Application of MgB_2 Wire to Liquid Hydrogen Level Sensor

–External-Heating-Type MgB_2 Level Sensor–*

M. Takeda[1], Y. Matsuno[2], I. Kodama[2], H. Kumakura[3], and C. Kazama[1]

[1]Graduate School of Maritime Sciences, Kobe University, JAPAN
[2]Iwatani Industrial Gases Corporation, JAPAN
[3]National Institute for Materials Science, JAPAN

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Abstract

A superconducting magnesium diboride (MgB_2) level sensor for liquid hydrogen has been timely noted as a new sensor from a viewpoint of the worldwide storage and transport of large quantities of hydrogen. The external-heating-type level sensors (200 and 800 mm long) based on MgB_2 wires are fabricated by an in situ method, and their level-detecting characteristics are studied in comparison with the actual liquid level using the liquid hydrogen experiment facility (LHEF). It becomes evident that an external-heating-type MgB_2 level sensor has a high linearity, a small measurement error, and a good reproducibility even in the pressure range of up to 200 kPaG despite the evaporation loss caused by the heater used.

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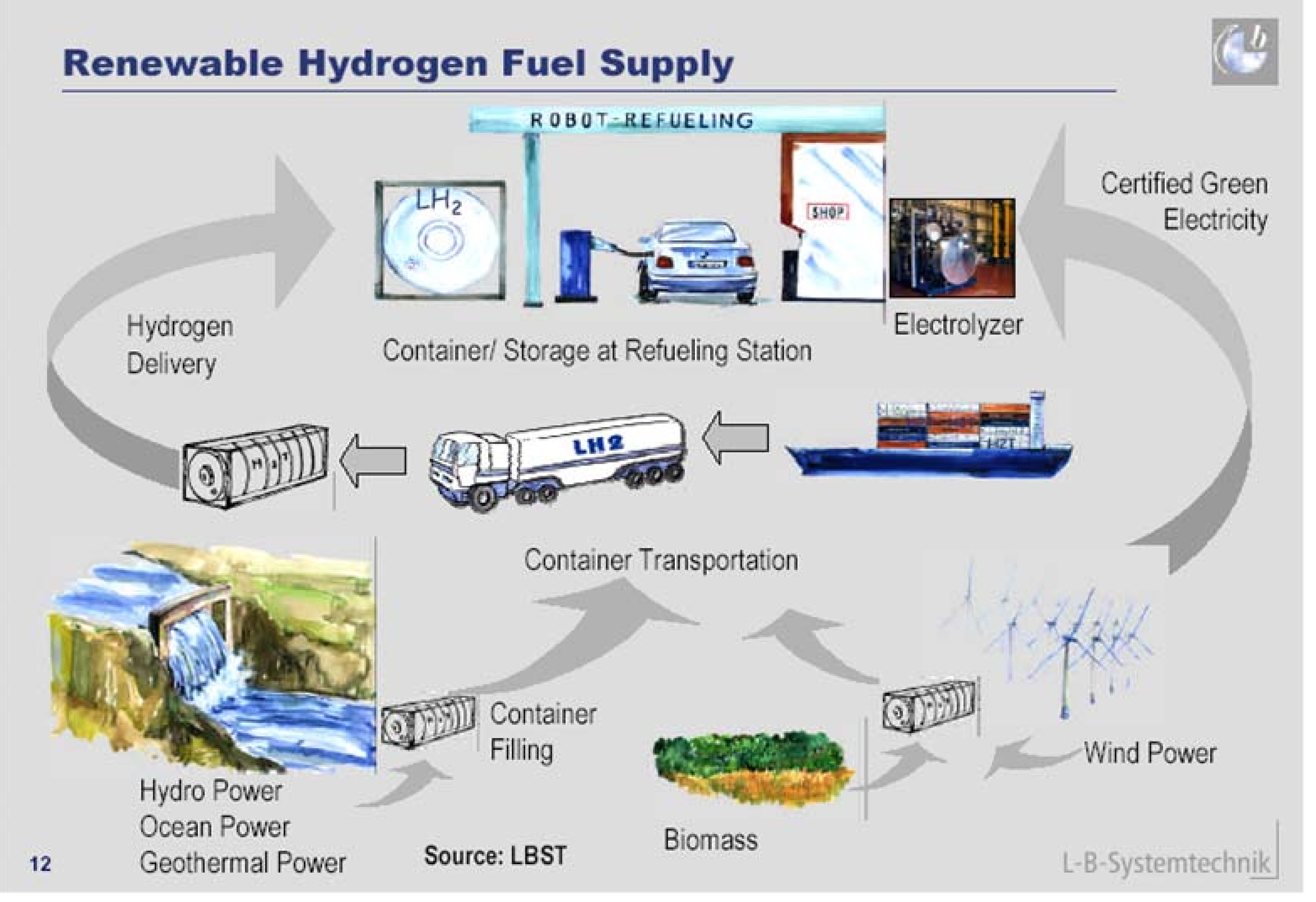
Background (1)



Background (2)

Precise level control of liquid hydrogen (LH_2) is desired from the viewpoints of economy and safety.

→ A liquid level gauge with high linearity and good reproducibility; superconductive MgB_2 level sensor (self-heating type) demonstrated by Haberstroh *et al*.

↕

We propose another type (external-heating type) of MgB_2 level sensor with a short response time, operating accurately even at low liquid levels etc.

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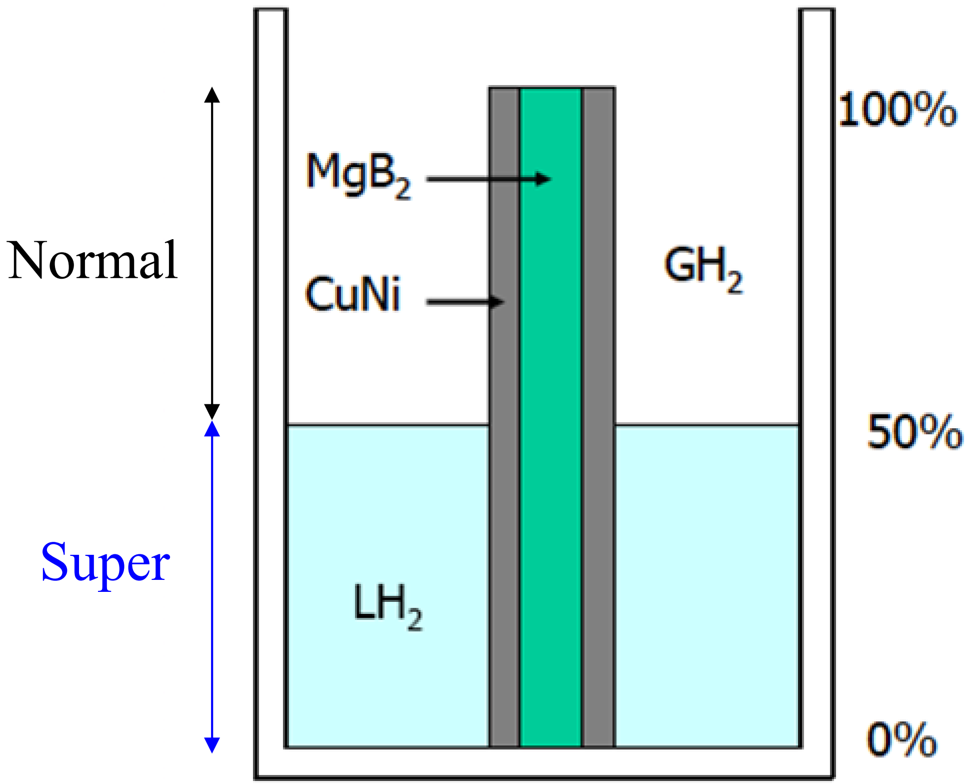
Objectives

To conduct a feasibility study of the external-heating-type MgB_2 sensor for detecting the level of LH_2.

To elucidate the level-detecting characteristics of the MgB_2 sensor including a relatively long sensor under pressurized condition.

MgB_2 Wires Fabrication System
Liquid Hydrogen Cryostat
Liquid Hydrogen Experiment Facility

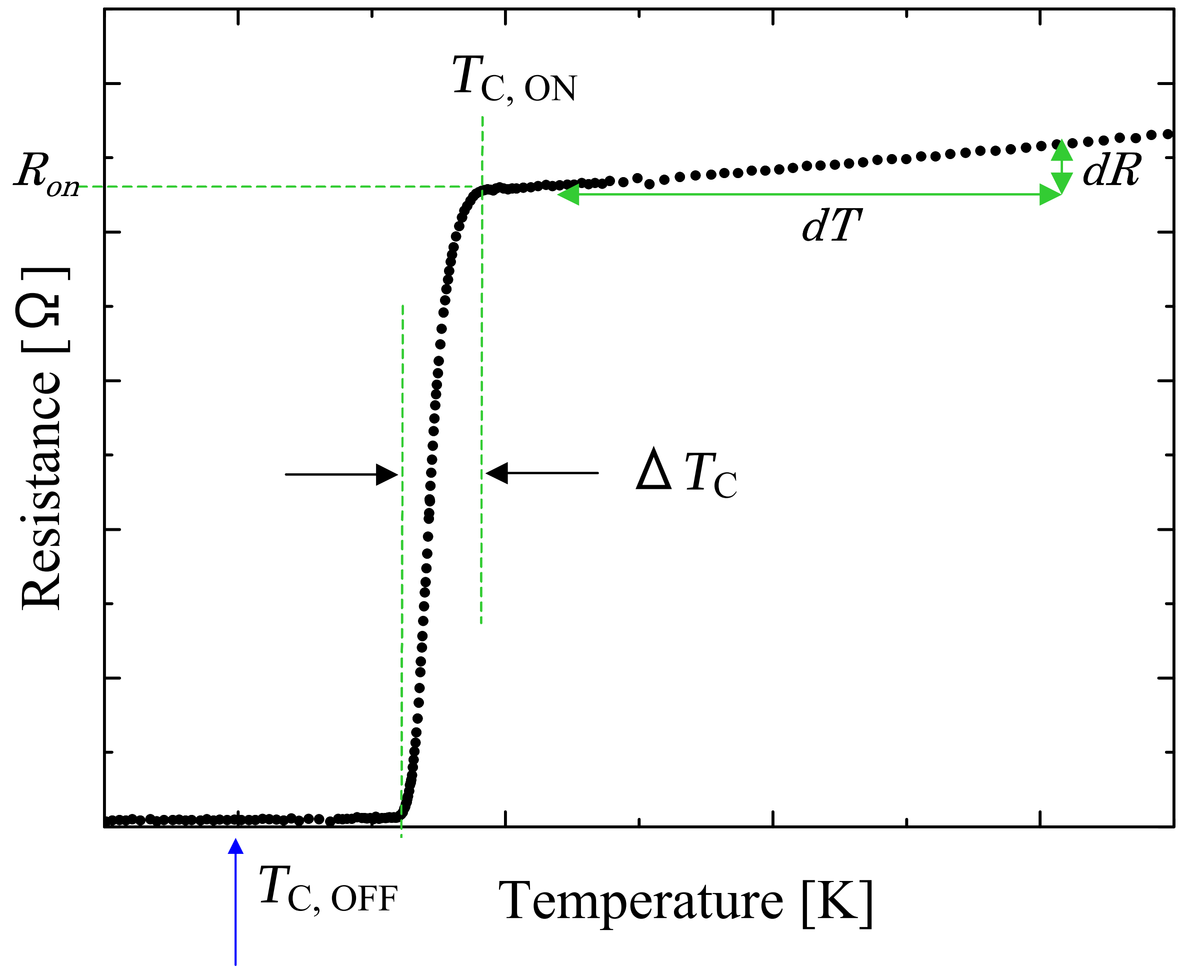
MgB_2 Level Sensor (1)



Conditions required for sc level sensor:

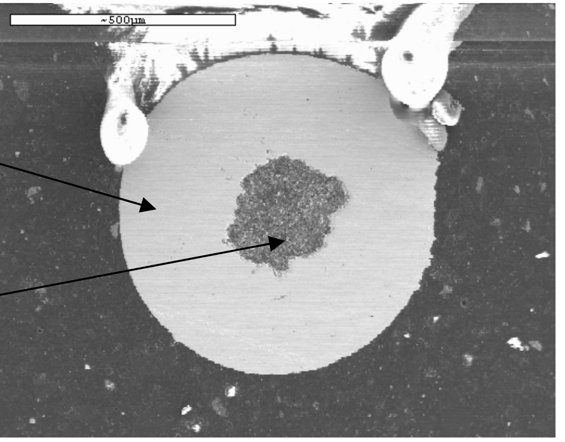
1) T_C close to LH_2 temp. (20K@1atm-25K@3atm)
2) Small transition width ΔT_C
3) High electric resistance and small temp. dependence of resistance in normal state

MgB_2 Level Sensor (2)



LH_2 temp. (20K@1atm-25K@3atm)

MgB_2 Level Sensor (3)



MgB_2 wires with SiC impurities

In situ method

600°C × 1 h

Sample	Additive	Diameter [mm]	$T_{C,ON}$ [K]	ΔT_C [K]
D-2	None	0.65	35.4	1.6
E-4	10 % SiC	0.32	33.0	3.0
E-5	10 % SiC	0.32	31.5	3.7

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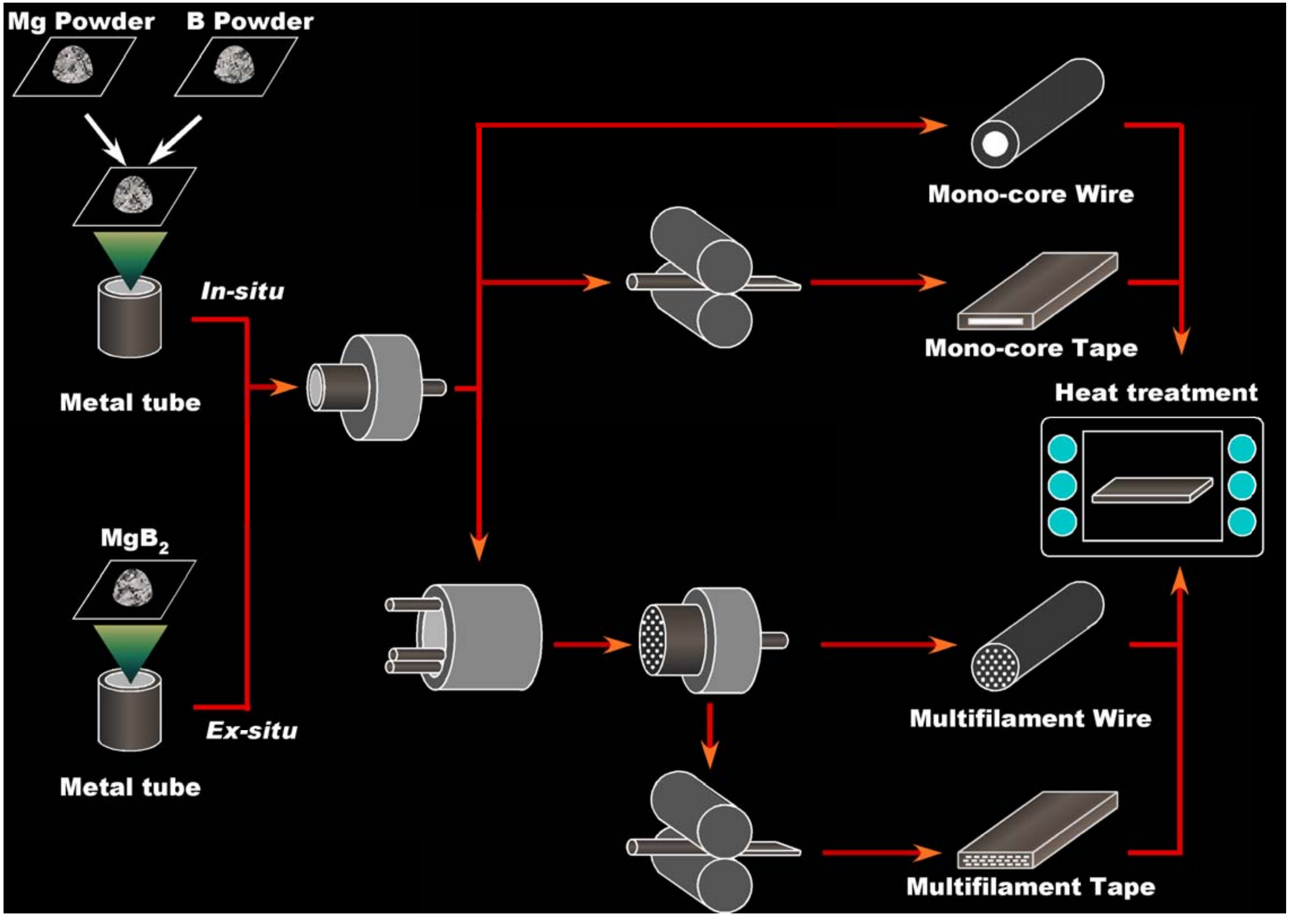
In Situ Method



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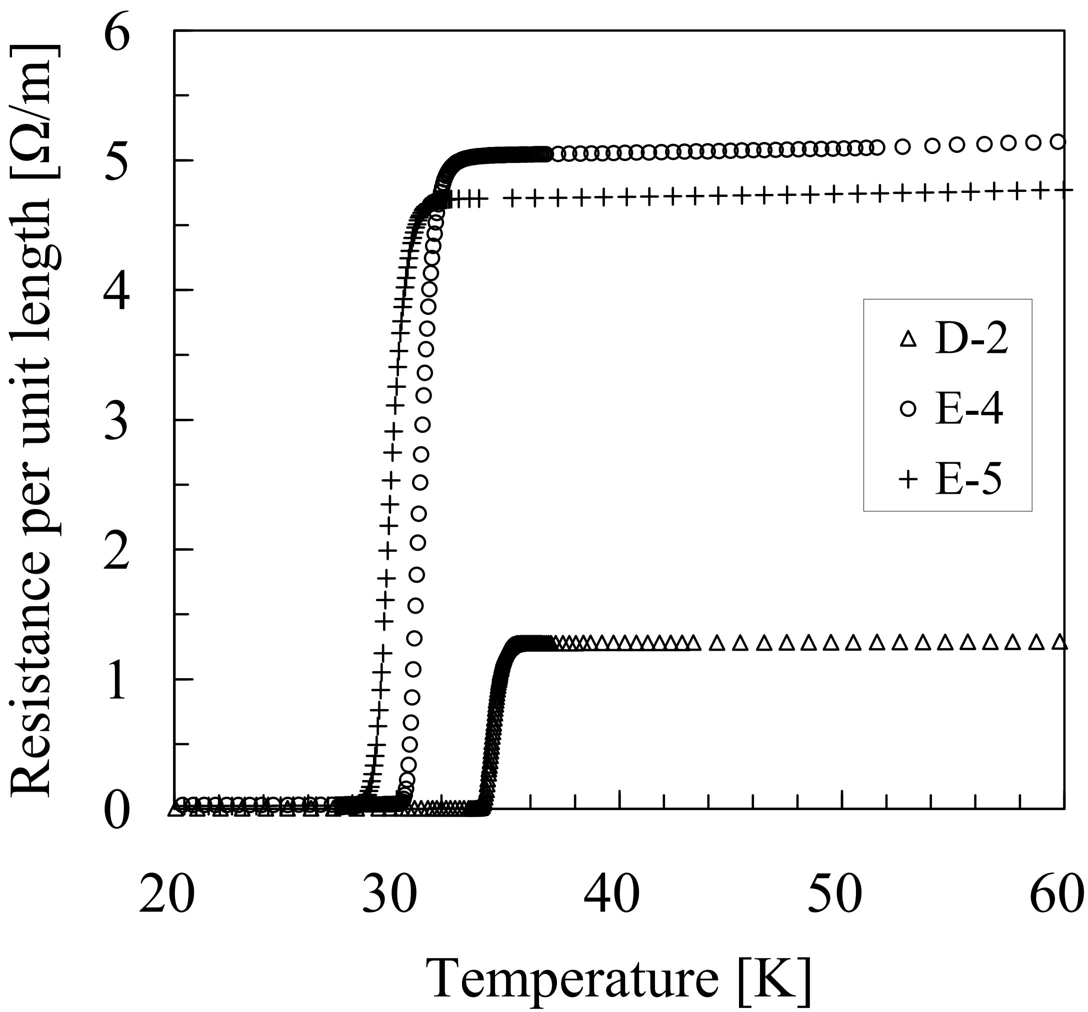
Resistance vs. Temperature



Liquid Hydrogen Experiment Facility

Dewar vessel

LH_2 tank

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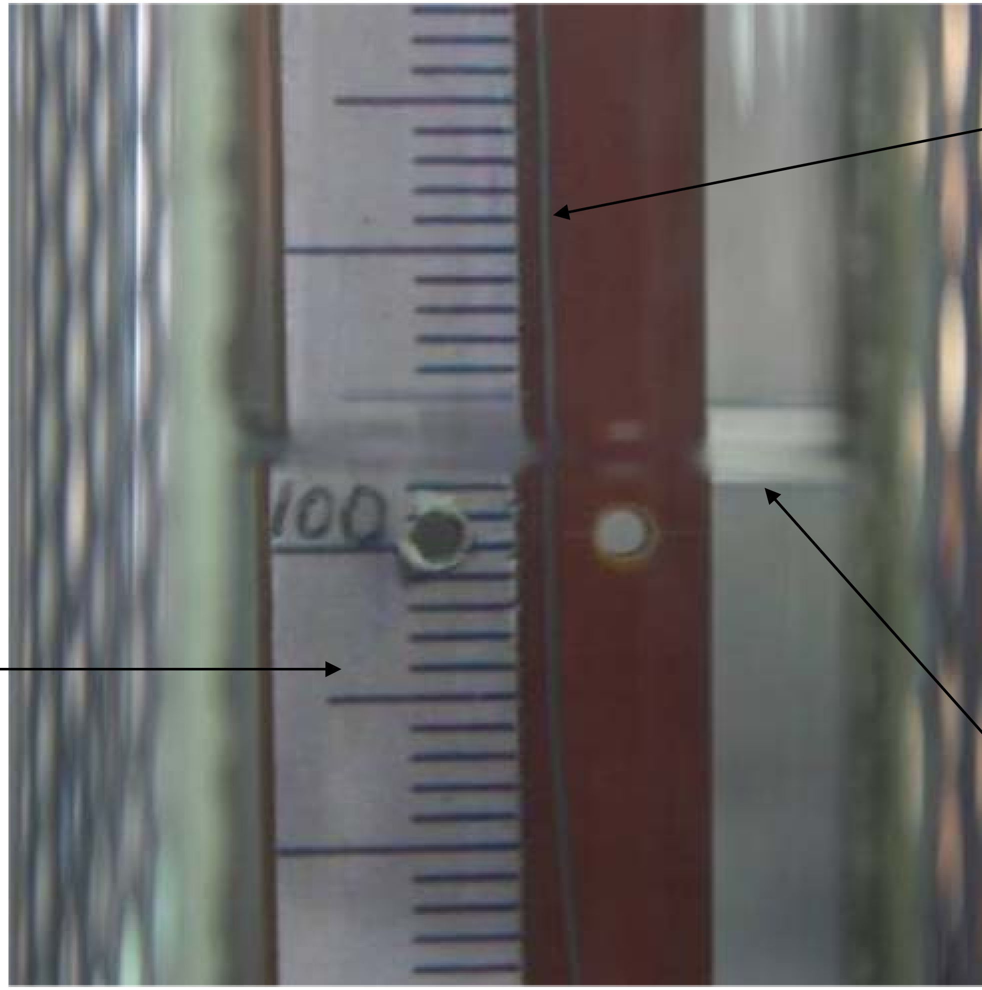
MgB_2 Sensor and Scale in LH_2 (25 K)



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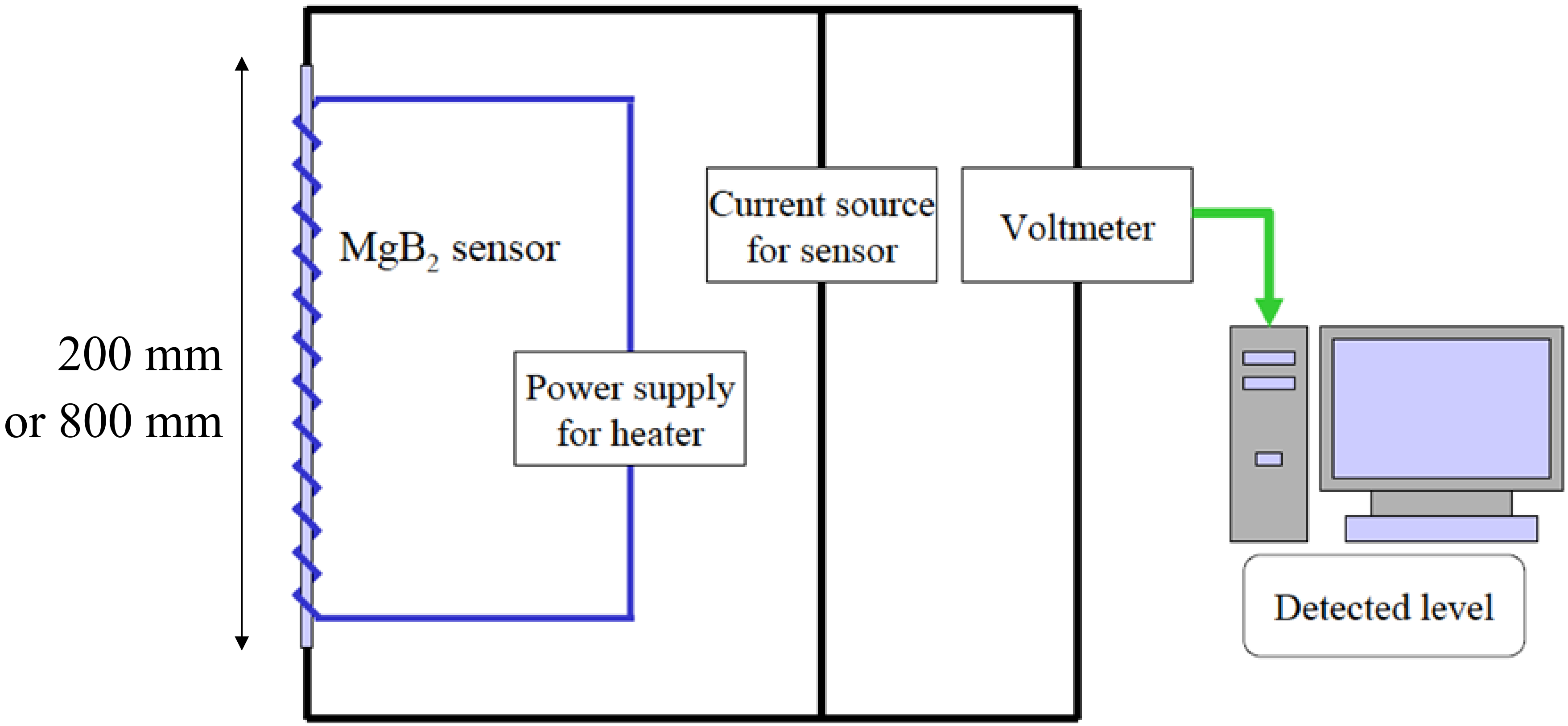
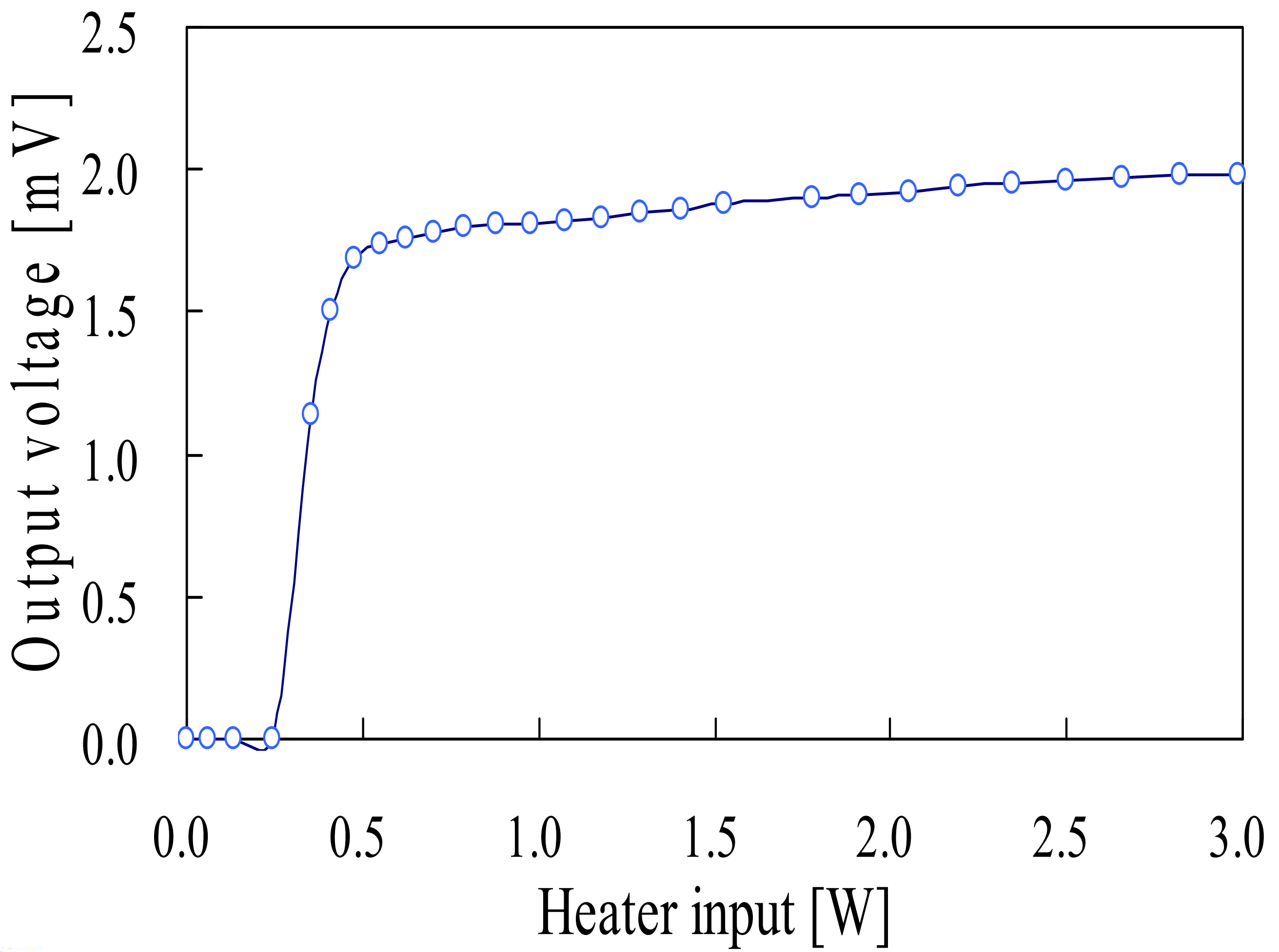
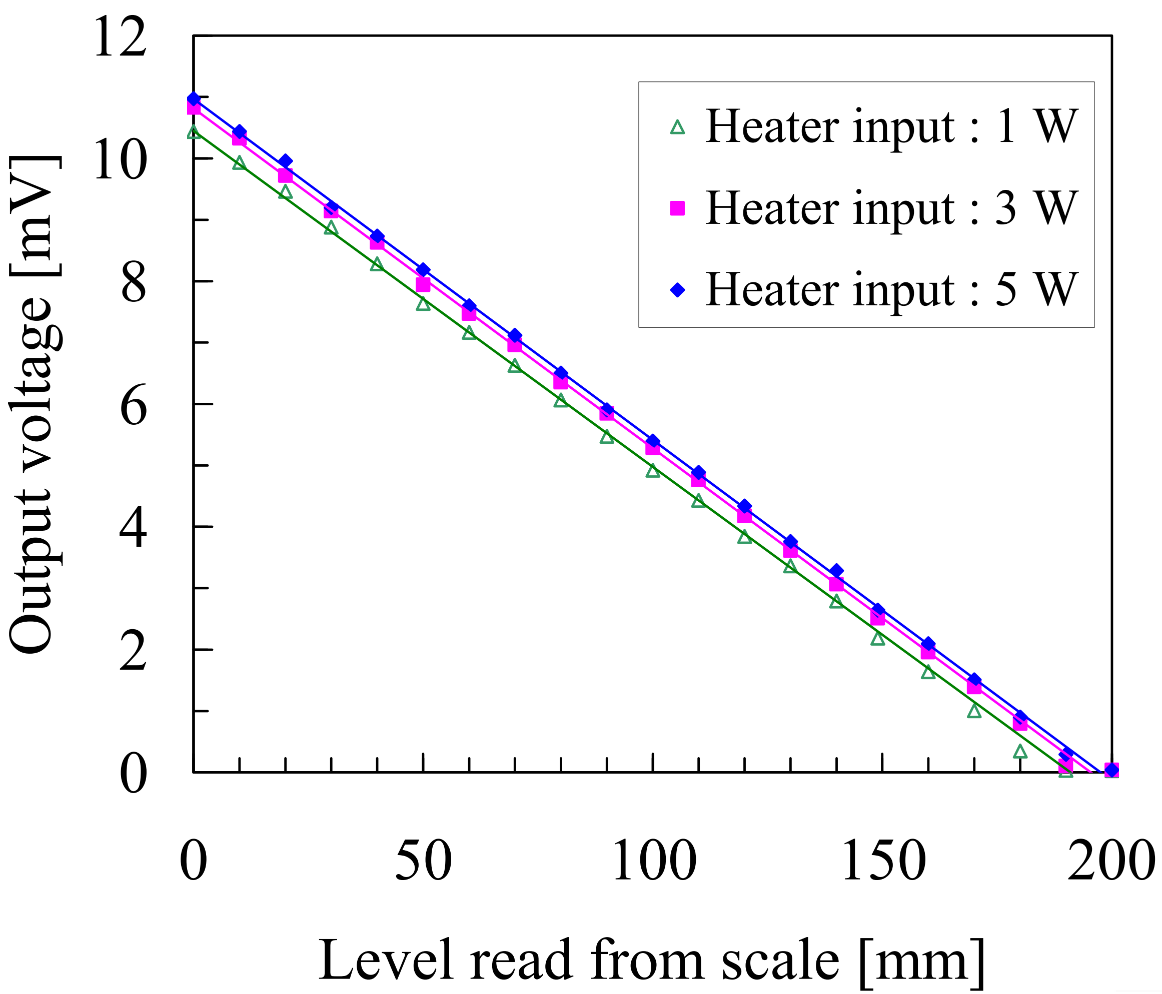
LH_2 Level-Detecting System



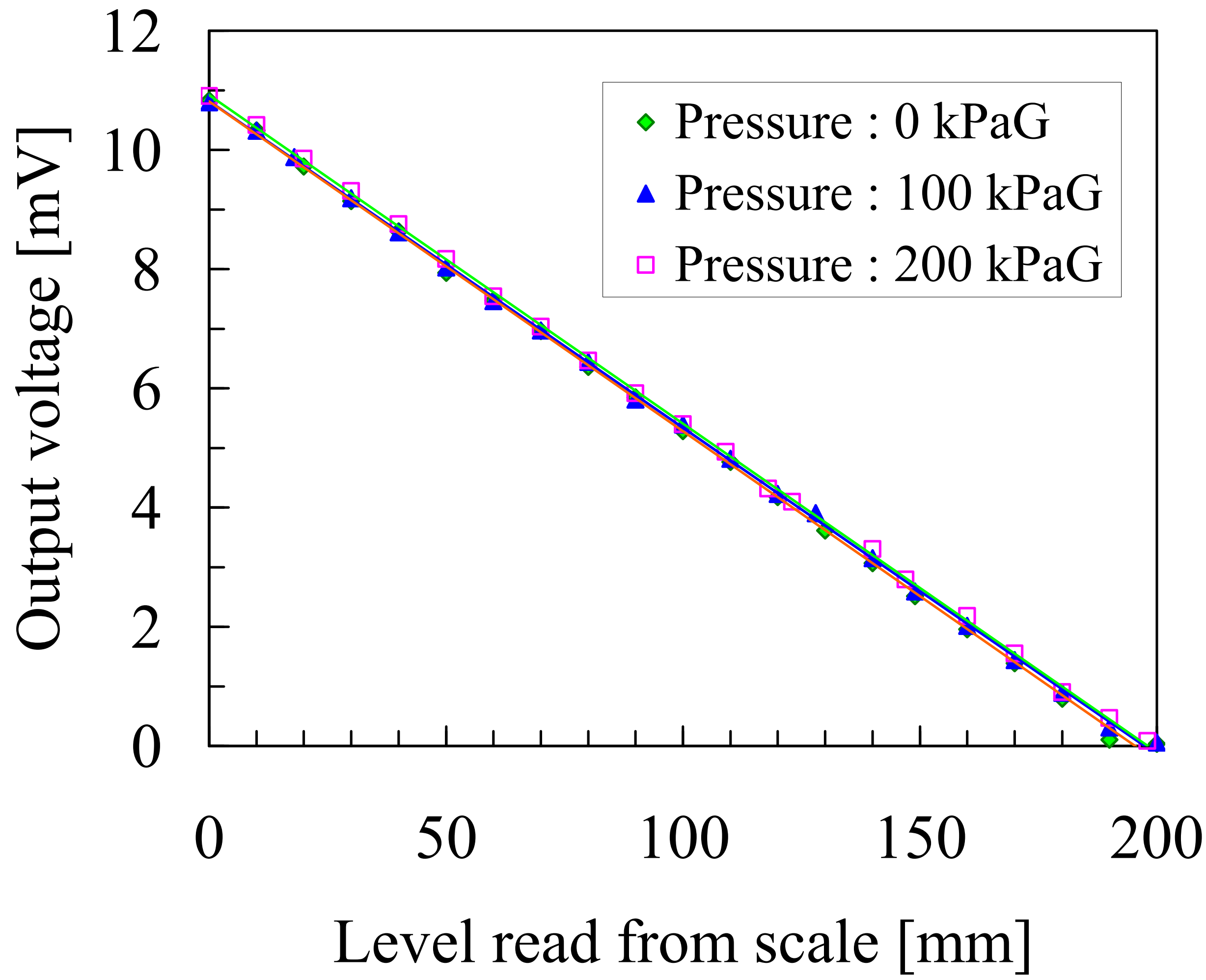
Experimental Results: V_{out} vs. $Heater_{in}$



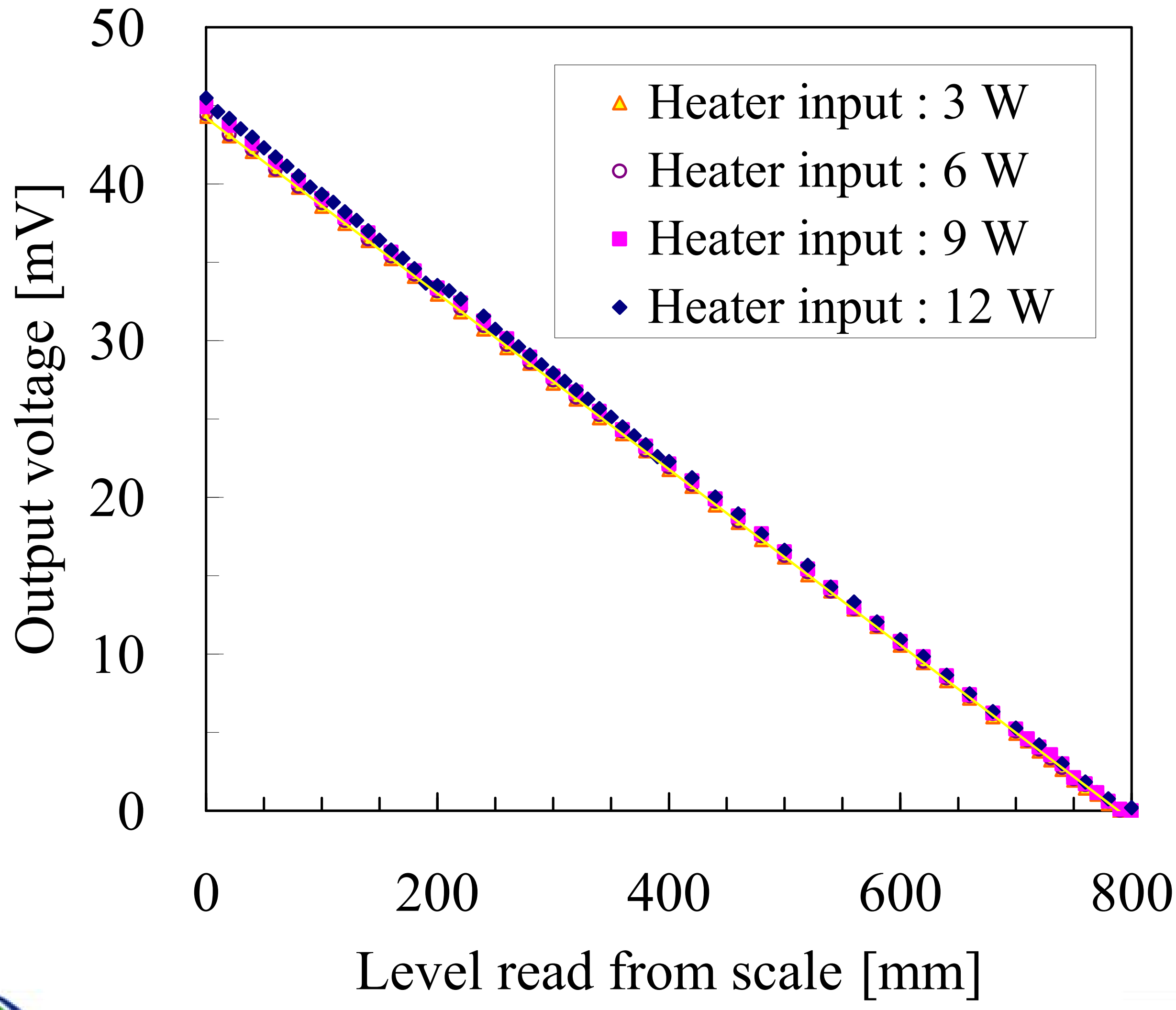
Experimental Results: 200 mm, 0 kPaG



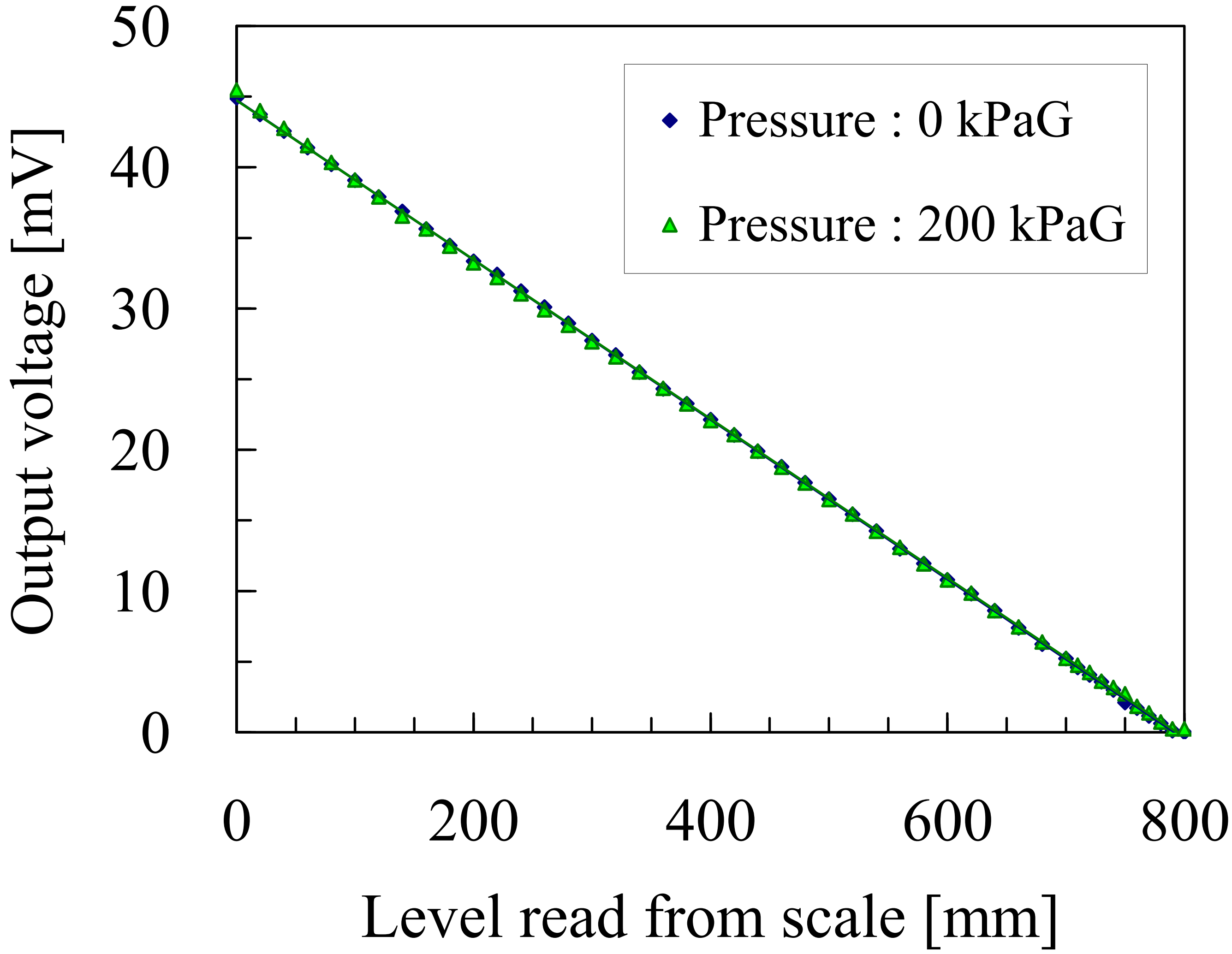
Experimental Results: 200 mm, 3 W



Experimental Results: 800 mm, 0 kPaG



Experimental Results: 800 mm, 9 W



Conclusion

(1) MgB_2 wires were fabricated by the addition of 10 % SiC, and the external-heating-type level sensors (200 and 800 mm long) based on the MgB_2 wires with a resistive heater were also fabricated.

(2) It becomes evident that the external-heating-type MgB_2 level sensor has a high linearity, a small measurement error, and a good reproducibility even under pressurized condition despite the evaporation loss caused by the heater.

(3) Future works should be conducted to study the level-detecting characteristics under vibration conditions of a liquid surface and to make a field test for a 1-m-class prototype level sensor installed in a LH_2 tank of 2 m^3.

Some Subjects for Feature Research

(1) The development of a flowmeter for LH_2

(2) The sloshing of the free surface of LH_2

(3) The cavitaion of LH_2

(4) The thermal oscillation of LH_2

(5) The rollover of LH_2

(6) The boiling heat transfer of LH_2

(7) The hydraulic loss of LH_2

(8) The development of an LH_2 pump for transport

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