National Institute of Standards & Technology

# Certificate

## Standard Reference Material® 5000

### Overlay Wafer Standard

Lot: Sample Serial No.: Sample

This Standard Reference Material (SRM) is a 200 mm double-etched silicon wafer containing calibrated overlay targets. SRM 5000 is intended primarily for calibrating optical microscopes used to make overlay (OL) measurements. It is also useful in calibrating other types of instruments capable of making overlay measurements, such as scanning electron microscopes or atomic force microscopes, provided that they have an appropriate level of magnification and have the proper sample-holding capabilities.

SRM 5000 consists of a grid of 93 rectangular dies, each die measuring 17.6 mm in the X-direction and 16.0 mm in the Y-direction. Figure 1 shows a progressively exploded view of the SRM 5000. The center die (Die 00-00) contains the calibrated Frame-in-Frame (FF) and Bar-in-Bar (RR) targets. Each die is divided into four quadrants: QI, QII, QIII, and QIV. QIII is further divided into 4 sub-quadrants: SQ1, SQ2, SQ3, and SQ4. SQ3 contains the relevant FF targets and SQ4 contains the relevant RR targets. Each sub-quadrant contains rows of overlay targets with different dimensions and offsets. Every two rows constitute a cell and there are 10 cells each in sub-quadrants 3 and 4. Figure 2 illustrates the labeling and layout of a cell. Ten targets in all were selected to calibrate; five FF targets from cell #8 and five RR targets from cell #9. The selected OL targets are listed in Table 1. A copy of the SP 260-165 [1], containing a detailed description of the SRM 5000 calibration process, is included with each unit for further reference.

Each wafer was measured at least five times on several days to adequately sample the reproducibility of the measurement system. A measurement of a given target within the total measurement sequence of a wafer consisted of individual auto-center and auto-focus operations, repeated three times at 0° and 180° orientations each, for a total of six independent dynamic measurements of a target on any given day and a complete measurement total of at least thirty measurements on that target. The difference between the 0° and 180° measurements gives the Tool Induced Shift (TIS), which was continuously monitored as an indication of a properly aligned tool. The average of the 0° and 180° measurements gives the TIS Corrected Mean (TCM). The average TCM is the result that is reported as the calibrated value.

**Certification Technique:** All measurements for certification were made on the NIST Overlay Metrology Tool (OMT). The performance of the NIST OMT system was assessed by monitoring the measurements of a control wafer throughout the calibration of each SRM 5000 wafer. The NIST OMT is a full-field Charge-coupled Device (CCD) based OL metrology optical microscope. OL is determined by analyzing images acquired by the NIST OMT with a set of OL algorithms developed at NIST.

**Expiration of Certification:** The certification of the SRM 5000 is valid indefinitely, within the measurement uncertainty specified, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Care and Cleaning"). Periodic recertification is not required; however, this certification will be nullified if the SRM is damaged, contaminated, or modified.

**Maintenance of SRM Certification:** NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The overall direction and coordination of this work was managed by M. Stocker and R. Silver of the NIST Manufacturing Engineering Laboratory.

Michael T. Postek, Chief
Precision Engineering Division

Gaithersburg, MD 20899
Certificate Issue Date: 14 August 2007

Robert L. Watters, Jr., Chief
Measurement Services Division

The responsibility for the development of the OMT was made by E. Kornegay, formerly of the NIST Manufacturing Engineering Laboratory, and R. Attota, an independent consultant to the NIST Manufacturing Engineering Laboratory.

Algorithms for determining and reporting the overlay registration values were programmed by J. Jun of the NIST MEL and an independent set of OL algorithms were developed by R. Attota to confirm various aspects of our uncertainty budget.

The statistical analysis was performed by N-F. Zhang of the NIST Statistical Engineering Division.

The support aspects involved in the issuance of this SRM were coordinated through the Measurement Services Division.

**INSTRUCTIONS FOR USE**

**Instructions for Care and Cleaning:** Care must be exercised when handling and storing the SRM. The process stack for this SRM wafer is double-etched silicon. Nothing must come in contact with the surface of the wafer. The wafer must be stored in a clean stable environment, preferably inside a wafer shell in a Class 100 or better cleanroom. Any contamination on the wafer within the optical proximity of the calibrated targets, typically on the order of 5 μm for these targets, will render the calibration void. This wafer is not intended to be separated into individual dies; doing so will void the calibration.

**Calibration Traceability:** Traceability to the meter was established through measuring a SRM 2800 Microscope Magnification Standard on the OMT. The measurement of this SRM 2800 allows for the determination of the effective scale calibration for the combination of the microscope and CCD. This scale factor is the means by which pixels are converted to nanometers in the OL measurements.

**Certified Measurements and Uncertainties:** The final measured values and their corresponding uncertainties are listed in the table below. All uncertainties are calculated according to the U.S. Guide to the Expression of Uncertainty in Measurement (GUM) [2].

| FF OL target | OL Value (nm) | Expanded Uncertainty (k=2) |
|---|---|---|
| XN100 | -122.44 | 3.45 |
| XN030 | -55.86 | 2.91 |
| XP000 | -29.66 | 2.76 |
| XP030 | -0.53 | 2.86 |
| XP100 | 72.50 | 3.29 |

| RR OL target | OL Value (nm) | Expanded Uncertainty (k=2) |
|---|---|---|
| YN050 | -39.13 | 2.68 |
| YN010 | 3.16 | 2.58 |
| YP000 | 13.88 | 2.60 |
| YP010 | 23.44 | 2.59 |
| YP050 | 64.51 | 2.90 |

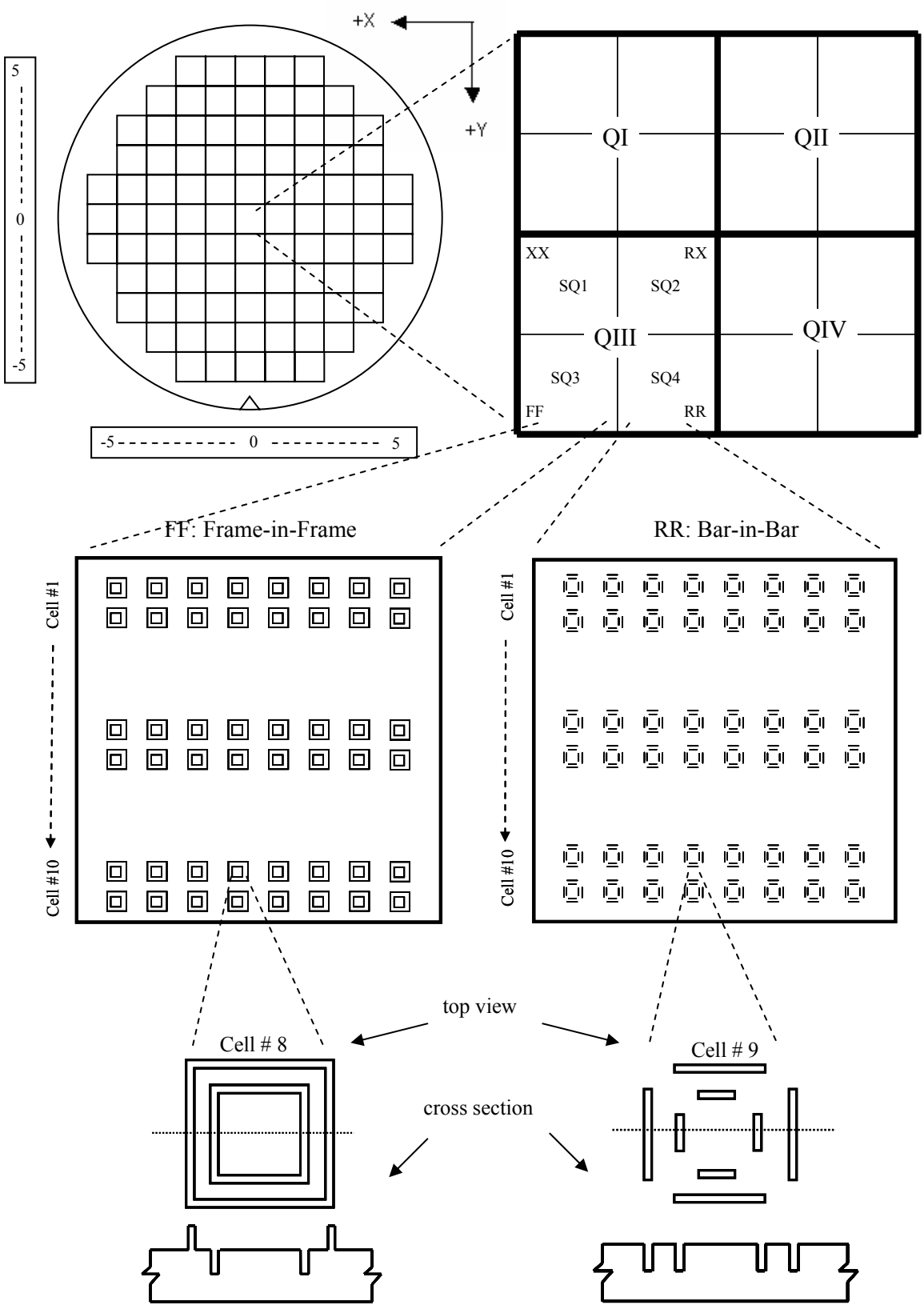


Figure 1. Exploded view of the center die of the SRM 5000

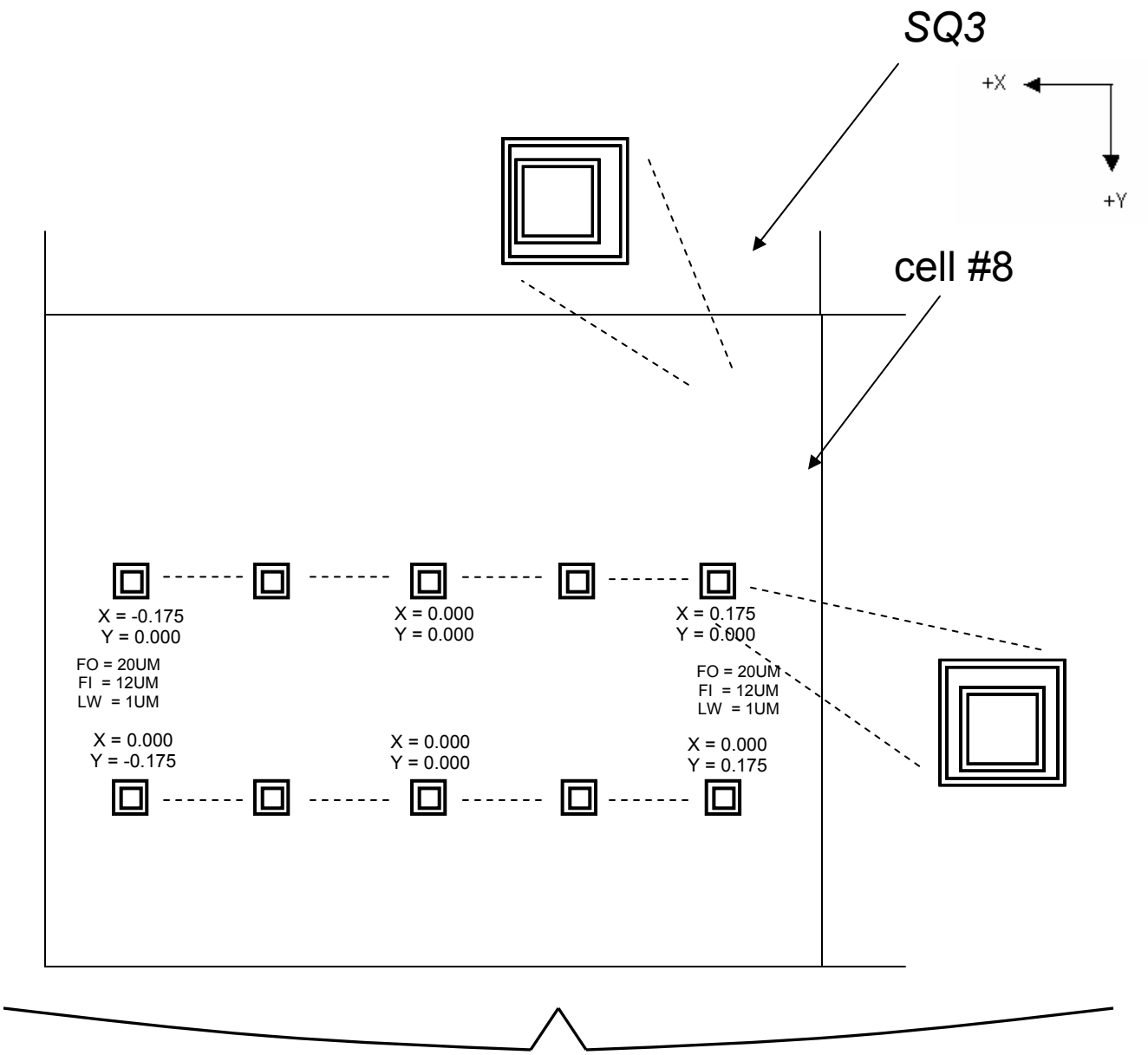


Figure 2. Illustration of relevant labeling in Sub-quadrant 3

Table 1. FF and RR offsets that are calibrated

| Type | Die | Quadrant | Sub-quadrant | Cell | Offset |
|---|---|---|---|---|---|
| FF | 00-00 | III | 3 | 8 | X=+0.100µm |
| FF | 00-00 | III | 3 | 8 | X=+0.030µm |
| FF | 00-00 | III | 3 | 8 | X=+0.000µm |
| FF | 00-00 | III | 3 | 8 | X=-0.030µm |
| FF | 00-00 | III | 3 | 8 | X=-0.100µm |
| | | | | | |
| RR | 00-00 | III | 4 | 9 | Y=-0.050µm |
| RR | 00-00 | III | 4 | 9 | Y=-0.010µm |
| RR | 00-00 | III | 4 | 9 | Y=+0.000µm |
| RR | 00-00 | III | 4 | 9 | Y=+0.010µm |
| RR | 00-00 | III | 4 | 9 | Y=+0.050µm |

## REFERENCES


[1] Stocker, M.; Silver, R.; Attota, R.; *Calibrated Overlay Wafer Standard*; NIST Special Publication 260-165, U.S. Government Printing Office: Washington, DC (2007).

[2] ANSI/NCSL Z540-2-1997; *U.S. Guide to the Expression of Uncertainty in Measurement*; NCSLI: Boulder, CO (1997).


*Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.*