

National Institute of Advanced Industrial Science and Technology  
National Metrology Institute of Japan



## Reference Material Certificate

NMIJ CRM 5606-a  
No. +++



## Single-Crystal Silicon for Positron Defect Measurements

This certified reference material (CRM) is a single-crystal silicon for positron defect measurement, and was produced based on NMIJ's management system in compliance with ISO GUIDE 34:2009 and ISO/IEC 17025:2005. This CRM is intended for use in controlling the precision of measured data and in confirming the validity of the measurement condition and the obtained results by positron defect measurements for metals, semiconductors and similar materials having a single positron annihilation component with a mean lifetime less than about 500 ps.

**Certified Value**

The certified value of this CRM is given in the table below. The uncertainty of the certified value 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 %.

	Certified value (ps)	Expanded uncertainty (ps)
Positron lifetime	220.6	6.2

**Analysis**

The certified value was evaluated as a mean of the lifetimes of positrons annihilated in a measurement sample, obtained by performing a least-squares fitting of the respective positron lifetime histogram to the convolution of a model function consisting of a linear combination of two exponential decays with a resolution function. The positron lifetime histograms were recorded by accumulating time intervals between the birth and annihilation of positrons emitted from  $^{22}\text{Na}$ . The uncertainty was estimated as the combined standard uncertainty taking account of the sample homogeneity and thermal stability, the repeatability of the measurements, the time-base accuracy of the measurement system.

**Metrological Traceability**

A measurement system with a calibrated digital oscilloscope was employed to determine the certified value, which assures traceability of the measured time of the certified value and uncertainty to the International System of Units (SI).

**Expiration of Certification**

This certificate is valid for one year from the date of the shipment, provided that the material is stored in accordance with the instructions given in this certificate.

**Description of the Material**

This CRM consists of two 1-mm-thick-square plates of silicon with a dimension of 15 mm x 15 mm, kept in a plastic container.

**Homogeneity**

The homogeneity of the CRM was determined by analyzing 32 pieces sampled from 120 plates cut from 5 single-crystal silicon wafers. Positron annihilation lifetime measurements were performed twice for each specimen to obtain the mean lifetime of positrons, and the homogeneity was estimated from the analysis of variance for the obtained lifetimes. The

Date of Shipment: Xxxxx xx, 20xx

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homogeneity of the CRM is reflected in the uncertainty of the certified value, and thus the CRM is confirmed homogeneous.

#### Instructions for Storage

This CRM should be kept in clean environment at a temperature between 15 °C and 35 °C and stored away from any radioactive source.

#### Instructions for Use

- This CRM is limited for use in testing and researching.
- One side of the CRM is finished with a specular surface and the other side is with an etching surface, and the specular surface has to be employed for the measurement.
- This CRM should be used in a clean environment at room temperature and its surface should be kept clean.

#### Precautions for Handling

This CRM is made of a fragile material. To keep from any injury and breakage, a serious physical impact should be avoided. Refer to the safety data sheet (SDS) on this CRM before use.

#### Preparation

This CRM consists of silicon pieces cut down from a single-crystal silicon of a single lot, manufactured by using a Floating Zone (FZ) method.

#### NMIJ Analysts

The technical manager for this CRM is ITO K. and the production manager and the analyst is YAMAWAKI M.

#### 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:  
National Institute of Advanced Industrial Science and Technology,  
National Metrology Institute of Japan,  
Center for Quality Management of Metrology, Reference Materials Office,  
1-1-1 Umezono, Tsukuba, Ibaraki 305-8563, Japan  
Phone: +81-29-861-4059; Fax: +81-29-861-4009, <https://unit.aist.go.jp/nmij/english/refmate/>

#### Revision history

April 1, 2015: "Metrology Management Center" was renamed to "Center for Quality Management of Metrology."  
February 13, 2018: The description in "Expiration of Certification" was changed to "one year after the date of the shipment"