

PROJECT MOTIVATION

- The problem:
 - Current solutions to stagetop incubation are prohibitively expensive; upwards of \$13,000 per unit [1].
 - The size and mobility of standard incubators are too limiting for infrequent use.
 - Forma™ Direct Heat CO2 Incubator dimensions: 66.0cm x 97.8cm x 63.5cm and weight: 93 kg (205 lbs) [2].
- The goal:
 - Keep unit price under \$100
 - Allow for easy transport and storage
 - Provide satisfactory cell incubation and allow for proper imaging



Figure 1. Competing design with a cost of \$13,000 [3].



Figure 2. Common desktop incubator [4].

BACKGROUND

- Cell cultures provide excellent model systems for studying the normal physiology of cells and the effects of drugs and toxic compounds on the cells[3].
- Cells require human internal physiological conditions to grow and thrive
- Incubators have to maintain these very stable environments with regulated temperatures, humidity, light, pressure, CO₂, O₂, pH levels, and other conditions [4].
- Without necessary countermeasures, condensation of the upper and lower viewing ports forms.
- Previous teams were able to create and maintain necessary internal environment conditions but failed to prevent condensation on either viewing port.



Figure 3. Example of Previous Team's Issue with Condensation

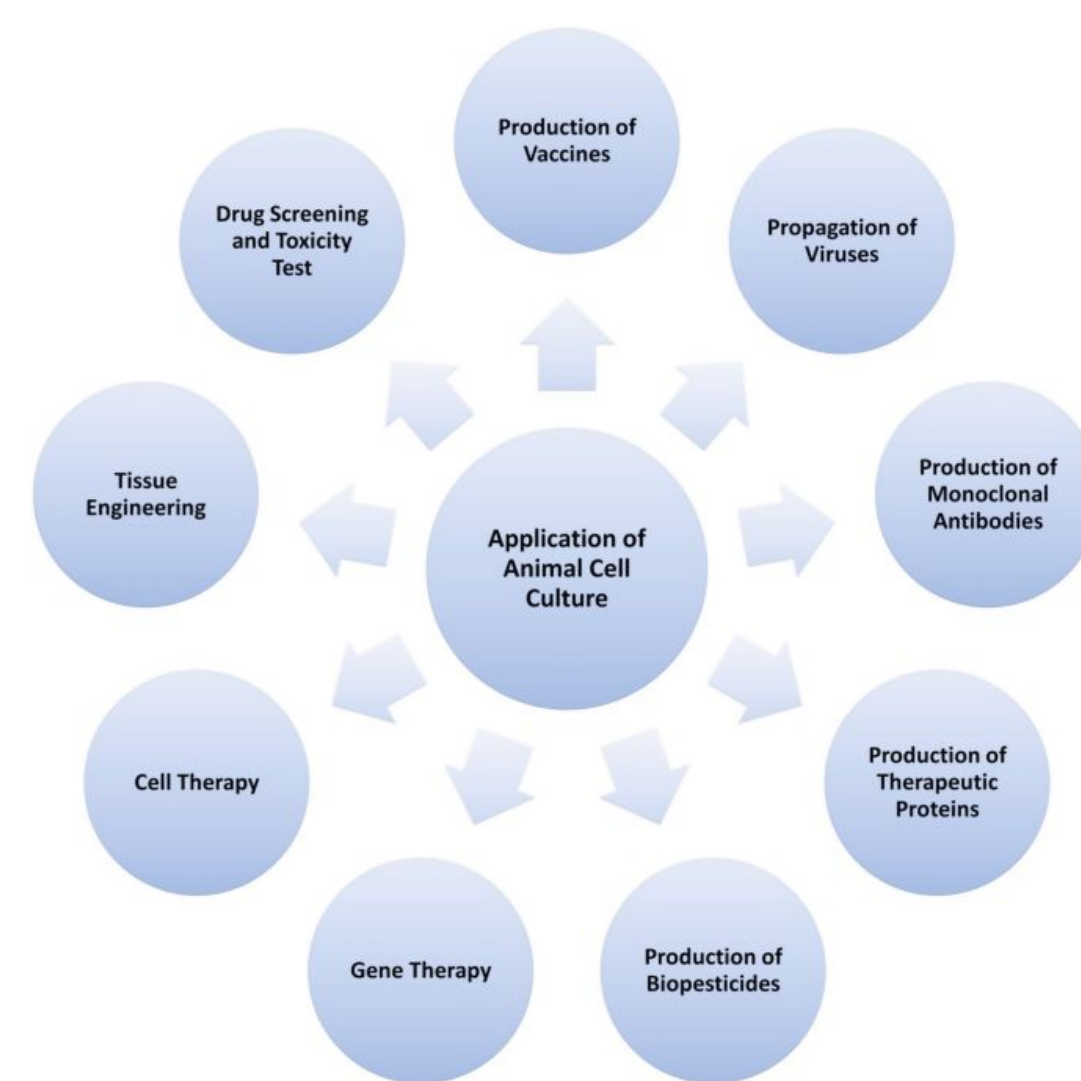


Figure 4. Illustration showing the many uses of animal cell cultures [5]

DESIGN CRITERIA

- Cost
 - Under \$100 per unit
- Interior Environment Conditions
 - 37°C ± 0.5°C
 - Humidity > 95%
 - CO₂ levels 5% ± 0.1%
- Size
 - 310 x 300 x 45mm
- Visibility
 - Must be able to see clearly through microscope
 - phase shifts must be visible

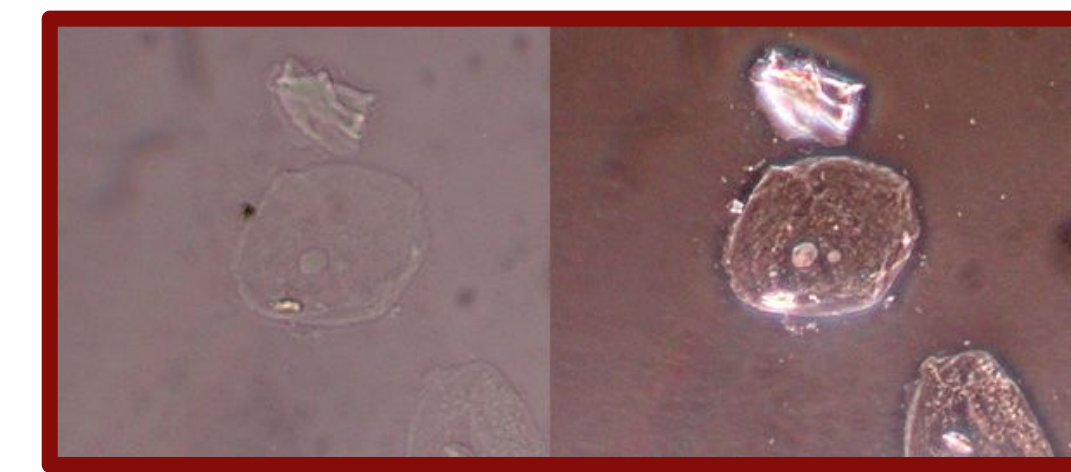


Figure 5. Image illustrating the importance of phase contrast [6]

TESTING AND RESULTS

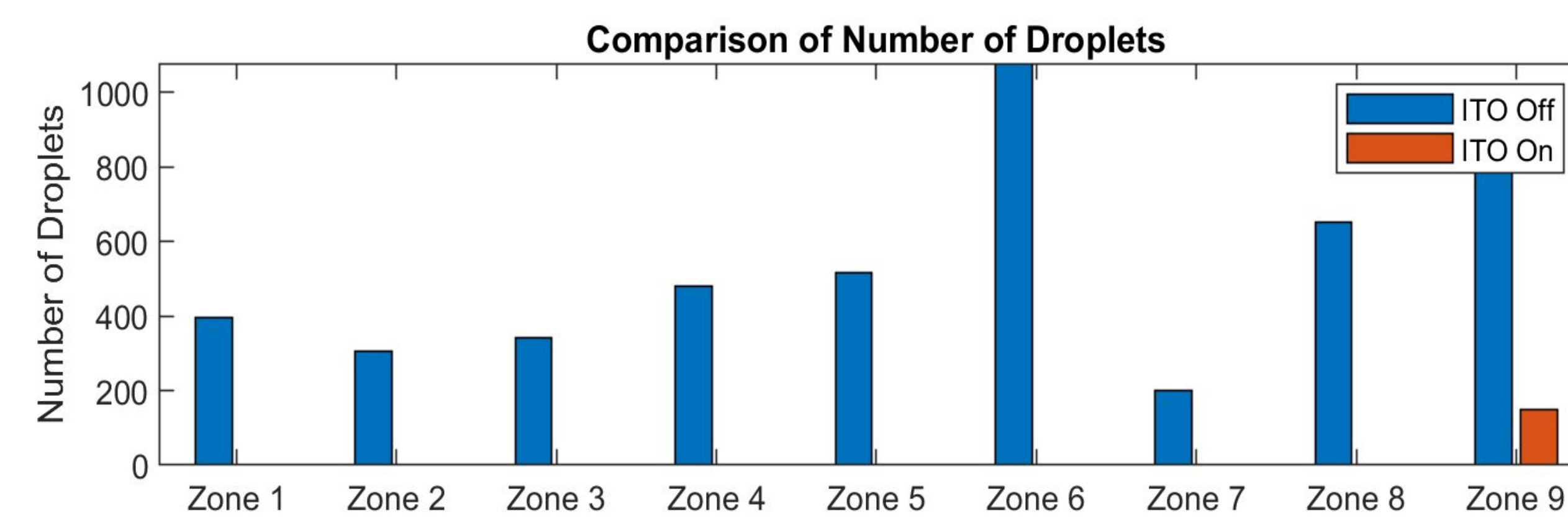
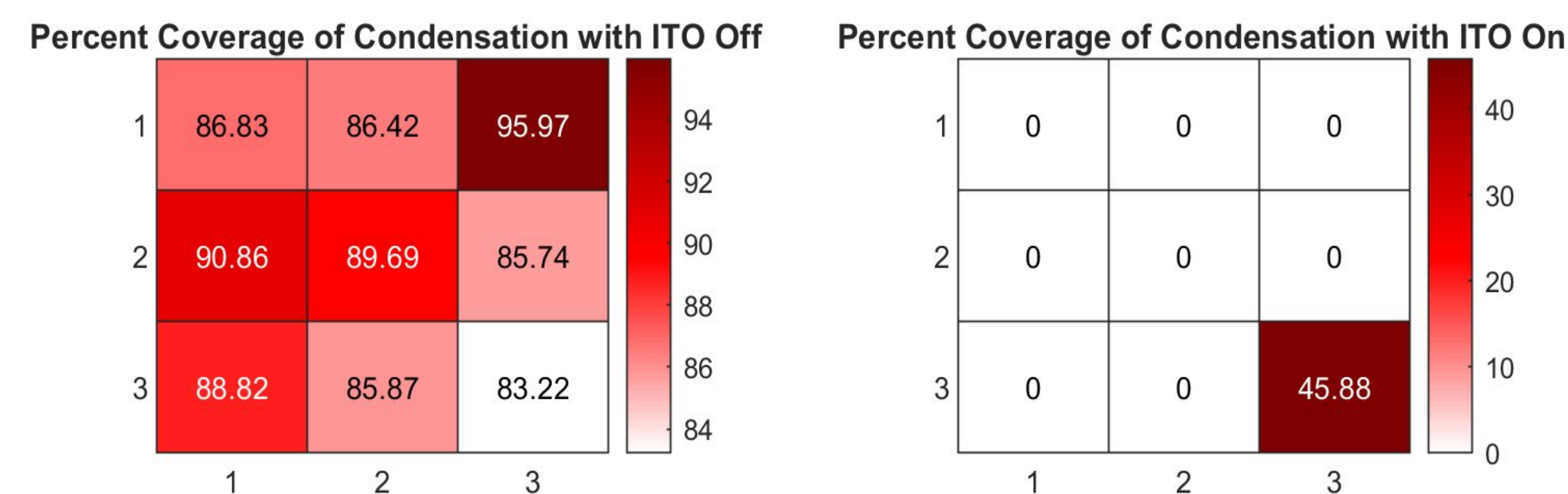
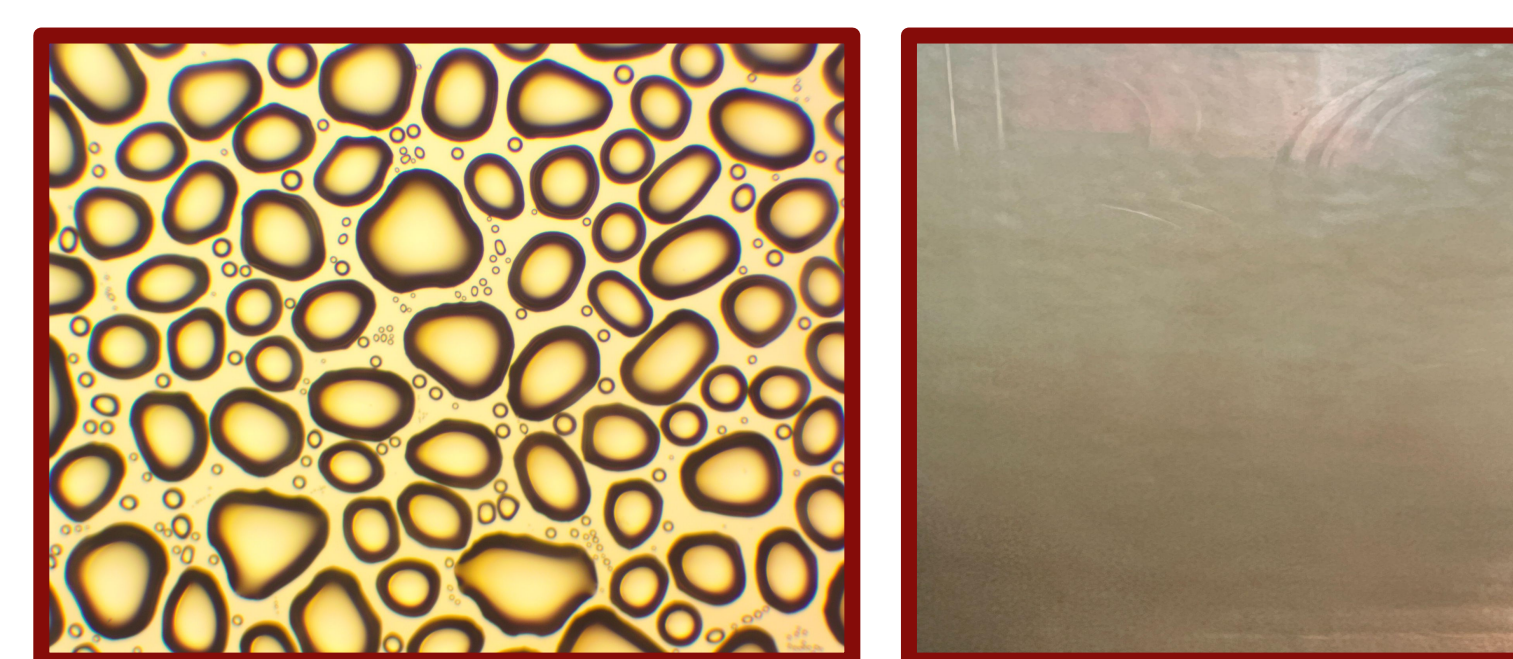


Figure 6. Heat maps and bar graph of ITO film condensation testing

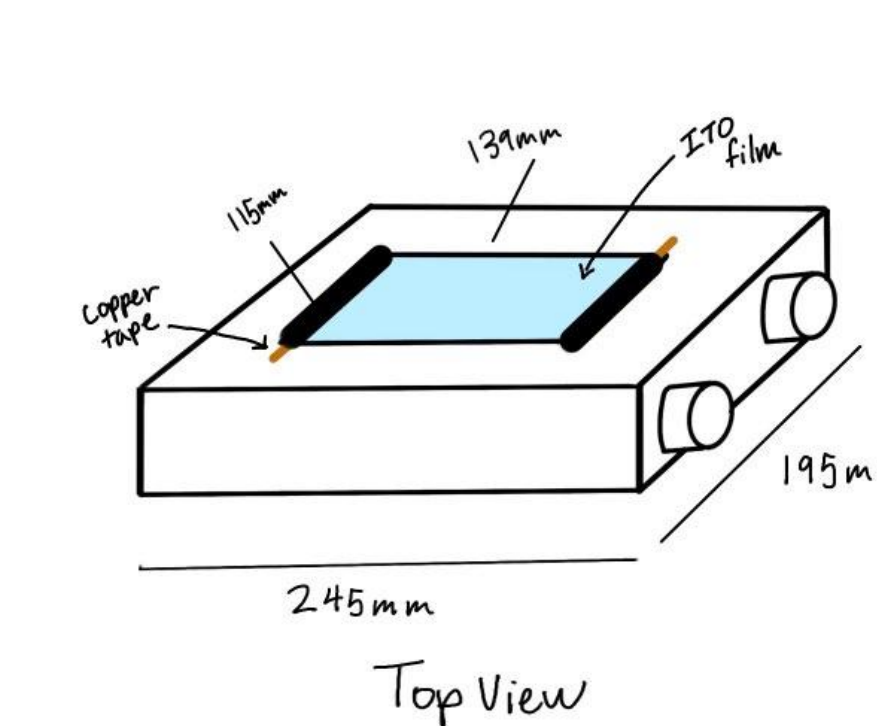


Figures 7 and 8. Images showing the difference in condensation before and after activating ITO film.

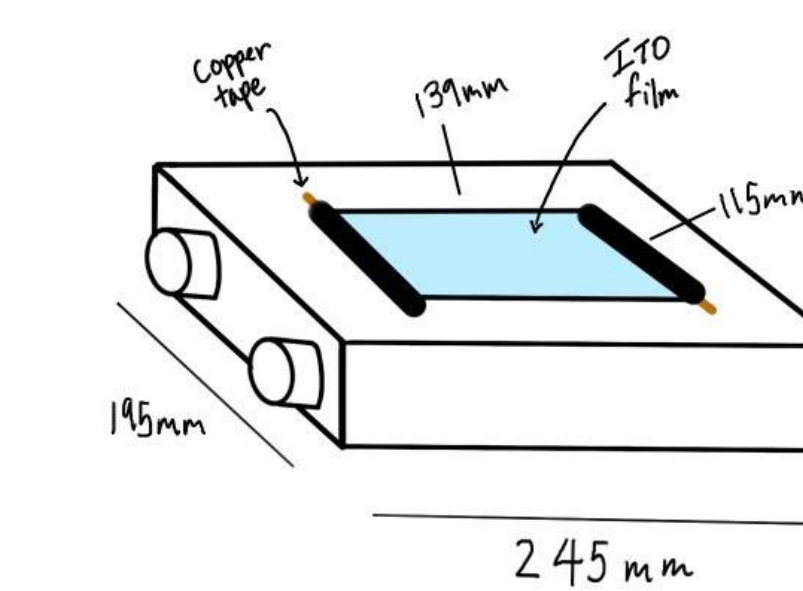
Condensation testing

- Done to see if the incubator looking ports remain clear while running in normal conditions.
- Recorded percent area covered by water droplets and the number of water droplets in 9 zones of the incubator
- Two tailed p-value of < 0.0001

FINAL DESIGN

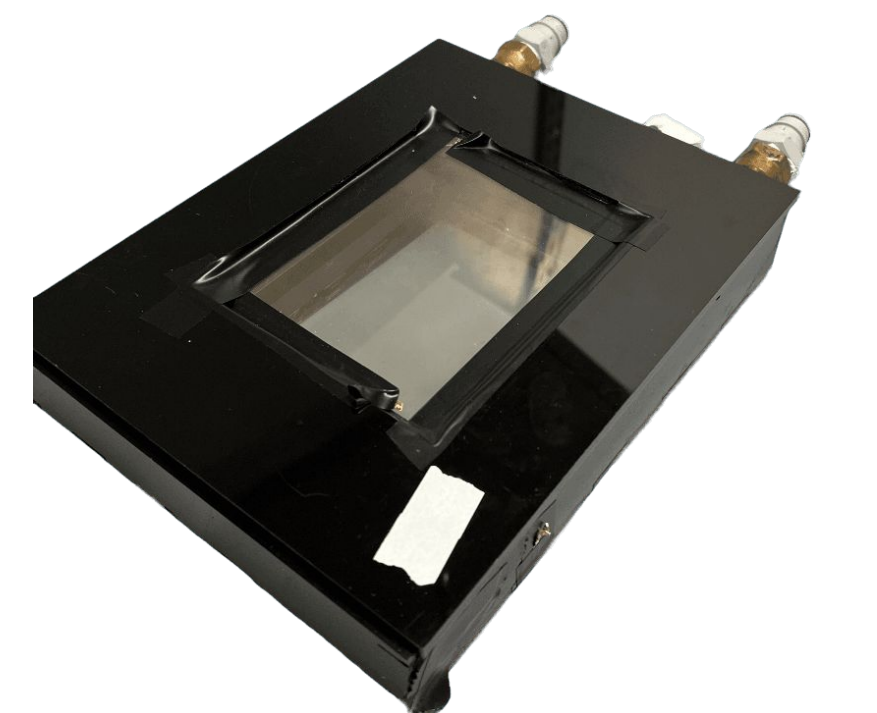
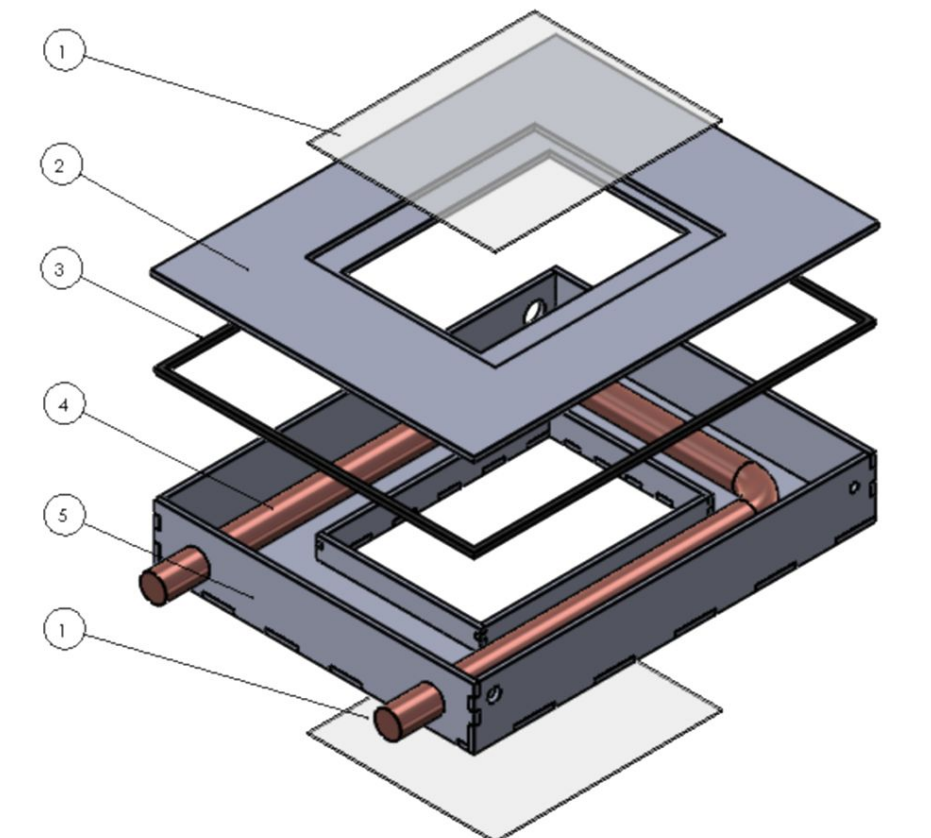


Top View



Bottom View

Figure 9. A drawn top and bottom view of our final design.



Figures 10 and 11. Exploded CAD model and Final Product

FUTURE WORK

- Find an alternative way to heat the viewing screens besides open wires
- Change the viewing screens from plastic to glass to allow for easier heat transfer from ITO and maintenance
- Minimize clutter of tubes and wires
- Run more trials with the ITO film while the whole setup is running, not just the water pump for more statistical power

CONCLUSIONS

- Strengths of design
 - Reduces condensation on the viewing ports
 - maintains conditions that are necessary
- Weaknesses of design:
 - Draws a significant amount of power
 - The tubes and wires can contribute to desk clutter
- Overall success in creating a low cost cell incubator

DESIGN USE

- Water pump heats the chamber by pushing warm water through the inner-pipes
- ITO film and copper wires on the polycarbonate viewing screens create a more uniform heat distribution across the chamber which reduces condensation on the screens
- Arduino microcontroller to monitor the CO₂ levels, temperature, and humidity

REFERENCES

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