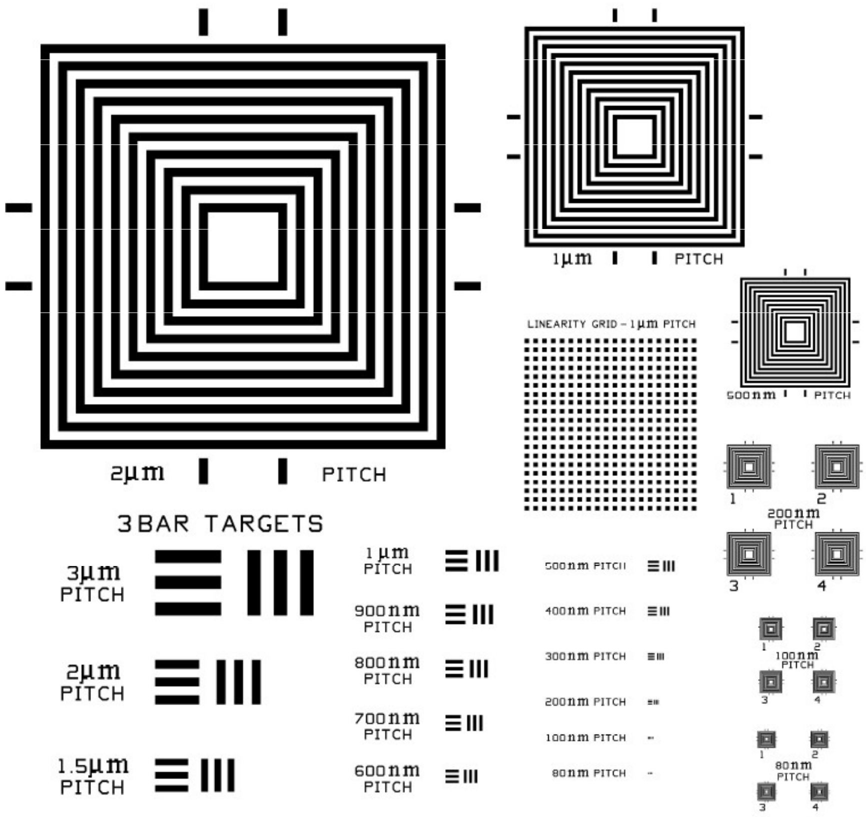
MRS-6

NIST and NPL (NIST counterpart in the U.K.) traceable - **Certified Reference Material**. A Magnification Reference Standard designed for Microscopy *by* Microscopists.

"Do It Right... The first time"

- THE 1,500X TO 1,000,000X STANDARD -

Optimized for high resolution low voltage scanning electron microscopes



- *0.08, 0.1, 0.2, 0.5, 1, AND 2µM PITCH PATTERNS*
- *3 BAR PATTERNS FROM .08 TO 3µM*
- *1µM PITCH TEST GRID X 20µM*
- *± 3 NM INDIVIDUAL PITCH 2σ UNCERTAINTY!*
- *± 2NM CUMULATIVE PITCH 2σ UNCERTAINTY*

Resource Guide

- **Product Design**
- **Magnification Measurement & Error Assessment**
- **Magnification Calibration Procedures for electron, optical, video, Vision Systems and scanning microscopies (following ASTM E766-98 and ISO-16700)**

MRS-6

This is our fifth generation, NIST and NPL (NIST counterpart in the U.K.) Traceable, Magnification Reference Standard & Stage Micrometer. For Instrument Calibration from 1,500X – 1,000,000X (80nm min. pitch).

- Electron Microscopy: SEM (secondary & backscattered electrons), TEM (for use with a bulk holder- the MRS-6 is conveniently sized at 2 X 2 X ½ mm.
- Scanning Microscopies and Profilometry: STM, AFM, stylus and optical etc. The pattern height is approximately 15 nm over single crystal silicon.
- Optical Microscopy: reflected, bright/dark field, differential contrast, and confocal.
- Chemical mapping: EDS, WDS, micro/macro XRF, XPS, Auger & others. The pattern is fabricated using 15 nm chromium film over single crystal silicon.
- Resolution testing: With a series of 3 bar targets (similar to the USAF 1953 patterns) ranging in size from 80nm to 3µm.
- Linearity testing: With a 1µm^2 patch pitch over 40 X 40µm.
- A Standard Ahead of Its Time: The MRS-6 represents a challenging next step. The nanotechnology sized patterns are a good test of your imaging systems.
  - Advanced optical microscopes now have sub-micrometer test patterns to measure resolution and linearity.
  - Scanning electron microscopes have a pattern that will show significant differences between backscattered and secondary electron type I and type II images. Imaging the pattern will also show their capabilities at low accelerating voltages.
  - Scanning probe microscopes have a pattern that is closely sized to the finest cantilever tips challenging their resolution ability.

INTRODUCTION

Geller MicroÅnalytical Laboratory introduces the MRS-6, the fifth in our series of magnification calibration standards (the MR-1, MRS-3 and MRS-4 are currently available). Our MRS series of calibration standards are highly accepted pitch standards, with well over 1,000 being used in laboratories over the world including national laboratories of the US, the UK and Germany. Our customers include Intel, AMD, IBM. NIST and NPL. We offer the MRS-6 as a certified reference material (a traceable standard) or, optionally, without traceability. We also offer a cleaning service and a recertification program, as required by international quality standards such as ISO and QS-9000 and ISO-17025.

PATTERN DESIGN & CLEANING

The MRS-6 is fabricated by using the highest accuracy electron direct write semiconductor manufacturing equipment available today. The pattern is built on a silicon wafer with ~15 nm Cr film. This film, which is significantly thinner that that of the MRS-5, has superior edge quality. Imaging contrast in both secondary and backscattered electron mode is possible with field emission SEMs and newer tungsten or LaB_6 SEMs. Contrast increases with lower accelerating voltage. 3 KeV may be optimum. The overall size is ~ 2.12 mm X 2.12 mm X 0.5 mm thick. The MRS-6 is fully conductive. No conductive coatings are necessary.
To clean the MRS-6 we use an SPI Supplies Plasma Prep II (that model is now replaced by the solid state Plasma Prep III) which has an RF frequency of 13.56 MHz. It uses isotropic rather than unidirectional etching. The system is operated at up to 100 watts power for 5 to 10 minutes using laboratory air (that is 20% oxygen - please note using pure oxygen may compromise the patterns). These conditions are only offered as a guideline from our experience. We cannot accept respon-sibility for damaged standards. Only ultrapure solvents like EPA and DI water should be used with gentle ultrasonic agitation.We offer a cleaning service for $175 on a best effort basis.

The geometric design of the MRS-6 and MRS-5 are the same. There are three different types of patterns.

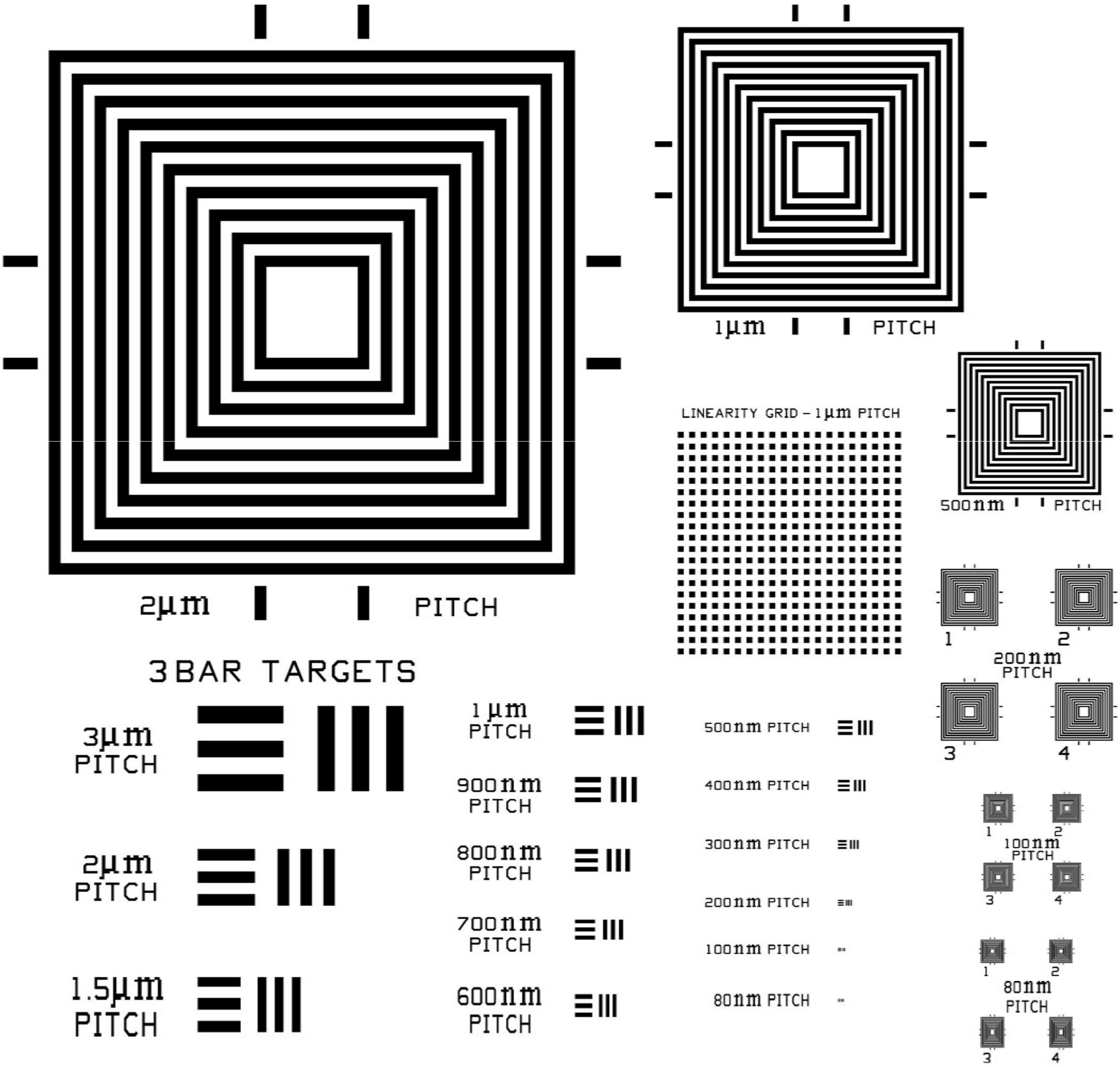
- Groups of nested squares spanning several orders of magnitude with pitches of 80nm, 100nm, 200nm, 500nm, ½µm, 1µm, and 2µm. to allow for more testing the 80, 100 and 200nm patterns are repeated four times.
- Incorporated into our standards is an extension of the 1951 USAF 3-bar targets. These finer patterns have pitches ranging from 80nm to 3µm in 15 steps. They will find good use measuring the resolution and modulation transfer functions of state-of-the-art optical microscopes (UV, confocal, laser scanning, etc).
- The ½ µm square test pattern, consisting of ½ µm squares with a 1 µm pitch over a 20µm X and Y field.

We measure and certify pitches (the distance between repeating parallel lines using center-to-center or edge–to-edge spacing). These are the only type of measurements that can be used to relate measurements from different microscopy techniques (see "Submicrometer Linewidth Metrology in Optical Microscopy", Nyysonen & Larrabee, Journal of the Research of the National Bureau of Standards, Vol. 92, No. 3, 1987). Linewidth measurements (the measurement of a single line or space width) can only be related if the same type of illumination is used as for the calibrating instrument since edge effects lead to uncertainty in the edge locations. Using pitch measurements, errors from edge-to-edge locations cancel as long as like positions are measured.

Square boxes and the 1µm pitch square test patterns are used for measuring magnification simultaneously in the X and Y directions. This gives a measure of image skew, barreling, pincushion and other non-linearity's which can have various origins, such as from stray magnetic fields. With the MRS-6 we have provided a large range of pitches to closely match the needs of your instrumentation.

The largest pattern has an overall dimension of 40µm square. It contains lines and spaces that are nominally 1µm wide. This can be used to check magnifications greater than 1,000X. The smaller patterns allow calibrations up to 1,000,000X.
The 3-bar targets were included as a response to many requests for a standard capable of measuring resolving power for patterns smaller than the 1951 USAF targets (see http://www.efg2. com/Lab/ImageProcessing/TestTargets/). They are often found covering a range of 0.25 to 228 cycles/mm. The standard target element consists of two patterns (two sets of lines) at right angles to each other. Each consists of three lines separated by spaces of equal width. The bar length to width ratio is 5X. The patterns change size exponentially in groups and elements. The range in line length for the original target was from 10mm to 0.08769mm. Others have expanded the range towards finer patterns. We now extend the range to a line width of 0.00004 mm! With these 15 patterns measurement of modulation transfer functions is made much simpler.

The patterns can also be used for determining imaging and chemical spatial resolution and chemical mapping using surface analysis instruments such as x-ray photoelectron and Auger spectrometers. Of course ion sputter cleaning should be avoided if possible.

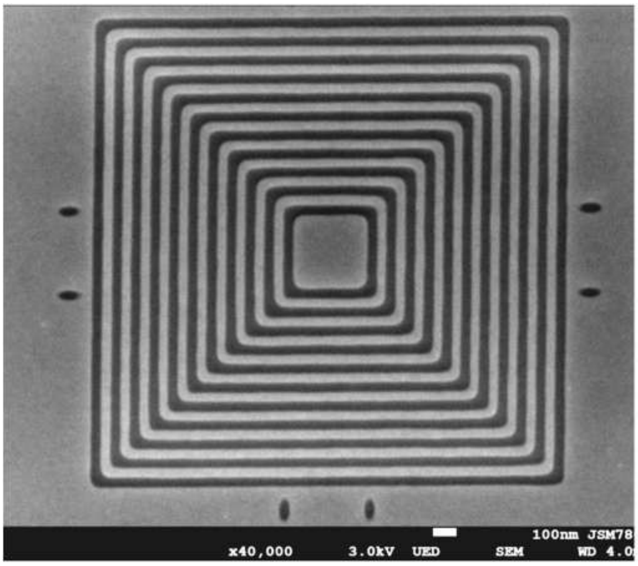


MRS-5 MAGNIFICATION/RESOLUTION STANDARD – WWW.GELLERMICRO.COM

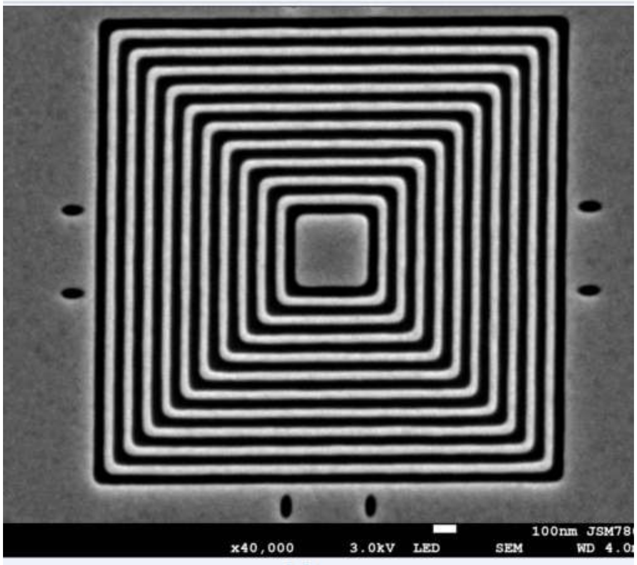
All the patterns above are included with the MRS-6

Pattern	Pitch (line + space) dimensions					
Nested boxes	2µm	1µm	500nm	200nm 4 each	100nm 4 each	80nm 4 each
3 bar targets	3µm	2µm	1µm	1.5µm	1µm	900nm
3 bar targets continued	800nm	700nm	600nm	500nm	400nm	300nm
3 bar targets continued	200nm	100nm	80nm			

FEGSEM images - 80 nm pitch (type II in-lens secondary electrons)



Same area with type I secondary electrons



TRACEABILITY

Why should you consider a traceable standard? Beyond the requirements of national and international quality standards, purchasing a CRM (certified reference material) from a national laboratory or a traceable standard from a certifying body (such as Geller MicroÅnalytical Laboratory) guarantees dimensions. Most commercially available standards have unknown accuracies. Measurements determined by optical methods measuring pattern frequency do not tell you about the individual variations in pitch measurements- and this is what you image. The MRS-6 is offered with or without traceability. The non-traceable standard differs only in documentation and cost. Traceability in the X and Y dimensions is established from a MRS-5 that has been measured by NPL (National Physics Laboratory), the NIST counterpart in the U.K. We are in the process of having the MRS-6 measured by a national laboratory and expect measurements with lower uncertainties. The non-accumulative 2σ pitch uncertainty is ± 3 nm. Through international agreements our ACLASS accreditation provides equivalency with NAVLP and A2LA. See http://www.gellermicro.com/quality_control/QC.html. Through national laboratory mutual recognition agreements NPL measurements are equivalent to NIST. **Please note that traceable measurements are only provided for the 2, 1 and 0.1 µm pitch patterns. A sample measurement certificate is on our website.**

RECERTIFICATION PROGRAM

We are often asked why the MRS needs re-certification. Under ISO-17025 guidelines your quality department should determine the re-certification interval as they are most familiar with your company's quality system requirements. Re-certification is a common practice for devices such as gage blocks and electronic instruments. Over the years we have found several standards which could not be recertified due to physical damage and excessive contamination. In a few cases we have seen electron beam damage and corrosion from storage in a contaminating environment. Re-certification insures your standard will perform its proper task and that you will be meeting your quality system directives. Recertification cost includes cleaning.

LOCATING THE PATTERNS

Patterns are placed in the center of the 3 mm square chip. We suggest you rotate the standard to align one edge of the chip with the X or Y stage axis. Next translate 1.5 mm to the chip center along that edge. Finally the pattern is found by translating another 1.5 mm in the orthogonal direction.

MAGNIFICATION MEASUREMENTS

Scanning Electron Microscopes can use type I or type II secondary electron or backscattered electron signals at an accelerating voltage of <=25keV.. Due to the thin chromium film contrast improves at low voltage (see the 3 keV sample images in this resource guide. To avoid pattern damage use <1 nA electron beam current.

Optical Microscope magnifications can be measured only in the reflection mode by directly on viewing CRTs, in reticles mounted within the ocular, or on photomicrographs. Please note the contrast depends upon illumination and is not particularly high. For instruments with verniers or electronic calipers distance measurements can be verified using a pitch pattern of appropriate size. The standard is ideal for measuring modulation transfer functions.

Scanning Probe Microscope operators must be aware of the fine dimension of the pitch patterns. The 80 nm pitch has a nominal space width of 40 nm. The cantilever tip must be smaller to define the pattern.

INTERNATIONAL CALIBRATION TEST METHODS

- **ASTM E766–2008: STANDARD PRACTICE FOR CALIBRATING THE MAGNIFICATION OF A SCANNING ELECTRON MICROSCOPE**
- **ISO 16700:2004 MICROBEAM ANALYSIS — SCANNING ELECTRON MICROSCOPY — GUIDELINES FOR CALIBRATING IMAGE MAGNIFICATION**
- **THERE ARE NO INTERNATIONAL STANDARDS FOR SPM MAGNIFICATION CALIBRATION AT THIS TIME**