

National Institute of Advanced Industrial Science and Technology

## National Metrology Institute of Japan



## Reference Material Certificate

NMIJ CRM 5804-b  
No. +++

## Isotropic Graphite for Thermal Diffusivity 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 diffusivity measurements.

**Certified Values**

The certified values for thermal diffusivity  $\alpha$  and the relative expanded uncertainties  $U$  of this CRM is given from the following equations. The uncertainty  $U$  is the half-width of the expanded uncertainty interval calculated using a coverage factor ( $k$ ) of 2, which gives a level of confidence of approximately 95 %.

$$\alpha / (\text{m}^2 \text{s}^{-1}) = -2.991 \times 10^{-5} + 3.379 \times 10^{-5} \cdot \exp\left(\frac{4.076 \times 10^2}{(T/\text{K})}\right) \quad (300 \text{ K} \leq T \leq 1500 \text{ K})$$

$$U / \% = 2 \sqrt{(8.39 - 3.01 \times 10^{-2} (T/\text{K}) + 4.71 \times 10^{-5} (T/\text{K})^2 - 2.98 \times 10^{-8} (T/\text{K})^3 + 7.05 \times 10^{-12} (T/\text{K})^4)^2 + 1.22^2} \quad (300 \text{ K} \leq T \leq 1500 \text{ K})$$

The calculated results from above equations at typical temperature points of this CRM are shown in the table below.

$T / \text{K}$	$\alpha / (\text{m}^2 \text{s}^{-1})$	$U / \%$
300	$1.02 \times 10^{-4}$	6.2
400	$6.37 \times 10^{-5}$	5.0
500	$4.64 \times 10^{-5}$	4.4
600	$3.67 \times 10^{-5}$	4.3
700	$3.06 \times 10^{-5}$	4.5
800	$2.63 \times 10^{-5}$	4.8
900	$2.32 \times 10^{-5}$	5.3
1000	$2.09 \times 10^{-5}$	5.8
1100	$1.90 \times 10^{-5}$	6.3
1200	$1.75 \times 10^{-5}$	6.9
1300	$1.63 \times 10^{-5}$	7.5
1400	$1.53 \times 10^{-5}$	8.1
1500	$1.44 \times 10^{-5}$	9.0

**Analysis**

The certified values (thermal diffusivity) were determined using the laser flash method. The function as the temperature dependence of thermal diffusivity was determined by a least squares fit for measured thermal diffusivity values of sampled 16

specimens. The intrinsic thermal diffusivity at the steady temperature was obtained as a value extrapolated to zero pulsed heating energy in the plot of apparent thermal diffusivity versus the temperature rise which depends on the pulsed heating energy. The each apparent thermal diffusivity was calculated from a temperature rise curve by analysis with the heat loss model. The thermal diffusivities were calculated using the specimen thickness measured by a linear gauge at room temperature.

The relative expanded uncertainty was estimated from the uncertainty components derived from the thermal diffusivity measurements, and from the determination of the certified values as a function of temperature and homogeneity.

### **Metrological Traceability**

Thermal diffusivity, derived from specimen thickness and heat diffusion time, was determined by the primary measurement system for thermal diffusivity in NMIJ. It is a thermophysical property dependent of temperature. The temperature where the measurements were carried out was also measured by the system. The primary measurement system in NMIJ was calibrated by block gauges, function generator and R-type thermocouple; those were calibrated to be traceable to the International System of Units (SI). The certified values (thermal diffusivity) are traceable to SI.

### **Expiration of Certification**

This certificate is valid from the date of shipment to March 31, 2026, provided that this CRM is stored in accordance with the instructions given in this certificate.

### **Sample Form**

This CRM consists of four disks with a diameter of 10 mm and thickness of 1.4 mm, 2.0 mm, 2.8 mm and 4.0 mm. These four disks are kept in a plastic container.

### **Homogeneity**

The homogeneity of this CRM was determined as the standard deviation of the thermal diffusivity values at 300 K of 24 specimens sampled from 240 specimens. The homogeneity is reflected in the uncertainty of the certified value. The homogeneity of each element is reflected in the uncertainty of the certified value.

### **Instructions for Storage**

This CRM should be stored at a temperature of  $23\text{ }^{\circ}\text{C}\pm 10\text{ }^{\circ}\text{C}$  and at a relative humidity of 50 % or less.

### **Instructions for Use**

This CRM can be measure by the flash method without coating. The thermal diffusivity should be calculated using specimen thickness measured at room temperature with the resolution of 1  $\mu\text{m}$ . This CRM should be used only for testing and experimental studies. Further, it should be used in vacuum or under an inert gas flow (Ar, etc.) above room temperature.

It is not available for use when this CRM is given some damages, for example, cracks and strain.

It is not available for use when some substances is absorbed or attached in the CRM because of change of thermal diffusivity.

### **Precautions for Handling**

Handling of the CRM is similar to that of solid-state graphite. Refer to the safety data sheet (SDS) on this material before use.

### **Preparation**

CRM specimens were prepared from a cubic block, with sides of 150 mm, of a grade of isotropic graphite.

### **Technical Information**

This CRM does not degrade with either five temperature rise from 300 K to 1500 K or with accumulated exposure to a high temperature above 1073 K.

Reactivity to typical heat-resistant materials: This CRM does not undergo any severe reaction with  $\text{Al}_2\text{O}_3$  and BN in the temperature range from room temperature to 1500 K and in vacuum or under an inert gas flow. Isotropic graphite sometimes smears sample holders with soot above 1000 K because of sublimation.

**NMIJ Analysts**

For this CRM, the technical manager is YAMADA N., and the production manager and analyst are AKOSHIMA M.

**Information**

If substantive technical changes occur that affect the certification before the expiration of this certificate, NMIJ will notify the registered customer. 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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National Metrology Institute of Japan,  
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Revision history

September 19, 2019: The limit of validity of the certificate was extended from “March 31, 2021” to “March 31, 2026.”