

## Research Result Report

### ICRR Inter-University Research Program 2023

Research Subject: Position control system for silicon monolithic suspension in cryogenic gravitational waves detectors.

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Summary of Research Result :

In 2023 we pursued our efforts to measure how the mechanical quality factor of a test-mass substrate evolves with the polishing of the side surface, with the processing of the side plates and with the bonding of different supports (such as ears and magnets) through the hydroxide catalysis bonding (HCB).

In our approach, the measurement is performed on the hanging payload.

In 2023 our goal was to stabilise the payload during the measurement. To reach this goal we planned:

- to design and build mechanical supports for four magnetic actuators and optical levers on an external structure;
- to design the control electronic system which includes optical lever readout and magnetic actuator drivers;
- to design the optical layout of the position sensing;
- to buy and to assemble the optical setup and the electronic hardware.

All these steps were successfully accomplished. In the beginning we designed and produced four coil formers in the fused deposition modelling technology and we fixed it to the supporting structure at the points corresponding to the magnets on the mirror.

We performed tests of the magnetic actuators driven by the coil driver. We set up the optical lever and we tested its readout on the quadrant photodetector. Electronic hardware: coils, coil driver, laser and quadrant photodetector we brought from Italy.

We purchased two Moku:Go controllers using Inter-University Research Program funds which we used in feedback control loop. After developing the feedback filter we managed to stabilize the suspended substrate. We successfully tested the suspension control system and optical vibration

readout setup in air.

Moreover, during the 2023 we developed a data acquisition system (DAQ) for the cryostat which registers its pressures and temperatures on a local web server. We have purchased a micro PC using Inter-University Research Program funds to host the server. A part of providing the web interface, the PC connects both to the vacuum gauge control unit and to the temperature controller. A simple script reads out the values from the devices and reports them to the web server database. An open-source software was used for data acquisition and visualization.

During our stay at ICRR laboratory this year, we performed several cooling and warming up cycles of the cryostat to test the DAQ system. The data acquired during the cooling cycles were used to calibrate the nodal suspension system which was installed inside the cryostat at the time of tests. Preliminary measurements of the substrate angle loss at the temperature below 45K exhibits values of order  $10^{-8}$ .

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