SQI Simpson Querrey Institute BioNanotechnology

NORTHWESTERN UNIVERSITY

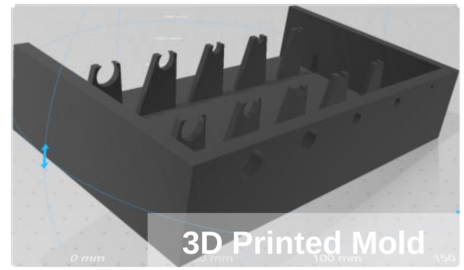
# Variable Flow Sensing with Thermal Anisotropy Checkpoint 1

## Objectives:

- Explore capabilities of flow sensing with thermal anisotropy in variable flow regimes (0.01 – 1000 mL/min)
- To build a phantom skin platform with variable vessel diameters and array of actuator geometries for testing a wide range of flow rates

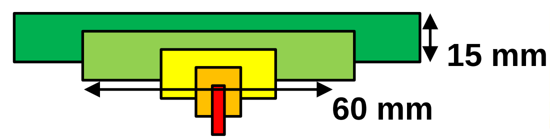
| | ultralow | low | medium | high | ultrahigh |
|---|---|---|---|---|---|
| Flow Rate | 0.01-0.1 mL/min | 0.1-1 mL/min | 1-10 mL/min | 10-100 mL/min | 100-1000 mL/min |
| Vessel Diam. | 1.6 mm | 3.2 mm | 4.1 mm | 6.4 mm | 8.0 mm |

## Technical Approach:





Actuator Geometries



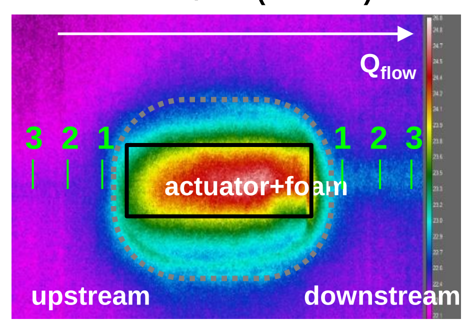


## Technical Accomplishments:

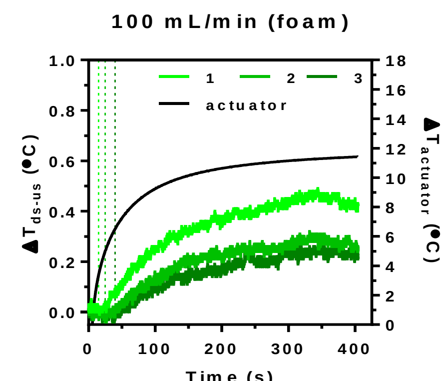
- Designed 3D printed mold (left and right) for phantom skin in SolidWorks
- Assembled and poured phantom (Sylgard170) with uniform skin thickness
- Preliminary tests of an actuator-only device at high flow (0 and 100 mL/min) with IR camera
- Measurements without insulation of sensor regions still demonstrates anisotropy
- **Future**: incorporate array of NTC sensors on different actuator geometries for sensing studies

## Preliminary IR Data

100 mL/min (t = 400s)




PD = 1 mW/mm$^2$




Sensitivity:
$\Delta T_{ds-us}/\Delta T_{actuator}$ (%)

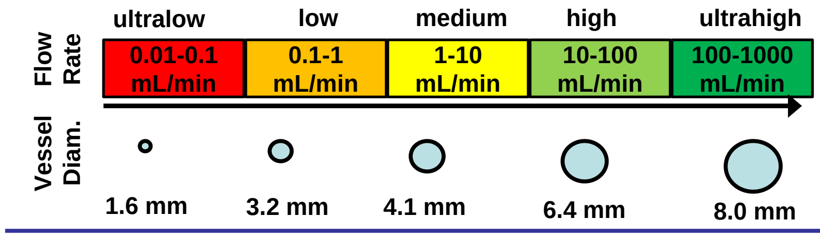
1: 3.5%
2: 2%
3: 2%

Contact: ObumnemeOsele2021@u.northwestern.edu

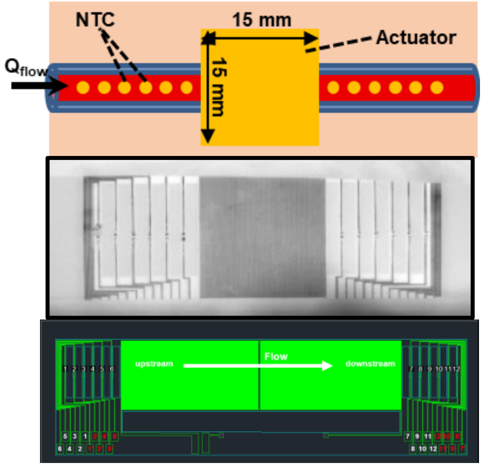
# Variable Flow Sensing with Thermal Anisotropy Checkpoint 2

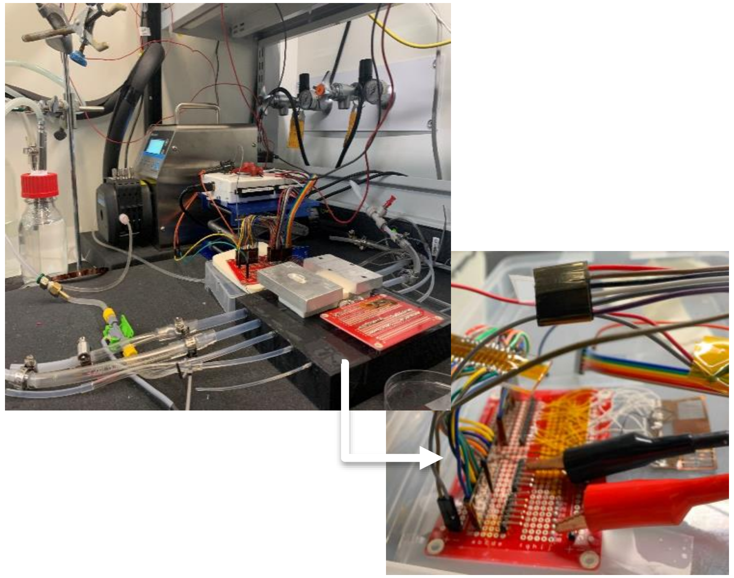
## Objectives:

- Assemble thermal actuator devices with varying NTC thermistor spacing for thermal anisotropy testing on phantom skin
- To establish a streamlined data acquisition system to perform multiple tests analyzing NTC spacing




## Technical Approach:



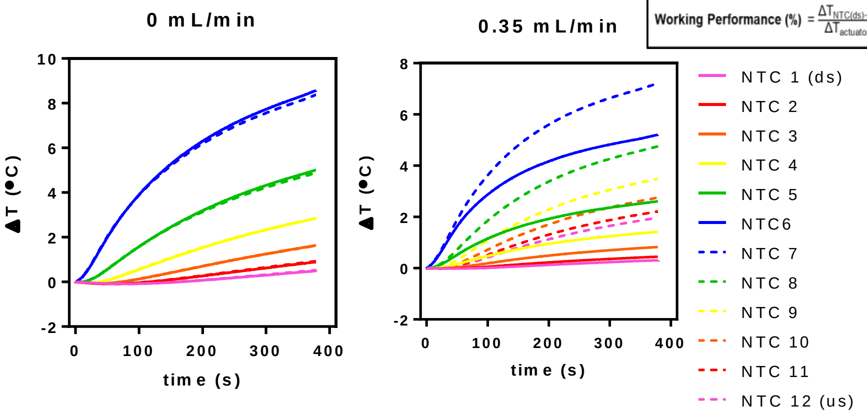
## Technical Accomplishments:

- Incorporated array of NTC sensors on 15 mm by 15 mm and 15 mm by 60 mm thermal actuator geometries for sensing studies
- Tests of 15 mm by 15 mm device at low flow (0 and 0.35 mL/min) with IR camera
- Assembled a circuit board utilizing a voltage divider and digital multimeter to track all NTC resistances simultaneously over time

**Future**: Continue tests with the remaining actuator geometries

## 15 mm by 15 mm Data

| | | |
|---|---|---|
| Sensitivity (%) | $= \frac{\Delta T_{NTC(ds)} - \Delta TNT_{C(us)}}{Q_{flow}} x100$ | 613.5% |
| Performance (%) | $= \frac{\Delta T_{NTC(ds)} - \Delta TNT_{C(us)}}{\Delta T_{actuator}} x100$ | 11.2% |
| Working Performance (%) | $= \frac{\Delta T_{NTC(ds)} - \Delta TNT_{C(us)}}{\Delta T_{actuator} * \chi A_{tubing}} x100$ | 35.0% |




PD = 2 mW/mm$^2$


Contact: ObumnemeOsele2021@u.northwestern.edu