



# Miniature Vacuum System for Photonic Levitation

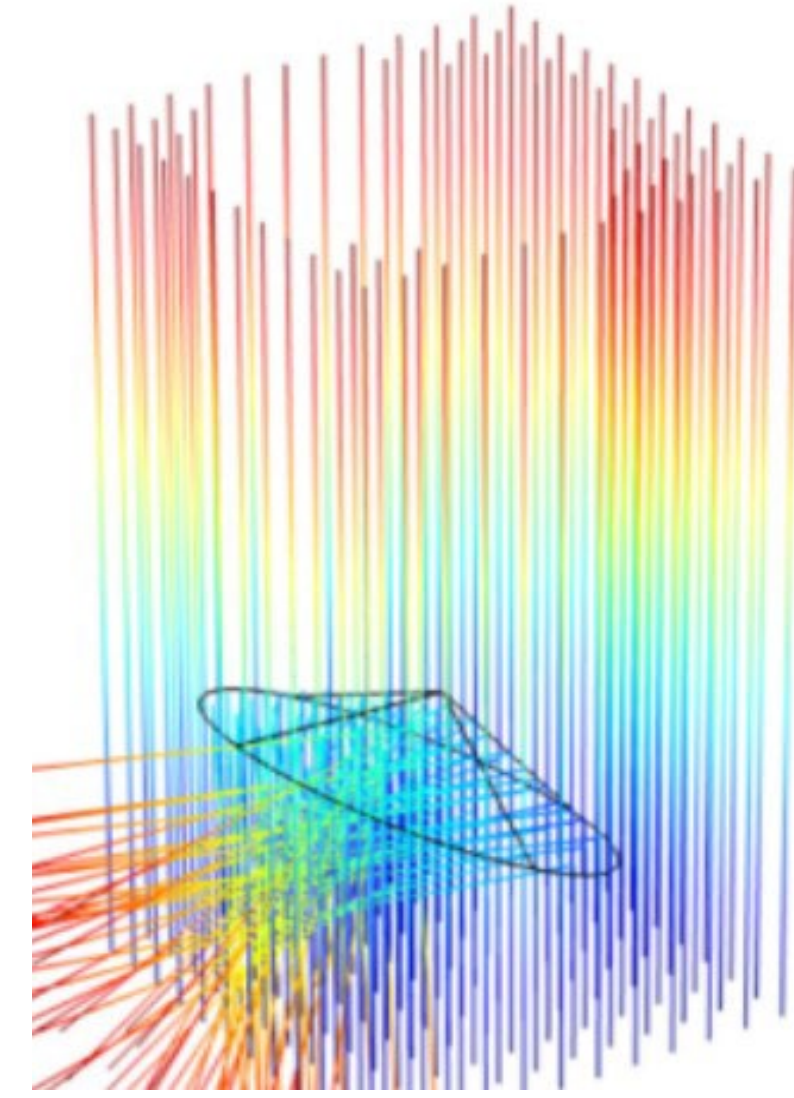
Contact

Simon Horning  
horni092@umn.edu

Simon Horning, Avinash Kumar, and Ognjen Ilic in the Laboratory for Nano Optics and Mechanics

## Abstract

The photonic levitation and propulsion of free-standing nanostructured objects is yet to be experimentally demonstrated. These structures have applications ranging from nanosatellites to exploration of deep space far beyond the solar system. The applications of self-stabilizing metasurfaces lie in regimes of pressure that are significantly lower than the pressure found on the surface of Earth. This project further investigates the dynamics of self-stabilizing objects under pressure variations of several orders of magnitude through the design and implementation of a variable pressure vacuum system.



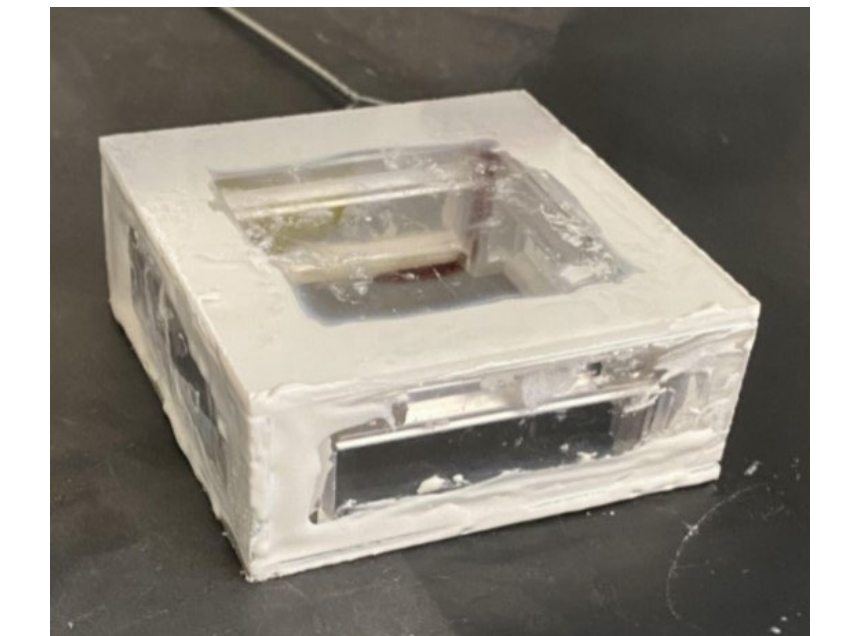
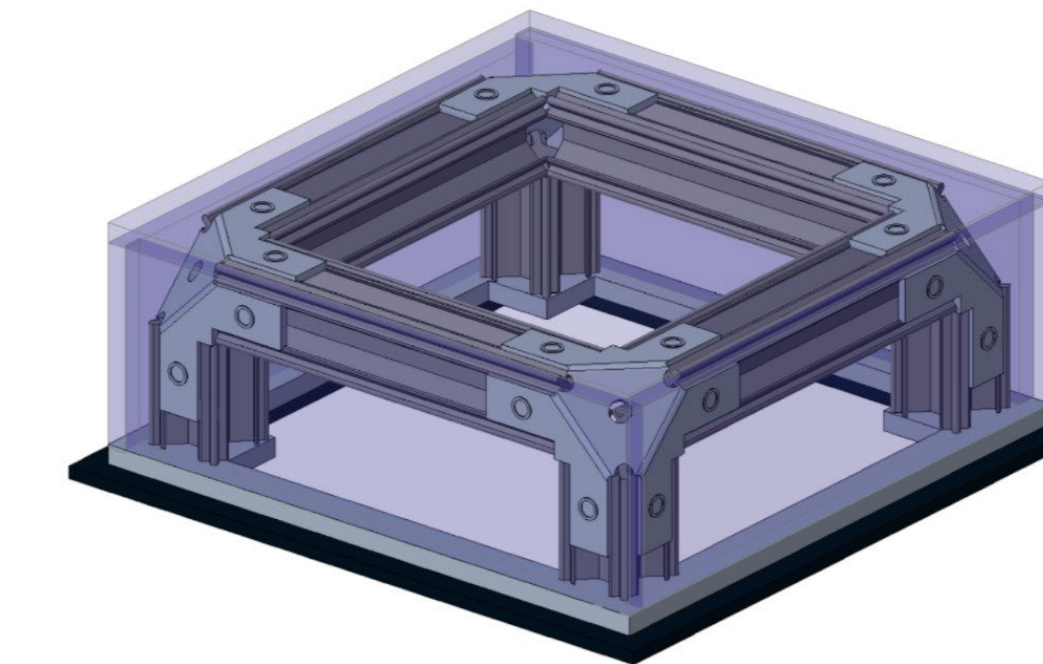
"Optomechanical Self-Stability of Freestanding Photonic Metasurfaces."  
Kumar, Kindem, Ilic. 21 July 2021.

## Vacuum Chamber

### 3 Frame Prototypes

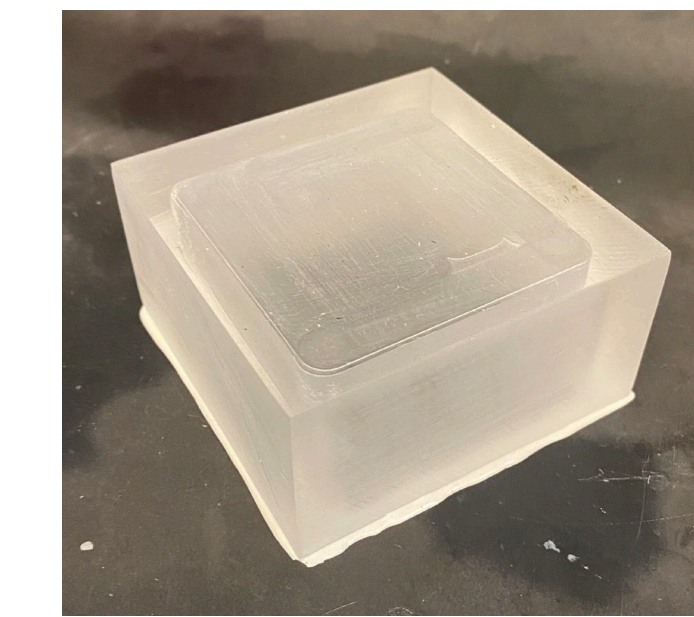
#### #1 Internal Support

- Compact/Sturdy
- Over-engineered
- Difficult fabrication



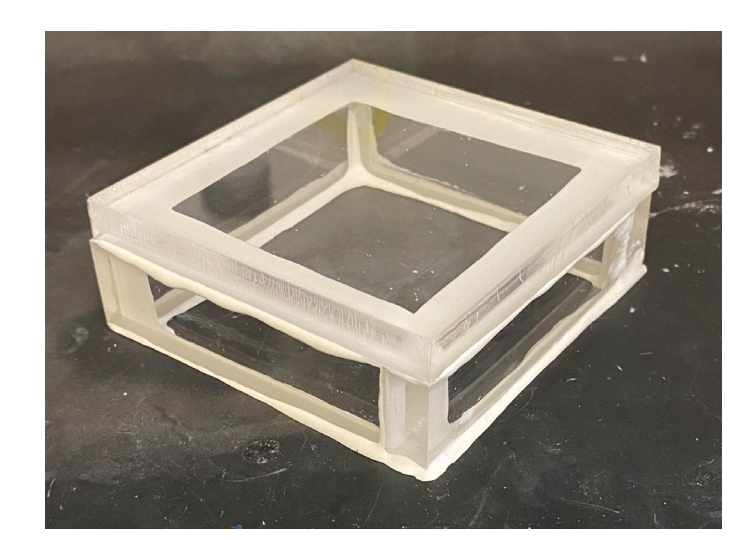
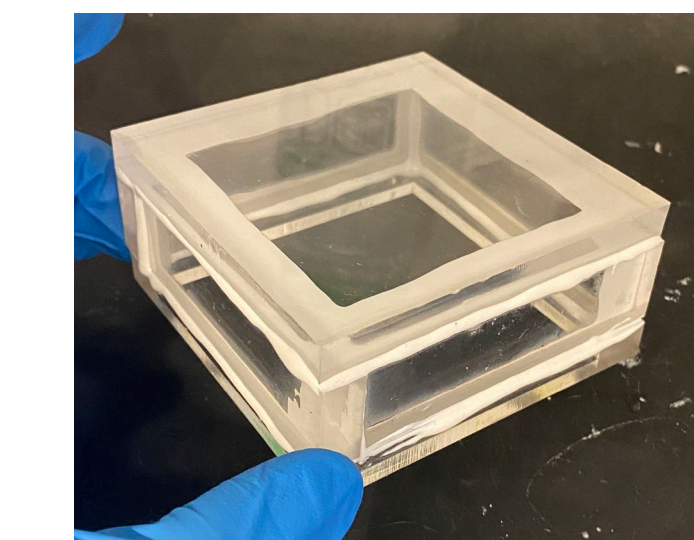
#### #2 Milled Cover

- Optically translucent
- Ineffective heat treatment
- Difficult fabrication



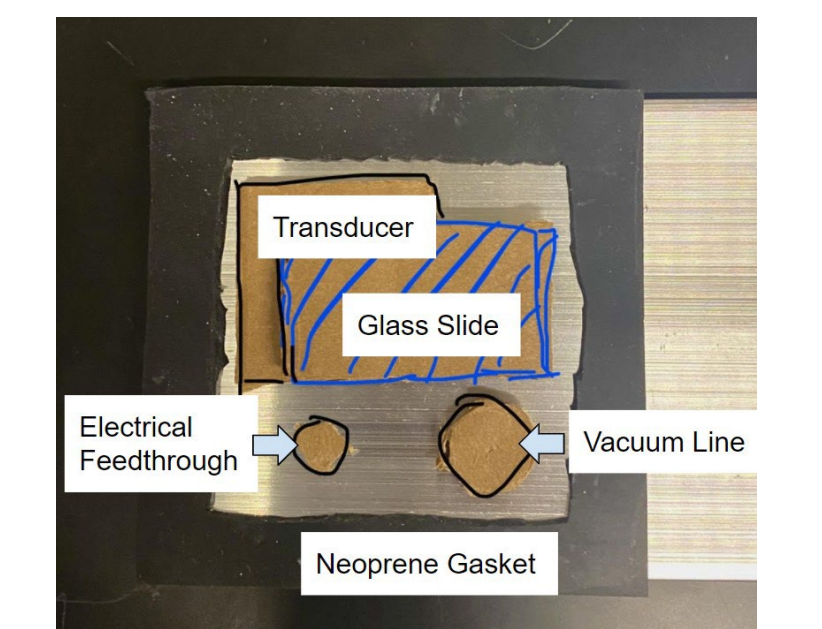
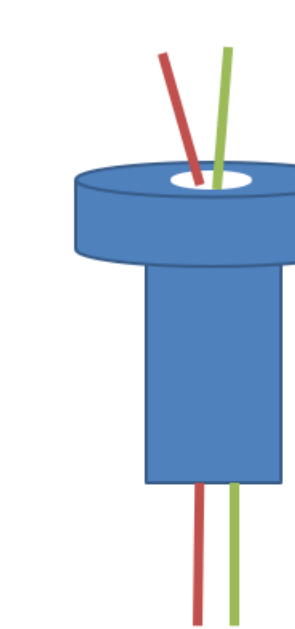
#### #3 Laser Cut Assembly

- Simple fabrication
- Clear internal view
- Structural vacuum epoxy



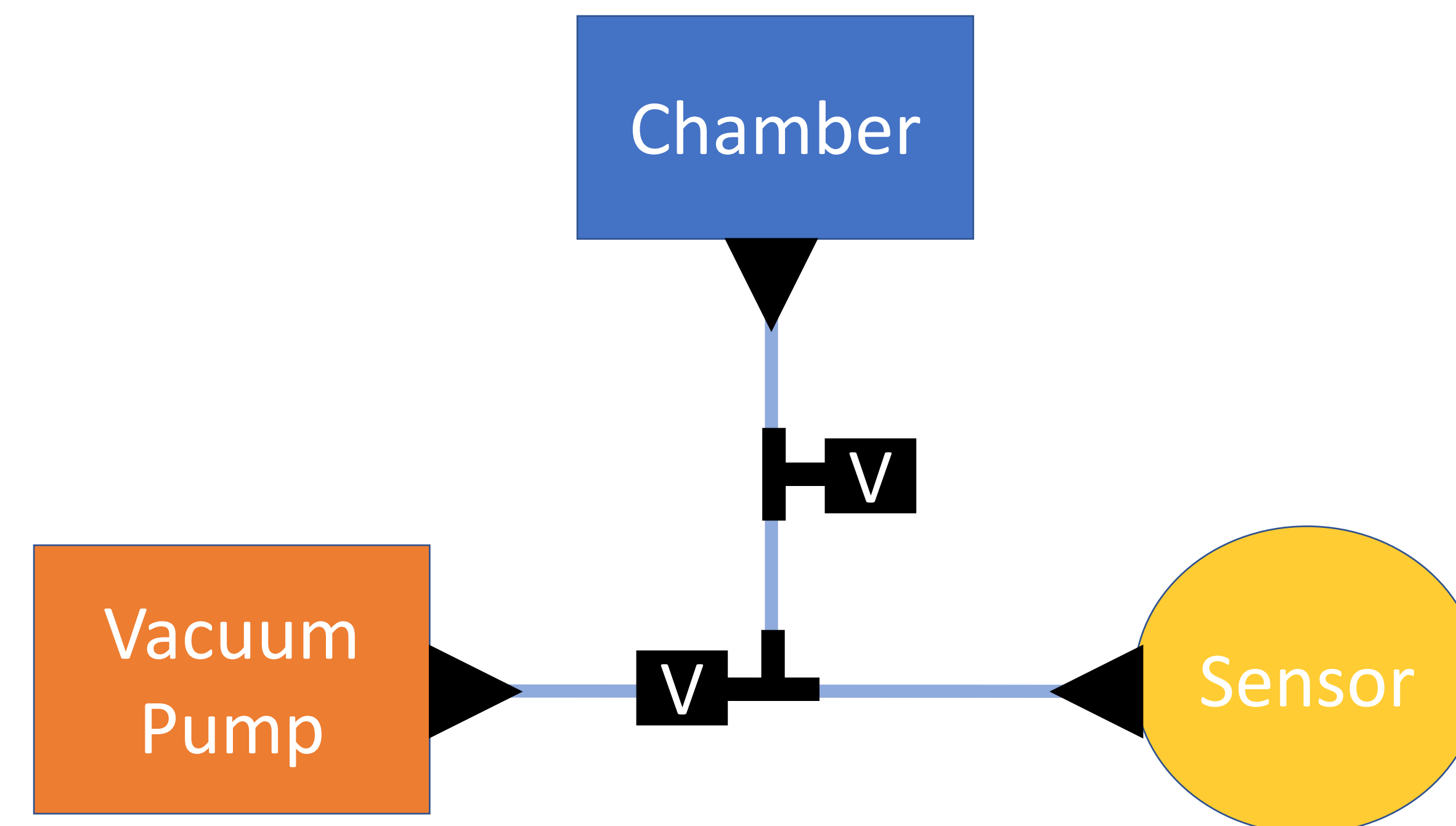
#### Chamber Base

- Transducer
- Electrical Feedthrough
- Vacuum Line
- Gasket



## System Specifications and Outline

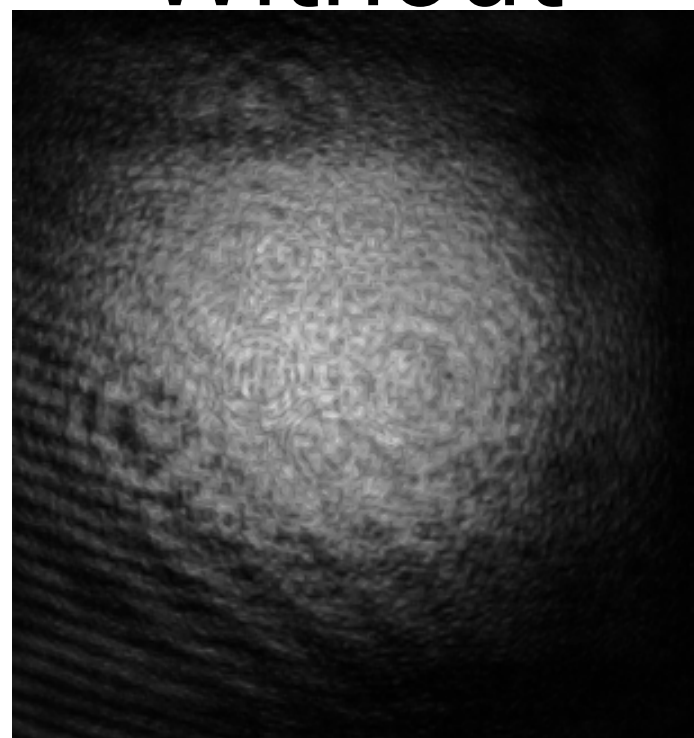
- Maximum Chamber Size: 80x80x50 [mm]
- Chamber Accommodations
  - Four Viewports: top, bottom, opposing sides
  - One 30x30 [mm] Acoustic Transducer
  - One 2 Pin Electrical Feedthrough
  - Vacuum Line Connection
  - Clear, Removable Frame
- Maximum Vacuum: 22.5 mTorr
- MKS 925 MicroPirani Pressure Transducer
- Release and Vacuum Lock Valves



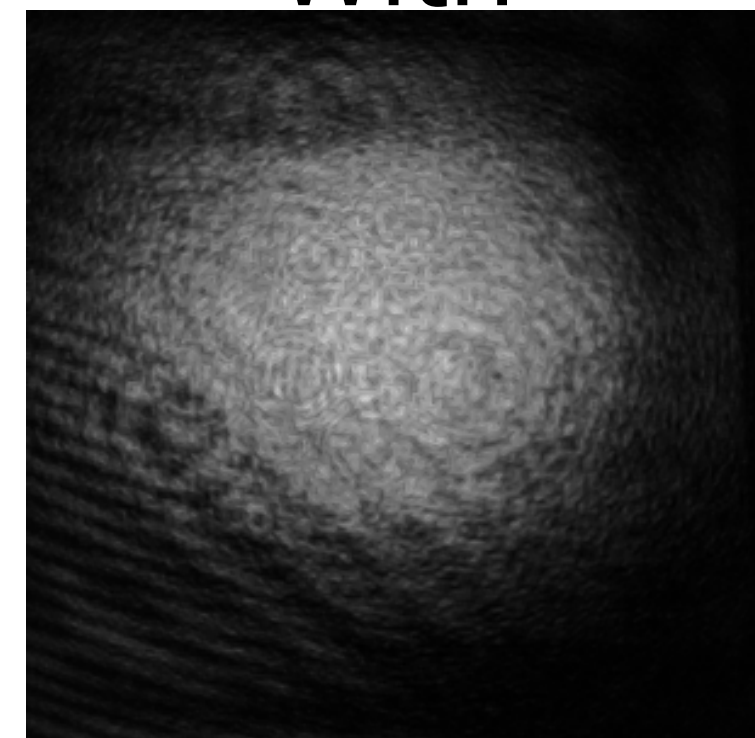
## Viewport Optics

- Viewports are constructed from acrylic slides
- High transmissibility at 633 nm and 1550 nm
  - 633 nm: 8.82% power decrease
  - 1550 nm: 8.87% power decrease

Without



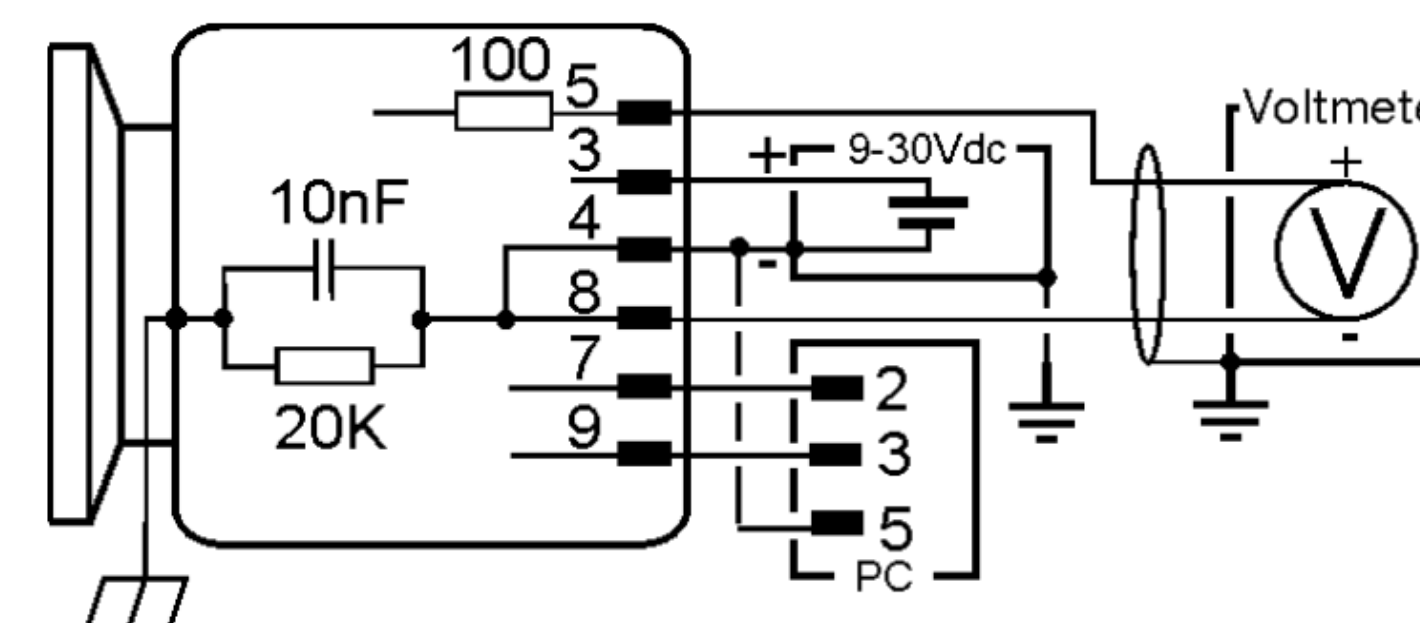
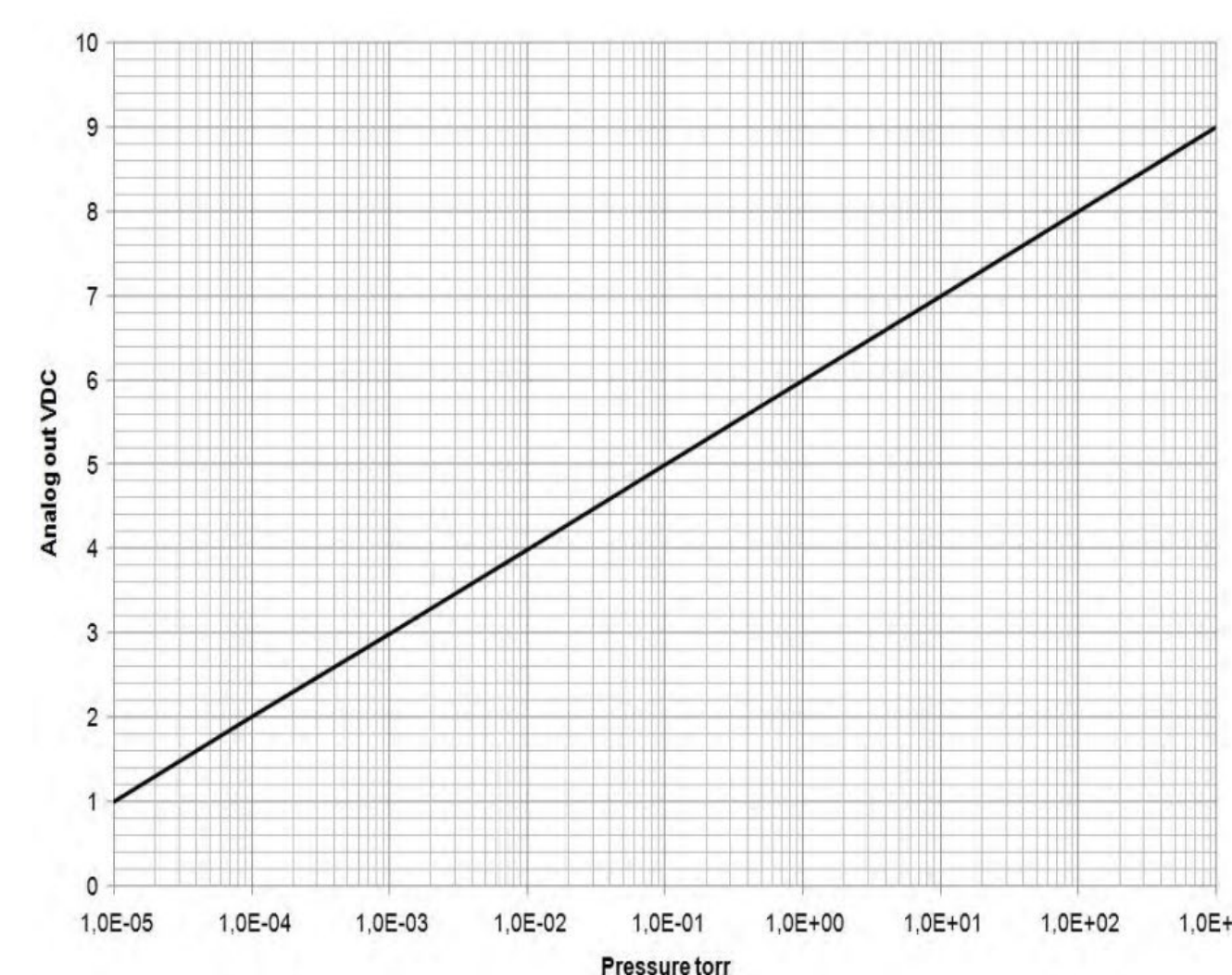
With



System Imaging With/Without Acrylic Slides

## Pressure Measurement

The 925 MicroPirani Pressure Transducer runs off 12-30VDC and has an analog voltage output that converts to pressure.



## Conclusions/Next Steps

- Acrylic is a suitable material for imaging purposes but has too high of an absorption at 633 and 1550 nm. Therefore, the chamber should integrate a more transmissible material.
- Frame Design Selection: Laser Cut Assembly for its simplicity, ease of manufacturability, structural stability, and potential for transmissible viewport integration.
- Fixturing the acoustic transducer with a mechanical lock is desired for testing apparatus, allowing for multiple uses and applications of the acoustic transducer.
- Gasket design and chemical/mechanical fixturing for ensuring a hermetic seal between chamber frame and chamber base.
- Implementation into optical experimental table.