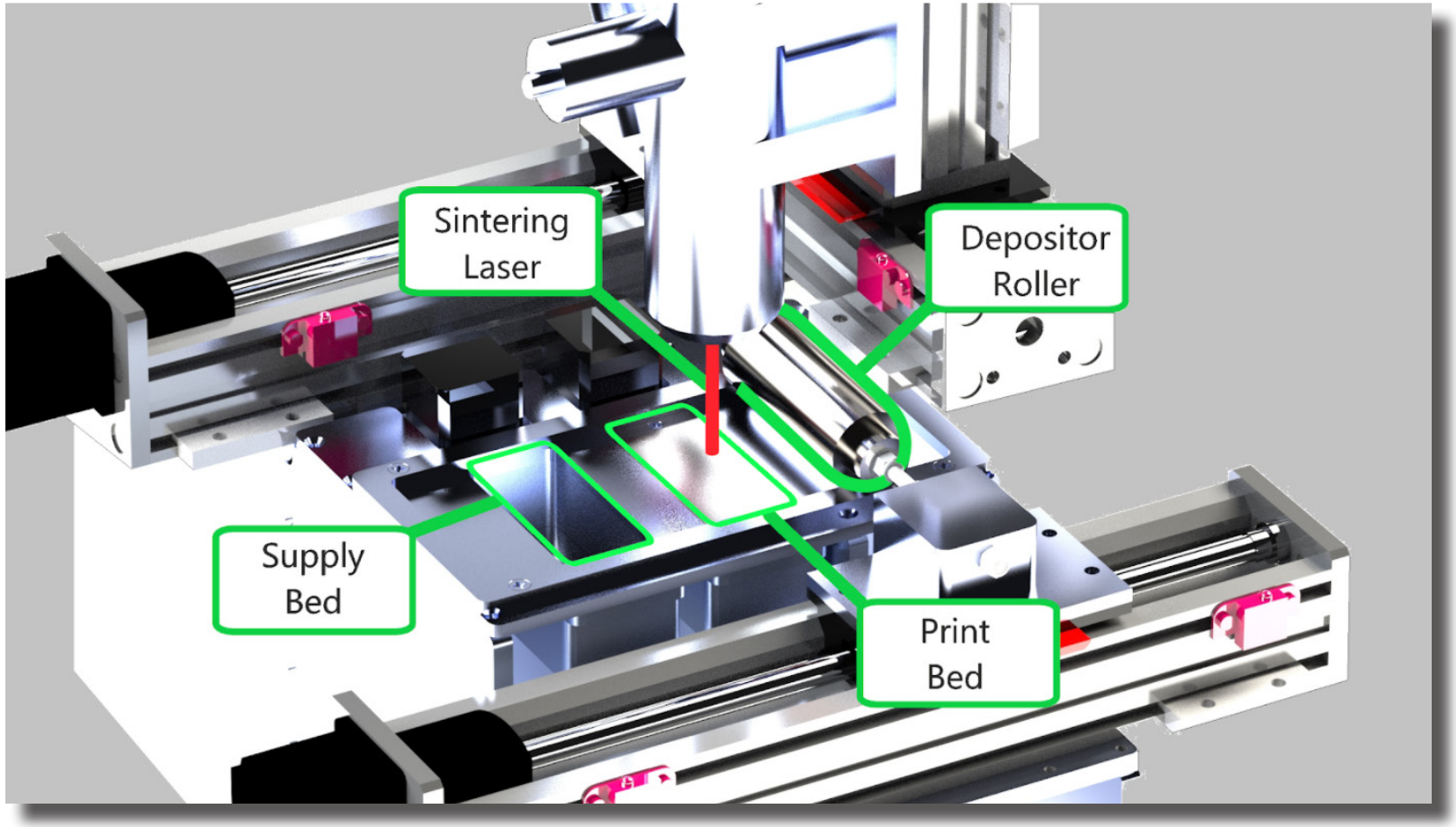
Functional Decomposition



MECHANICAL SYSTEM

Print Beds and Roller



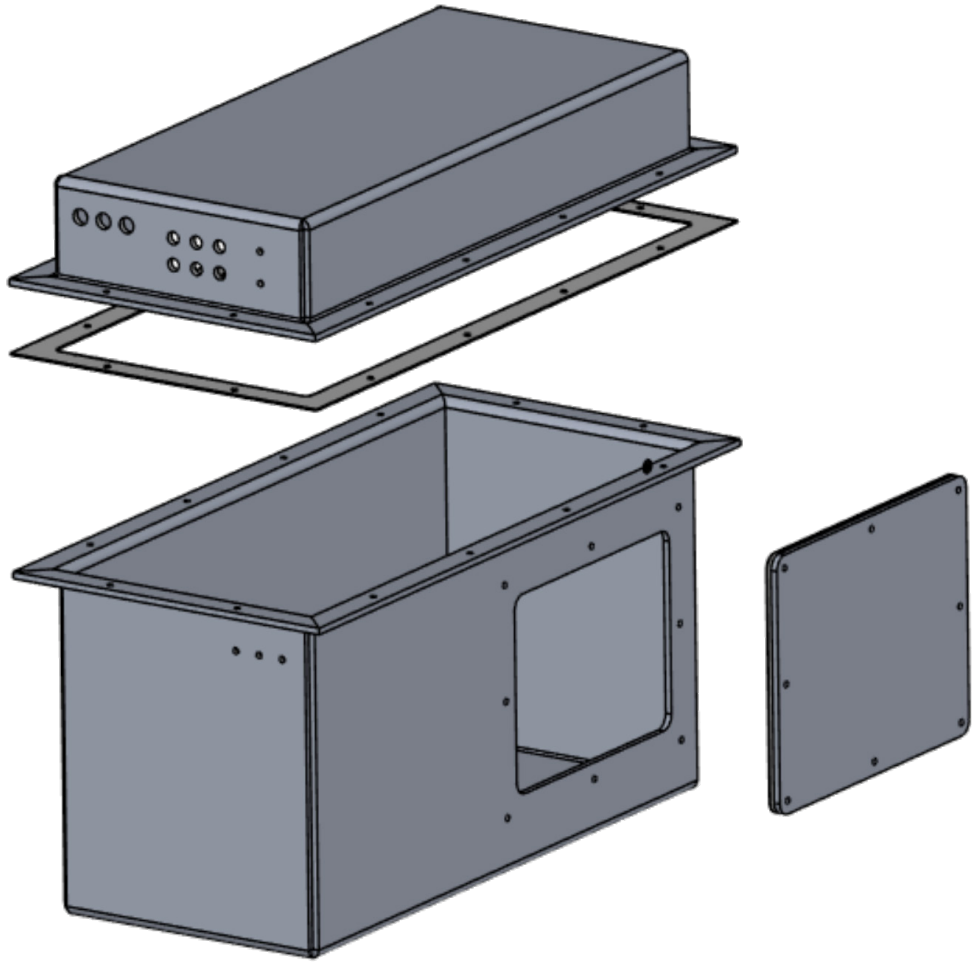


Print Beds, Laser, and Roller Diagram.

Velmex Slides and Motor Controls

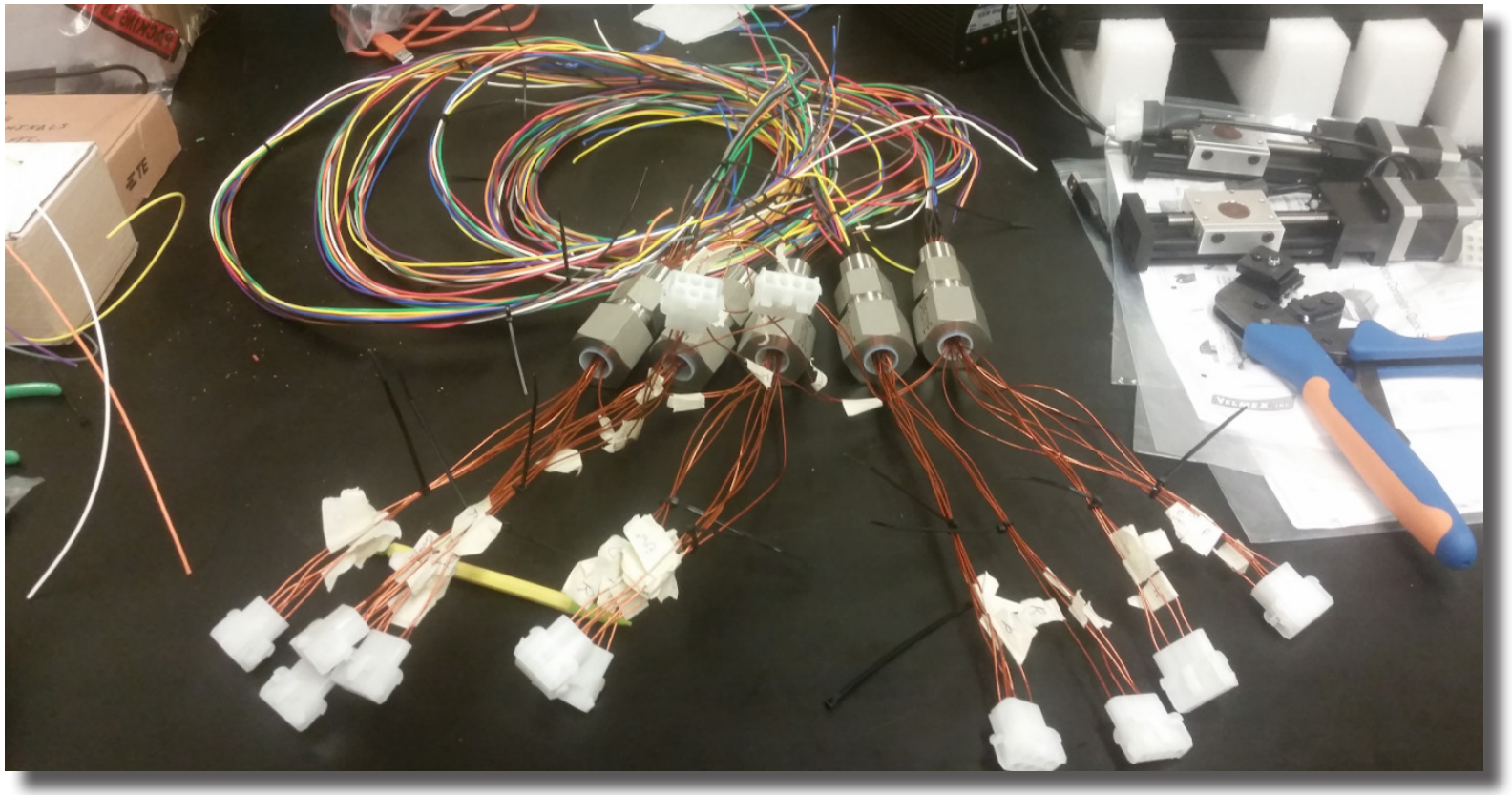
Vacuum Chamber

- Manufactured by Sargent Metal Fabricating
- Ship-in-a-bottle problem
- Rubber gasket selected to withstand high temperatures and pressures
- Vacuum rated sealing and hardware used - washers, tubing



Wiring and Vacuum Feedthroughs

- 66 wires needed to pass through chamber wall
  - Preserved original connectors
- Spectite WF Feedthrough



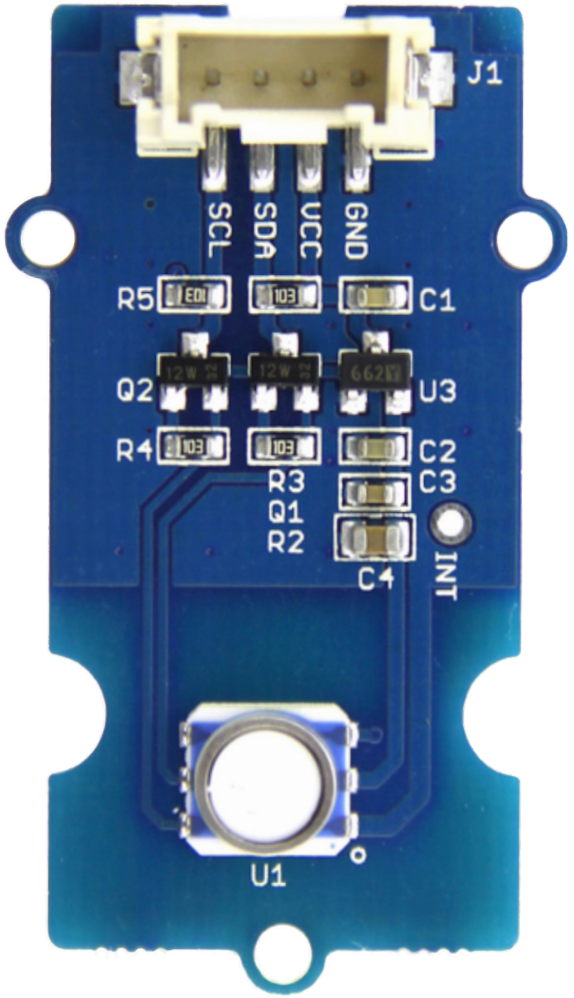
SENSOR SYSTEM

Oxygen Sensor

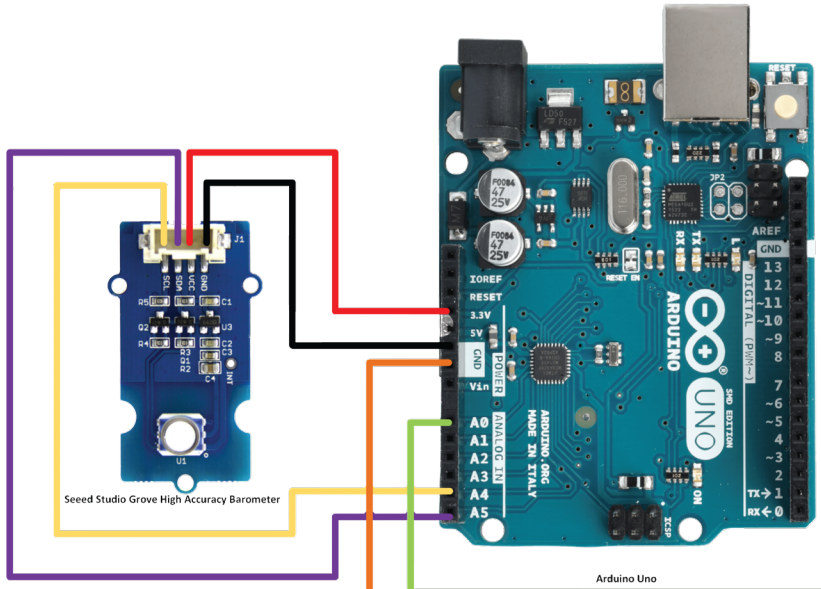
- AMI 2001LC Trace Oxygen Analyzer
- Measures as low as 0.05ppm
- Outputs a 4-20mA signal

Pressure Sensor

- Seeed Studio Grove Barometer
- I2C interface
- Able to measure pressure ranging from 300mbar-1200mbar
- Compatible with 3.3v and 5v
- Also measures temperature



Sensors Integrated with Arduino



AMI 2001LC Trace Oxygen Analyzer

Front Panel

Back Panel

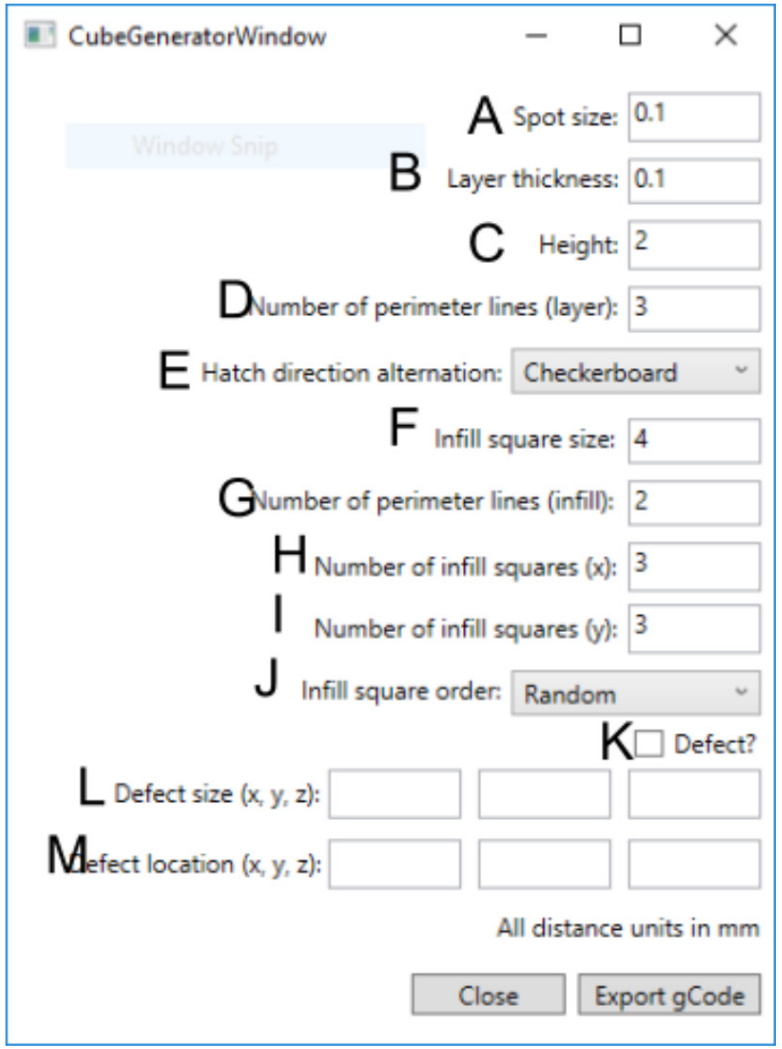
External Oxygen Sensor

- BW Honeywell Clip 2.0
- Detects H_2S, CO, SO_2, O_2
- Want it to detect O_2
  Range: 0-25.0 ppm
  Alarm: 19.5-23.5%

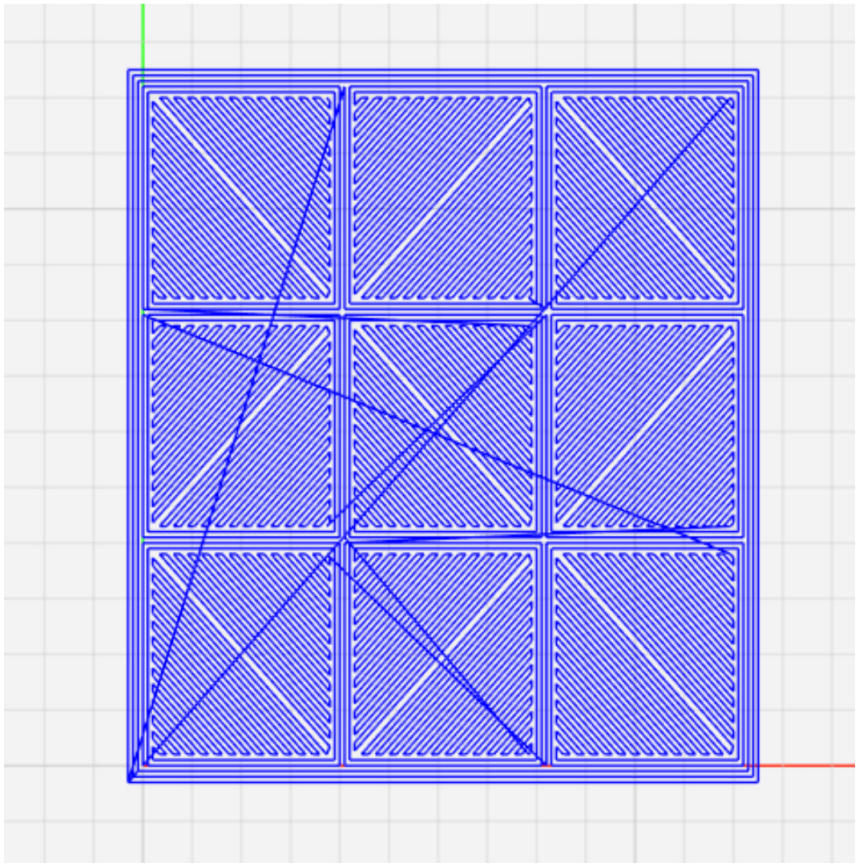
SOFTWARE

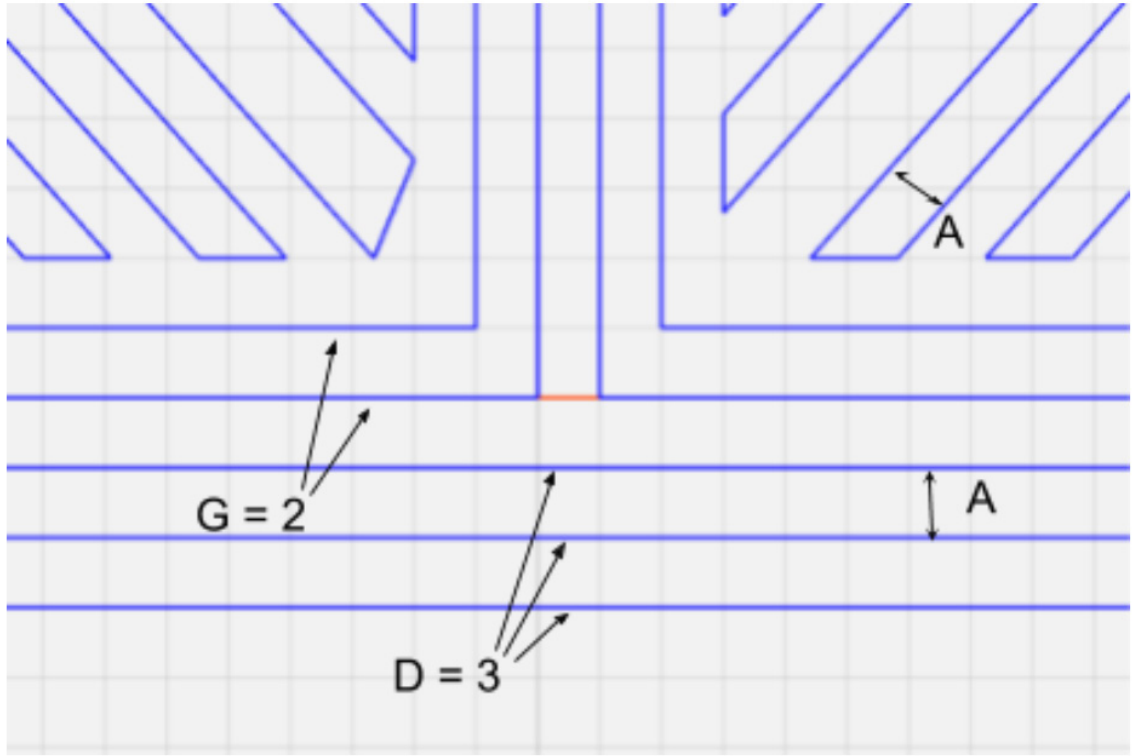
G-Code Generator

A. Laser spot size
B. Z layer thickness
C. Height of rectangular prism
D. Number of perimeter lines per Z layer
E. How to alternate infill hatch direction (checkerboard, random, same direction)
F. Infill square size
G. Number of perimeter lines per infill square
H. Number of infill squares (x/width)T
I. Number of infill squares (y/height)
J. Order of printing infill squares (sequential, random, every other)
K. Defect enabled (if unchecked, following text boxes ignored)
L. Size of defect bounding box (x, y, z)
M. Location of origin of defect bounding box (x, y, z)

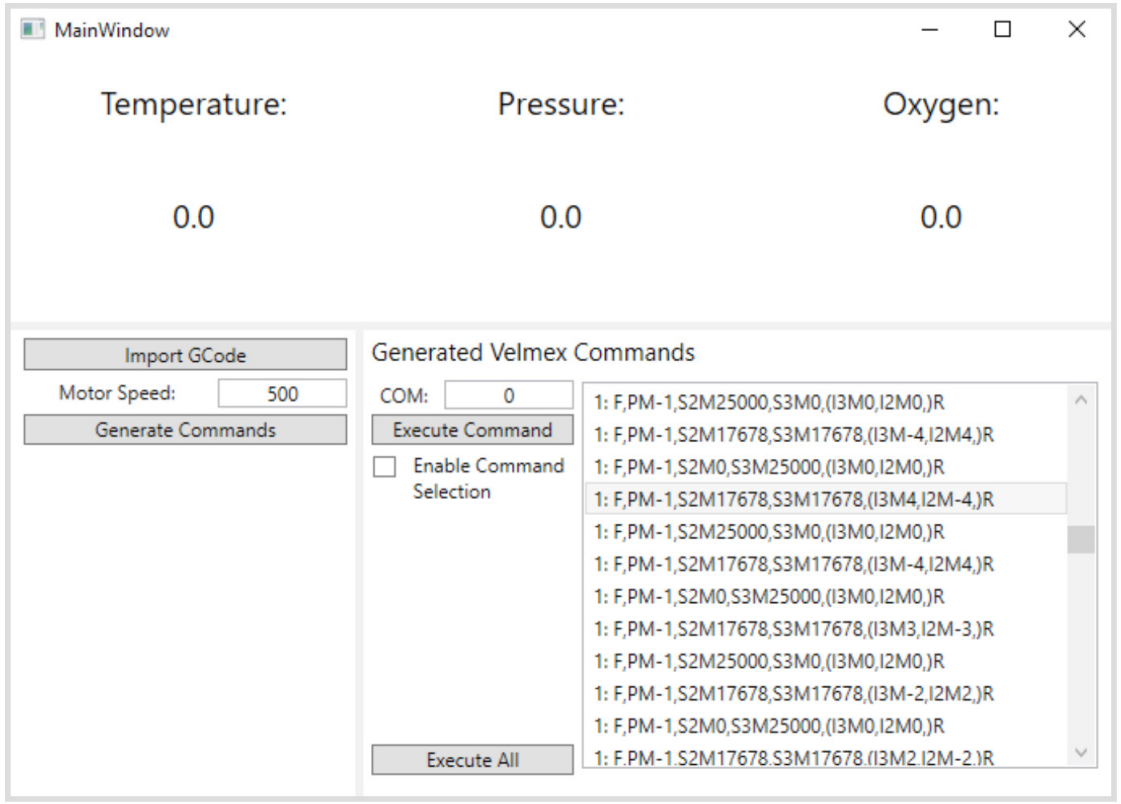


Visualization of G-Code Output



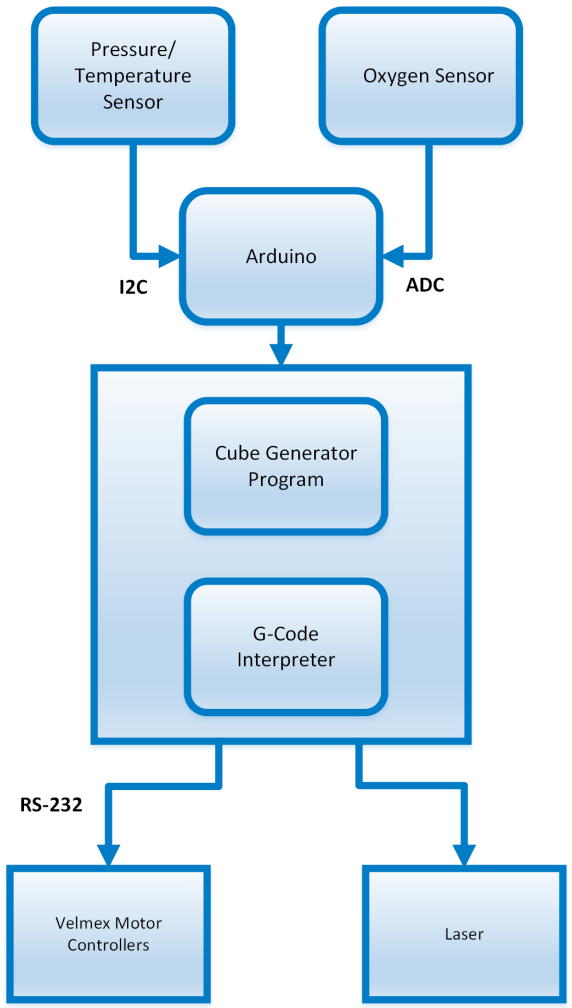


G-Code Interpreter



The front end interface for temperature, pressure, and oxygen sensor reading and Velmex command generation and execution from G-Code input.

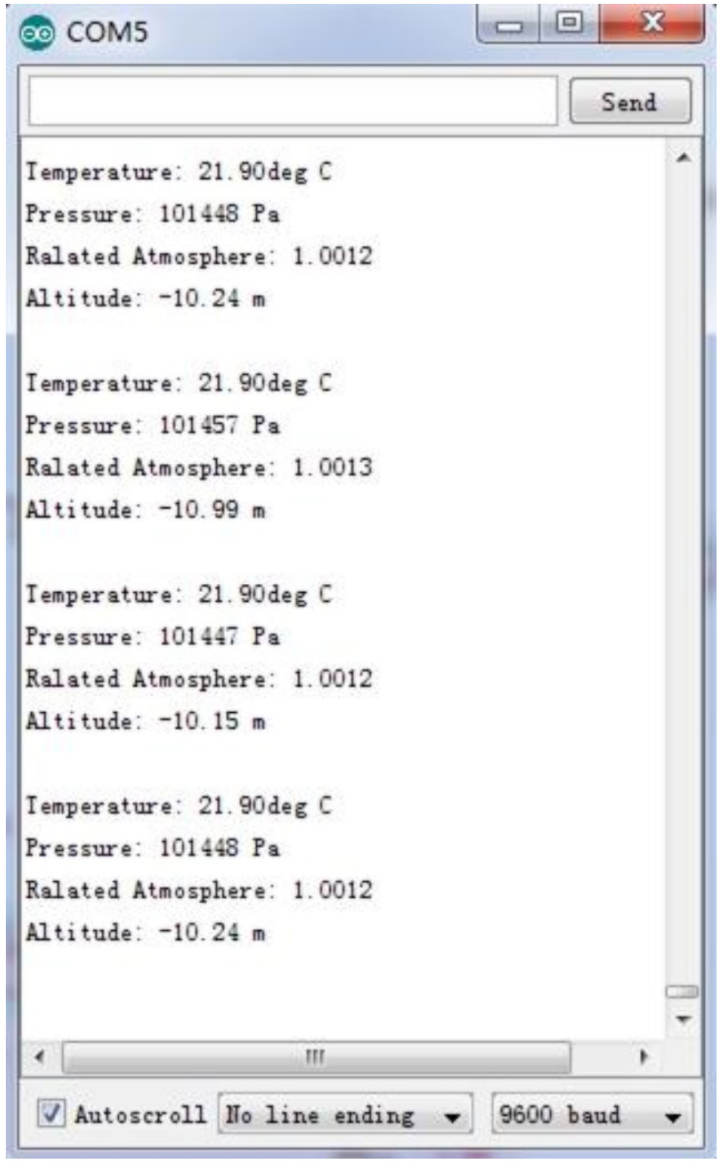
Sensor System Integration with Software



TESTING

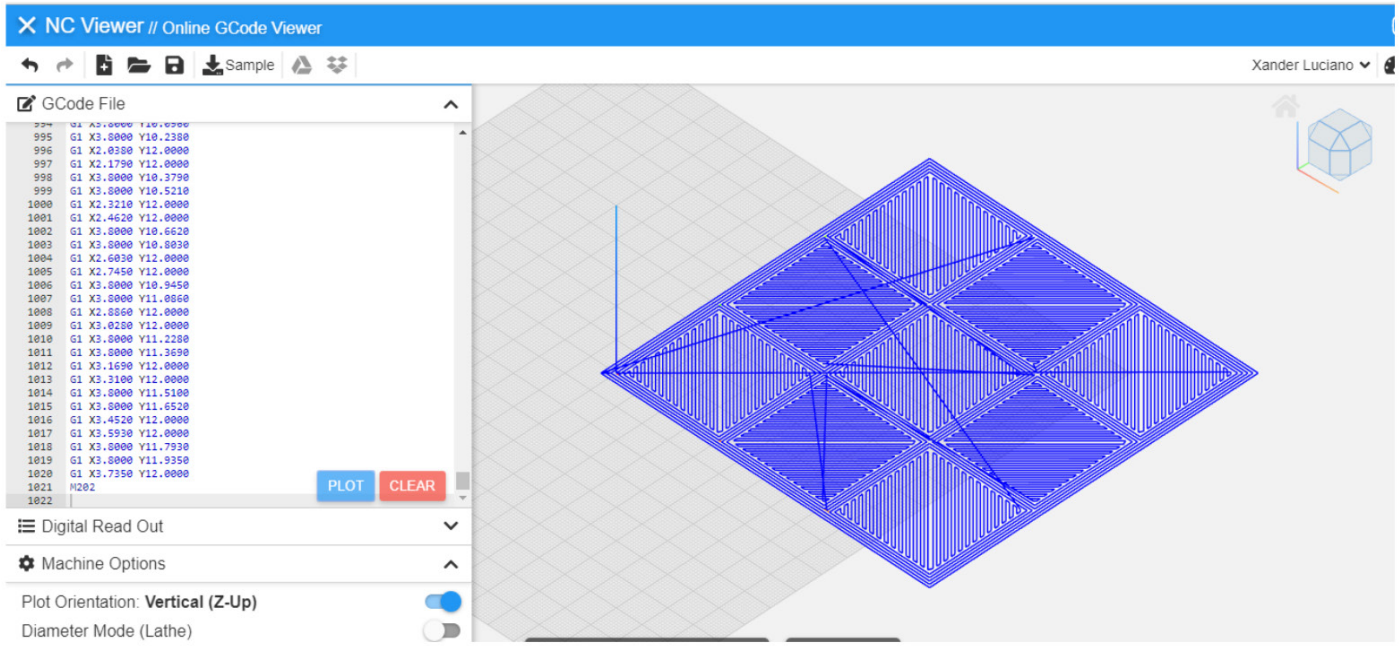
Sensor Testing

- Seeed Studio Grove Barometer
  - Temperature
  - Pressure
- AMI 2001LC Trace Oxygen Analayzer

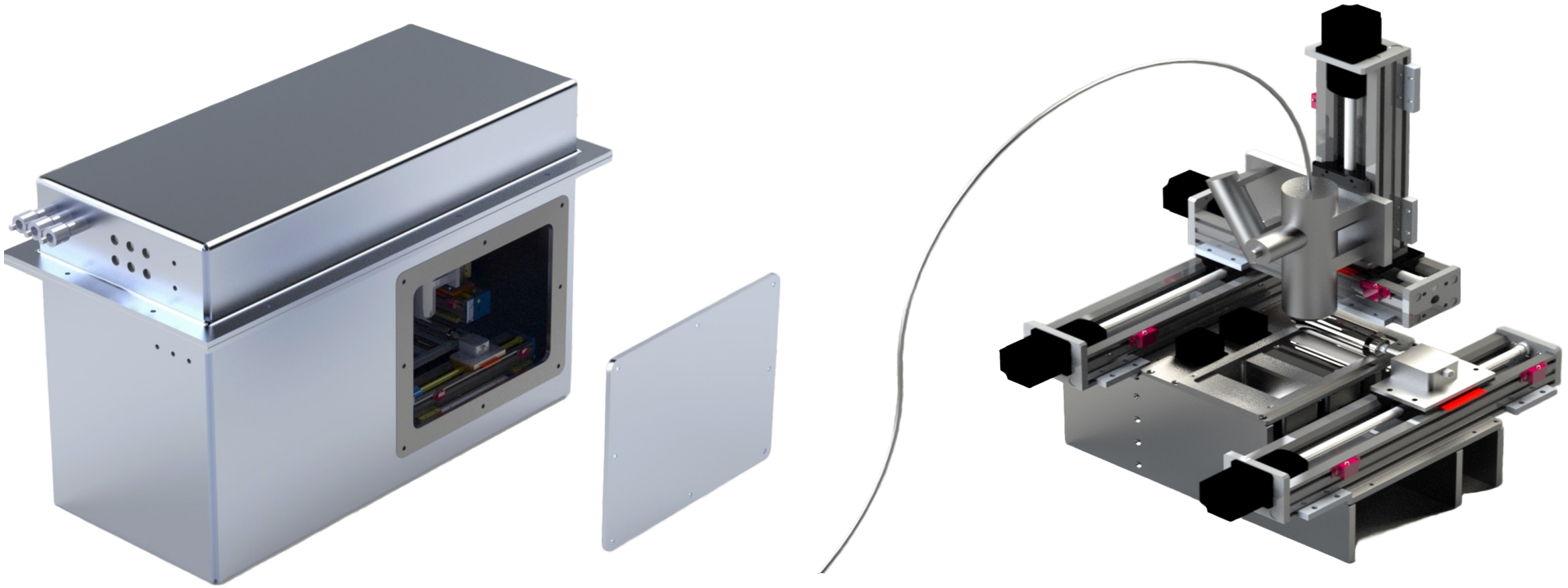


Software Testing

- Testing motor controller command syntax
- Use of visualization tools to verify cube generator outputt



Final Design



Vacuum Chamber and Selective Laser Sintering (SLS) System Rendering

COSTS

Spending Summary

Item	Cost
Trace Oxygen Sensor (internal sensor)	$1,840.00
Mechanical hardware order (vacuum chamber, frame)	$698.38
Waterjet stock order	$396.03
Sensor order (external oxygen, internal pressure, arduino)	$156.85
Connectors	$41.96
Power strip, wire, wiring accessories	$144.25
Kapton wire	$118.62
Vacuum feedthroughs	$1,455.00
Desktop PC	$400.00
Boyd Lab Labor for Frame Machining	$230.00
Velmex Slides and Motor Controllers	$11,880.00
Vacuum Chamber Labor	$3,925.00
Total	**$21,286.09**

What We've Learned

- Many small tasks and challenges came up along the way
  - Table, outlets, vacuum
- Adapting to unfamiliar projects and learning quickly

THANK YOU

QUESTIONS?