

Tiny Sensors for Big Safety Monitoring Gases in Nuclear Storage

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Pathways to Safe Storage of Spent Nuclear Fuel

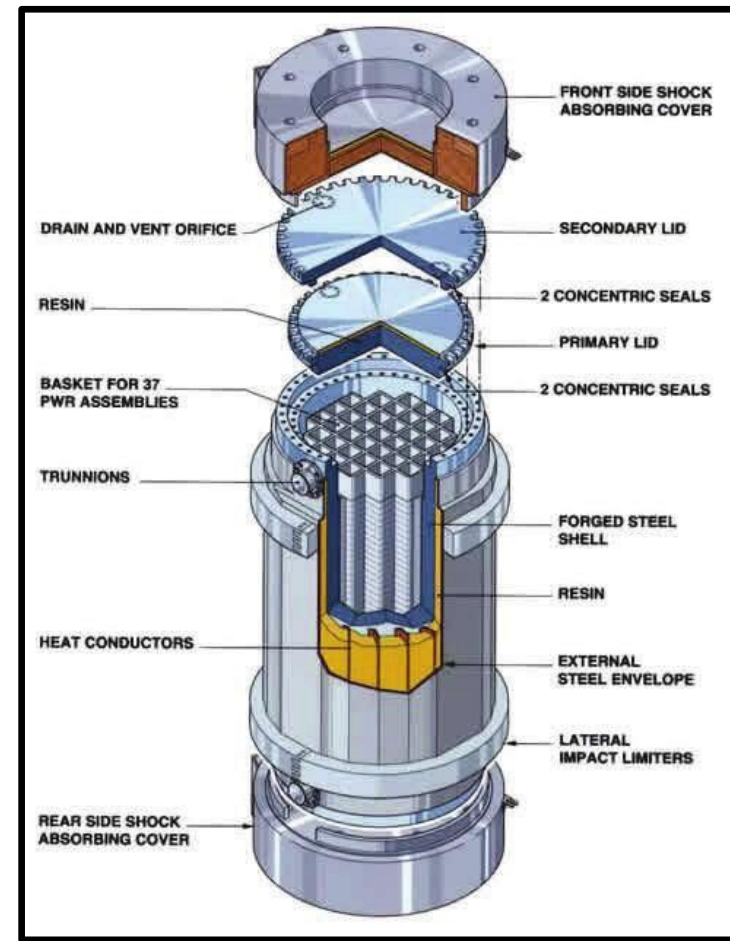
Introduction

Spent nuclear fuel is stored for decades in sealed steel canisters that are designed to safely contain radioactive material during long-term storage.

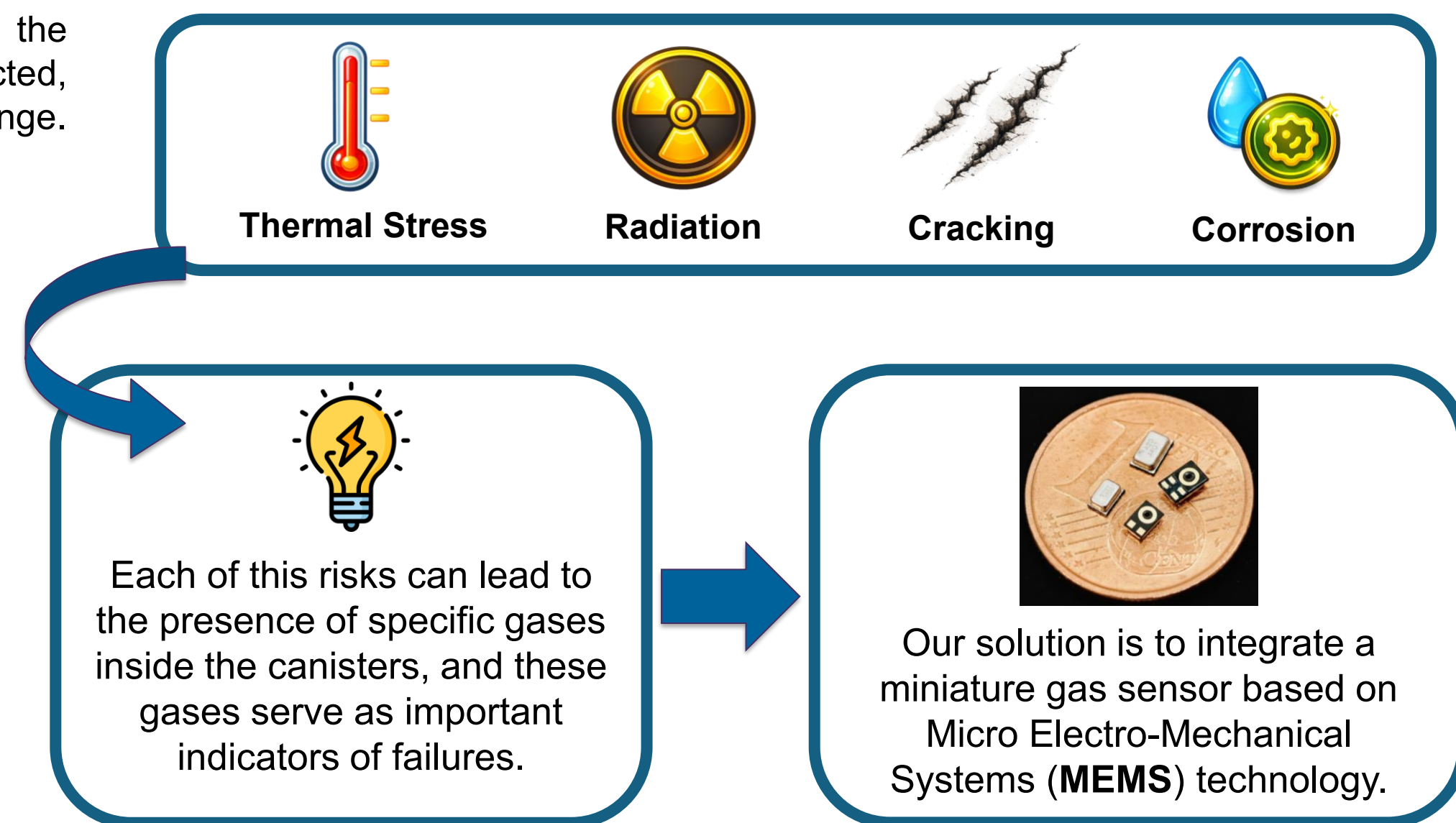


Motivation

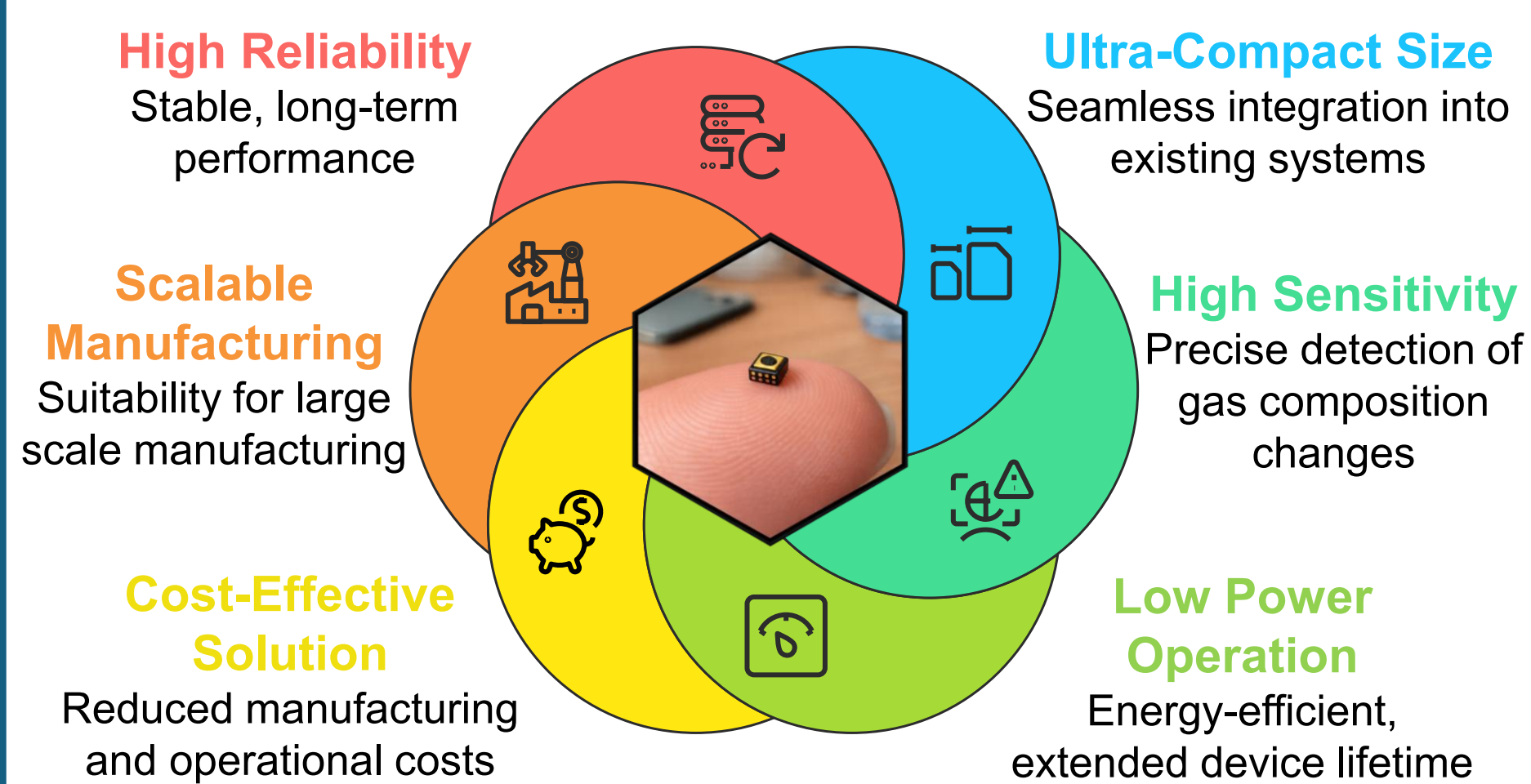
Once filled with helium and sealed, the interior cannot be directly inspected, creating a long-term monitoring challenge.



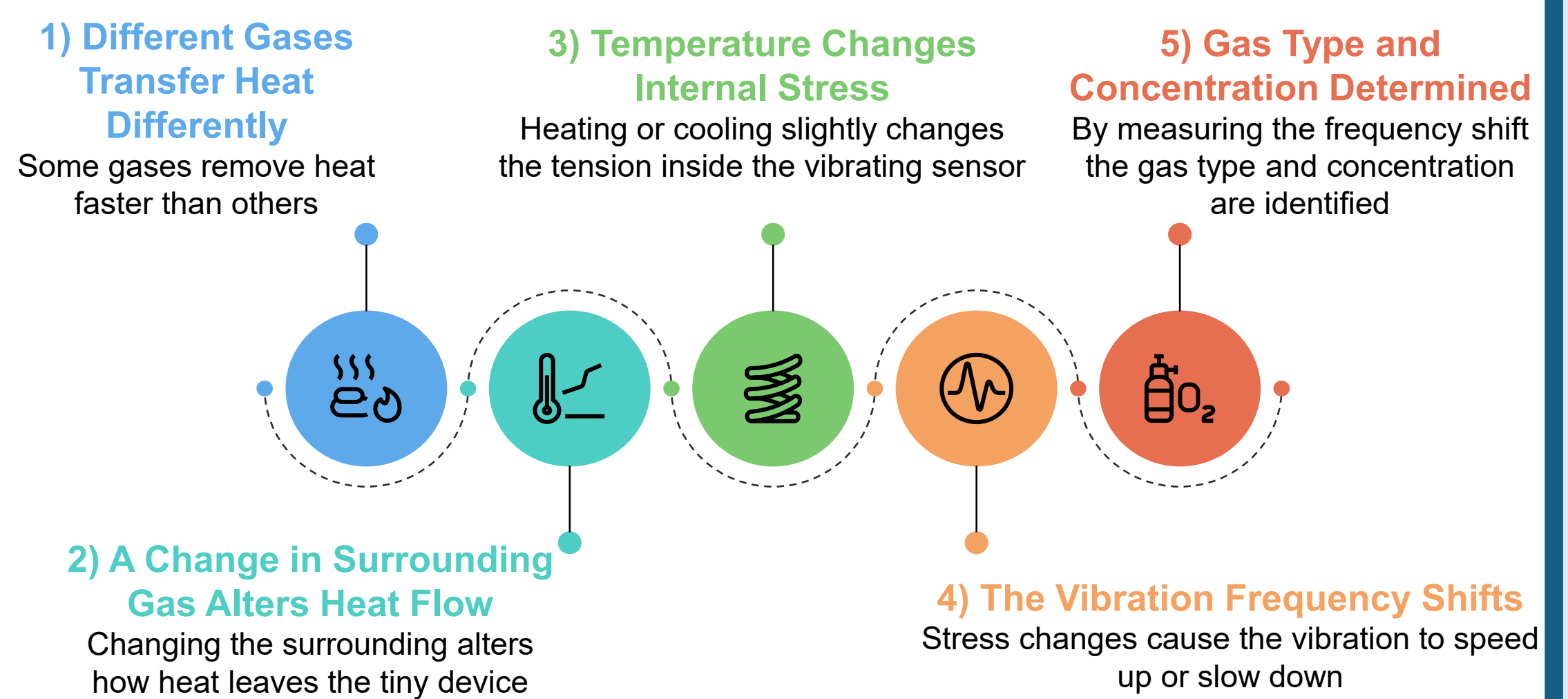
Challenges in Spent Fuel Storage



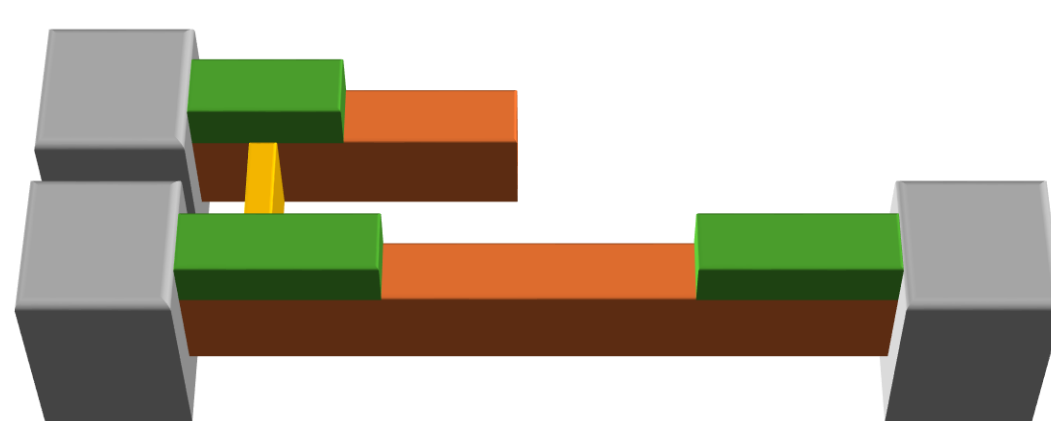
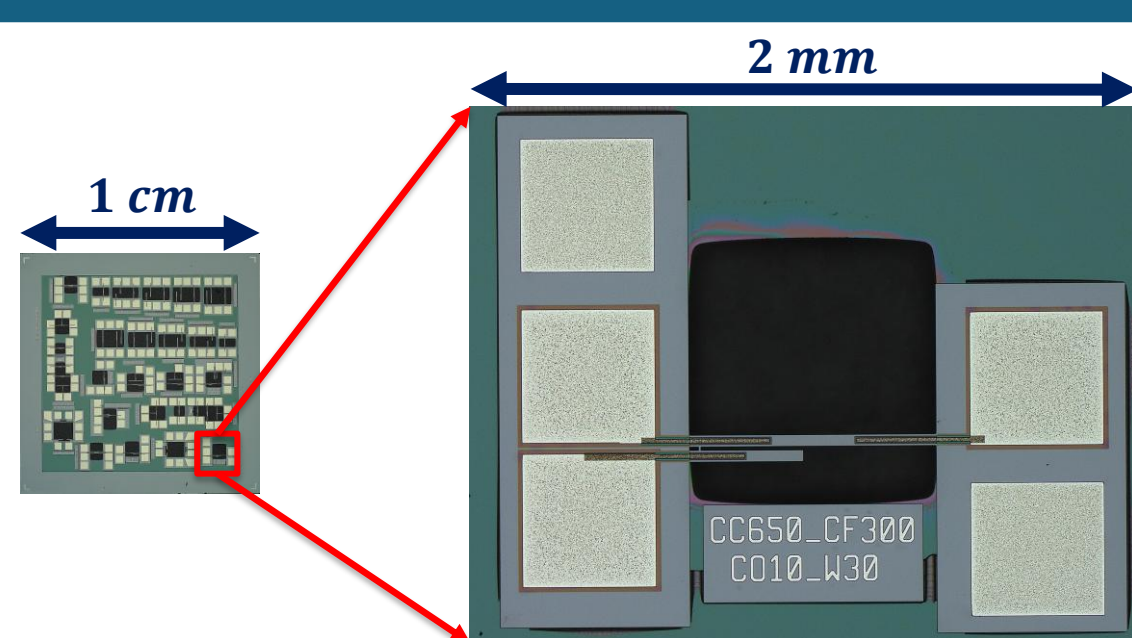
Advantages of MEMS



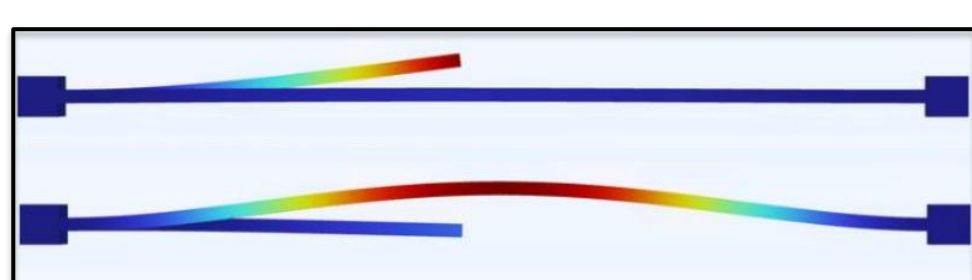
Gas Sensing Mechanism



Sensor Design



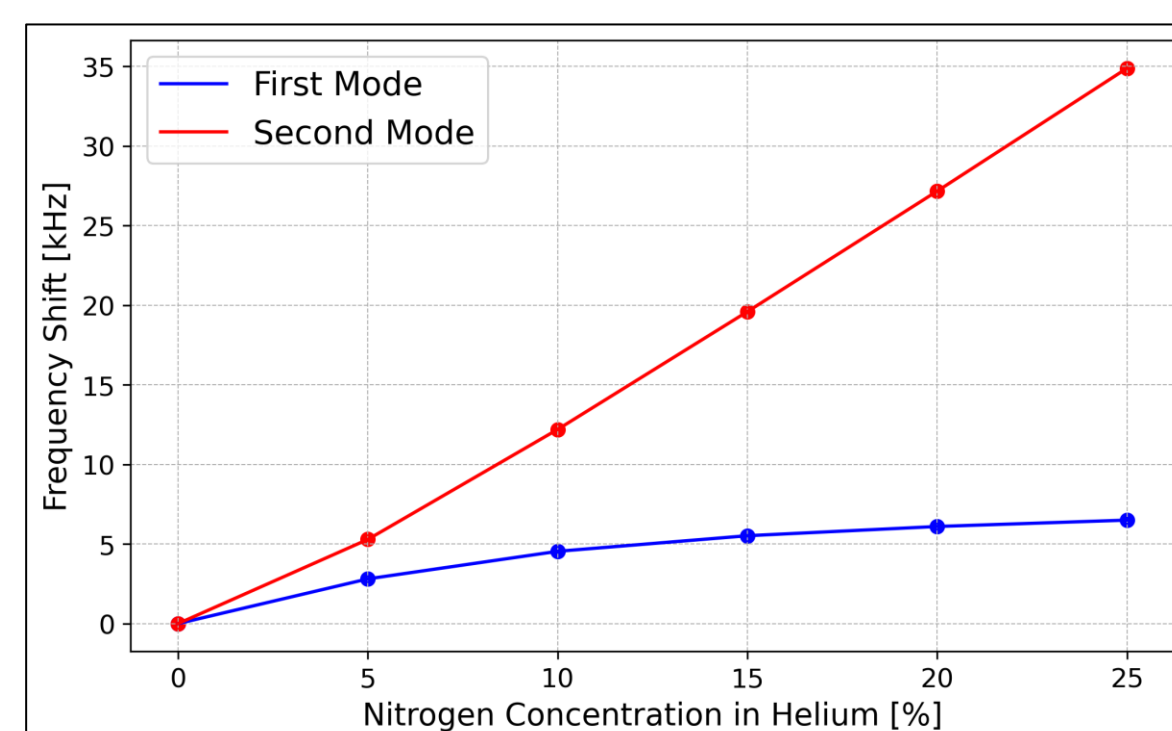
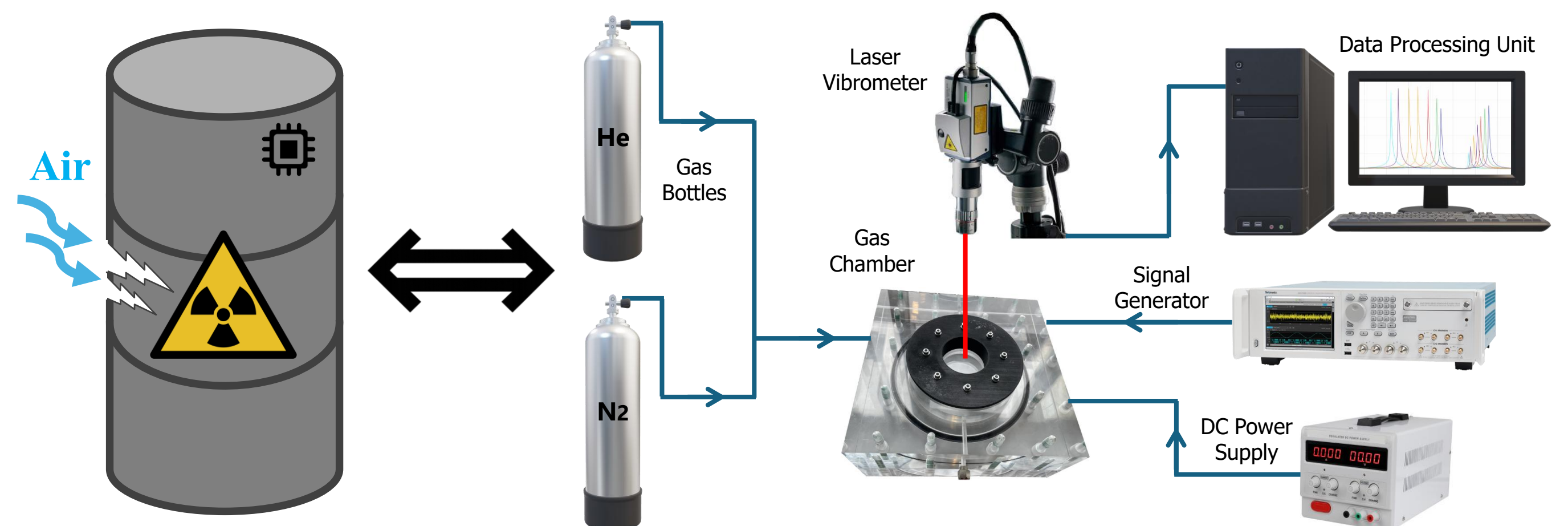
The sensor consists of a clamped-clamped beam, a cantilever beam, and a coupling beam connecting them, all made of silicon.



Before fabrication, the design dimensions were optimised using finite element analysis software.

Testing and Validation

To simulate a real leak and test the sensor, we place it in a gas chamber filled with helium. Then we introduce nitrogen, which constitutes about 78% of air and measure how the sensor's frequency changes.



Conclusions

- The experimental results demonstrate the high sensitivity of the MEMS sensor for gas detection and concentration measurement under dry storage conditions.
- The sensor enables early detection of internal degradation processes in spent nuclear fuel canisters, supporting reliable monitoring of canister integrity.
- It offers a scalable, low-power solution for long-term nuclear waste storage monitoring, with potential future expansion toward multi-gas detection for comprehensive condition assessment.

Acknowledgement