

Development of Measurement Device of Thermal Expansion of Artificial Graphite Materials at High Temperature

Background

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Artificial graphite materials are used for manufacturing industries, **electric furnace steel manufacturing, silicon and SiC semiconductor manufacturing, and aluminum refining.**



【熱ストレス抵抗 (TSR)】

Thermal Stress Resistance:

$$TSR = \frac{TC \cdot FS}{CTE \cdot YM \cdot ER}$$

TC: Thermal Conductivity

FS: Flexural strength

CTE: Coefficient of thermal expansion

YM: Young's Modulus

ER: Electrical Resistivity

TSR

1900 1920 1940 1960 1980 2000 2020

Application temperature

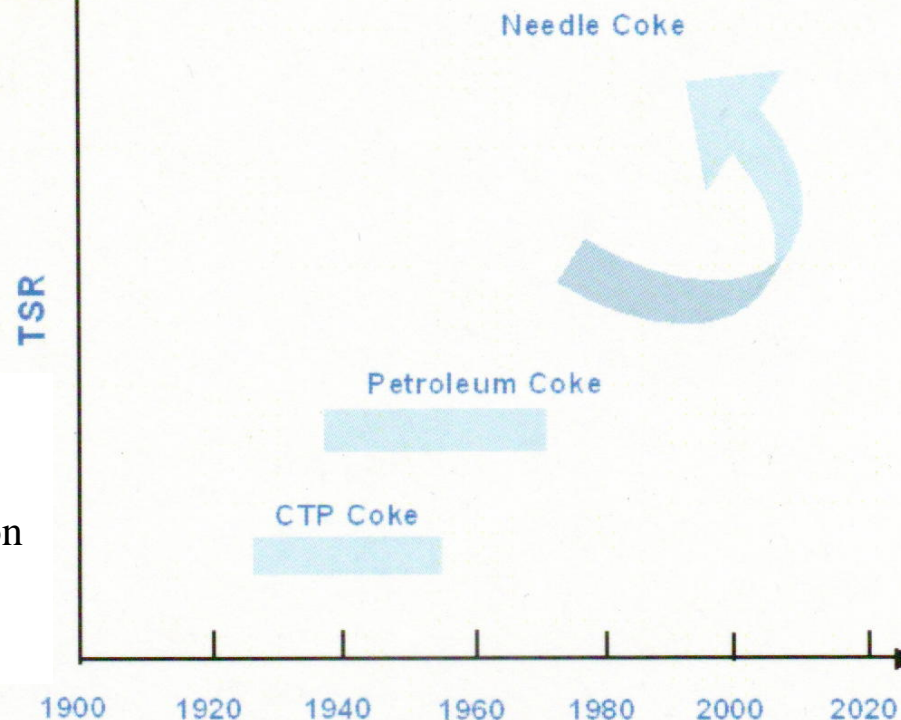


Fig. 9 Steps in raw material based graphite electrode quality expressed by thermal stress resistance

[SGL-carbon presented in Carbon2007](#)

TRS : one of the measure for graphite materials applied at high temperate.

High temperature *CTE* could not be measured in my Lab.

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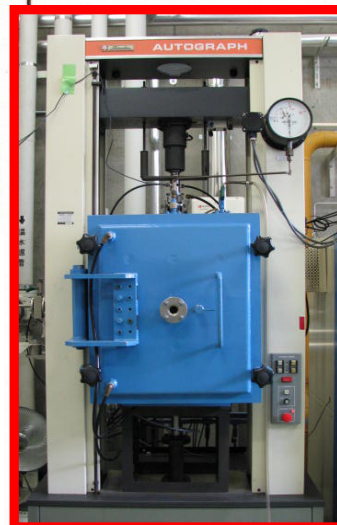
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CTE: Coefficient of thermal expansion

YM: Young's Modulus

ER: Electrical Resistivity

TSR



Needle Coke



1900 1920 1940 19

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【Coefficient of thermal expansion】

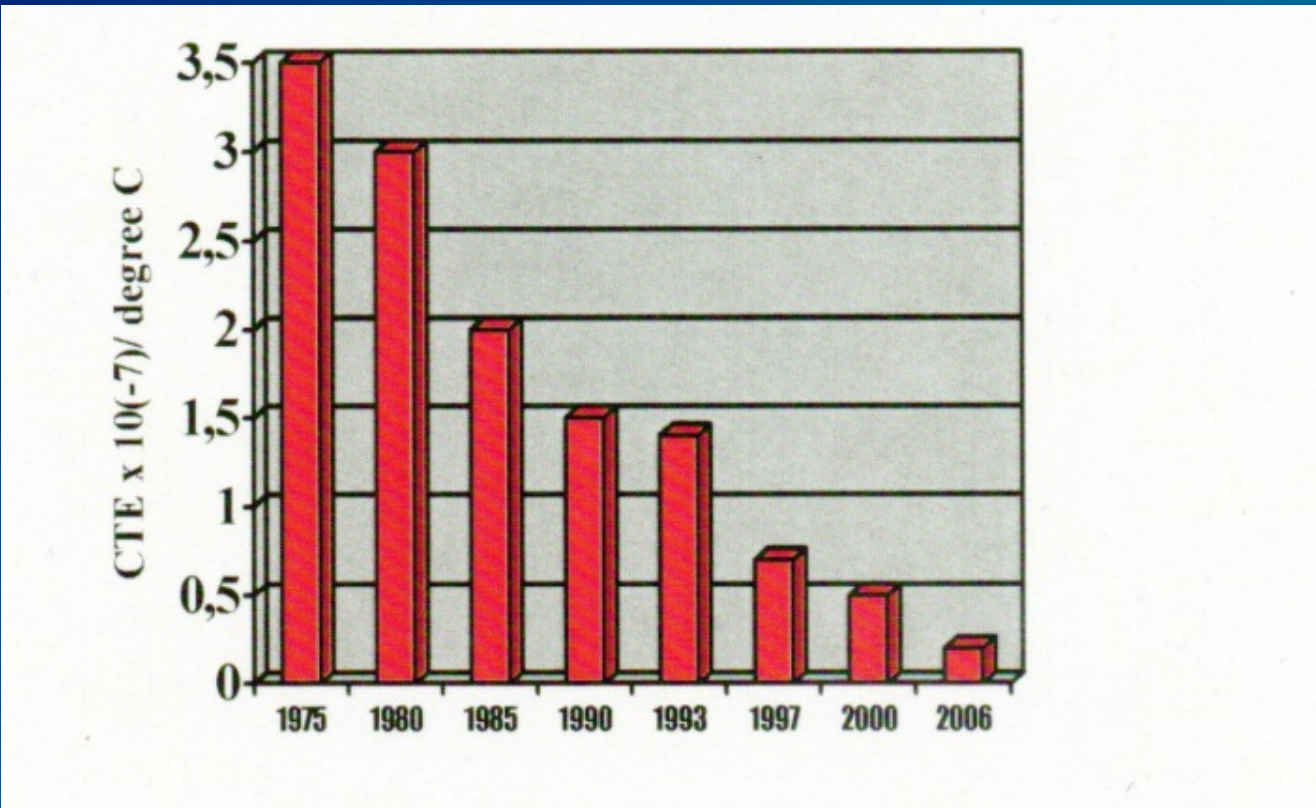


Fig. 16 Coke CTE improvement over past 30 years

Aim of this work

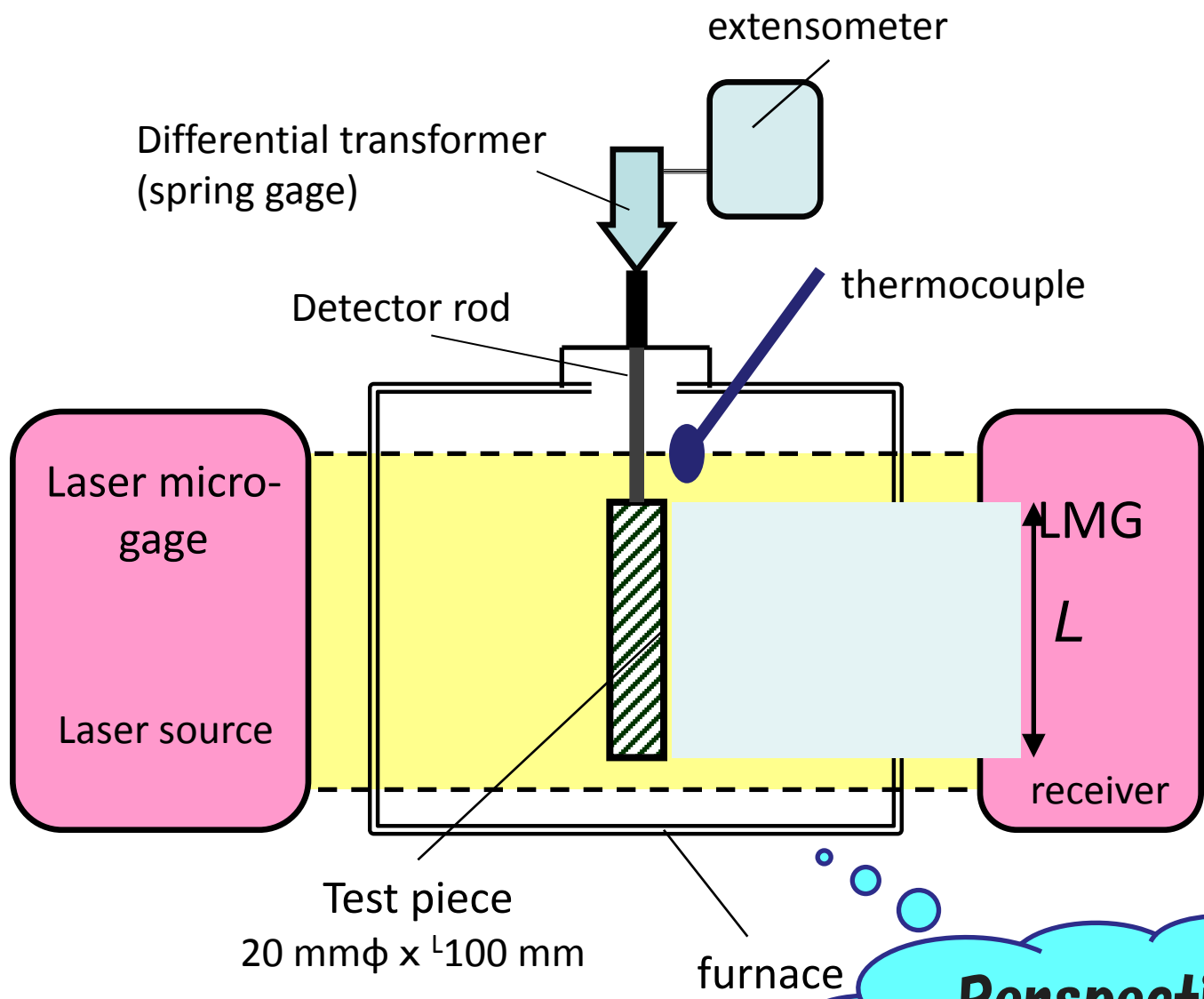


For measurement of thermal expansion of artificial graphite materials above 2000°C, special electric furnace with the device measuring specimen dimension has been developed on the basis on JIS R2207.

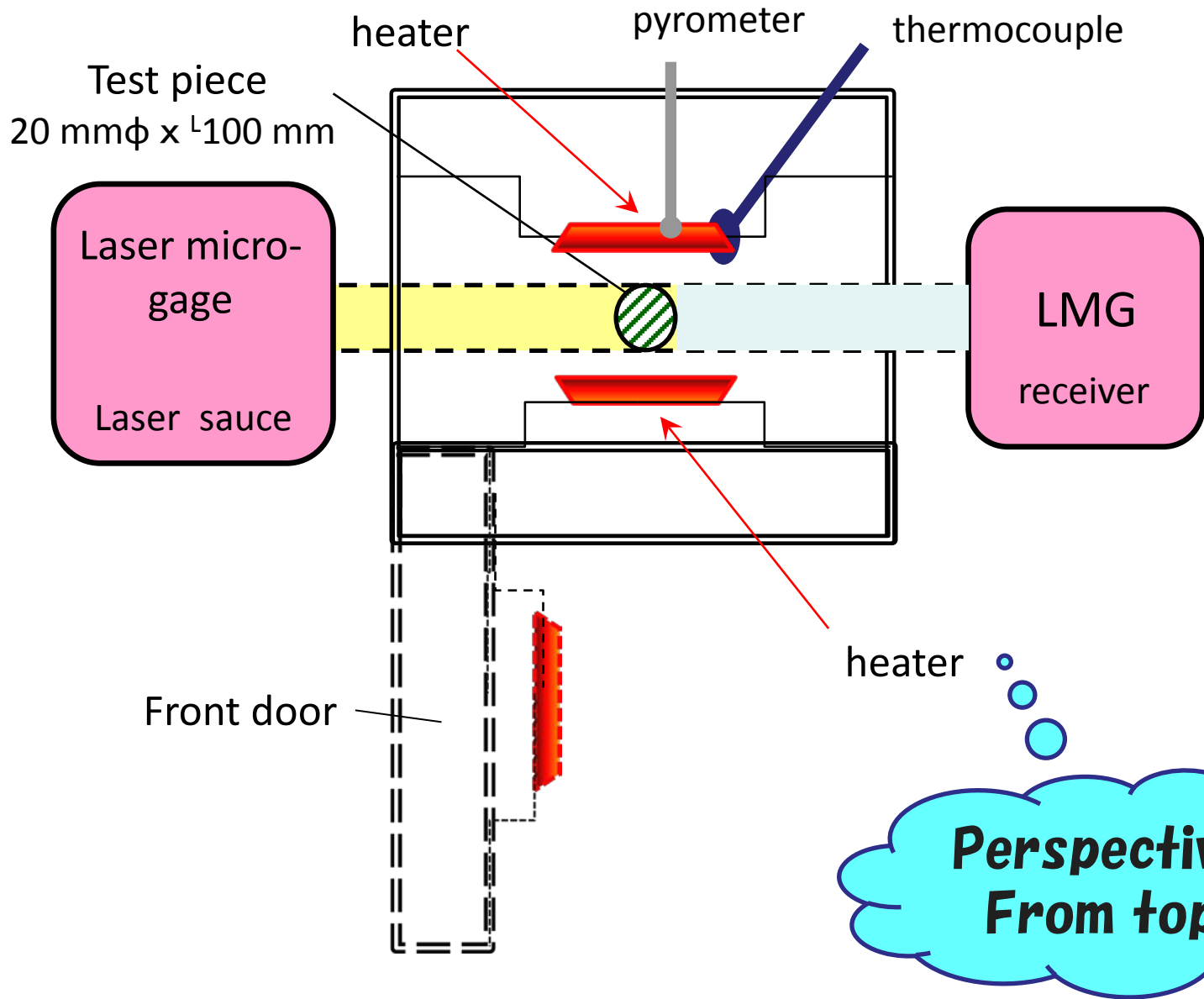
“Idea of development” of thermal expansion measurement device of graphite materials at high temperature

For the measurement at the temperature above 2000 degree-C, we used "isotropic graphite" as furnace heater and measurement jigs.

And also as the reference materials for thermal expansion measurement with contact method, isotropic graphite was used.



**Perspective
From the front**

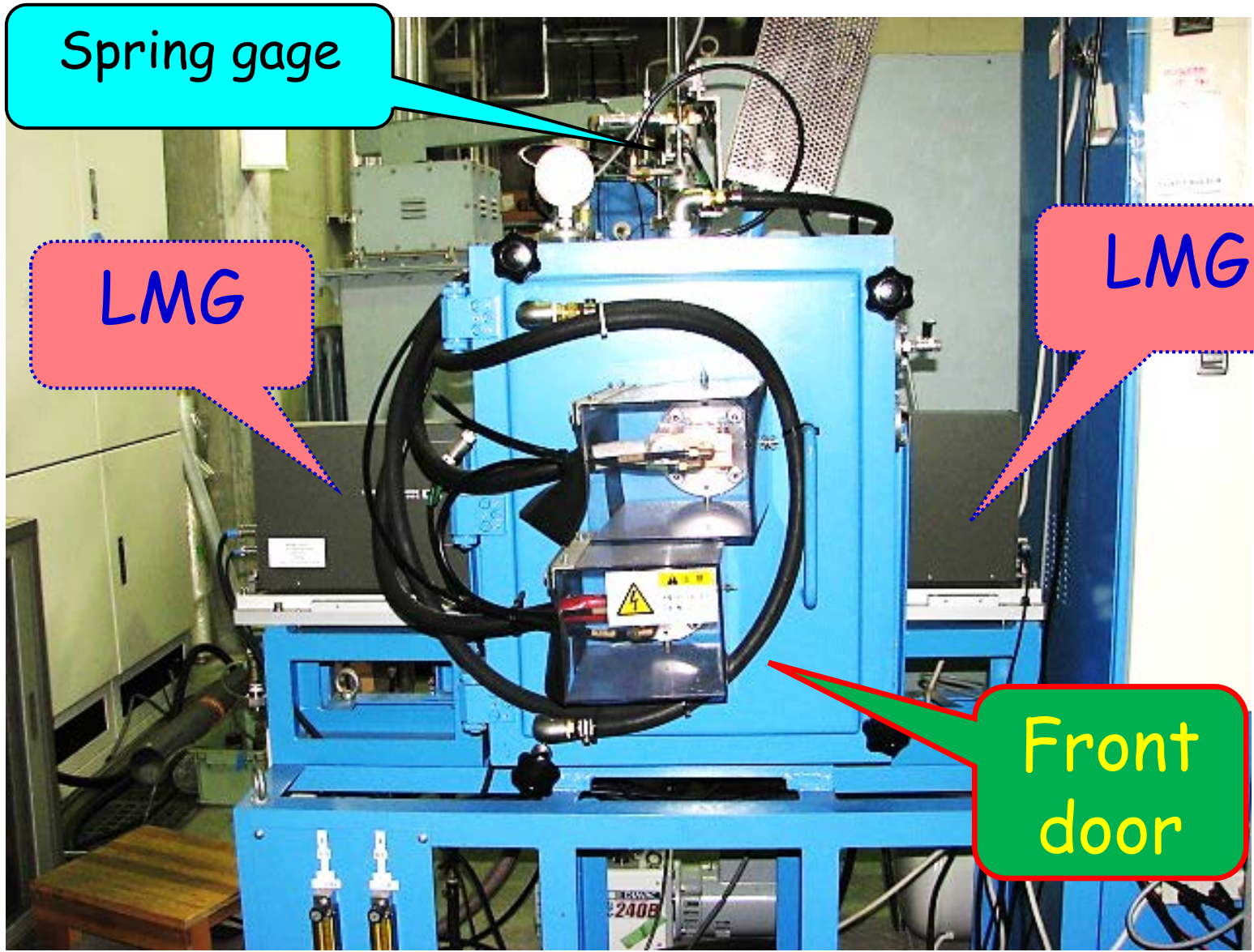




ここに
技あり

halber

Punkt



Spring gage

LMG

LMG

Front door

LMG: TOE D5-1505 II -HS

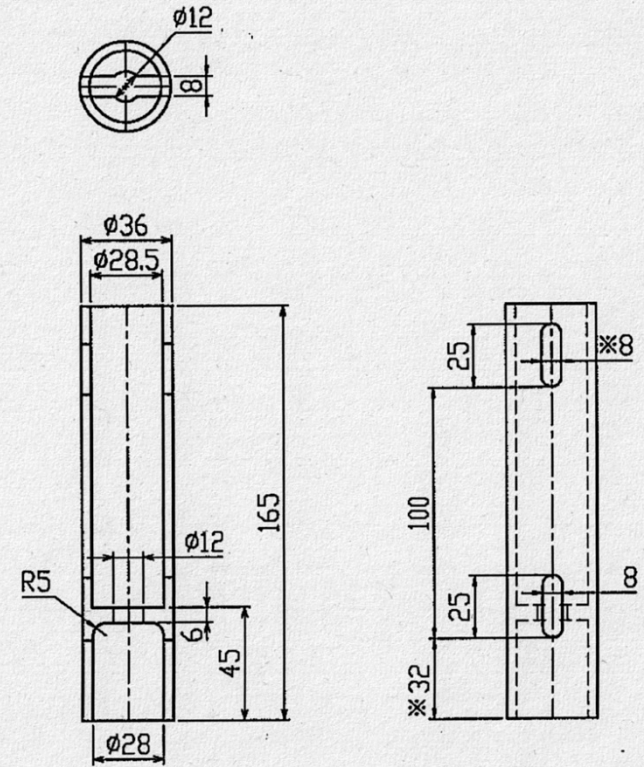
Furnace inside

Pass slit for laser beam

Detector rod

Back heater

Pass slit for laser beam



Support tube

**Support
tube**

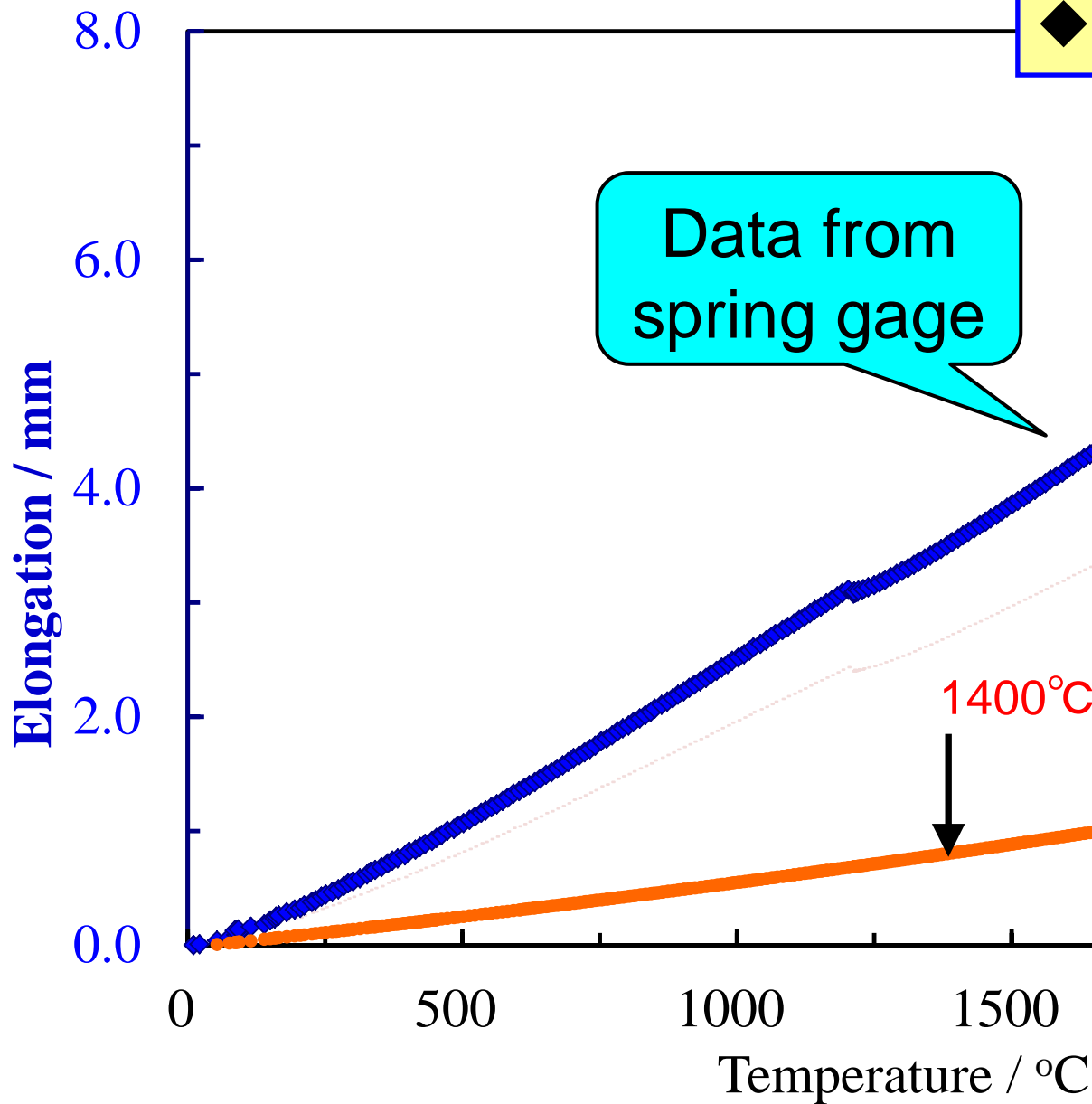
**Detector
rod**

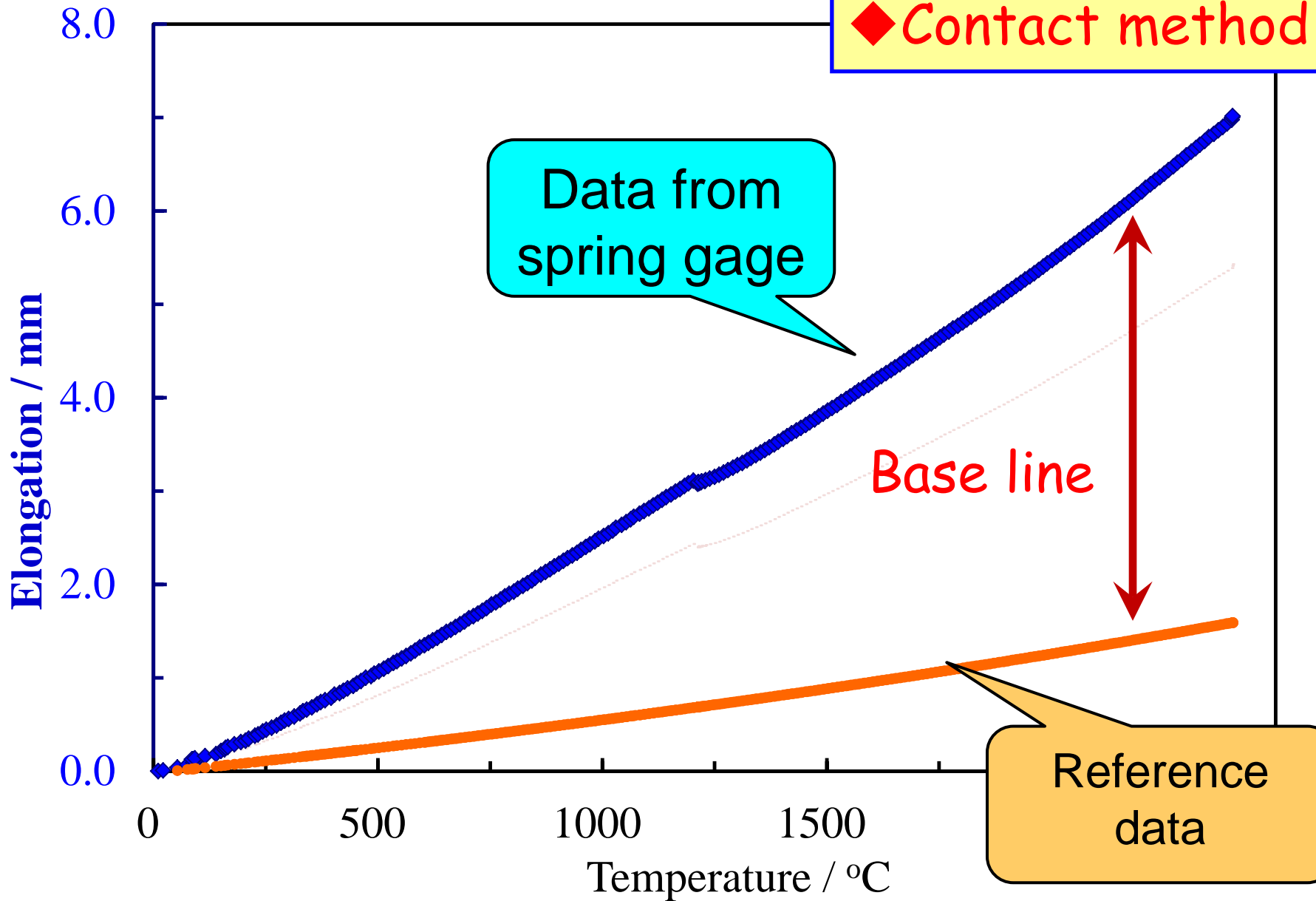
**Test piece
($\Phi 20$ mm x 100 mm)**

◆ Heat Rate: 10°C/min

Data from spring gage

Reference data





Idea 2

Laser beam & Support tube

test piece

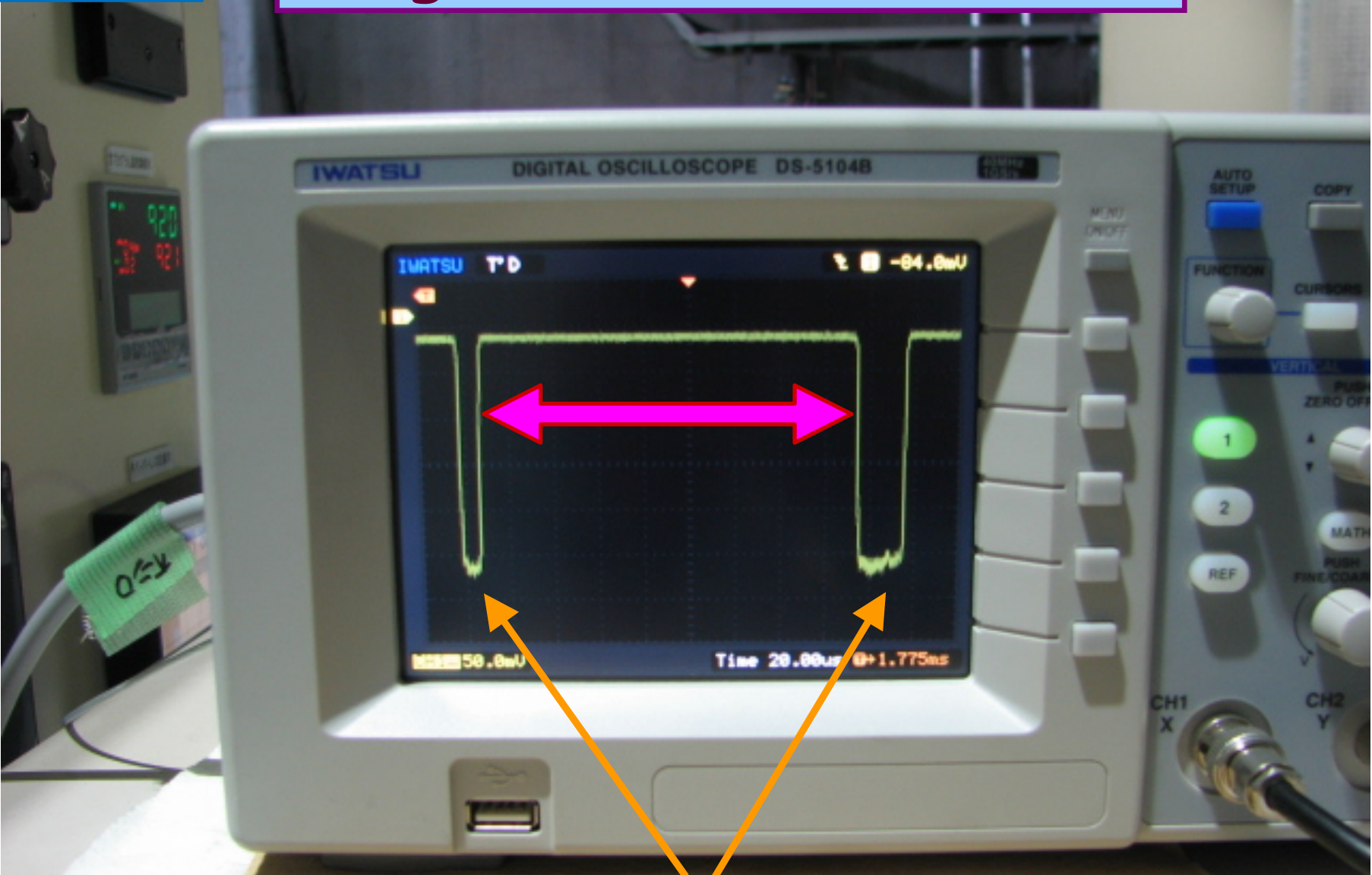
Pass slit for laser beam in thermal insulator

Laser beam

Pass slit for laser beam

Idea 2

Signal of LMG receiver

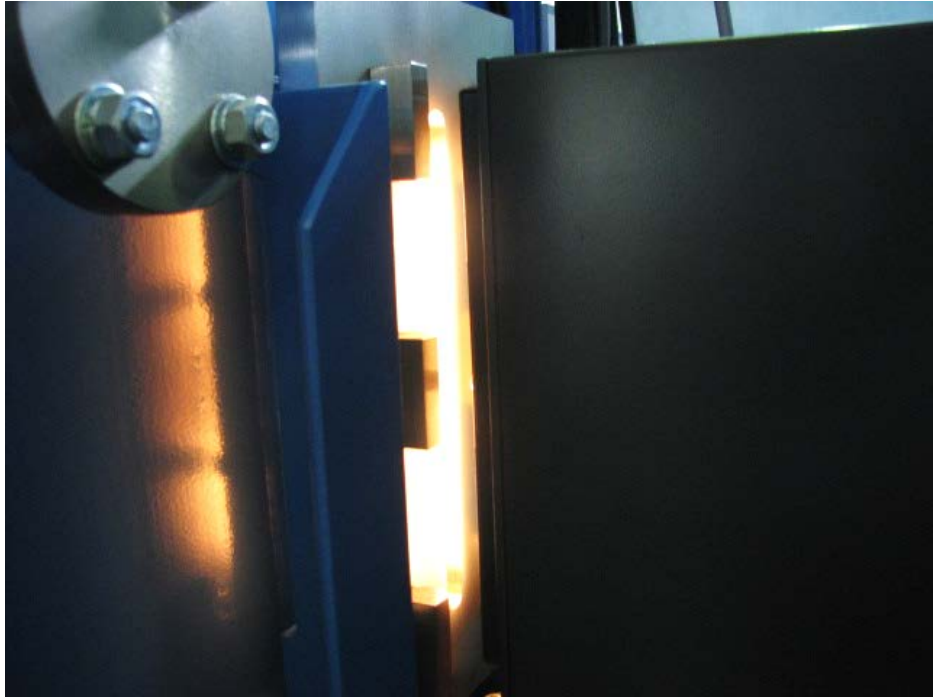


Laser beams reached to receiver

@ 2400°C

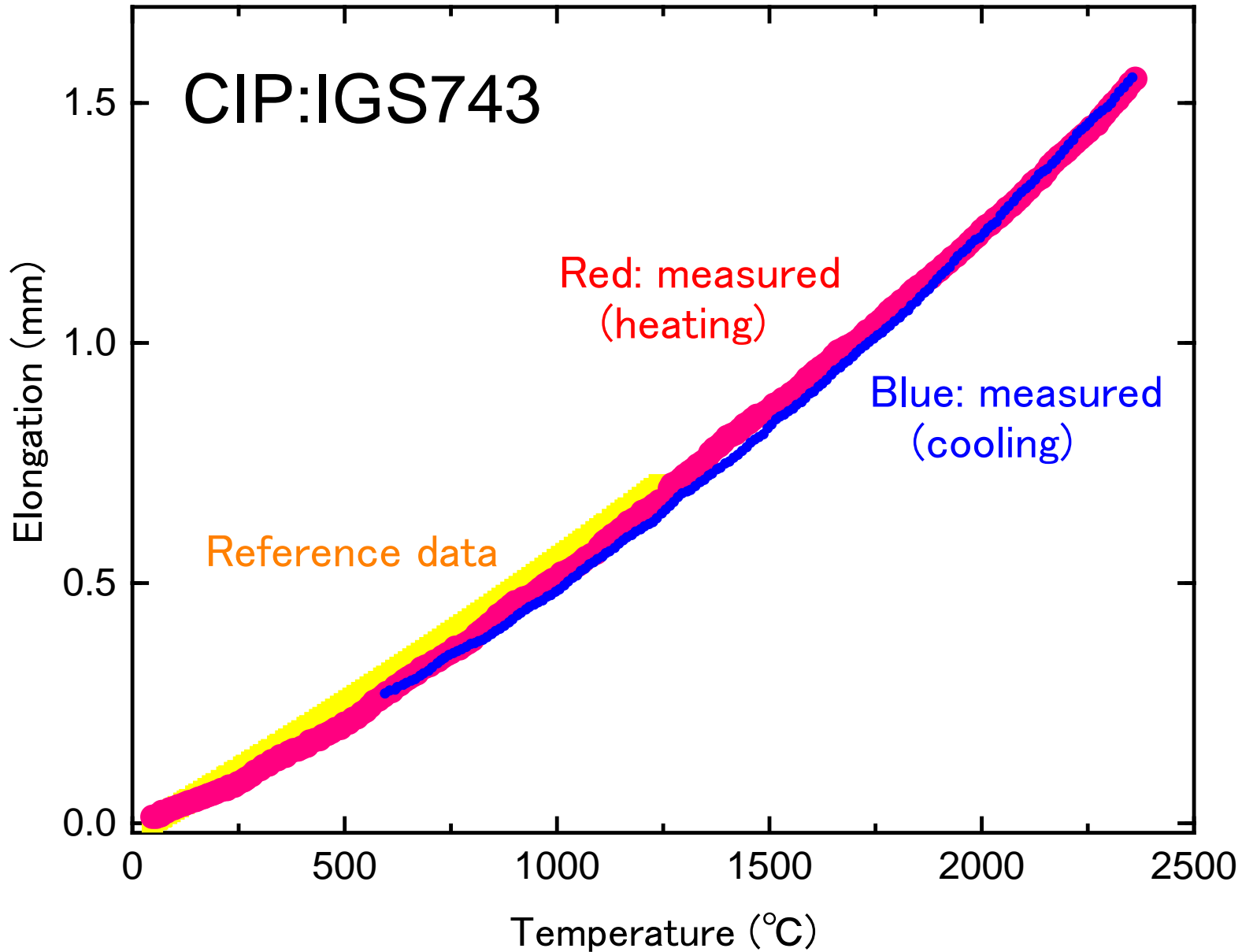


Laser source



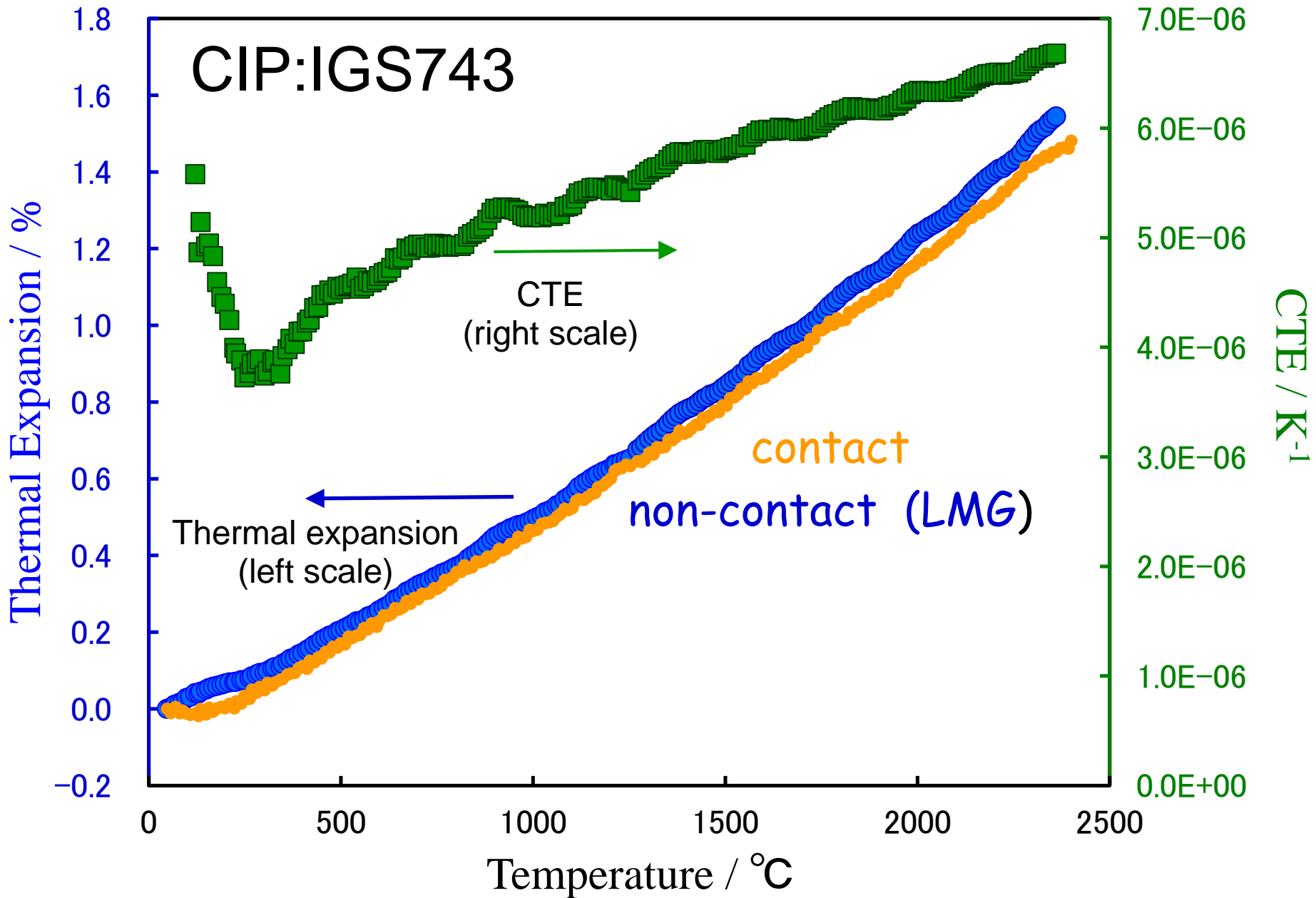
Receiver

Elongation measurement by LMG

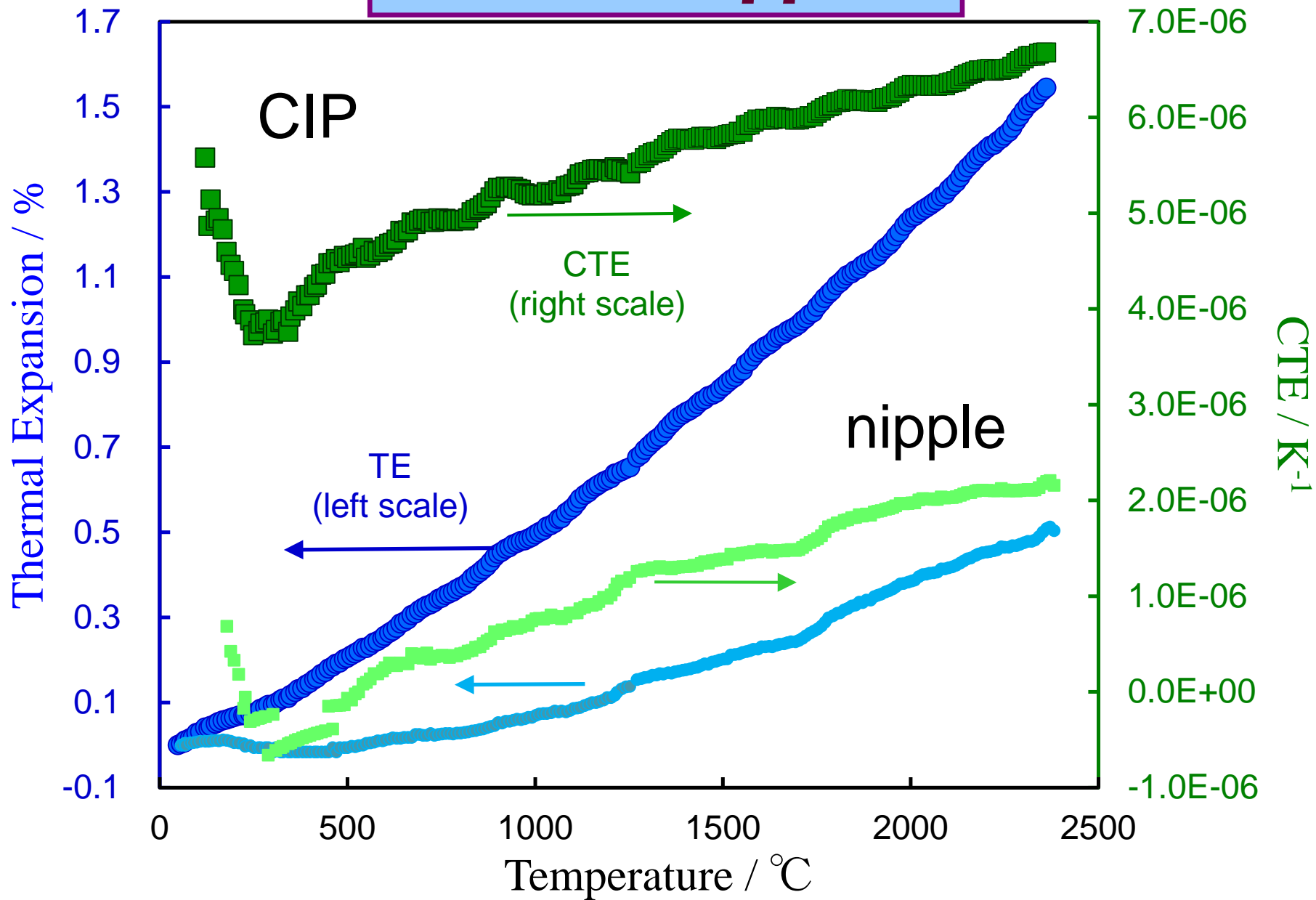




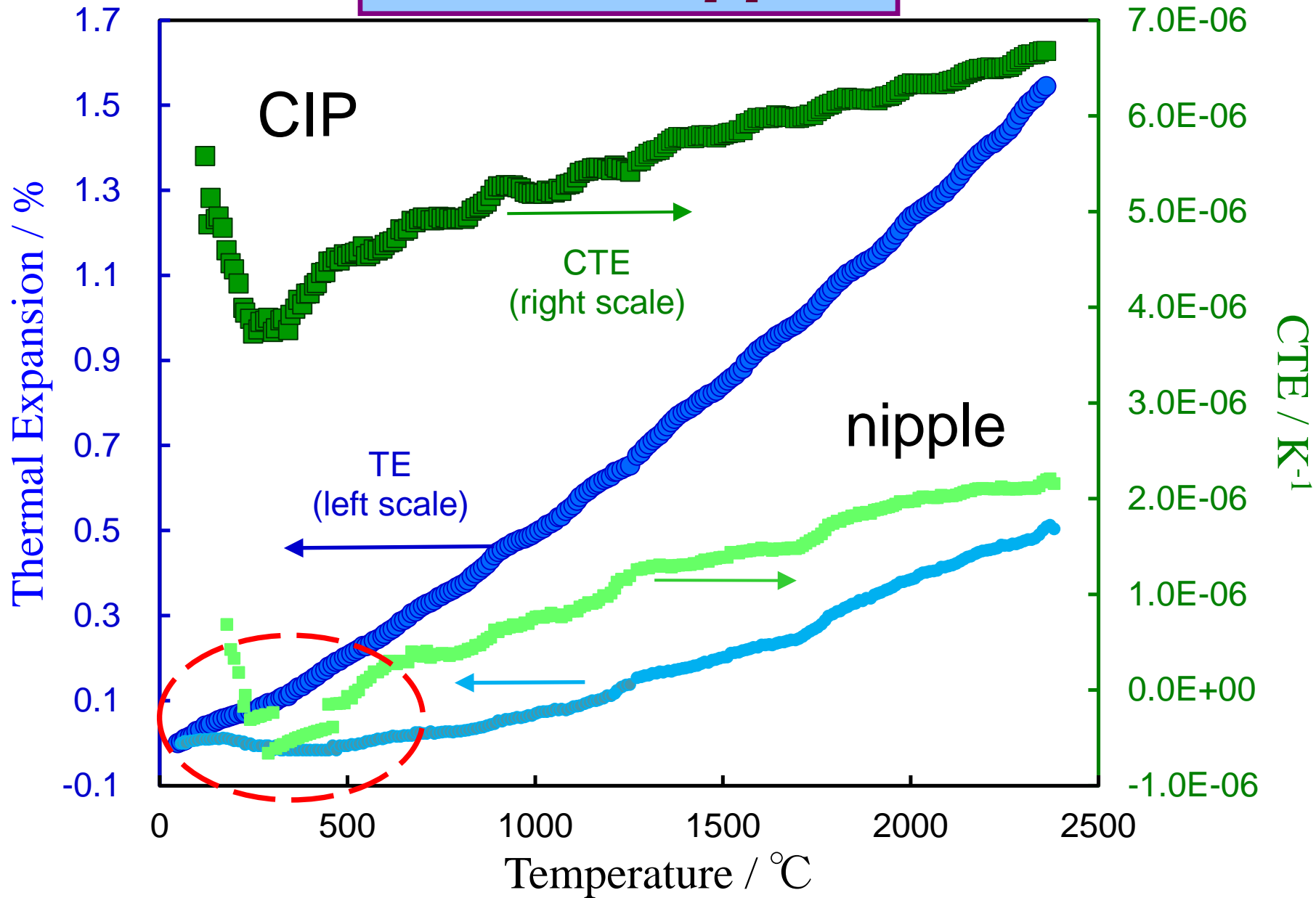
Good Job!
Gut gemacht!



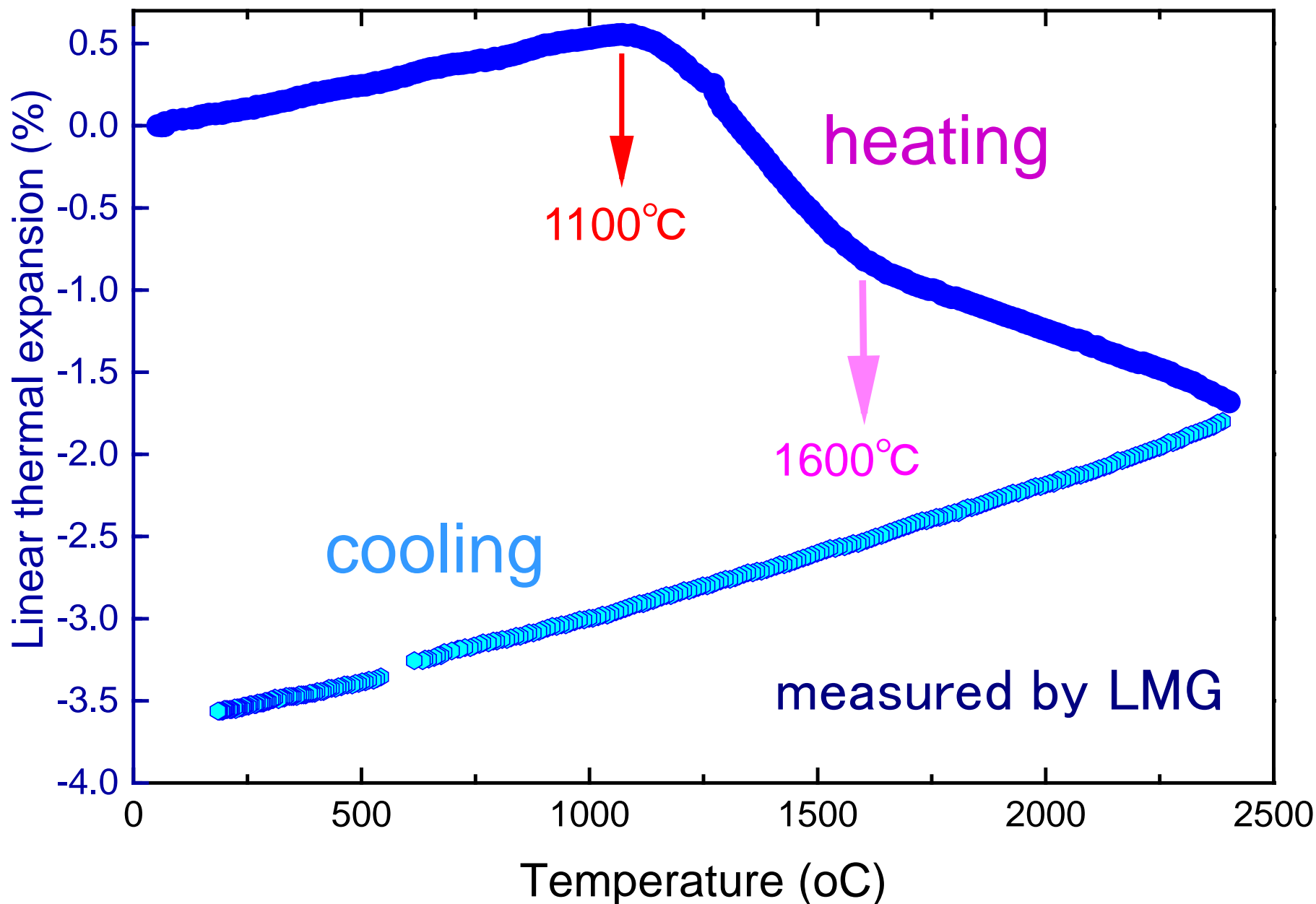
CIP & Nipple



CIP & Nipple



Sample Dimension Change of "carbonized block"



Summary

- The development the measurement device of thermal expansion of artificial graphite at high temperature can be succeeded using isotropic graphite, as heater, measurement jigs and the reference materials
- Not only contact method, but also non-contact method for the measurement of thermal expansion can be adapted in the device.
- By introducing the non-contact method with LMG, accurate thermal expansion can be measured up to 2400 °C.

Summary 2

- CIP isotropic graphite has three times larger thermal expansion and CTE than Nipple electrode.
- In the case of Nipple electrode with strongly anisotropic orientation, negative thermal expansion at the temperature between 200~300 °C was observed with LMG.
- By the developed device, thermal shrinkage of carbonized block can be observed at high temperature above 1100 °C. Two steps of shrinkage behavior against temperature was observed.

Thank you very much for
your attention





Good Job!
Gut gemacht!