National Institute of Advanced Industrial Science and Technology

National Metrology Institute of Japan

Reference Material Certificate

NMIJ CRM 5801-a
No. +++

Alumina Ceramics for Thermal Expansivity Measurement

This certified reference material (CRM) is produced in accordance with the NMIJ's management system and is in compliance with ISO 17034 and ISO/IEC 17025. This CRM is intended for use in the calibration and validation of instruments for thermal expansivity measurements.

Certified Values

The certified values of thermal expansivity α and the expanded uncertainties U in this CRM are given from the following equations. The value of U given by the equation is the expanded uncertainty obtained by multiplying the combined standard uncertainty by a coverage factor (k) of 2, and it is the half-width of an interval estimated to have a level of confidence of approximately 95 %.

$$\alpha/\left(10^{-6}\mathrm{K}^{-1}\right) = -3.7182 + 5.3799\times10^{-2}\cdot(T/\mathrm{K}) - 1.0631\times10^{-4}\cdot(T/\mathrm{K})^2 + 1.1442\times10^{-7}\cdot(T/\mathrm{K})^3$$
$$-6.2855\times10^{-11}\cdot(T/\mathrm{K})^4 + 1.3822\times10^{-14}\cdot(T/\mathrm{K})^5$$

$$U/\left(10^{-6}\mathrm{K}^{-1}\right) = 0.072$$

at 293.15 K $\leq T \leq$ 1100 K.

The calculated results from above equations for this CRM at typical temperatures are shown in the table below.

Temperature T / K	Thermal expansivity $\alpha/(10^{-6}\,\mathrm{K}^{-1})$	Expanded uncertainty $U/(10^{-6}\,\mathrm{K}^{-1})$
293.15	5.365	0.072
300	5.467	
350	6.124	
400	6.647	
450	7.068	
500	7.410	
550	7.693	
600	7.933	
650	8.142	
700	8.327	
750	8.495	
800	8.649	
850	8.792	
900	8.925	
950	9.046	
1000	9.158	
1050	9.260	
1100	9.353	

Analysis

The equation for calculating the certified values of this CRM was derived from the thermal expansivity measurements of seven rectangular specimens (15 mm long, 26 mm wide, and 6 mm thick), all of which were cut from the base material of this CRM. The thermal expansivity was measured at temperatures ranging from 293.15 K to 1100 K by using a laser interferometric dilatometer based on the following principle;

$$\alpha(T)=\frac{1}{L_0}\frac{L_{n+1}-L_n}{T_{n+1}-T_n};\ T=(T_{n+1}+T_n)/2,$$

where L_0 is the length of a specimen at room temperature 293.15 K (20 °C), T_n and T_{n+1} are the adjacent temperatures of the specimen in a stepwise heating cycle. L_n and L_{n+1} are the lengths of the specimen at T_n and T_{n+1}, respectively. The value of L_0 was obtained by a digital linear scale. The temperature difference $(T_{n+1}-T_n)$ was set to be approximately 50 K or 25 K.

In order to determine the certified values, the measured values of the thermal expansivity for the seven specimens were fitted into a fifth-order polynomial function of temperature based on the least squares method.

Metrological Traceability

Thermal expansivity, derived from the temperature and length of a specimen, was determined by a laser interferometric dilatometer. A gauge block, a frequency-stabilized He-Ne laser, and Pt/Pd elemental thermocouples of the dilatometer were calibrated with their primary standards traceable to the International System of Units (the SI), and thus the certified values (thermal expansivity) are traceable to the SI.

Expiration of Certification

This certificate is valid from the date of shipment to March 31, 2030, provided that this CRM remains unopened and is stored in accordance with the instructions given in this certificate.

Description of the Material

This CRM, which is composed of polycrystalline alumina, is distributed in the form of quadrangular prism (6 mm x 6 mm x 30 mm) in a plastic case.

Homogeneity

The homogeneity of thermal expansivity within the base material of this CRM was determined by analyzing variance of the measurement results of the seven specimens. The uncertainty derived from the homogeneity of thermal expansivity has been incorporated in the expanded uncertainty of the certified value.

Instructions for Storage

This CRM should be stored at temperatures of 23 °C ± 10 °C and relative humidity of 50 % or less.

Instructions for Use

This CRM is allowed to be made in any shapes by using any means appropriate for the calibration or verification of measuring instruments, provided that its quality is not significantly deteriorated. No serious heat- or mechanical-shock should be applied to this CRM to prevent crack formation. This CRM should not be heated to above 1100 K. Care should be taken prior to use about potential chemical reactions between this CRM and other materials which come in contact with it at elevated temperatures.

Precautions for Handling

This CRM can be handled in a similar way to ceramics. Refer to the safety data sheet (SDS) on this CRM prior to use.

Preparation

The total of 227 quadrangular-prism-shaped specimens of this CRM were cut out from the base material plates of polycrystalline alumina, all of which were prepared in a single process with a single charge of raw materials.

Technical Information

No significant variation in thermal expansivity of a specimen of this CRM was detected after the total of 50 cycles of heating and cooling process in which temperatures were varied between room temperature and 1100 K in vacuum.

NMIJ Analysts

The technical manager for this CRM is YAMADA N., and the production manager and analyst are WATANABE H.

Information

If substantive technical changes occur that affect the certification before the expiration of this certificate, NMIJ will notify the registered customers. Customer registration on the NMIJ Website (given below) will facilitate notification. Technical reports regarding this CRM can be obtained from the contact details given below.

Reproduction of Certificate

In reproducing this certificate, it should be clearly indicated that the document is a copy.

April 1, 2020

ISHIMURA Kazuhiko
President
National Institute of Advanced Industrial Science and Technology

If you have any questions about this CRM, please contact:
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Revision history
January 25, 2024: The limit of validity of the certificate was extended from “March 31, 2025” to “March 31, 2030.”