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

Reference Material Certificate

NMIJ CRM 5207-a
No. +++
Tungsten Dot-array

This certified reference material (CRM) was produced in accordance with the NMIJ’s management system and in compliance with ISO GUIDE 34:2009 and ISO/IEC 17025:2005. This CRM is intended for use in the magnification calibration of instruments, and the examination of instrument conditions through image sharpness measurements using scanning electron microscopy (SEM).

Certified Values
This CRM has three orthogonal tungsten dot-arrays in different sizes fabricated on a silicon substrate. The dot pitches of these dot-arrays (dot-array A, B and C) are certified respectively. The certified values are given in the table below. The uncertainty of the certified values 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%.

<table>
<thead>
<tr>
<th>CAS No.</th>
<th>Certified value, dot pitch x (nm)</th>
<th>Expanded uncertainty dot pitch x (nm)</th>
<th>Certified value, dot pitch y (nm)</th>
<th>Expanded uncertainty dot pitch y (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten Dot-array Dot-array A</td>
<td>Si:7440-21-3 W:7440-33-7</td>
<td>119.0</td>
<td>1.5</td>
<td>119.0</td>
</tr>
<tr>
<td>Tungsten Dot-array Dot-array B</td>
<td></td>
<td>199.1</td>
<td>2.4</td>
<td>199.1</td>
</tr>
<tr>
<td>Tungsten Dot-array Dot-array C</td>
<td></td>
<td>597.7</td>
<td>7.3</td>
<td>597.7</td>
</tr>
</tbody>
</table>

Analysis
The certified values of each dot-array were determined using an SEM. The dot pitch was defined as the distance between two neighboring dots in a secondary electron image taken at 15 kV of the primary beam condition. According to this definition, the dot pitch values were obtained via image analysis.

Metrological Traceability
The certified values of each dot-array were determined by using an SEM instrument calibrated with a CRM for magnification calibration (Geller MicroAnalytical Laboratory, MRS-6), which has traceability to the International System of Units (SI) via a metrological atomic force microscope in the National Physical Laboratory in UK. Therefore, the certified values are traceable to SI.

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

This CRM is in the form of a rectangular chip: 7 mm (width) × 7 mm (length) × and 0.7 mm (thickness). The CRM has three dot-arrays at the center on one side of the double-sided mirror surface substrate, and stored in a plastic container dot-array side up. The three arrays are placed as shown in Figure 1(a); the dot-array on the top left is dot-array A, the top right dot-array B and the bottom left dot-array C. The x- and y-axes are taken along the direction shown in Figure 1(a). It is noteworthy that the pattern on the bottom right is only used for the fabrication process. Figure 1 (b)-(d) show the typical SEM image of each dot-array.

![Figure 1](image)

**Figure 1** Chip pattern of the CRM (a). Typical SEM image of dot-arrays A (b), B (c) and C (d). The accelerating voltage was 15 kV.

Homogeneity

The homogeneities of the CRMs were determined by analyzing the variance of 10 samples, which were systematically selected from 441 samples considering their positional symmetry on the silicon wafer. The homogeneity of each dot pitch is reflected in the uncertainty of the certified values.

Instructions for Storage

This CRM should be stored at a temperature between 5 °C and 35 °C in a nitrogen atmosphere.

Instructions for Use

This CRM may have few dots with shape anomalies in the dot-arrays (Figure 2). These dots should be kept out of the field of view of a micrograph for the magnification calibration or image sharpness evaluation with this CRM. The clean area of the CRM should be chosen for SEM observations to avoid the effect of carbon contamination caused by electron beam irradiation.

Precautions for Handling

To avoid surface contamination of the CRM, appropriate tools such as clean gloves and tweezers should be used during handling. Refer to the safety data sheet (SDS) on this material before use.

Preparation Method

The tungsten dot-array was fabricated on a 300-mm silicon wafer by semiconductor fabrication technologies in the super clean room facility in the TIA central office, National Institute of Advanced Industrial Science and Technology, and subsequently individually packed in National Metrology Institute of Japan.

NMIJ Analysts

The technical manager is A. Kurokawa for this CRM. The production manager and the analyst is K. Kumagai.
Date of Shipment: ***** xx, 2018

Technical Information
Customer registration on the NMIJ Website (given below) will facilitate notification of any revisions of the information given above. 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.

March 14, 2018

Ryoji Chubachi
President
National Institute of Advanced Industrial Science and Technology

If you have any questions about this CRM, please contact:
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