Pressure Transducer for Flow Chemistry

Designed by Hubert Hellwig[a], under supervision of Jean-Christophe M. Monbaliu[a,b]

a) *Center for Integrated Technology and Organic Synthesis (CiTOS), MolSys Research Unit, University of Liège, B6a, Room 3/19, Allée du Six Août 13, 4000 Liège (Sart Tilman), Belgium; webpage: https://www.citos.uliege.be*
b) *WEL Research Institute, Avenue Pasteur 6, B-1300 Wavre, Belgium*
E-mail: hhellwig@uliege.be; jc.monbaliu@uliege.be

Design of chemically resistant pressure transducer

Presented pressure sensor holder is designed for use with Metallux ME780 Al_2O_3 ceramic pressure sensors, which are available for a wide range of pressures. In this project, we use the calibrated 50-bar version with a linear analog output 0.5-4.5 V (part number: ME780R050010000).

Materials in contact with the process fluid:

- Al_2O_3 ceramic (face of the ceramic ME780 pressure sensor)
- PTFE (disc with the angled fluid channels)
- FFKM (O-ring, e.g. 11.10 x 1.60 mm, Kalrez 6375)
- Fluidic connectors (e.g. IDEX or VICI 1/4-28 UNF HPLC-type connectors) – a variety of ferrule materials are available, such as ETFE, PCTFE, known for its excellent resistance

The pressure sensor used in this project provides an analog voltage output proportional to the applied pressure. The full range of 0-50 bar (gauge) corresponds to a voltage range of 0.5–4.5 V, which can be read using an ADC (Analog-to-Digital Converter) and a microprocessor, such as an Arduino board. Alternatively, the sensor can be connected to a variety of pre-made panel meters with analog voltage inputs (many options are available on the market).

The pressure sensor holder assembly is fastened by M4 bolts with cylindrical heads - four in the upper section (M4x16) and four in the lower section (M4x8). The centering ring serves to correctly position and hold the FFKM O-ring. Note that the centering ring must always be of lower height than the height of the O-ring. The O-ring creates a seal between the PTFE disc and the ceramic face of the pressure sensor, and the dead volume inside of the device largely depends on the O-ring size. The choice of O-ring is limited by the sealing area on the pressure sensor's face (see figure 1).

The design and assembly process are illustrated with accompanying photographs in this document (see figures 1 - 22). The metal components were machined from 316 stainless steel, while the polymer part being in contact with the measured fluid was machined from PTFE. Although the metal parts and bolts do not come into contact with the measured fluid, it is recommended to use stainless steel (preferably 304 or better 316 type) to prevent corrosion from lab atmospheres and inevitable spills during regular use.

The sensors built at CiTOS were tested with pure HCl gas (>20 bar), HCl solutions, 90% HNO_3, liquid NH_3 (above 40 bar), pure O_2 gas (above 40 bar) and various solvents. The maximum allowable flow rate depends on the viscosity of the fluid and the size of the angled channels in the PTFE component (in this project 1.0 mm). The sensor can also be connected to the fluidic system in a non-flow-through configuration by capping one connector with a 1/4-28 UNF plug and using a tee connector, allowing to use it with large scale system.

In some cases, for enhanced sealing between the 1/4-28 UNF connectors and the PTFE surface, small FFKM O-rings (e.g., 3.00 x 1.00 mm, Kalrez 6375) can be placed in the 1/4-28 UNF screw ports.

The pressure transducer designed and described here is occasionally referred to as "MPS," derived from "Metallux Pressure Sensor."

3D design drawings

Files containing the 3D-designed pressure sensor holder are available in the repository. These include *f3d* and *3mf* files with the complete design, *STEP* files for individual components, and *PDF* files with 2D drawings. The file names are self-explanatory, reflecting the corresponding pressure sensor holder parts.

Figures

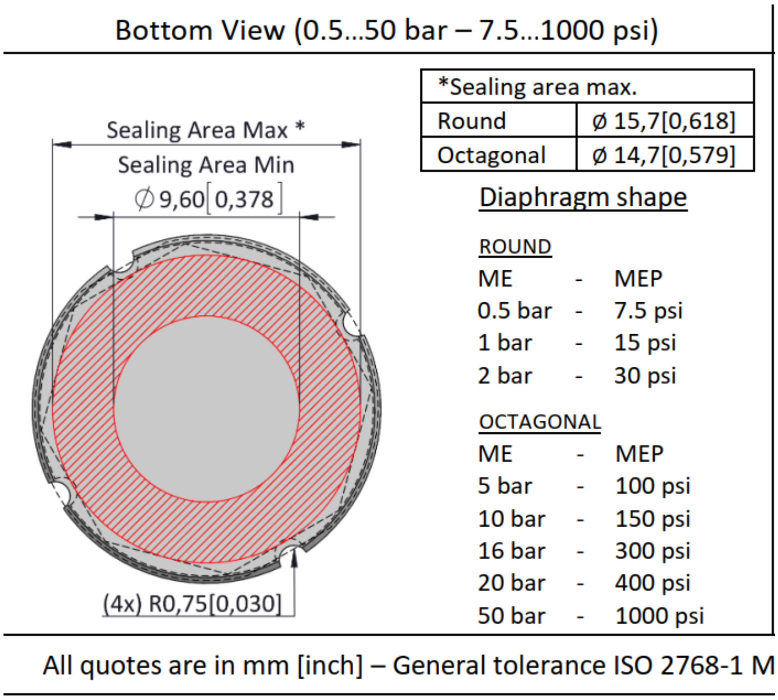

Figure 1. Sealing area of ME780 sensor – figure from the Metallux ME78x pressure sensor datasheet file.

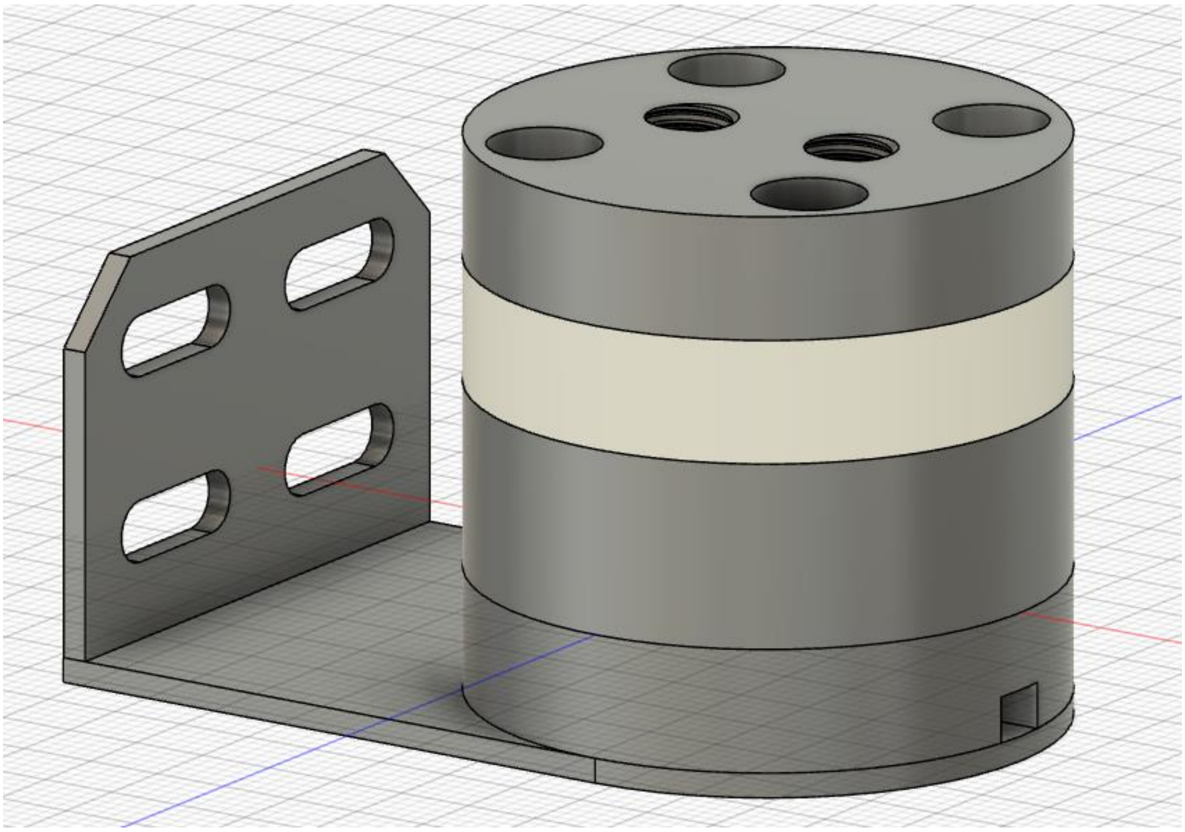

Figure 2. Overview of 3D design.

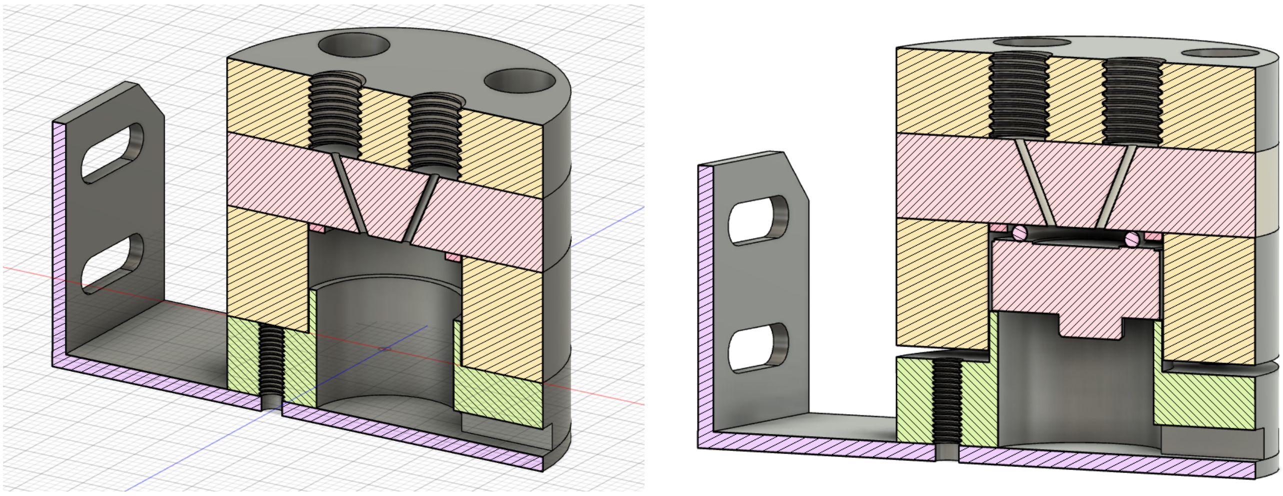

Figure 3. Left side: Section view of 3D design. 1/4-28 UNF sockets, angled fluid channels in the PTFE disc and the cavity for sensor visible. In the bottom part a channel for the output cable is present. Right side: the pressure sensor and O-ring are shown. The clearance between the bottom component, which pushes the pressure sensor upward, and the middle holder allows for bolt tightening, which compresses the O-ring to create a proper seal.

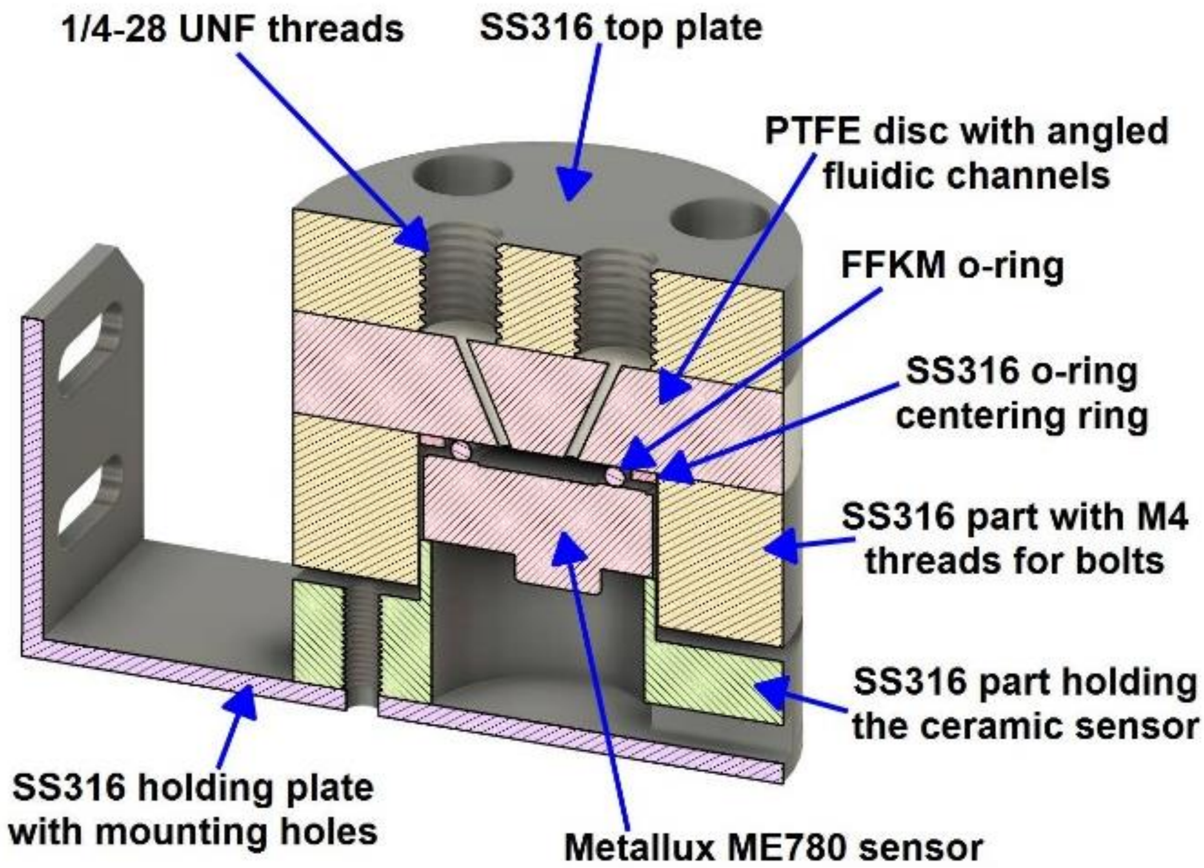

Figure 4. Description of elements. Metal elements manufactured from stainless steel (in normal working conditions, metal parts will be not in contact with fluid).

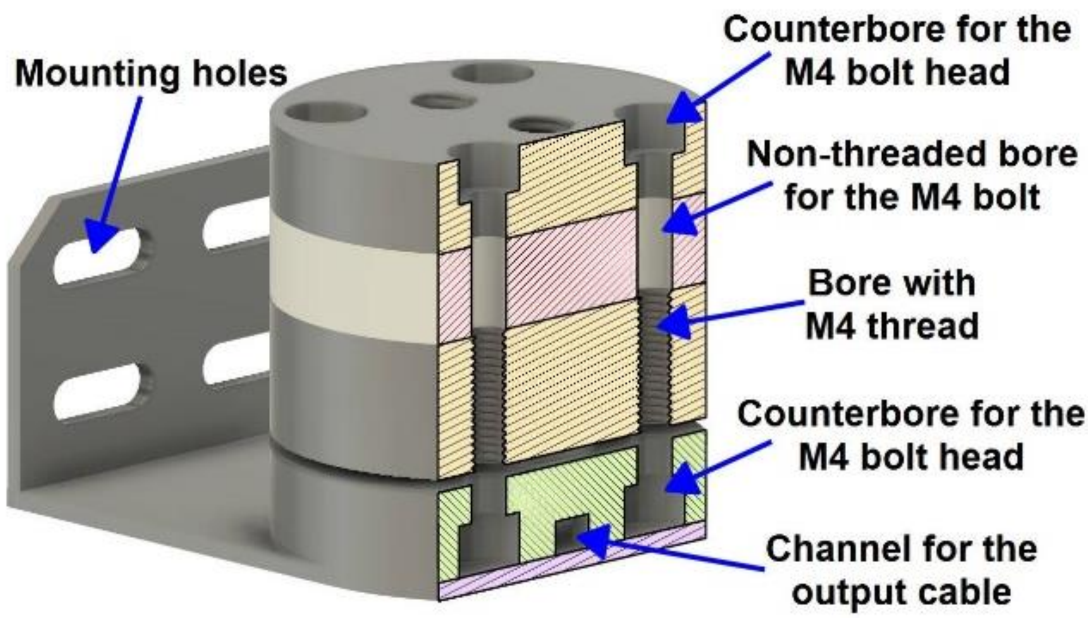

Figure 5. Section view of 3D design. M4 bolts bores visible, with threaded part in the element directly below PTFE disc. Counterbores for bolts' heads are present in the top and the bottom element.

Figure 6. Photograph of upper side of 3D-printed prototype during first tests before ordering machined parts. IDEX 1/4-28 connector screwed in.

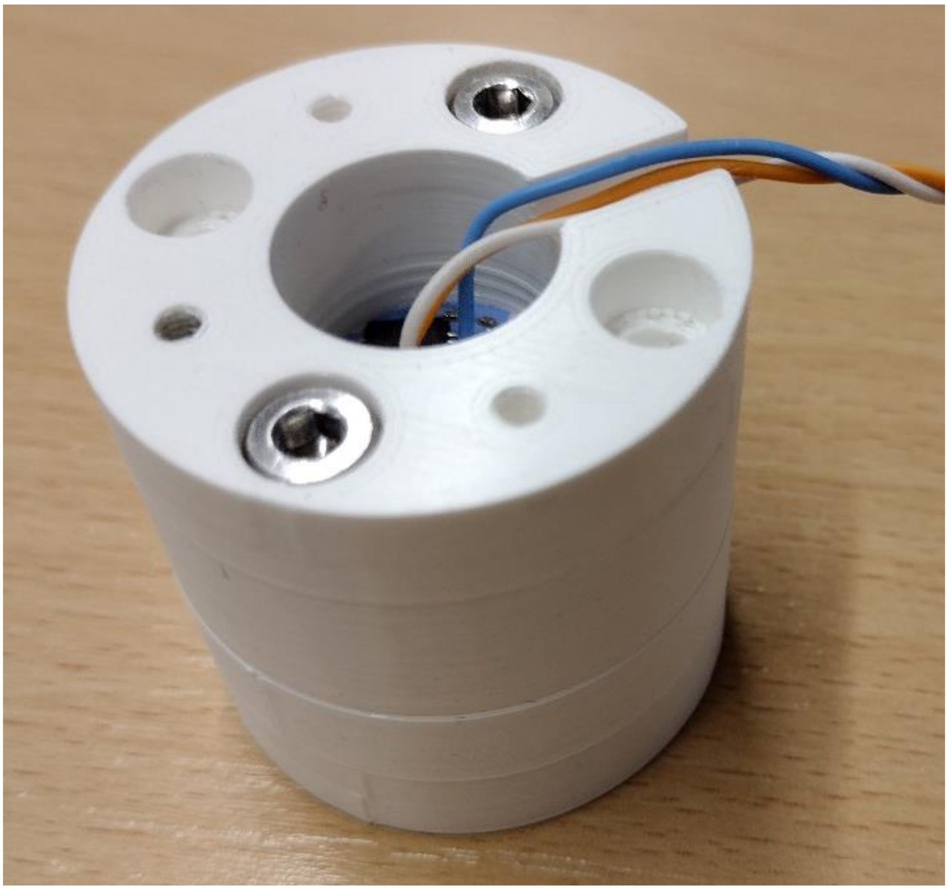

Figure 7. Photograph of 3D-printed model. Test of pressure sensor fit and electrical connection.

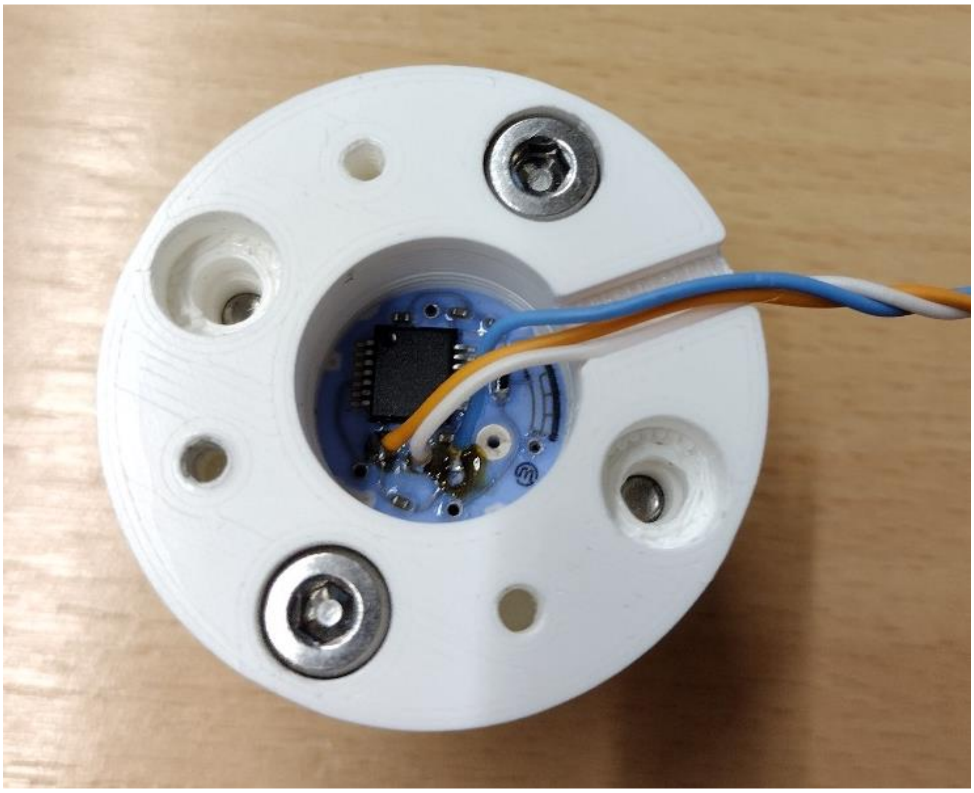

Figure 8. Photograph of bottom side of 3D-printed model. The three wires soldered to the pressure sensor are visible (blue: GND, orange: +5 V, white: signal output).

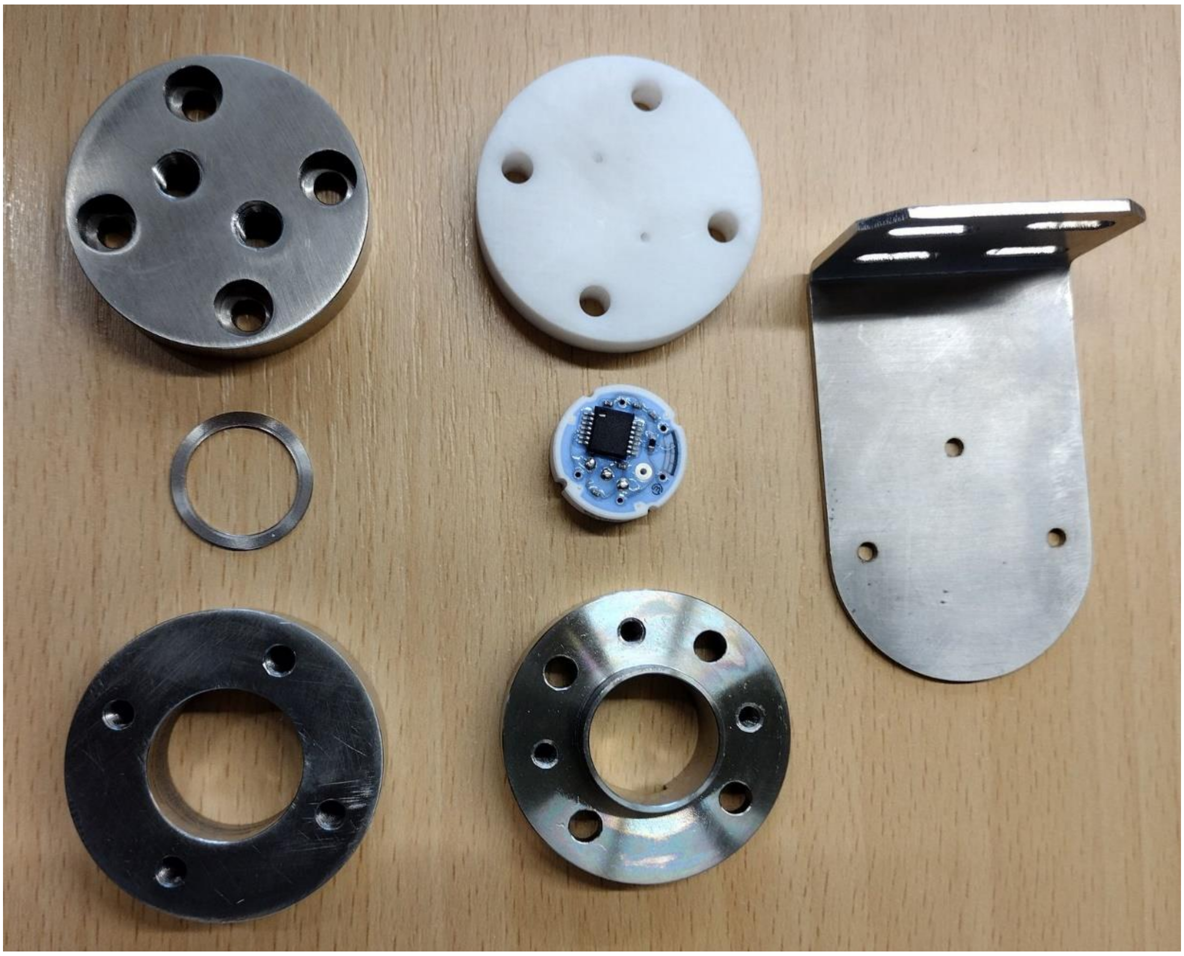

Figure 9. Parts machined from 316 stainless steel and PTFE obtained from Xometery (first order) and ME780 sensor.

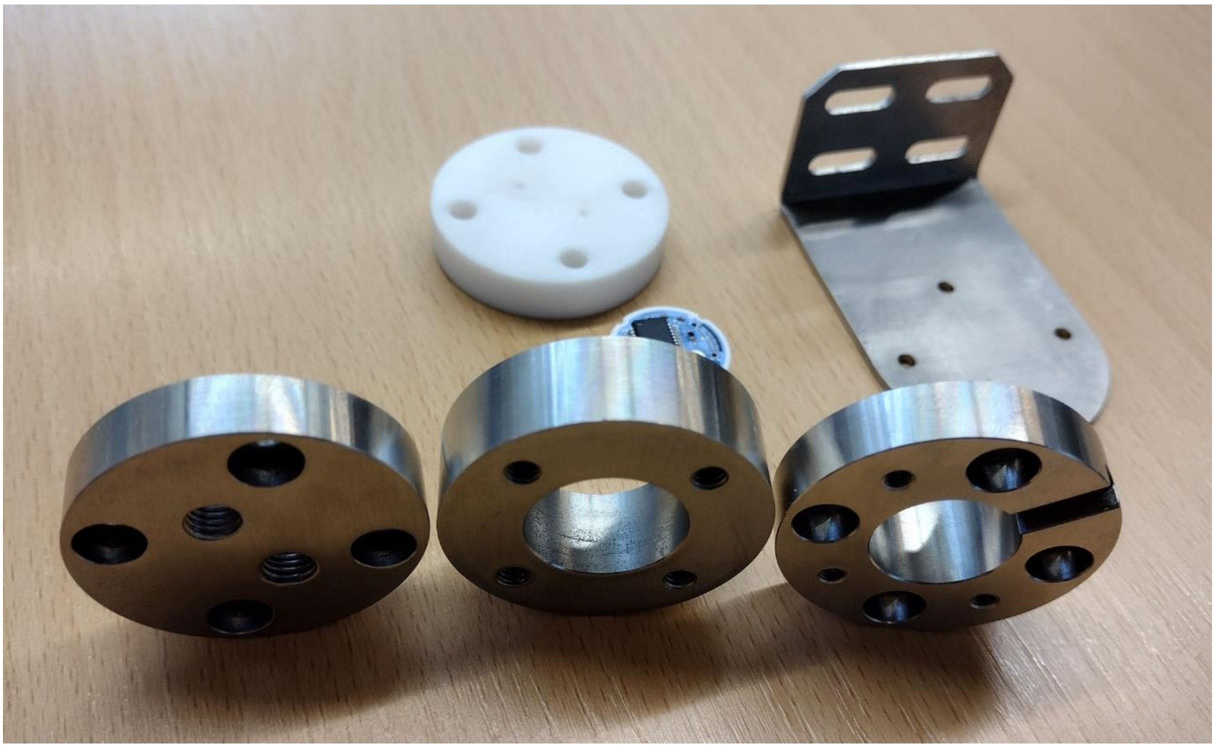

Figure 10. Parts machined from 316 stainless steel and PTFE obtained from Xometery.

Figure 11. Parts machined from 316 stainless steel and PTFE obtained from Xometery and ME780 sensor.

Figure 12. All parts before assembling. Lengths of screws M4x8, and M4x16

Figure 13. View on the centering ring and FFKM o-ring placed on the PTFE part.

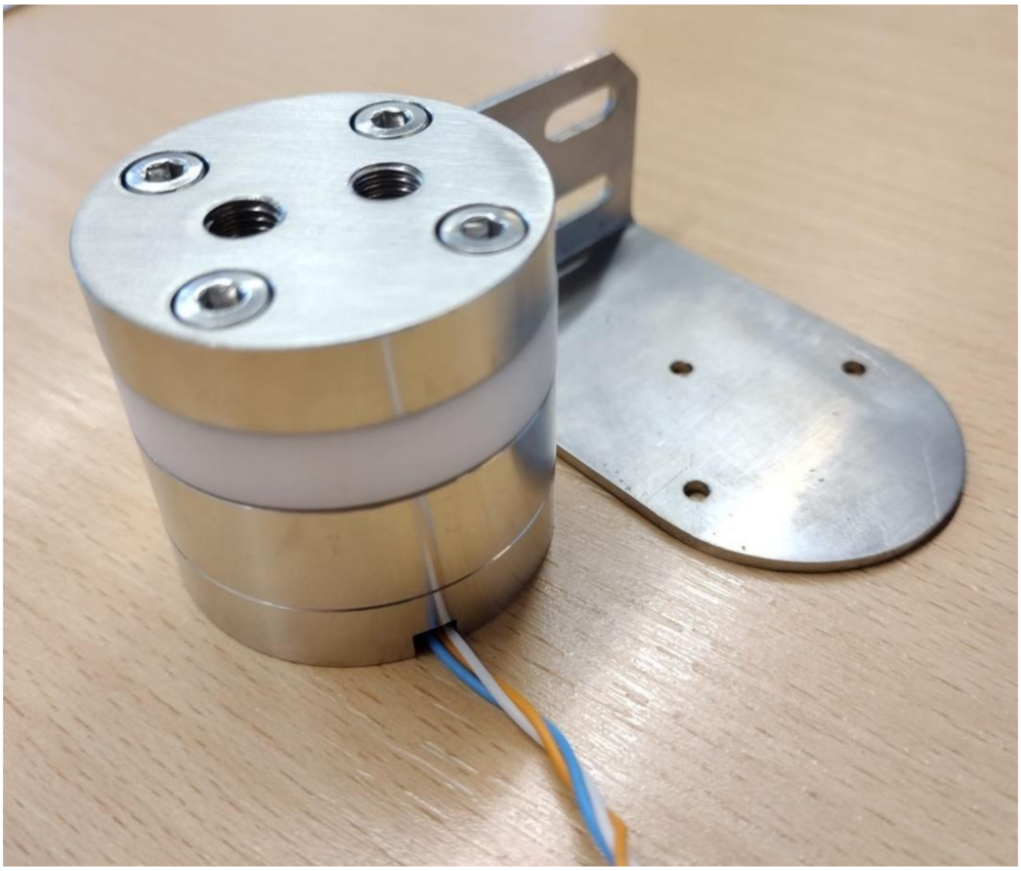

Figure 14. Transducer (MPS) fully assembled and prepared for first tests.


Figure 15. Assembled transducer – different angle.

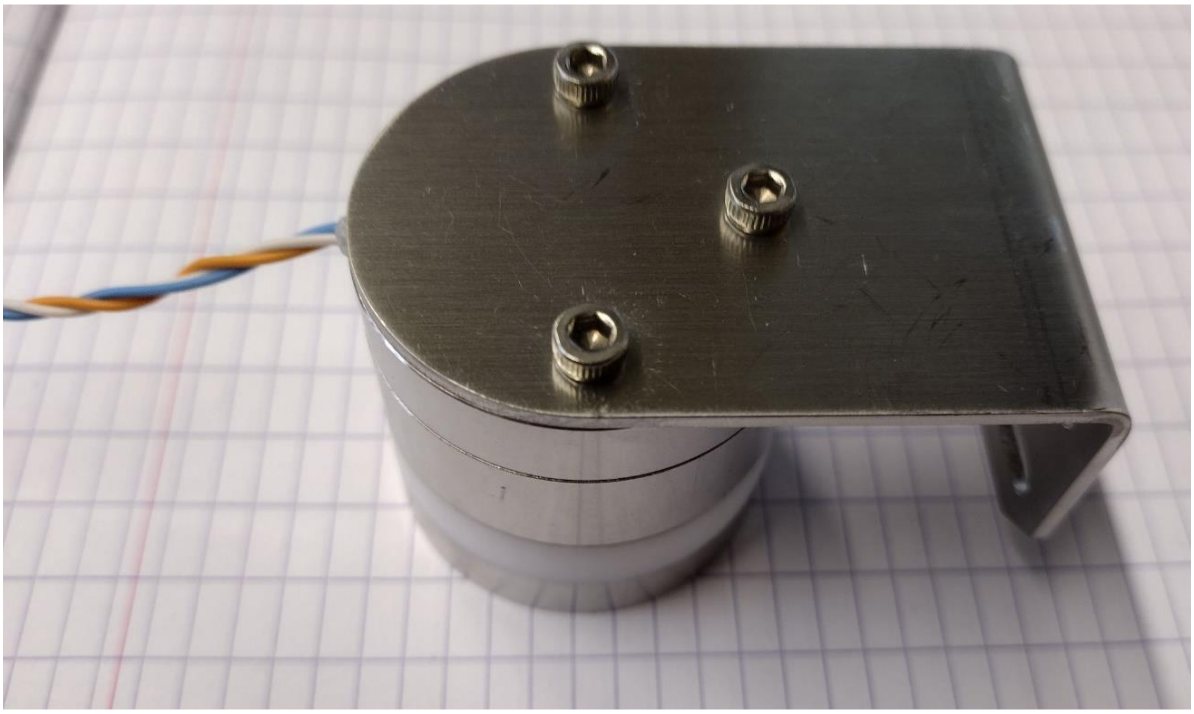
Figure 16. Assembled transducer with holding plate – view from bottom side.

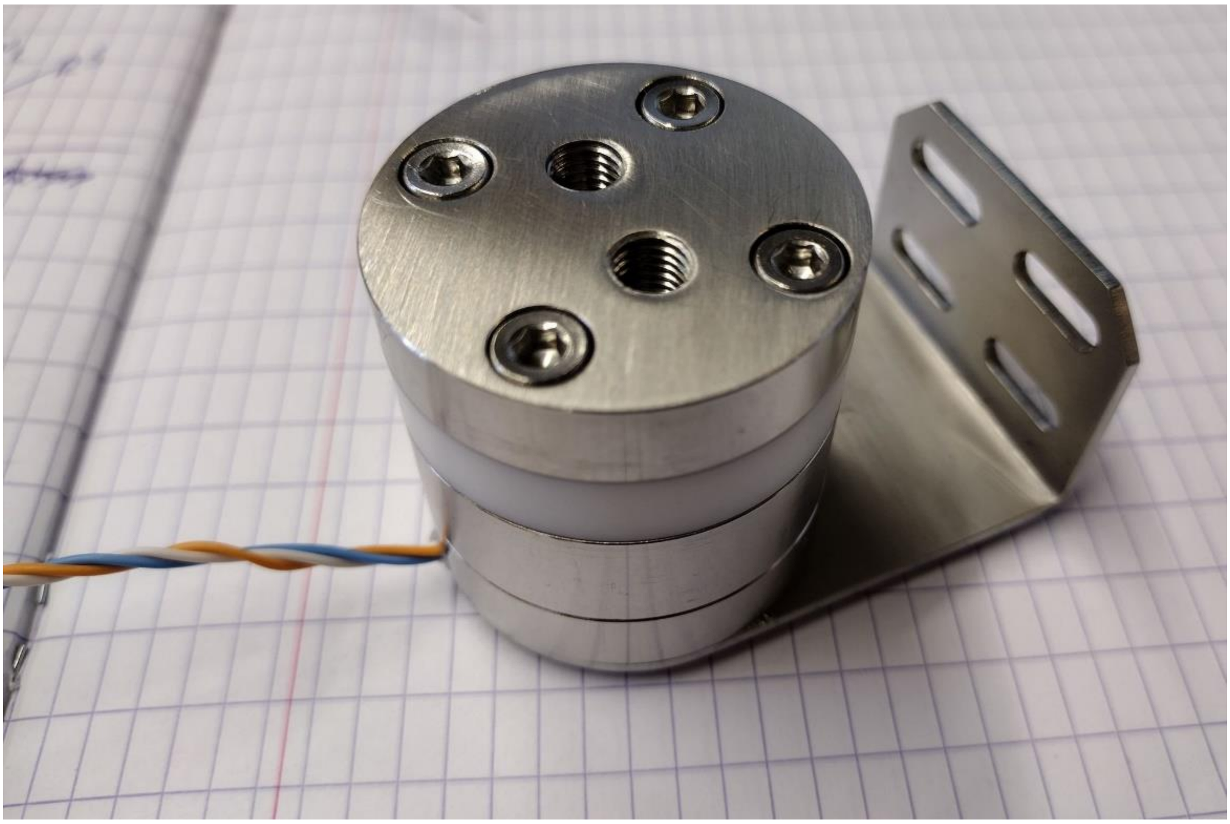

Figure 17. Assembled MPS with holding plate – view from the top.

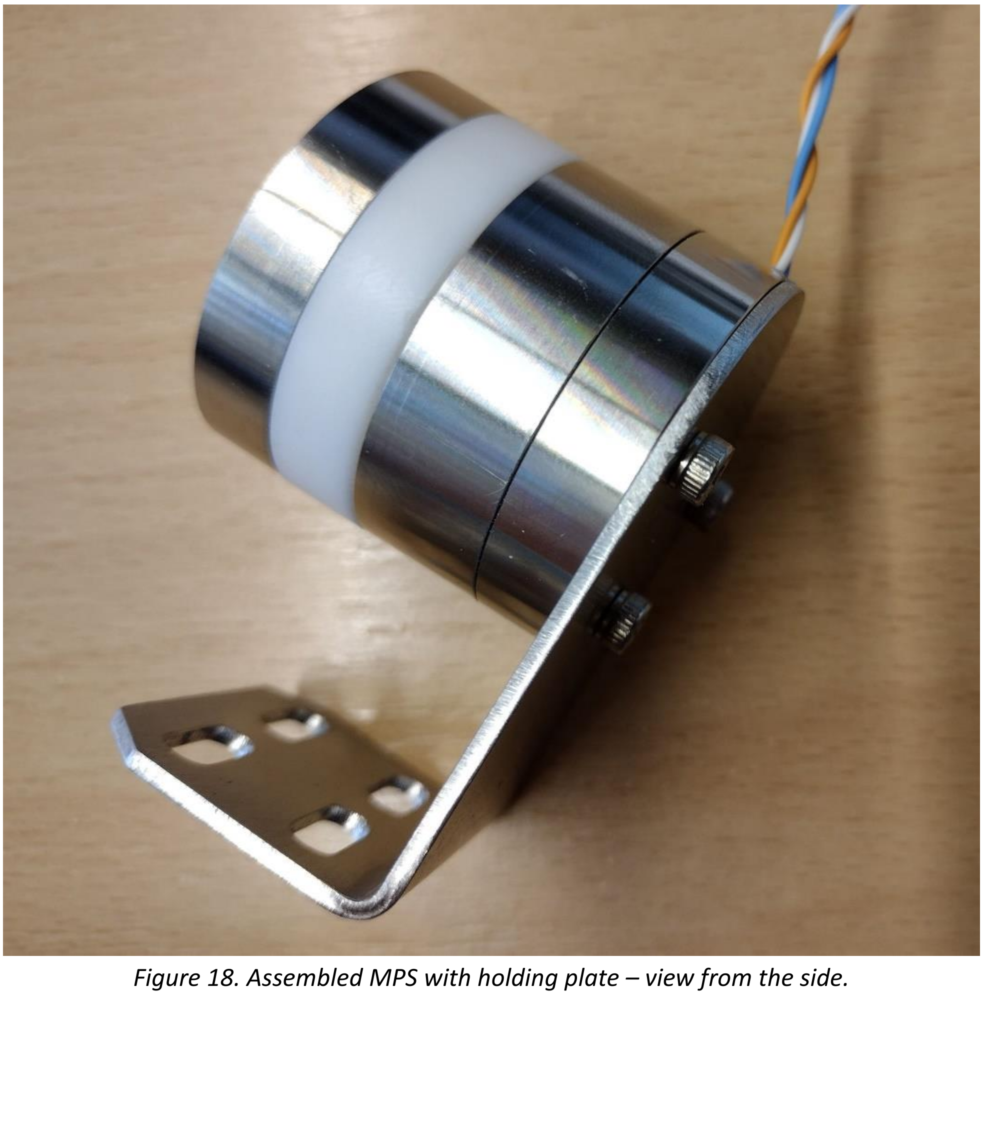

Figure 18. Assembled MPS with holding plate – view from the side.

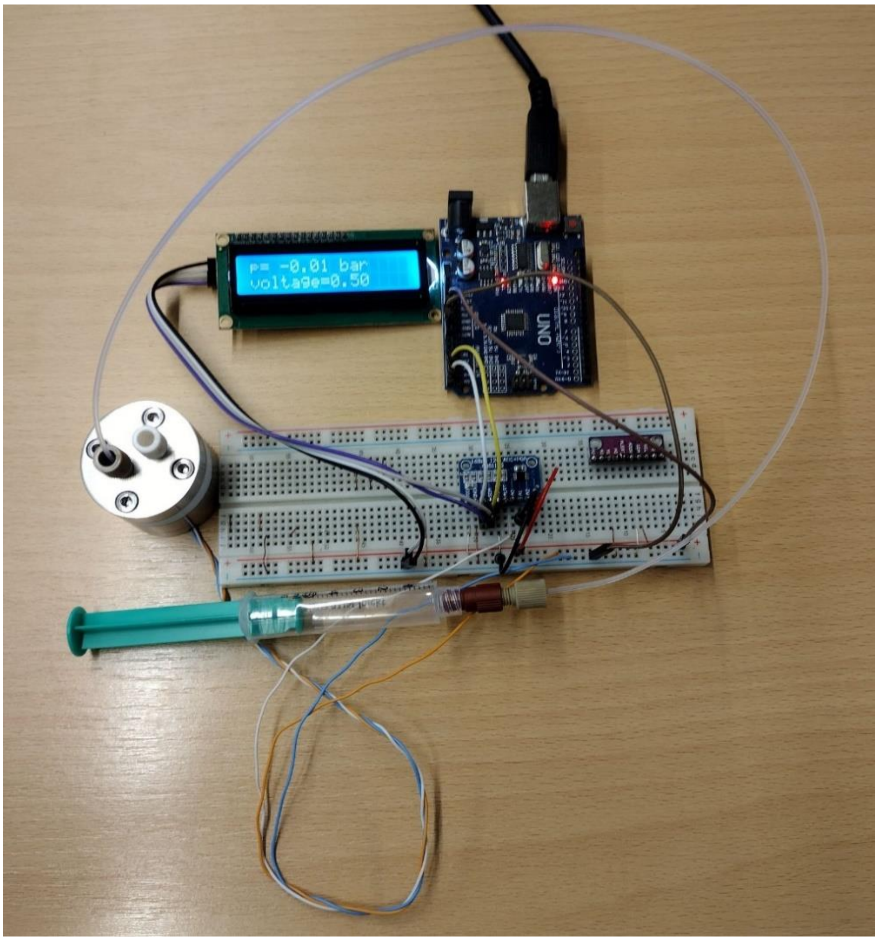

Figure 19. First test of pressure reading using an ADS1115 analog-digital converter and Arduino with LCD display. Pressure was created using a syringe and isopropanol.

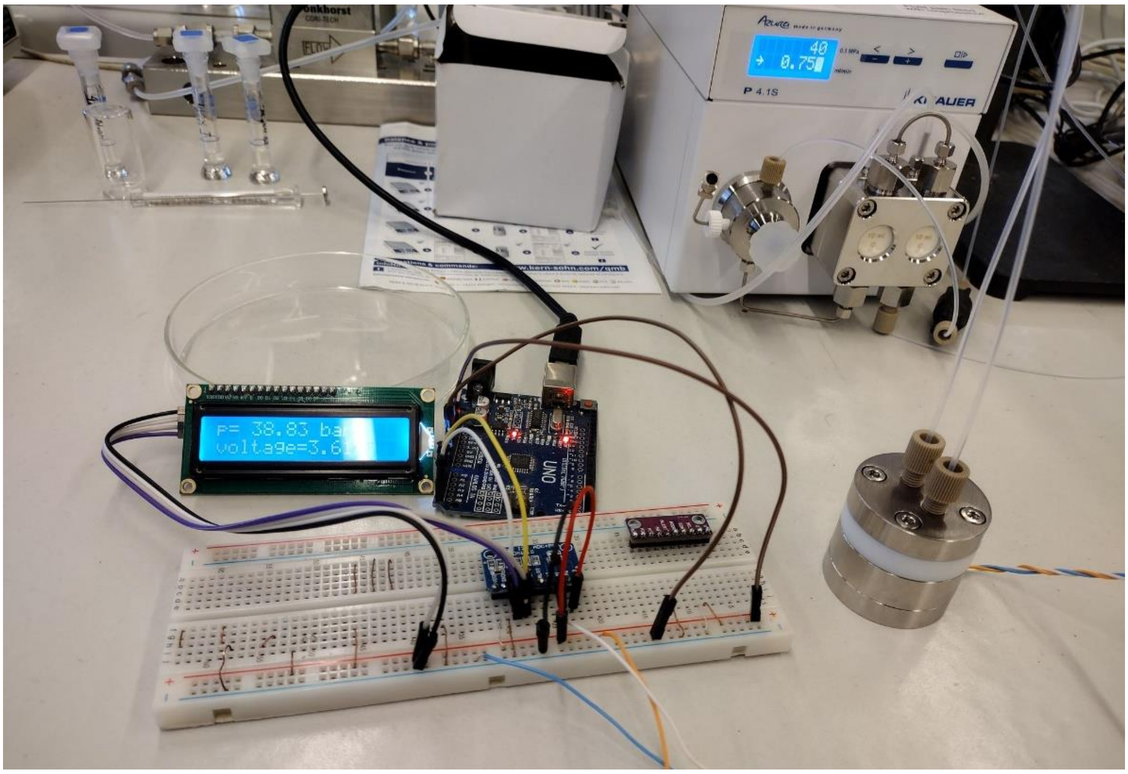

Figure 20. Tests of the pressure sensor at around 40 bar pressure, using Knauer Azura P4.1S pump (pumping isopropanol).

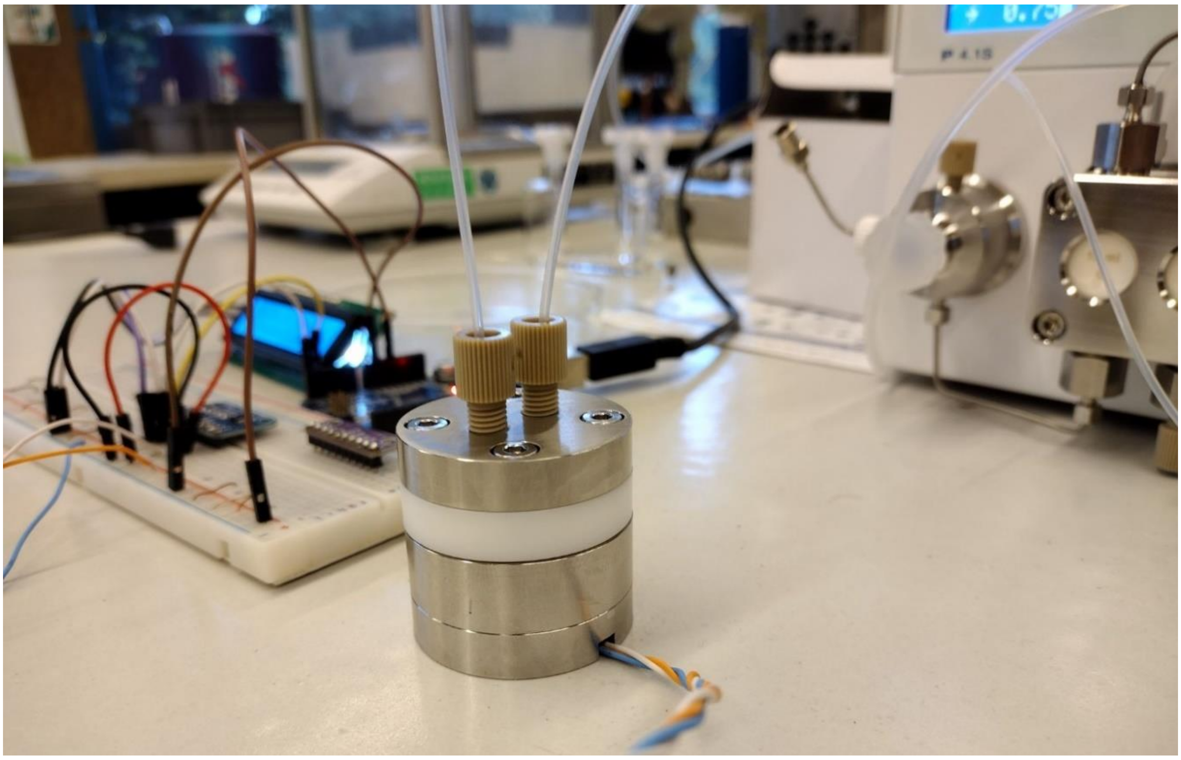

Figure 21. Tests of the pressure sensor at around 40 bar using Knauer Azura P4.1S pump (pumping isopropanol).

Figure 22. Three assembled pressure sensors with shielded, high-quality cables (AlphaWire 3303). At the point where the cable enters the metal housing, it is wrapped in PTFE tape to create a friction-secured mount with a holding plate. The cable shielding braid makes direct contact with the stainless steel housing, ensuring proper grounding and protection against electrical noise.

Acknowledgments

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