Development of Control Circuit for Inductive Levitation Micro-Actuators

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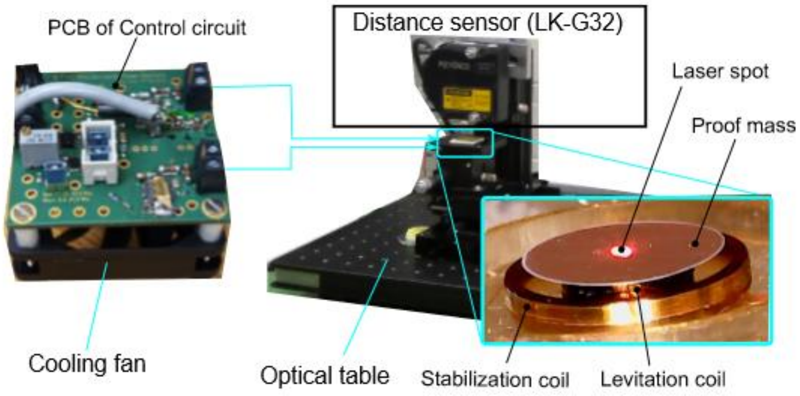

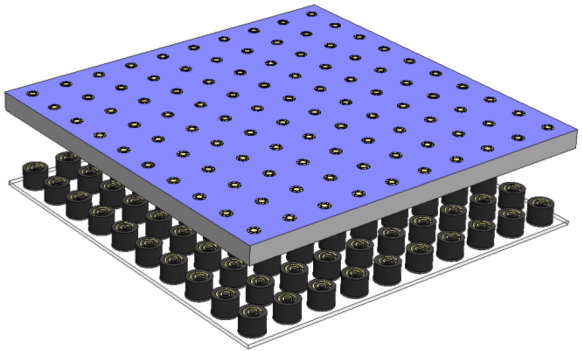

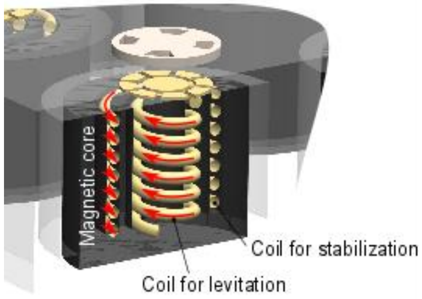

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Cooperative Multistage Multistable Microactuator Systems

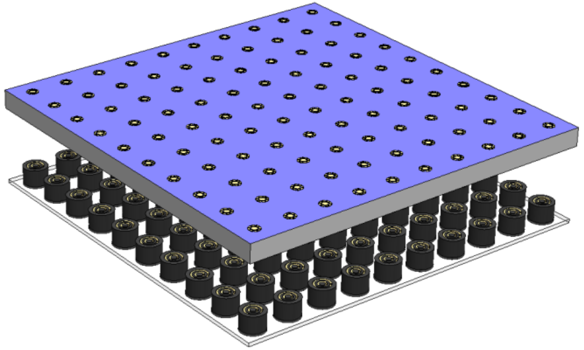
Introduction

A 2D array of cooperative hybrid levitation micro-actuators (2DAMA)

Research grant KO 1883/26-1

Investigation and development of an innovative and smart micro-actuation system.

- Newly improved performances:
  - Small operation current
  - Low operation temperature (it is comparable to the ambient temperature)
  - Considerably extended motion range
  - Wider operational capabilities
  - Transportation and manipulation of micro-objects
  - Higher accuracy and faster time of actuation
  - Significant reduction of the dissipated energy
  - Preventing a contact with harmful surfaces and the ensured long lifetimes.



A 2D array of micro-actuators

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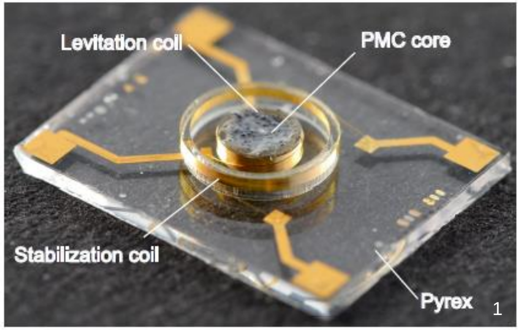
Introduction

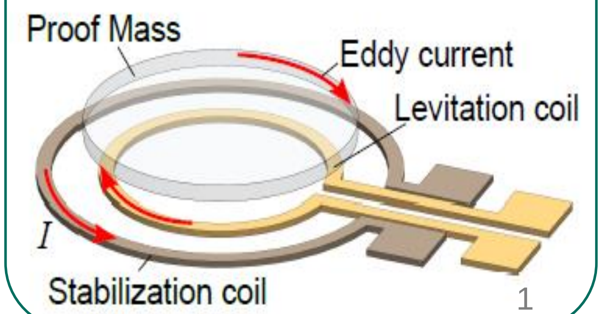
- Several techniques can provide the implementation of electromagnetic levitation into a micro-actuator systems.
- Classification according to the materials used and the sources of the force fields.
- Two major branches:
  - Electric levitation micro-actuator (ELMA)
  - Magnetic levitation micro-actuator (MLMA)
    - MLAM can be further split into:
      - Inductive (ILMA)
      - Diamagnetic (DLMA)
      - Superconducting micro-actuators
      - Hybrid levitation micro-actuators (HLMA)



1 - Poletkin, K., et al. “Energy-aware 3D micro-machined inductive suspensions with polymer magnetic composite core,” Journal of Physics: Conference Series, 2018.

Methods

2D technology



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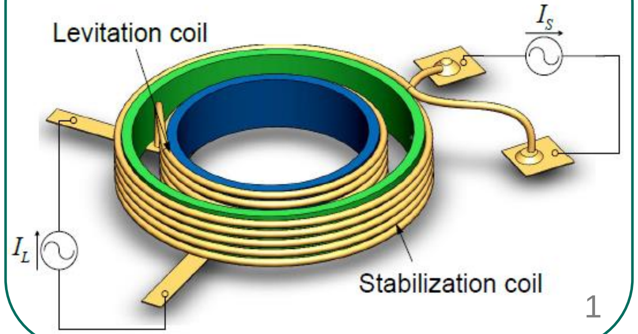
3D technology



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- Low operation temperature
- Small operation current
- Significant reduction of the dissipated energy 2

1 - Kirill Poletkin - Levitation Micro-Systems: Applications to Sensors and Actuators

2 - Lu, Z. et al. Performance Characterization of Micromachined Inductive Suspensions Based on 3D Wire-Bonded Microcoils. Micromachines, 2014.

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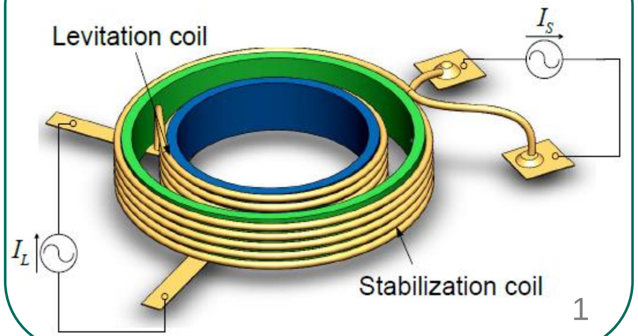
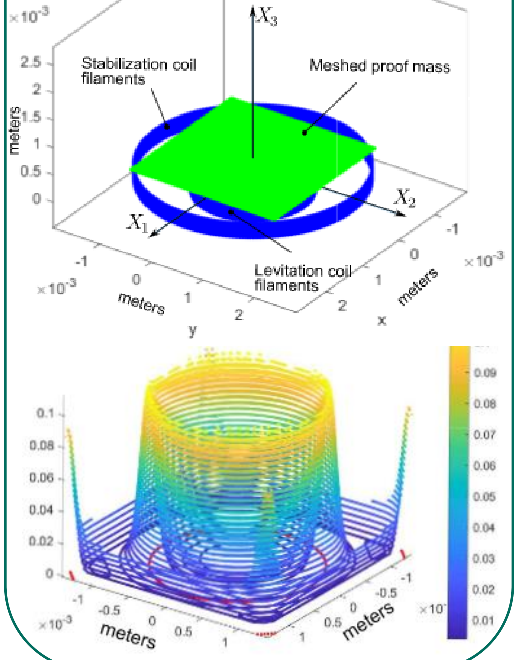
Methods

3D technology



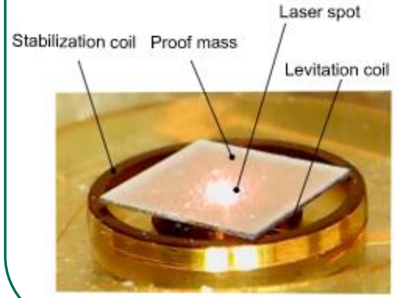
- Low operation temperature
- Small operation current
- Significant reduction of the dissipated energy

Simulation (quasi-FEM method)



- Optimal design
- Coil eddy currents
- Electrical parameters

Coils Microfabrication

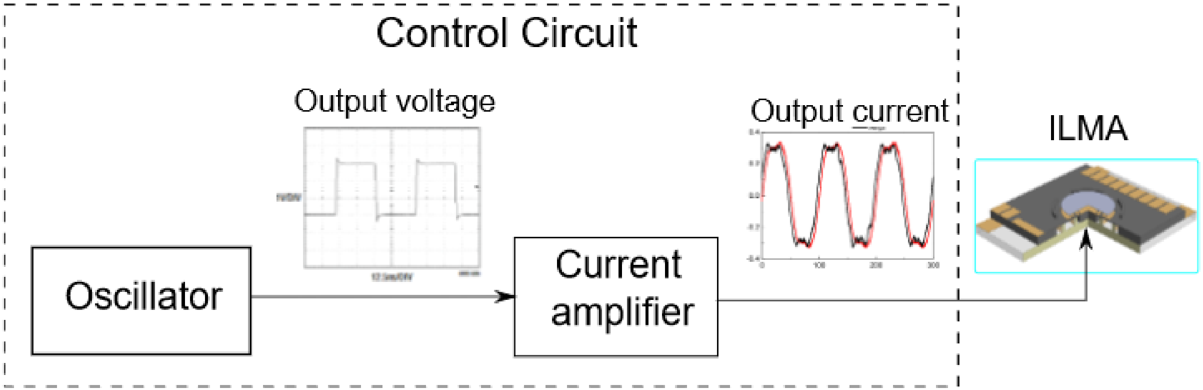


- Current coils
- High frequency output

1 - Kirill Poletkin - Levitation Micro-Systems: Applications to Sensors and Actuators

Results

- High frequency output voltage suppler from 0 to 40 Vpp
- High frequency current (maximum peak to peak) from 0 to 400 mA
- Rectangular waveform of the current
- Frequency operation range from 8.4 to 40 MHz. 2



2 - Lu, Z. et al. Performance Characterization of Micromachined Inductive Suspensions Based on 3D Wire-Bonded Microcoils. Micromachines, 2014.

Development

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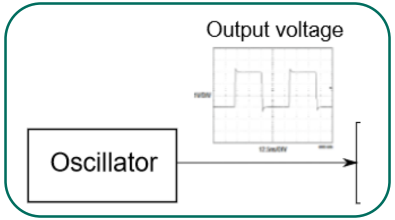

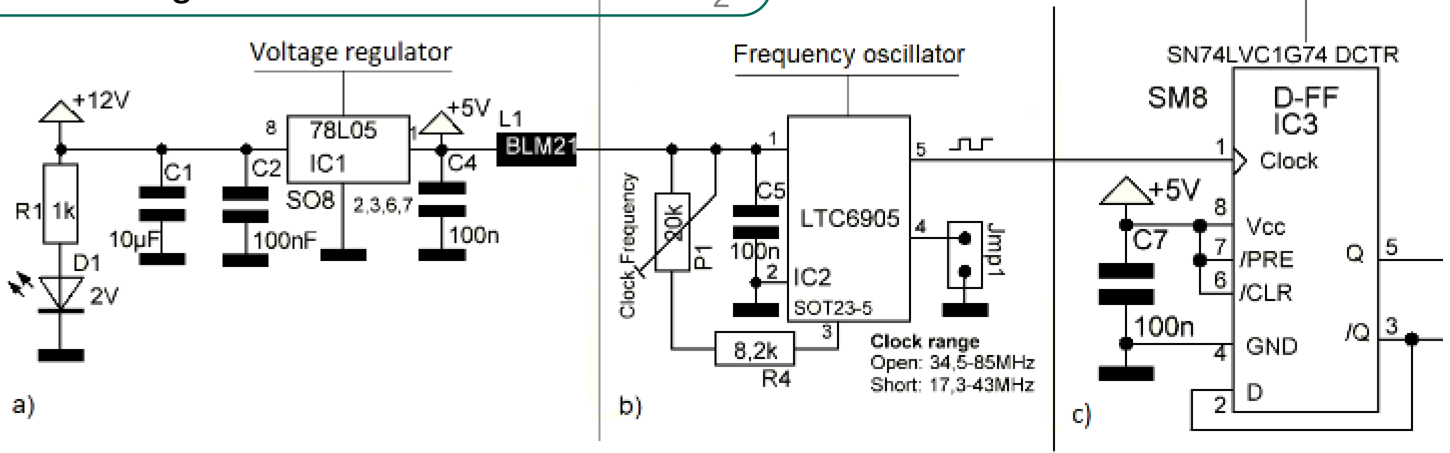

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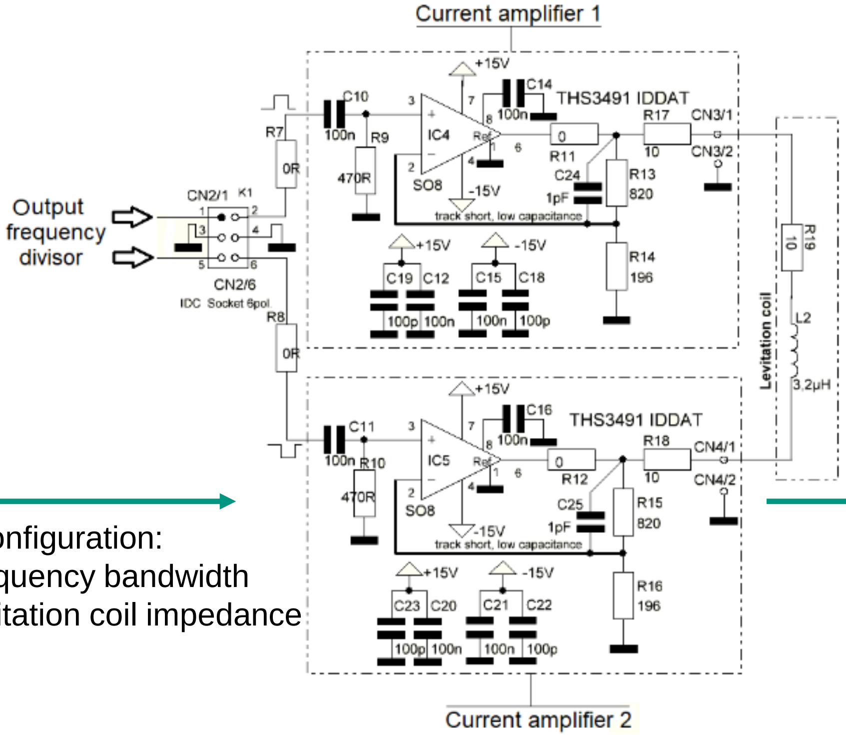
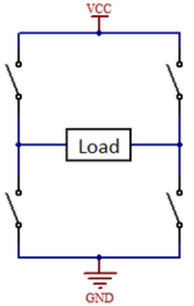
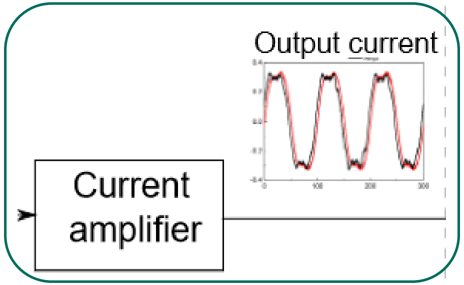
Development

- High frequency current from 0 to 400 mA [2]





- H-bridge configuration:
  - High frequency bandwidth
  - High levitation coil impedance



It avoids the usage of a transformer (bandwidth limitation) and enhanced input current consumption

2 - Lu, Z. et al. Performance Characterization of Micromachined Inductive Suspensions Based on 3D Wire-Bonded Microcoils. Micromachines, 2014.

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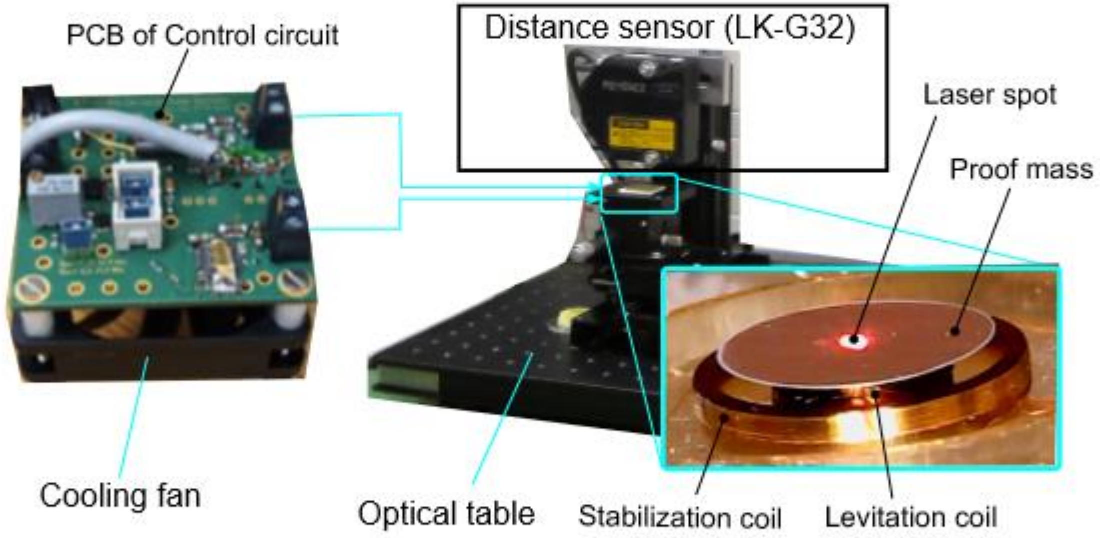
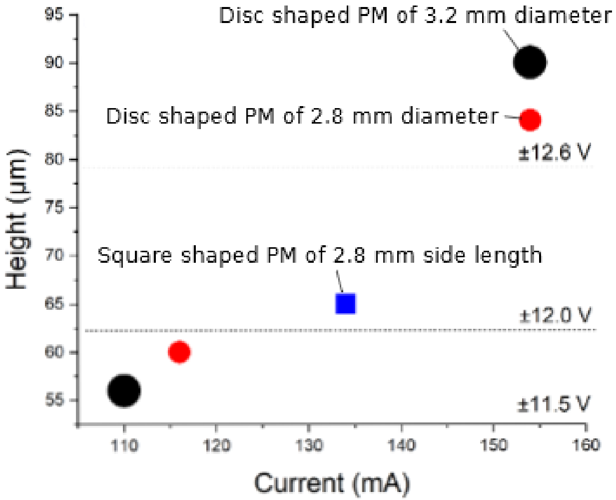
Experimental setup



Results



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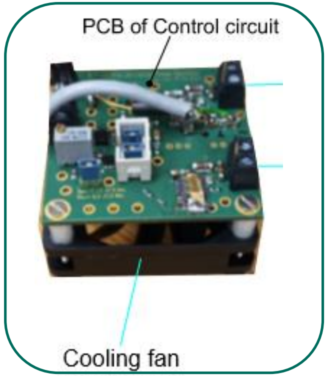
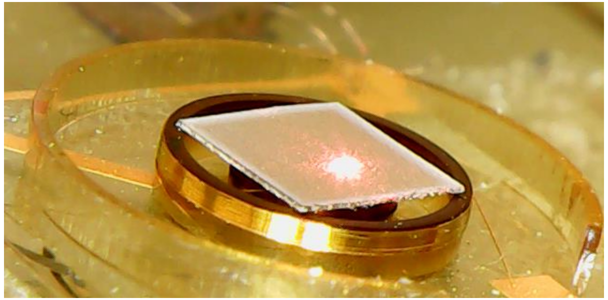
Conclusions

- Applying a quasi-finite element method simulation:
  - The eddy current within the square shaped PM were simulated
  - The numerical analysis of the force interaction between the coils and the levitated proof mass confirms that the two coil design is the optimum design.
- A control circuit for application to inductive levitation micro-actuators was developed
- The size dimensions (60 × 60 × 25 mm) of the control circuit were comparable with ILMA setup
- The control circuit is able to generate AC current with squared shape in a range of frequency from 8 to 43 MHz and with peak-to-peak amplitude up to 420 mA.
- Successful levitation of disc shaped PM of diameters of 2.8 and 3.2 mm and, for the first time, square shaped PM of a side length of 2.8 mm.
- This fact confirmed the efficiency of the proposed circuit design and its compatibility with micro-actuation system.





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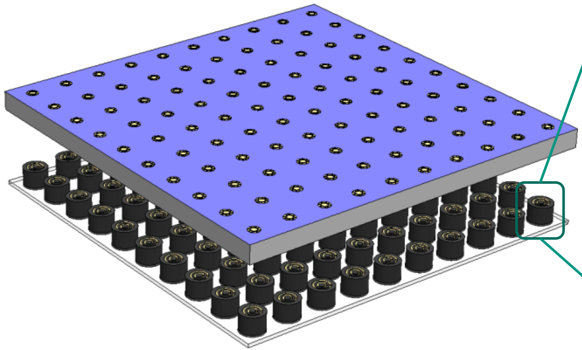
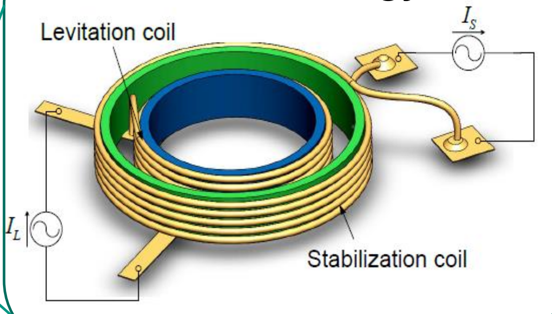
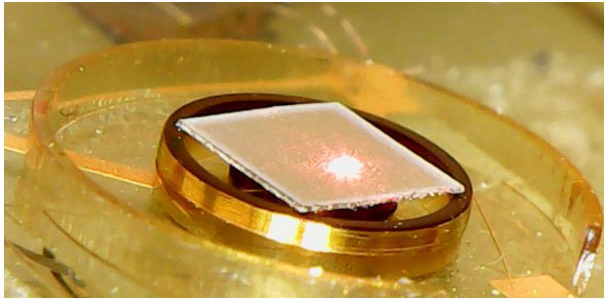
Outgoings

- Miniaturization of the control circuit
- ILMA experimental setup with an array of 3D coils



3D technology





Acknowledgements

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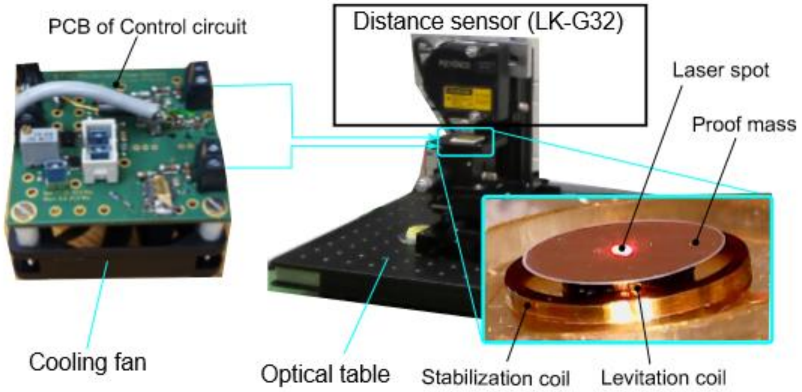

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Thank you for your attention

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