

Temperature dependence of electrical resistance of jointed graphite electrodes

ON. Iwashita (AIST)

T. Okamoto, W. Nishiumi, T. Yamanaka (SEC-Carbon)

Electric Arc Furnace (EAF) 電炉



※ you tube

Electric Arc Furnace (EAF) is used for steelmaking of construction materials from iron scrap. Furnace consists of a big pot having cover inserted graphite electrodes. Electric arc is generated by applying current between charged iron scrap and graphite electrode, heating up to more than 1600 °C, the scrap iron is melted.

EAF is the biggest market for Carbon industries.

Welcome “Giga-Carbon” Field



Nippon Carbon



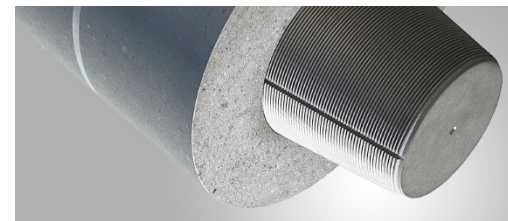
Techno Carbon



SEC Carbon



Graftech



SGL-Carbon

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Objective

Graphite electrode has been used as jointing between nipple and pole with screw.

Electrical resistance of screw jointed graphite electrode with different coefficient of thermal expansion (CTE) was measured at 2500°C.

Effect of combinations on temperature dependence of resistance of jointed graphite electrode was investigated.



Materials

Pole, Nipple, TKTAN (特炭)

Combinations

A) Pole凹 – Nipple凸

B) TKTAN凹 – Nipple凸

C) Nipple凹 – TKTAN凸

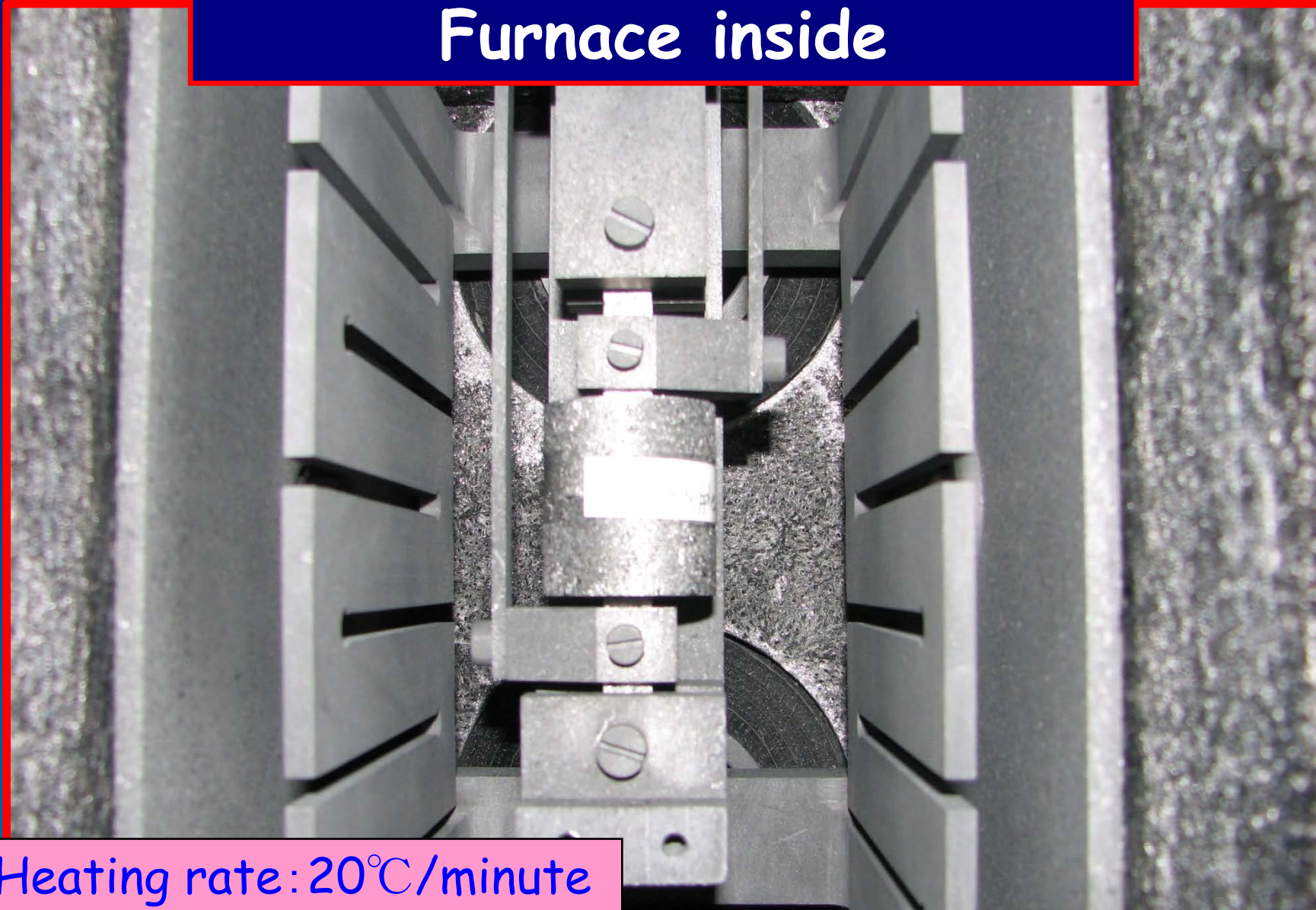
D) Nipple凹 – Nipple凸

Measurement of high temperature Resistance

B) TKTANㄣ = Nippleㄣ



Resistance measurement Furnace inside

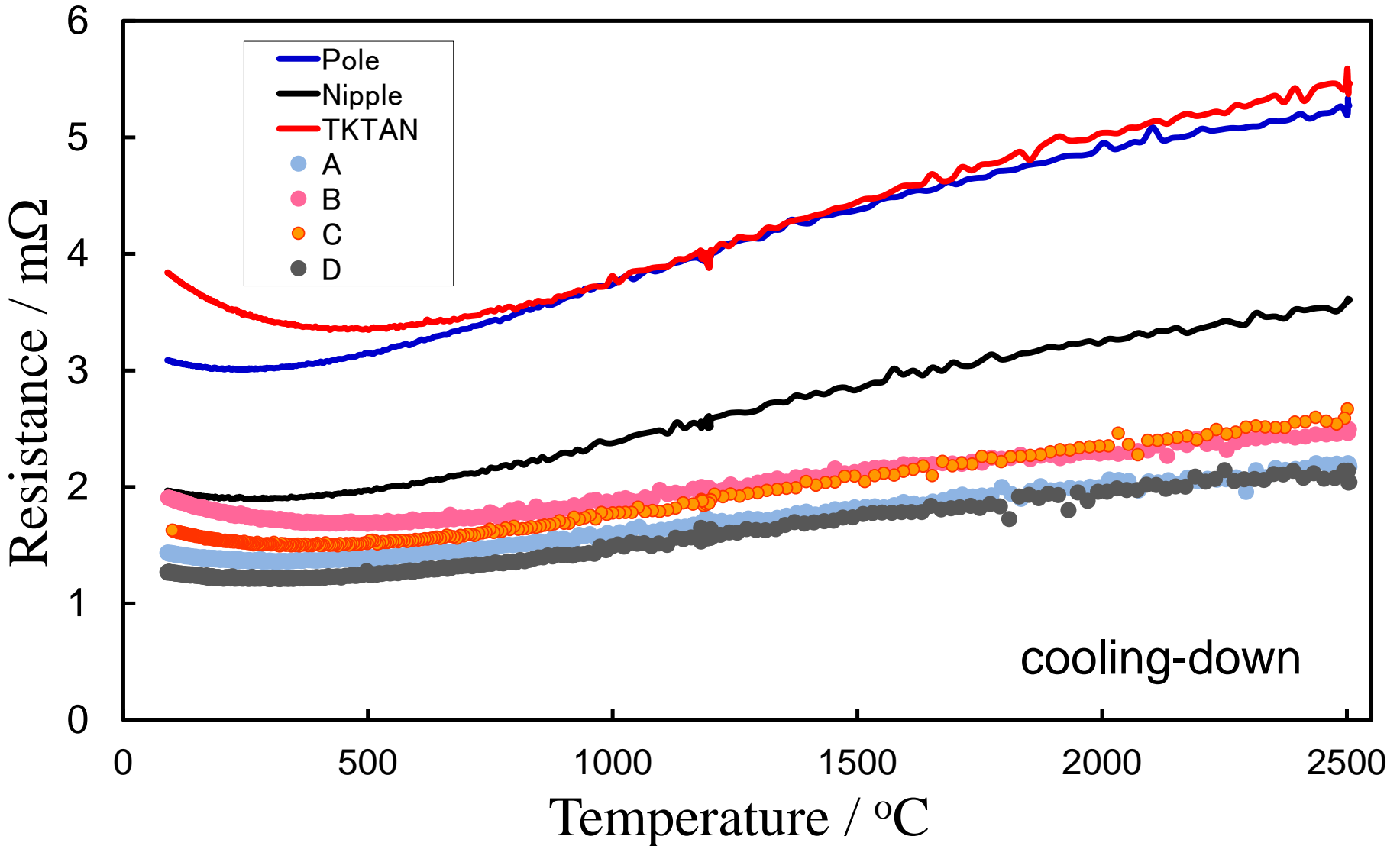


Heating rate: $20^{\circ}\text{C}/\text{minute}$

Sampling: every 1 minute

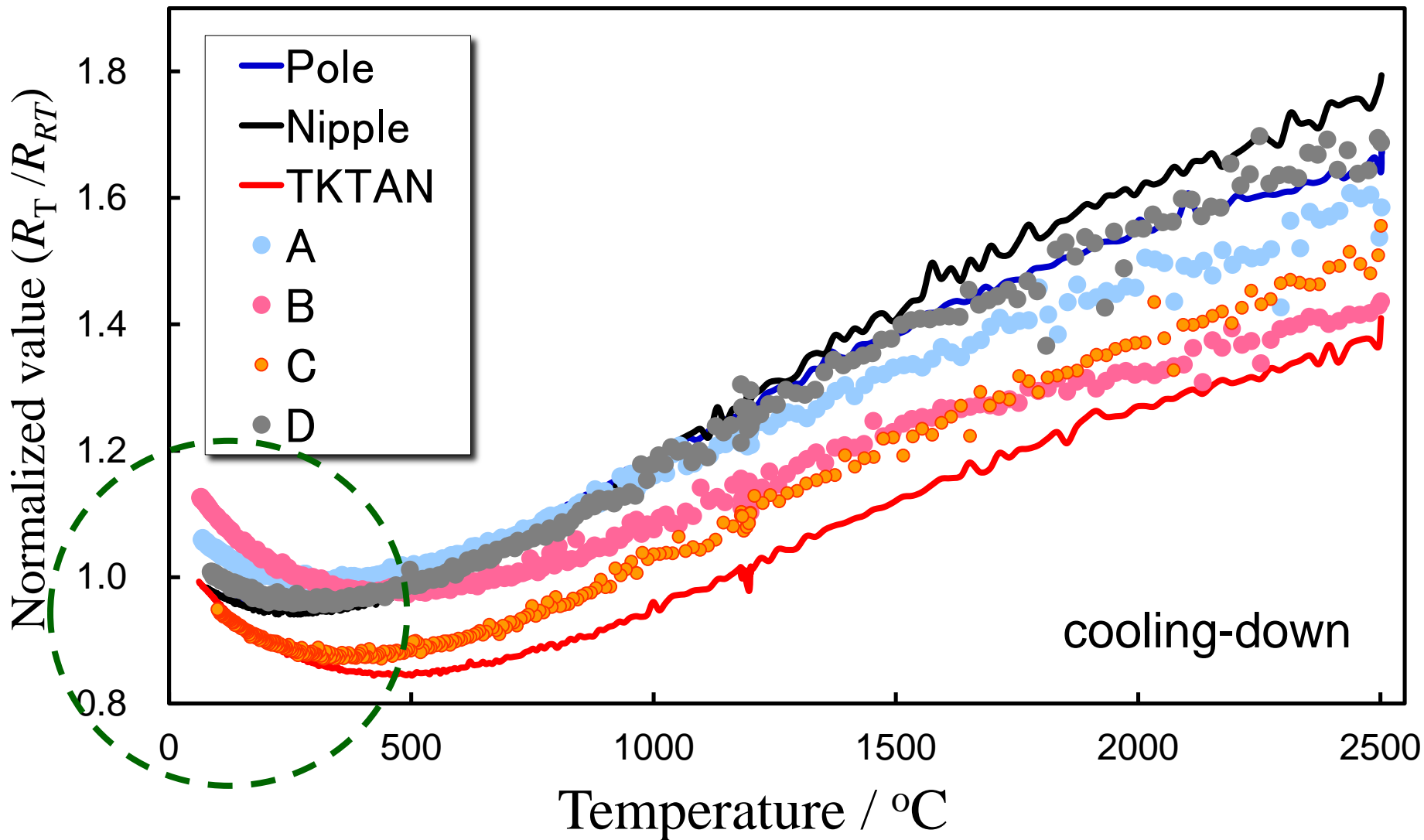
Constant current: $\pm 100\text{ mA}$

結果 Result Temperature dependence of Resistance

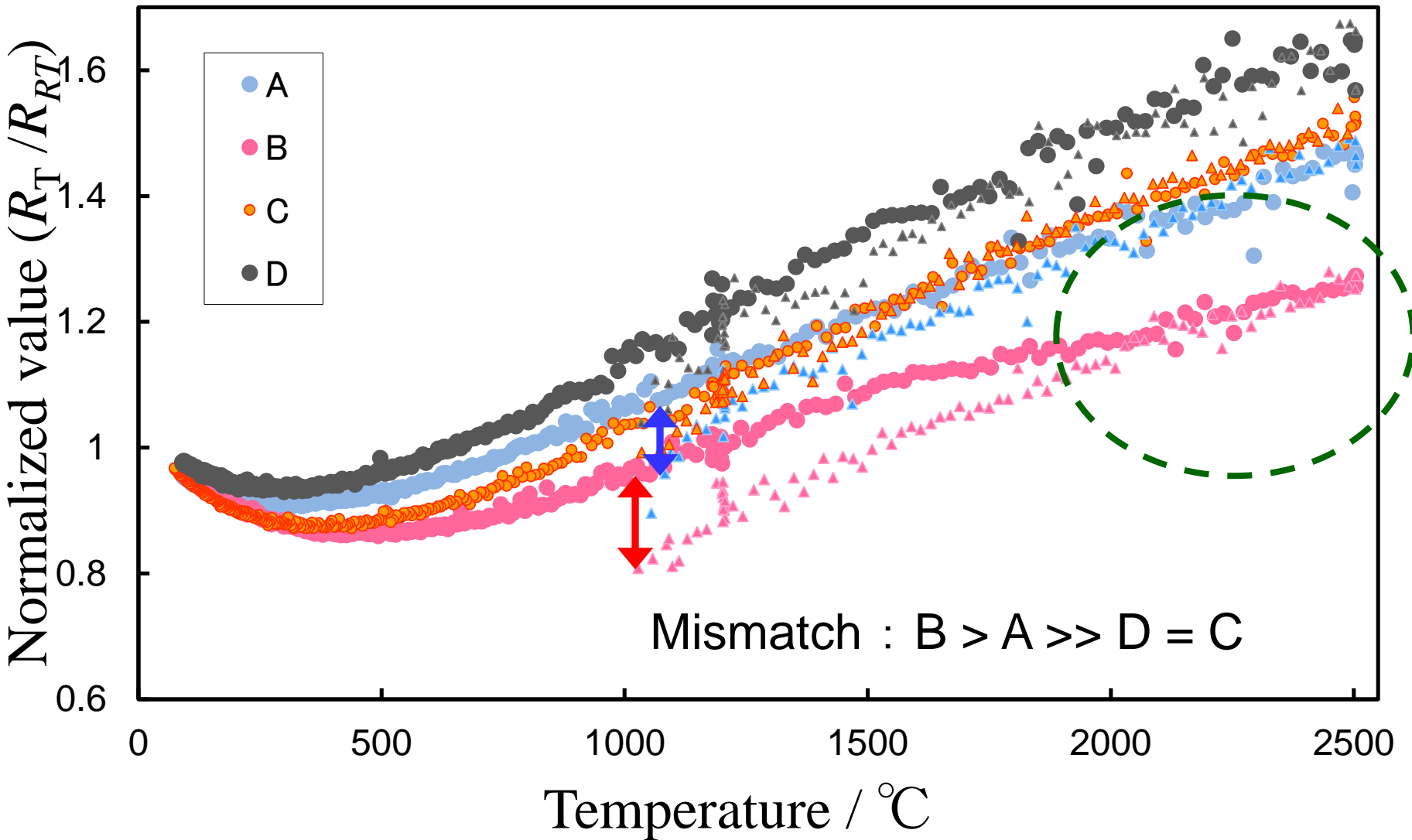


cooling-down

Normalized to initial value at RT

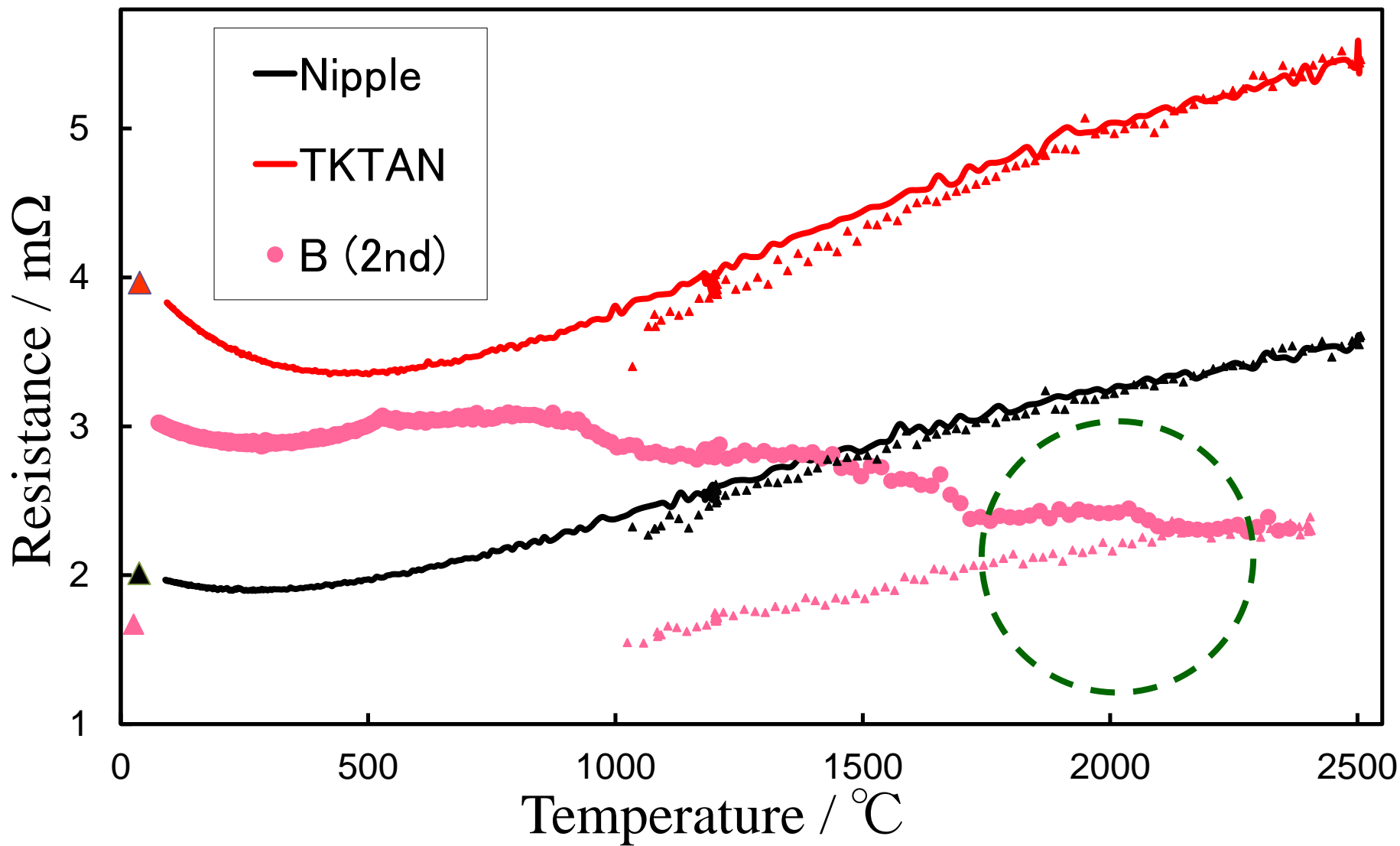


Mismatch between heating and cooling



Combination B (2nd cycle)

Heating & cooling



B) TKTAN  = Nipple 






After 2nd cycle

考察 Discussion

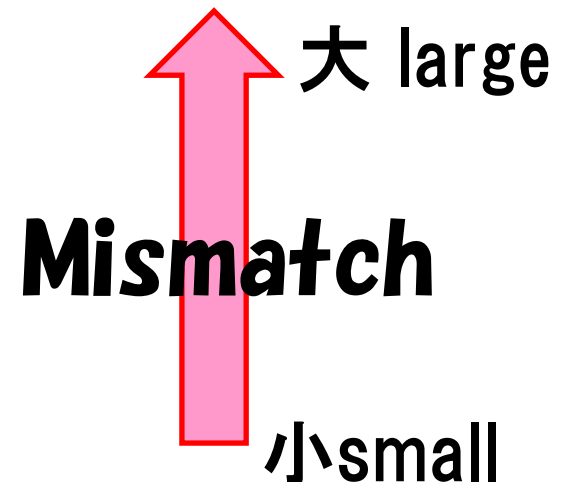
The "Mismatch" between heating-up and cooling-down of high temperature resistance of the jointed graphite electrode results in mismatch of "thermal expansion"

B) TKTAN  = Nipple 

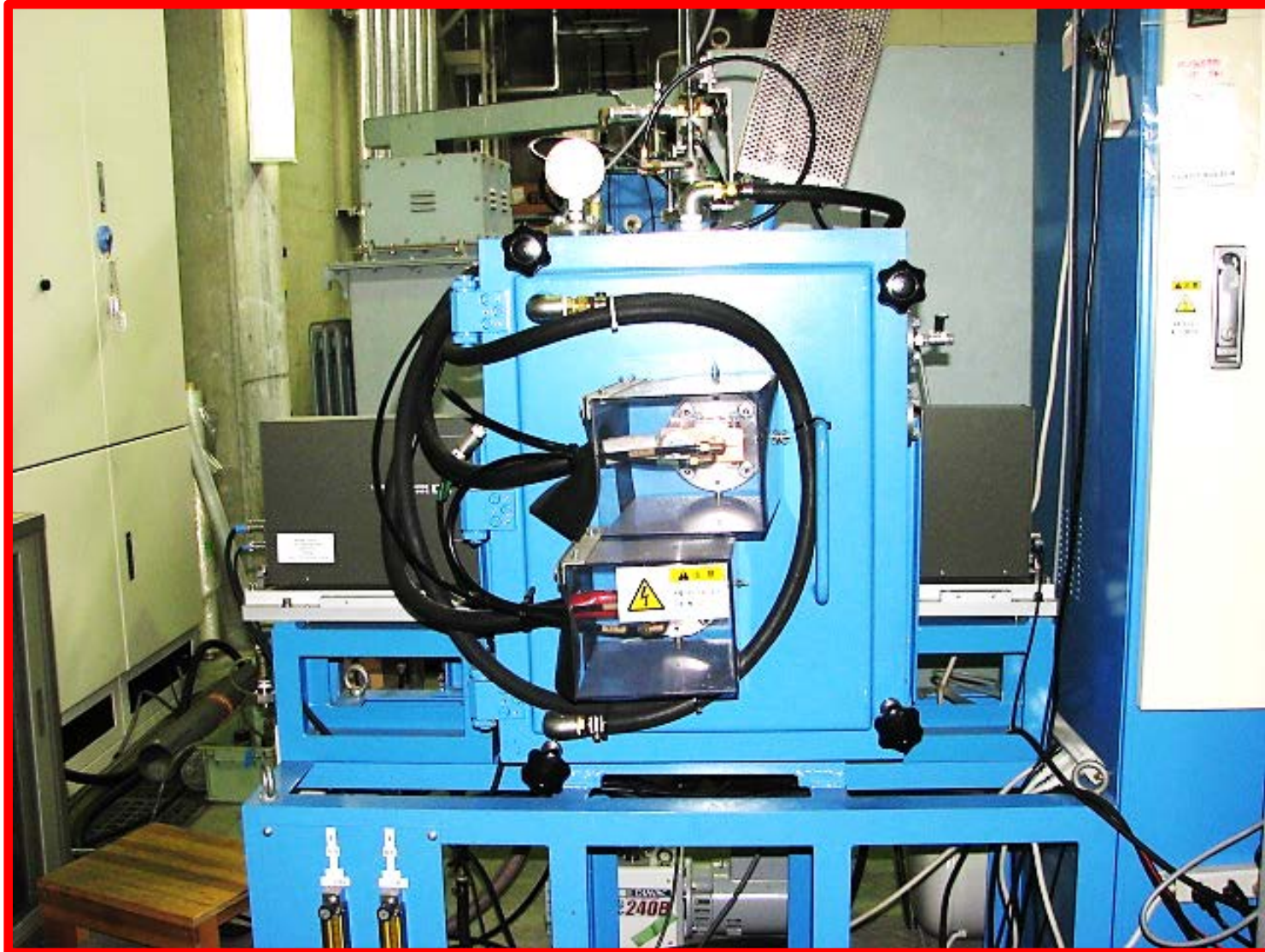
A) Pole  = Nipple 

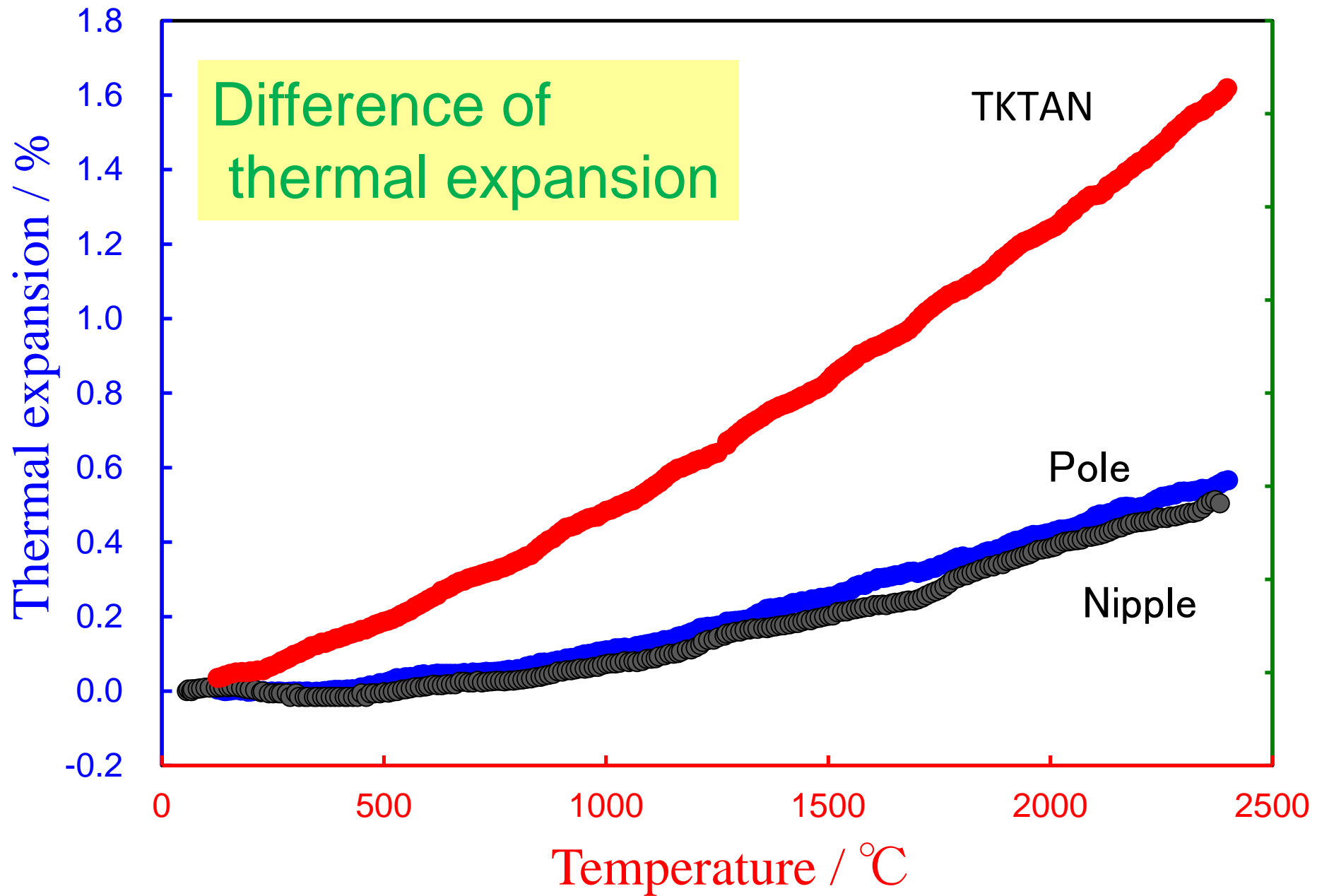
C) Nipple  = TKTAN 

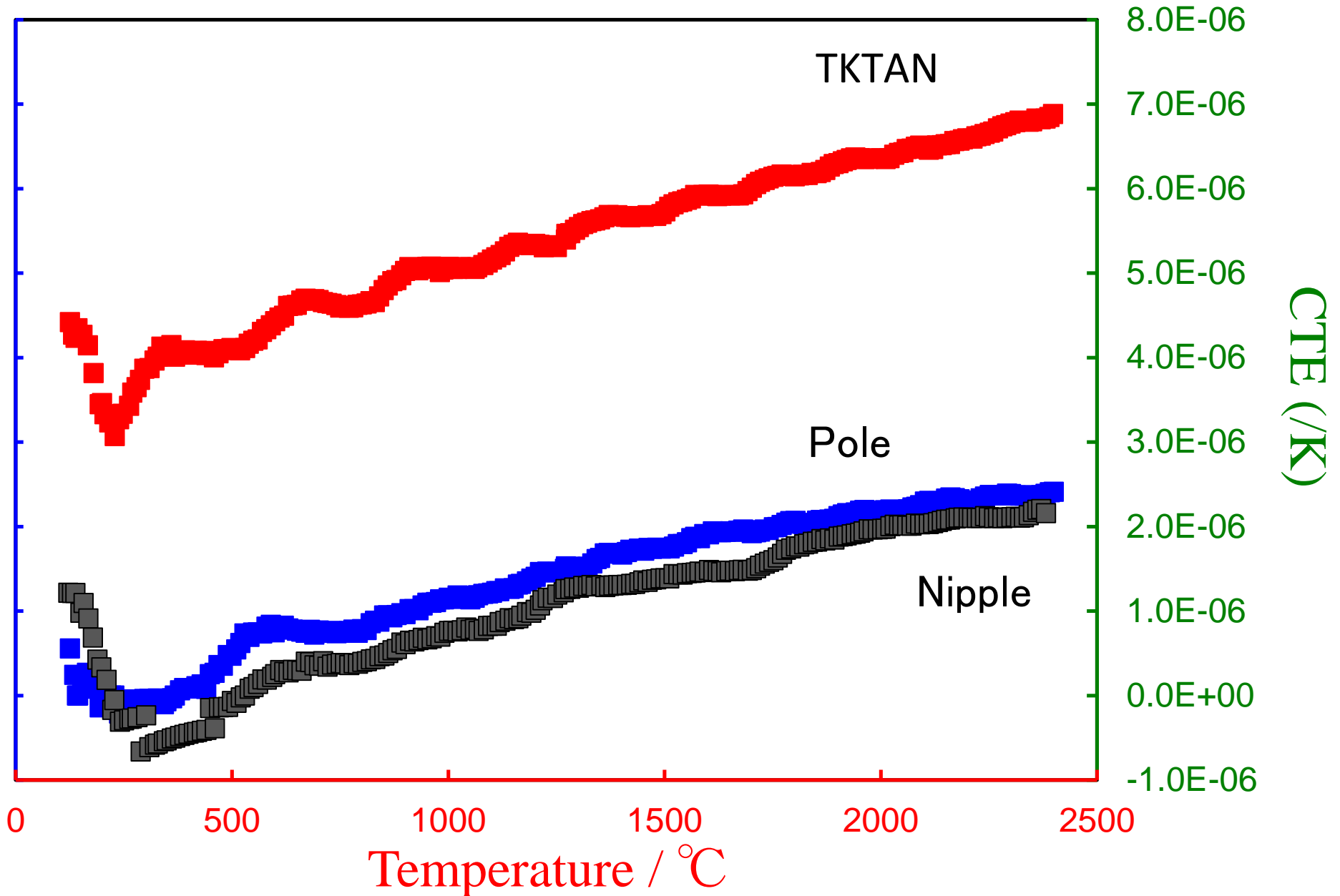
D) Nipple  = Nipple 



Device of measurement of thermal expansion

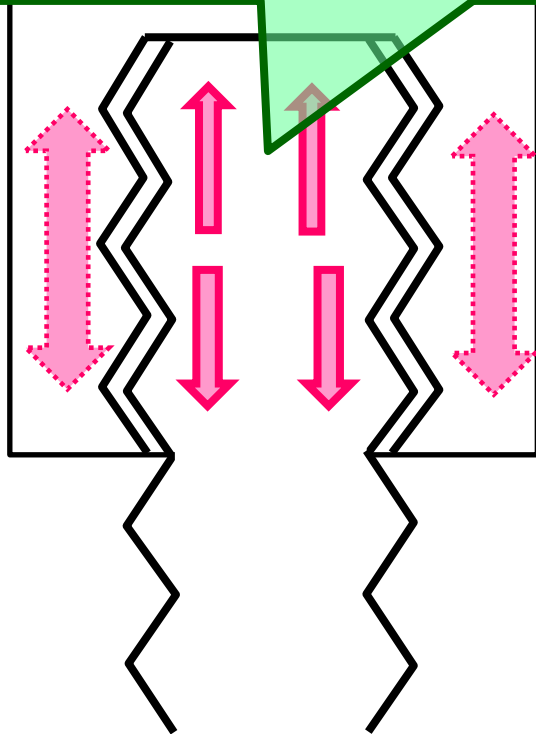






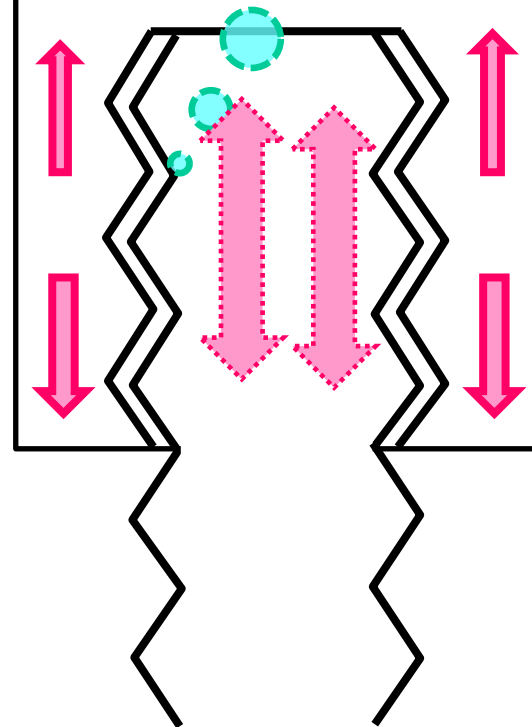
Combination B

TKTAN \square generates tensile stress to Nipple \square by mismatch of thermal expansion





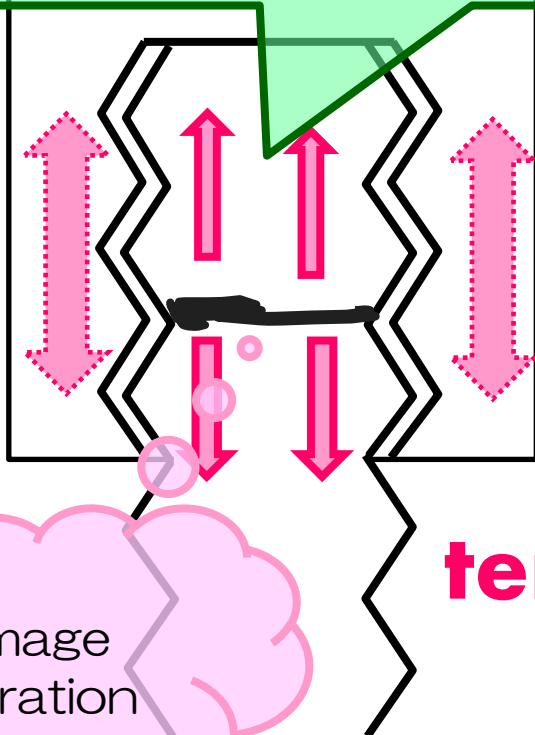
Combination C

TKTAN \square is more expansive than Nipple \square





Combination B

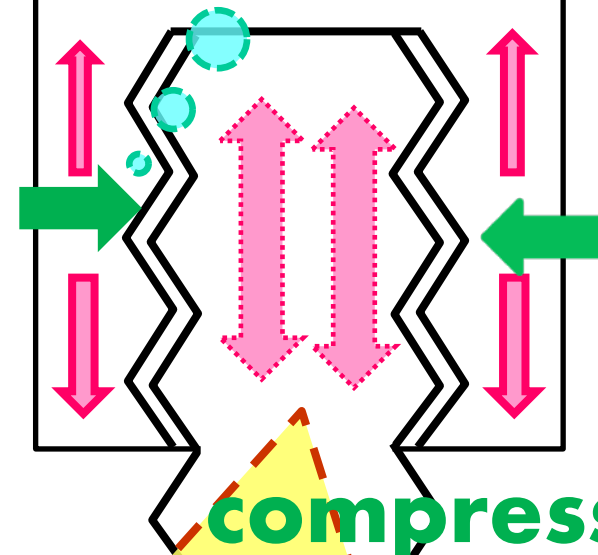
TKTAN  generates tensile stress to Nipple  by mismatch of thermal expansion



tensile



Combination C

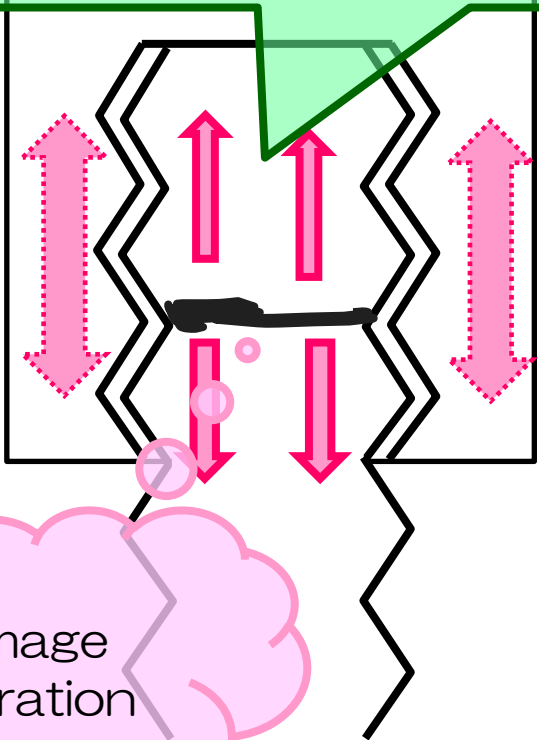
TKTAN  generates tensile stress to Nipple ,





compressive
screw contact is tightened well by thermal expansion

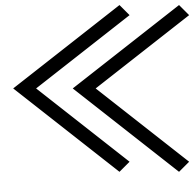
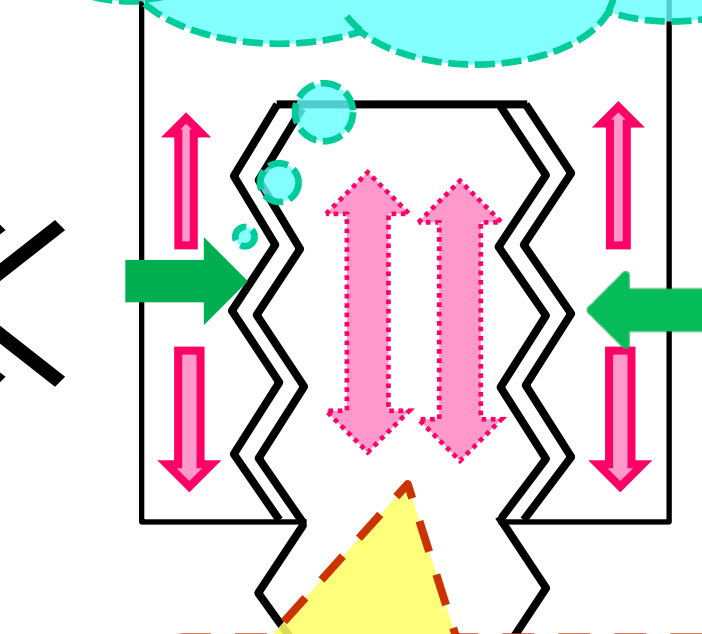
Combination B

TKTAN  generates tensile stress to Nipple  by mismatch of thermal expansion



Combination C

TKTAN  generates tensile stress to Nipple ,





screw contact is tightened well by thermal expansion

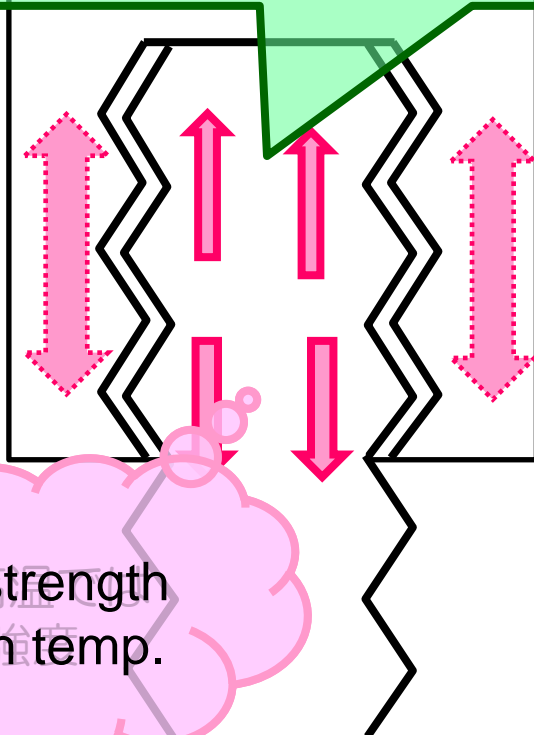
Damage generation

Combination B

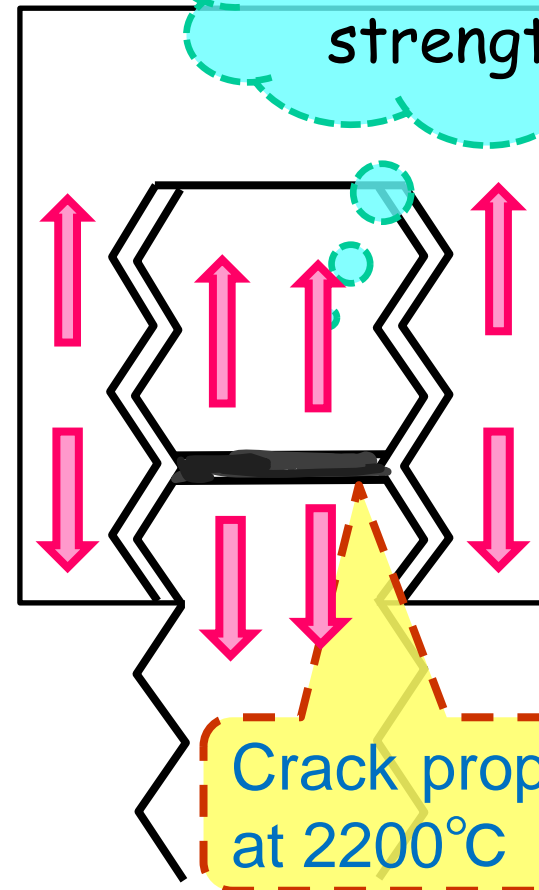
Heating-up

Cooling-down

TKTAN  generates tensile stress to Nipple  by mismatch of thermal expansion



Lowering tensile strength



high strength
At high temp.

Crack propagation
at 2200°C

Thank you very much for
your attention

