POSTER #SWTA24-31

DEVELOPMENT OF LOW CTE LTCC MATERIAL FOR ST SUBSTRATES

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Introduction

Raw material composition)
Existing LTCC materials
MLS-26 ：Glass + Alumina
MLS-28 ：Glass + Alumina + Willemite ($2ZnO \cdot SiO_2$)

	MLS-26	MLS-28
Bending strength (MPa)	375	311
Fracture toughness K_{1C} (MPa・$m^{1/2}$)	2.3	1.9
Coefficient of thermal expansion (ppm/℃) @-40～125℃	4.7	3.7

Newly developed LTCC material
MLS-29 ：Glass + Alumina + Cordierite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$)

	Cordierite	Willemite
K_{1C} (MPa・$m^{1/2}$)	2.0～3.0	＜1
CTE (ppm/℃)	1.5～2.5	3.2

✓**Lowering CTE of LTCC by adding small amounts**
✓**Increase of fracture toughness of LTCC**

Materials and Methods

Newly developed LTCC material

Slurry — glass, alumina, cordierite binder, plasticizer

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Green sheet — doctor blade method

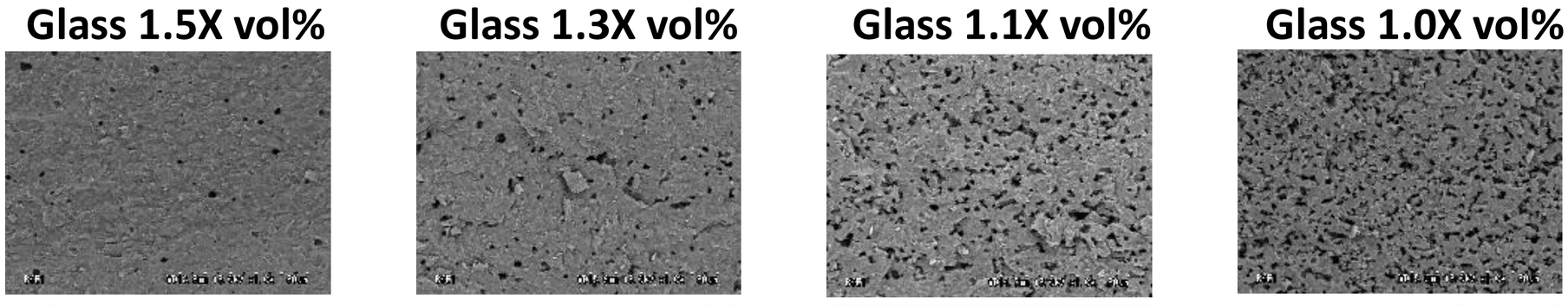
Optimization of the glass ratio
✓**Bending strength measurements**
✓**Fracture surface observations**

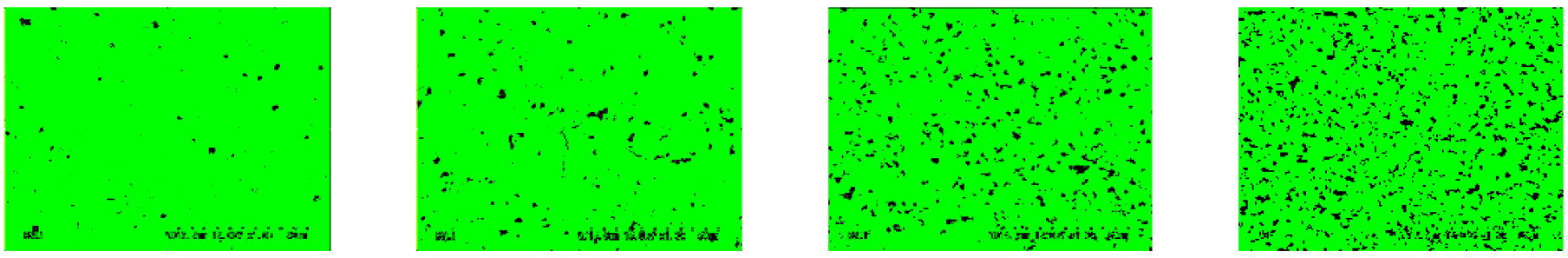
Results and discussion

SEM observation of fracture surfaces of LTCC

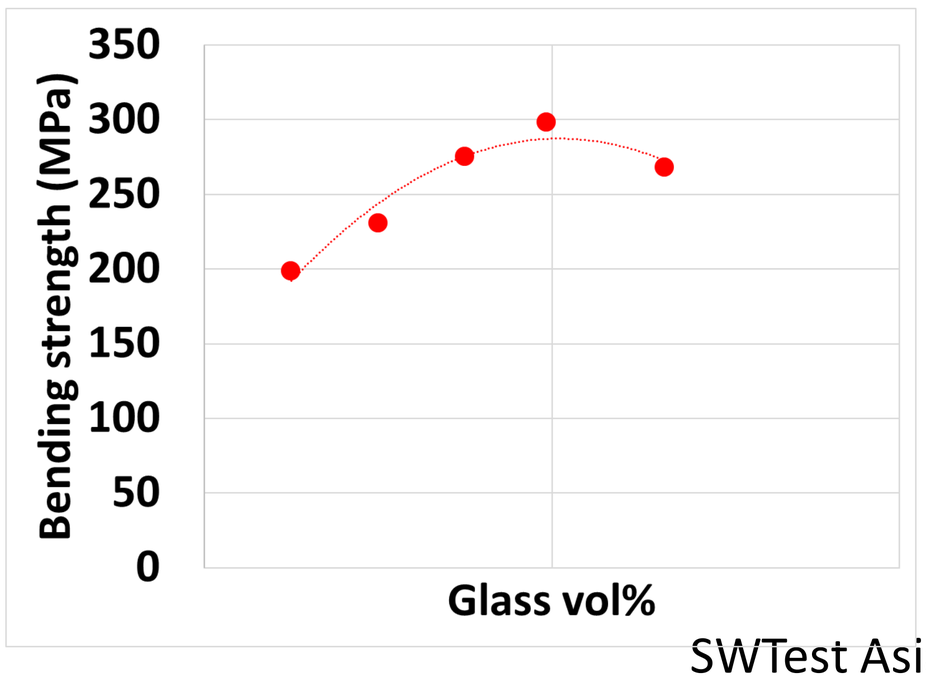
Voids in LTCC materials were evaluated by processing these SEM images.

Glass 1.5X vol% | **Glass 1.3X vol%** | **Glass 1.1X vol%** | **Glass 1.0X vol%**





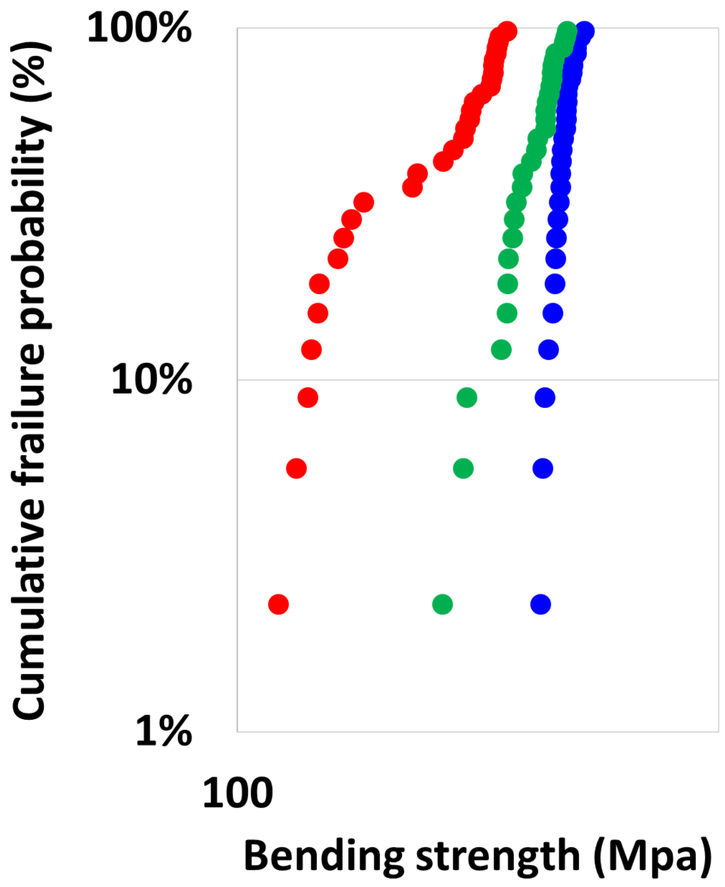
Void area 1.5% | **Void area 3.3%** | **Void area 6.8%** | **Void area 12.1%**

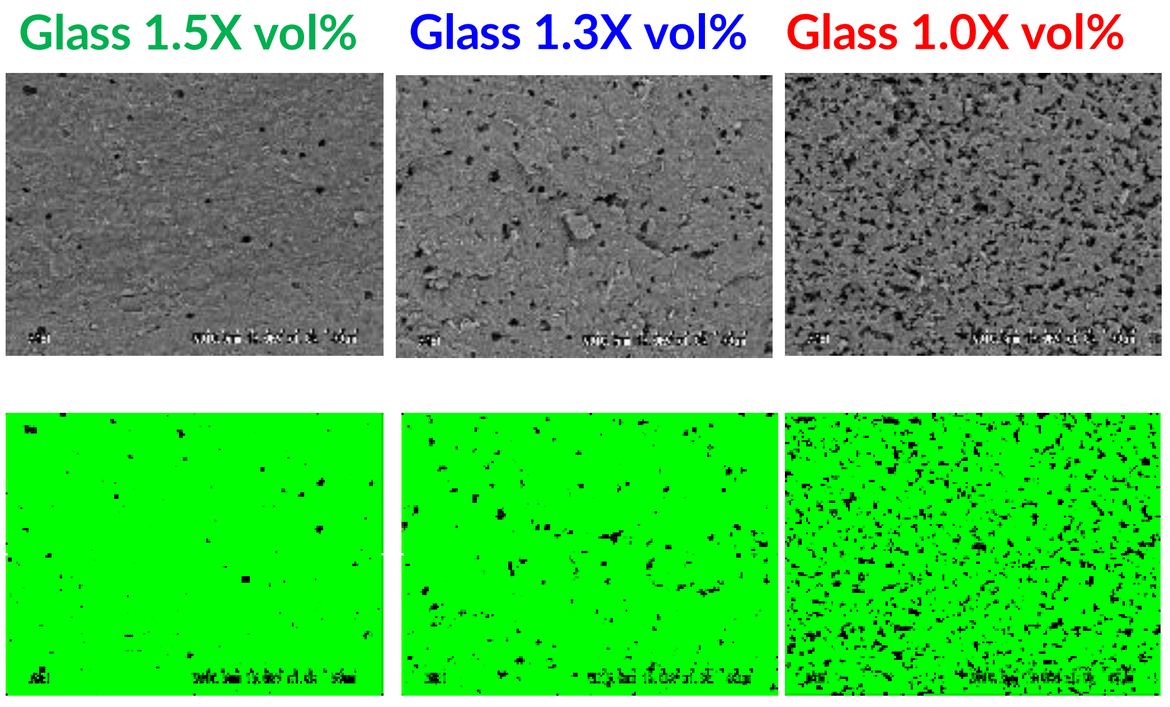


✓**Void area decreases with increasing glass volume ratio.**
✓**Bending strength is maximum at specific glass volume ratios.**

Results and discussion

Impact of glass volume ratio on bending strength



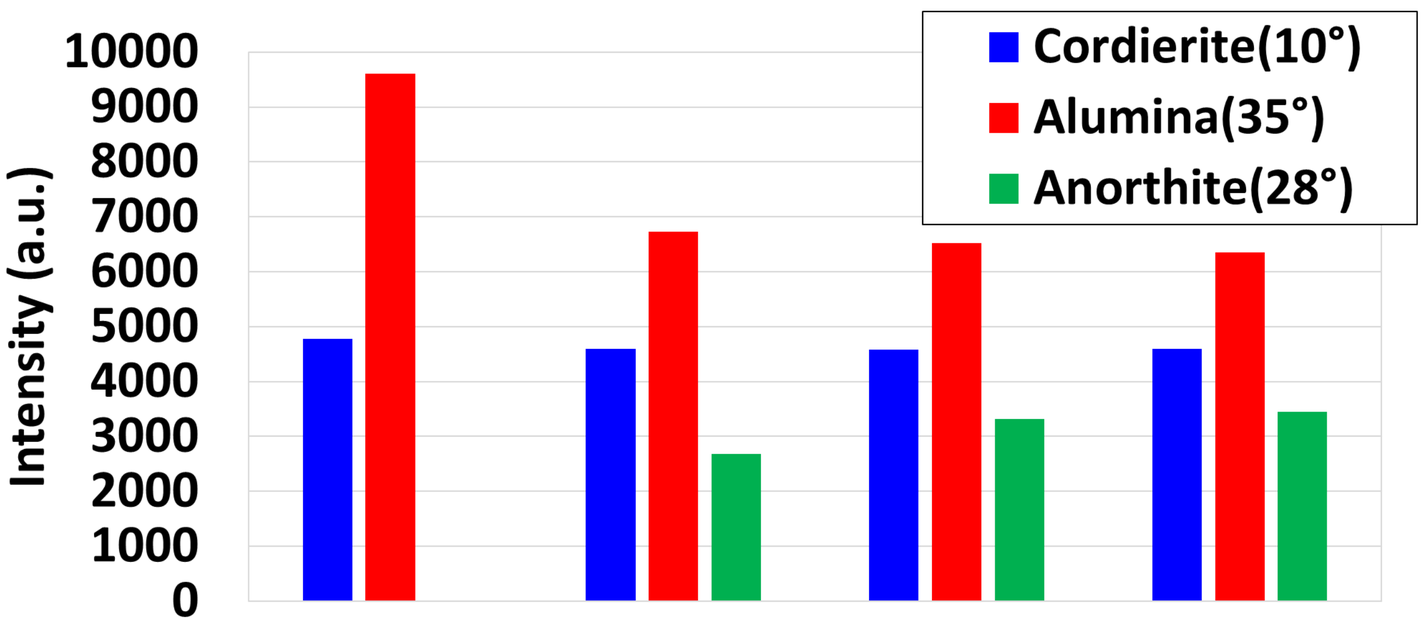


✓Bending strength decreases with increasing voids (Glass 1.0X vol% region).

✓Bending strength is low due to the low strength of the glass itself (Glass 1.5X vol% region).

Impact of holding time

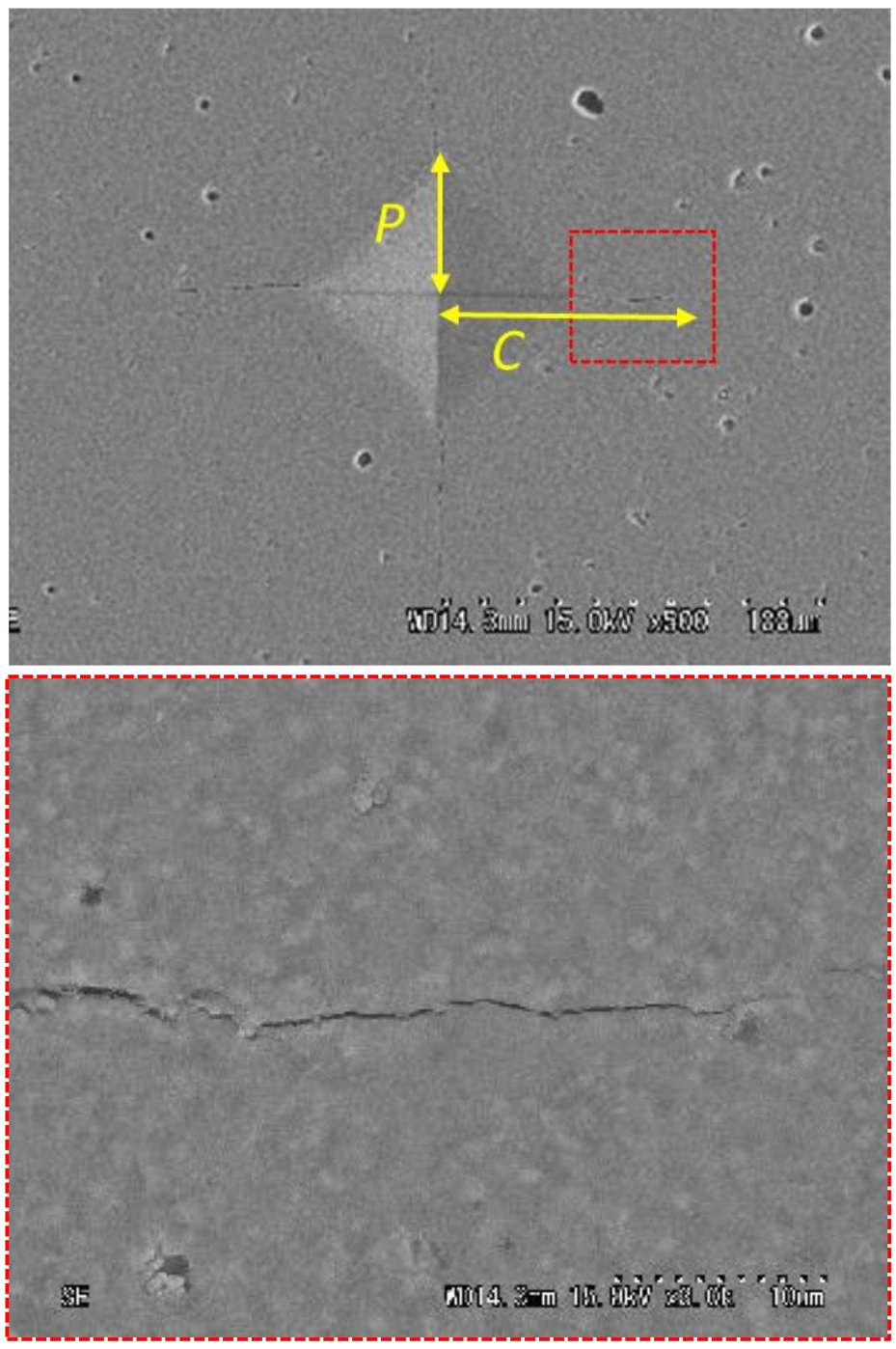
X-ray diffraction measurements



✓ Cordierite was constant regardless of holding time.

✓ Anorthite increased and alumina decreased with increasing holding time.

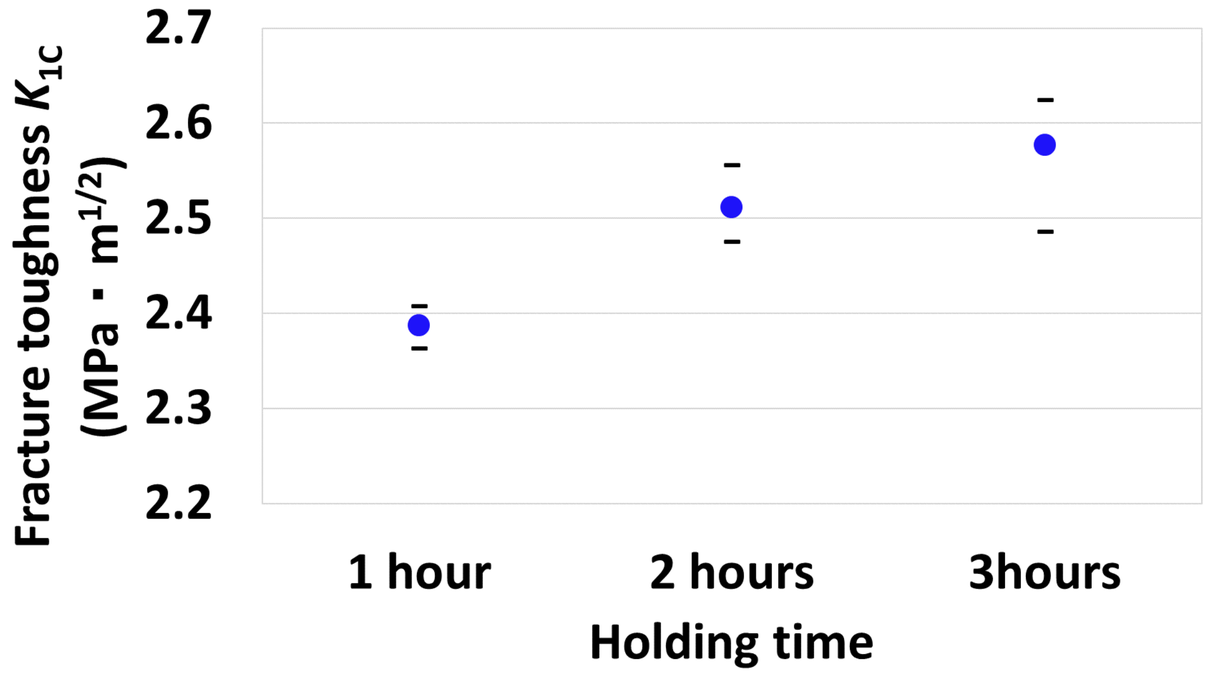
Fracture toughness evaluation



Indentation fracture method

$$K_{1C} = 0.018\left(\frac{E}{H}\right)^{1/2}\left(\frac{P}{C^{3/2}}\right)$$

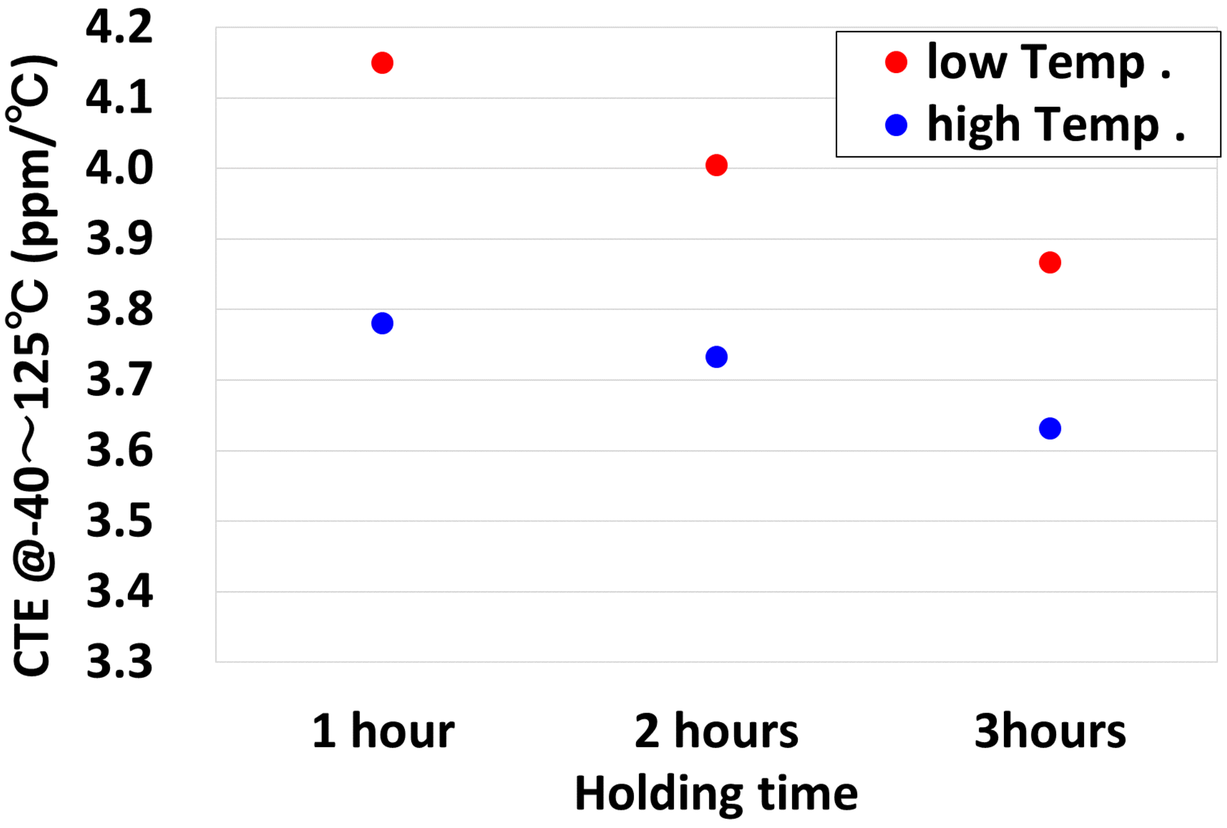
E: Elastic modulus, ***H***: Vickers hardness,
P: Half of indentation length, ***C***: Half of crack length



✓ Increasing the sintering time promotes crystallization in the glass region, leading to higher fracture toughness.

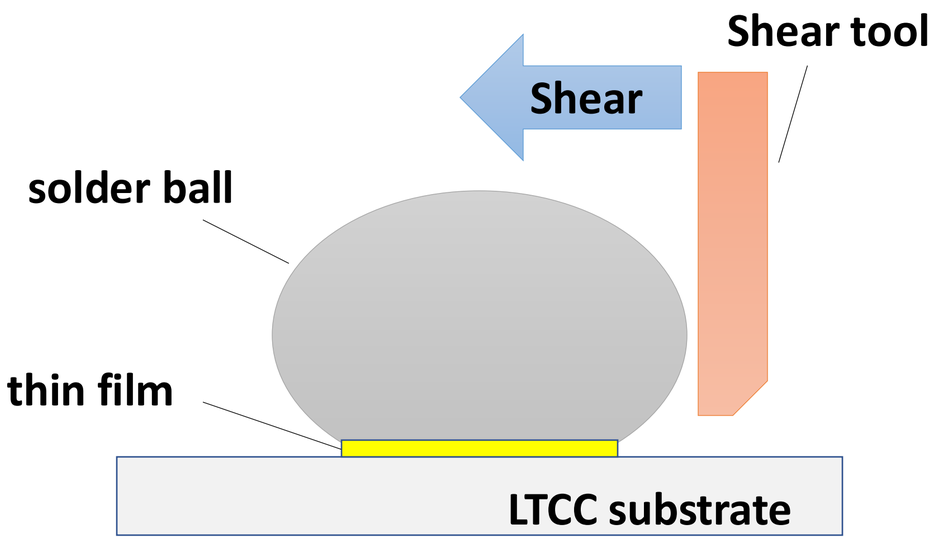
Results and discussion

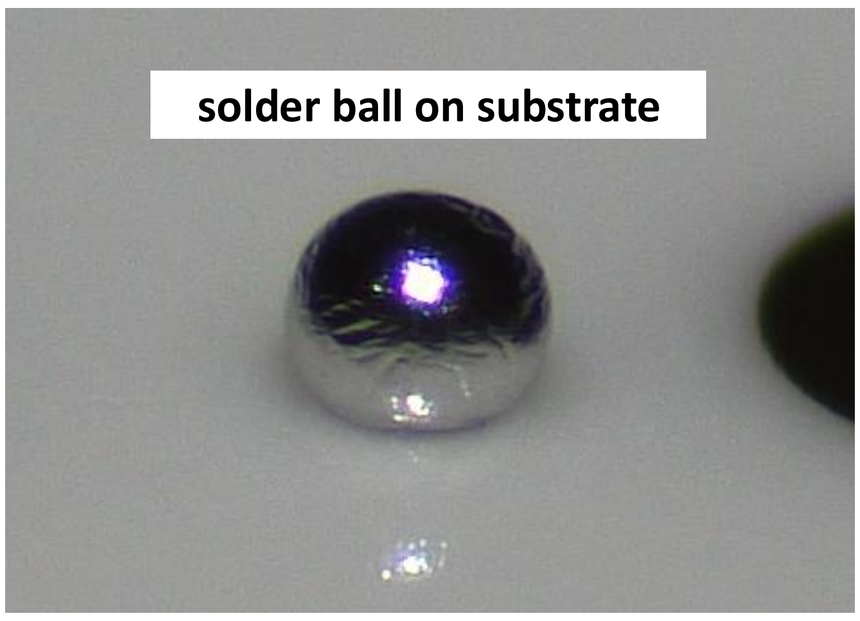
Impact of sintering temperature and holding time on CTE

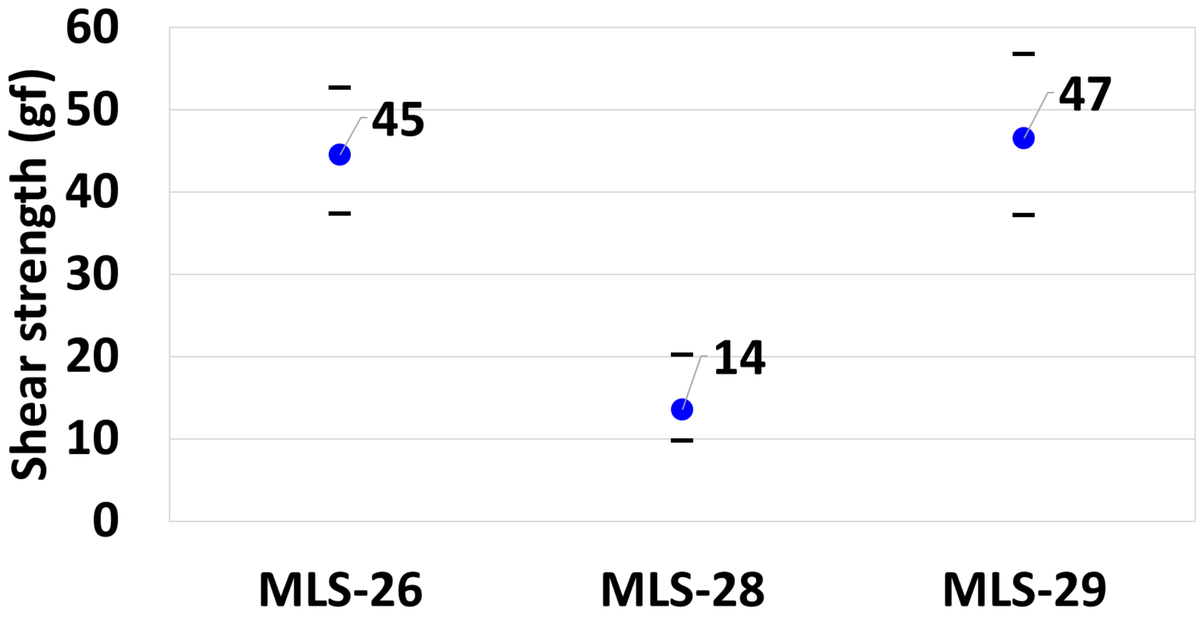


- ✓The higher the sintering temperature, the lower the CTE.
- ✓CTE decreases with increasing holding time.
- ✓Decrease in CTE is attributed to the reduction of alumina with high CTE.

Shear strength evaluation







Shear strength of MLS-29

- ✓Equivalent to MLS-26
- ✓Three times higher than MLS-28

Conclusions

	MLS-26	MLS-28	MLS-29
Bending strength (MPa)	375	311	350
Fracture toughness K_{1C} (MPa・$m^{1/2}$)	2.3	1.9	2.6
Coefficient of Thermal Expansion (ppm/℃) @-40～125℃	4.7	3.7	3.6

MLS-29 with low CTE, high strength, and high fracture toughness was developed.

Raw material composition

- ✓Selection of cordierite, a low expansion filler
- ✓Optimization of glass volume ratio

Sintering conditions

- ✓Optimization of sintering temperature and holding time