Ladd Research
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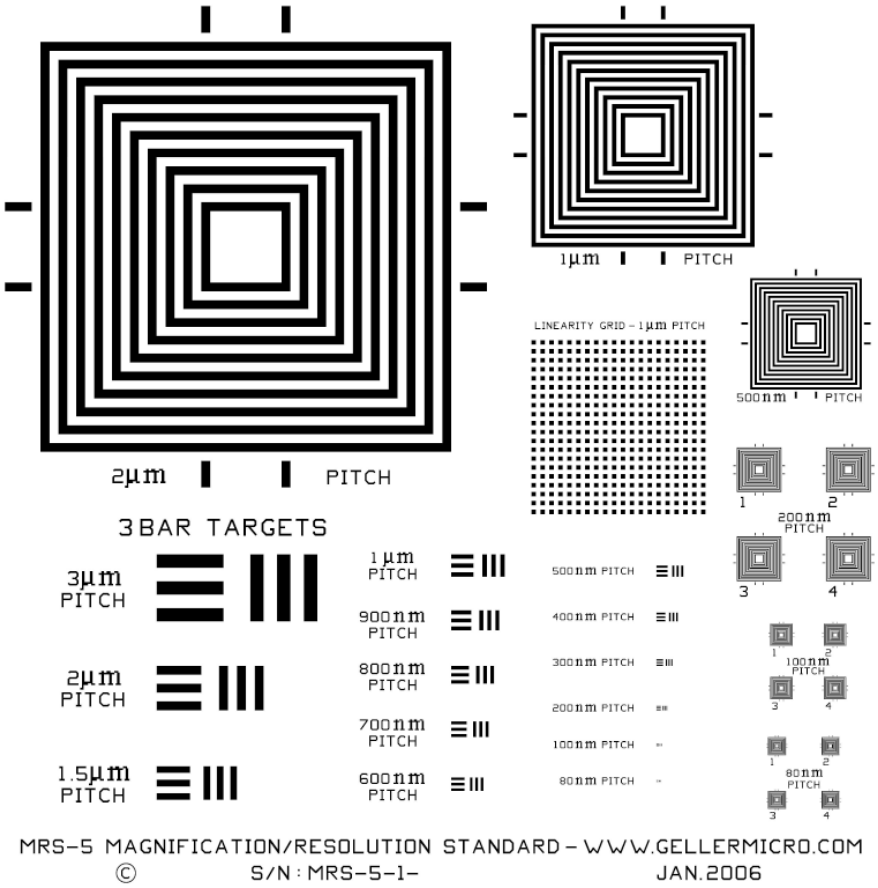
Ladd Catalog Numbers: LMRS-5NT & LMRS-5XY

MRS-5

Applied for under our ACLASS ISO-17025 Scope of Accreditation.

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



- *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 optical, video and scanning microscopies (following ASTM E766-98)**

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MRS-5

This is our fourth 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-5 is conveniently sized at 2 X 2 X ½ mm..
- Scanning Microscopies and Profilometry: STM, AFM, stylus and optical etc. The pattern height is 0.1µm.
- 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 100nm tungsten film over a thin SiO_2 film over a silicon substrate.
- Resolution testing: With a series of 2 bar targets (similar to the USAF 1953 patterns) ranging in size from 80nm to 3µm.
- Linearity testing: With a 1µm^2 patch over 40 X 40µm.
- A Standard Ahead of It's Time: The MRS-5 represents a challenging next step. The nanotechnology sized patterns will be 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 tax their low accelerating voltage capabilities.
  - 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-5, the fourth 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 industrial customers include Intel, AMD, and IBM. We offer the MRS-5 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, QS-9000 and ISO-17025.

PATTERN DESIGN

The MRS-5 is fabricated by using the highest accuracy electron direct write semiconductor manufacturing equipment available today. The pattern is built on a silicon wafer with a 400nm SiO_2 layer and then 65nm of tungsten on top. Imaging contrast in both secondary and backscattered electron mode is very high. The overall size is ≅2mm X 2mm X 0.5 mm thick.. For applications requiring an electrically conductive sample (SEM at ≅1.5 keV and higher), the MRS-5 is coated with a proprietary carbonaceous material which allows for image observation at any accelerating voltage. A distinct advantage of this coating is that electron beam tracks from are removable by plasma etching. Applying a fresh coating restores the MRS-5 to like new condition. This is all done here at Geller MicroÅnalytical Lab.

The geometric design of the MRS-5 has 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.
- Newly 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 of state-of-the-art optical microscopes (UV, confocal, laser scanning, etc.
- The ½ µm square test pattern will help analyze your images for all types of dimensional distortions, vibrations and magnetic fields. This pattern contains 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 is the only type of measurement 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-5 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 around 1,500X. The smaller patterns will allow calibrations up to 1,000,000X. The "ruler" has an overall length of 6mm in the X and Y directions. The 1µm increments have graphics every 10µm and emphasized lines and graphics every 50µm and 100µm.

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 length of 0.00004mm! 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.

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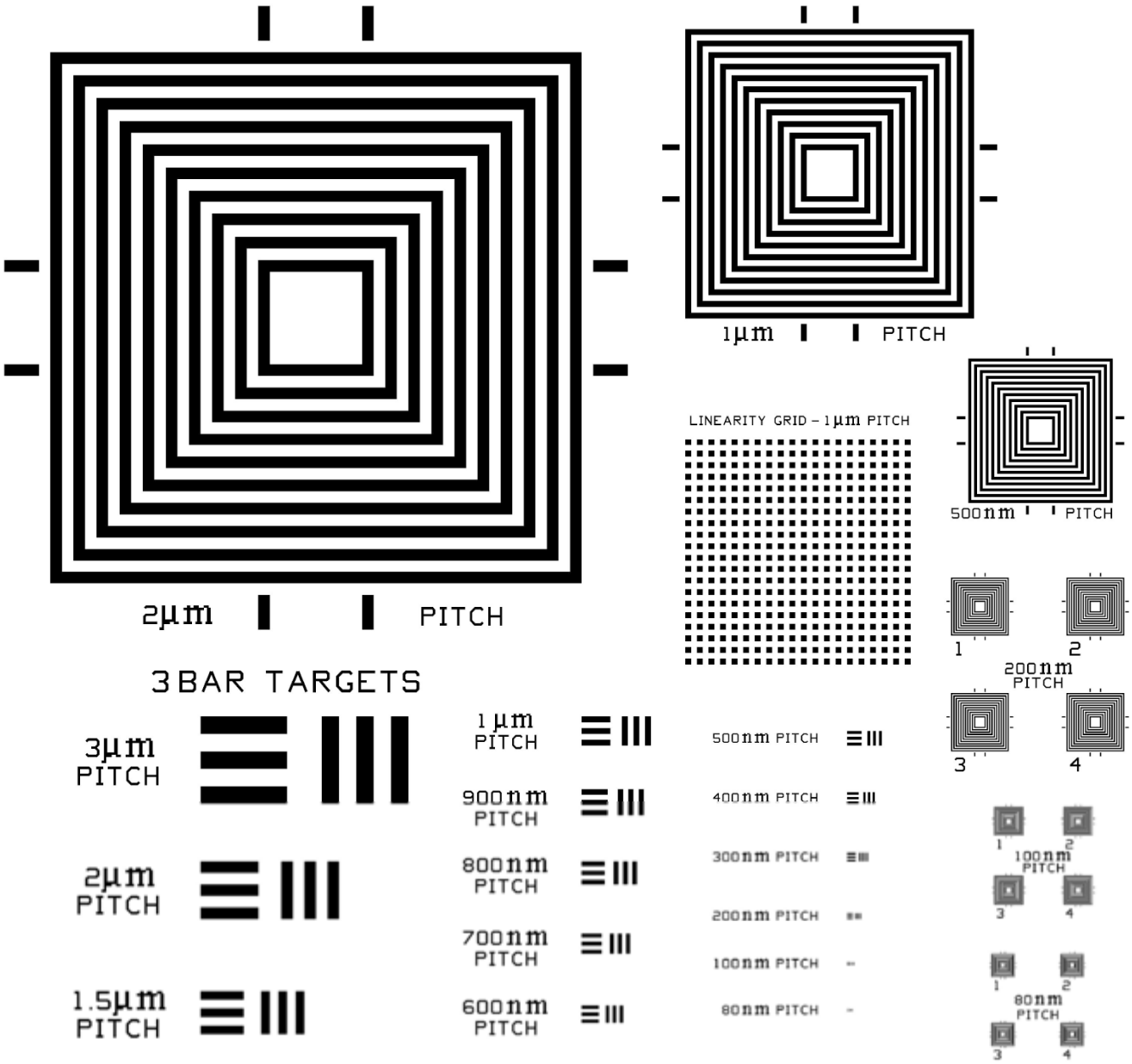

All the patterns above are included with the MRS-5

Pattern	Pitch Spacings					
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			

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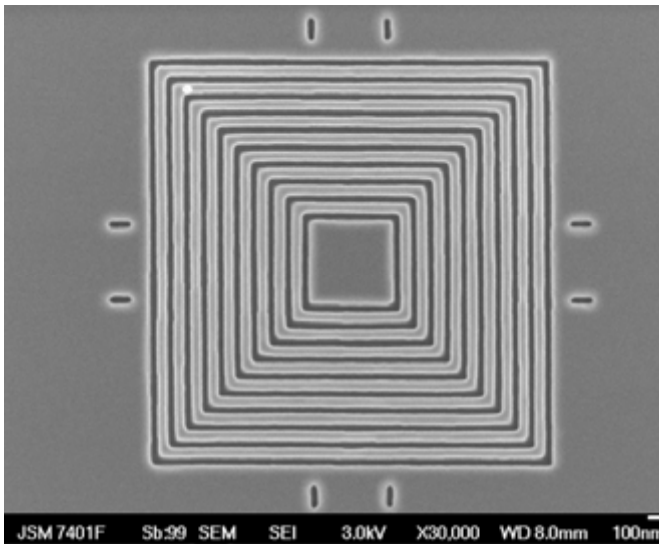
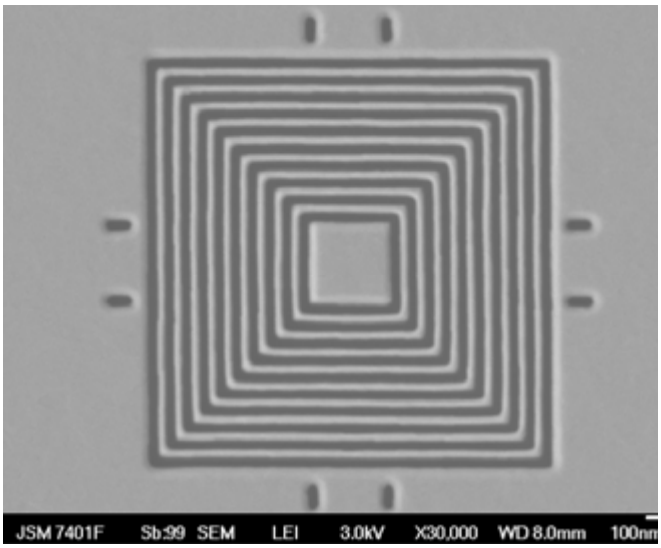
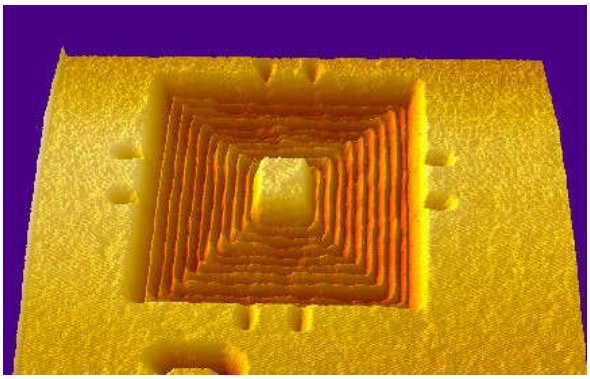


Scanning electron microscope, type II secondary electrons



Scanning electron microscope, type I secondary electrons



AFM image taken with sharpened tip (NPL) - 80nm pitch pattern

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-5 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. 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. **Traceable measurements are only provided for the 2, 1 and 0.1 µm pitch patterns. Details can be found on the provided measurement certificates.**

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 includes cleaning and application of a new coating, if needed.

MAGNIFICATION MEASUREMENTS

Optical Microscope magnifications can be measured directly on viewing CRTs, in reticles mounted within the ocular, or directly on photomicrographs. For instruments with verniers or electronic calipers distance measurements can be verified using a pitch pattern of appropriate size. Magnification is simply the image size divided by the object size (be careful to use the same units).

Scanning Electron Microscopes can use the secondary electron signal at an accelerating voltage of <=5keV preferably with type II secondary electrons to get more of a surface image. The low voltage requirement is due to the line height variations, as shown in the AFM image to the left, which reveal penetration differences. Backscattered electron imaging is not recommended for the same reason. For SEM applications we recommend the device with the electrically conductive coating for two reasons. First, it the tungsten film is electrically isolated from the silicon chip by a thin SiO_2 layer and second, the coating is removable. When it is removed electron beam tracks from contamination go with it. A cleaning service is provided for a nominal fee. Cleaning is included at no charge with the suggested yearly recertification program. To avoid pattern damage use <1 nA electron beam current.

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. As shown in the AFM image to the left the pattern lines have variable height.

INTERNATIONAL CALIBRATION STANDARDS

- **ASTM E766–2003: STANDARD PRACTICE FOR CALIBRATING THE MAGNIFICATION OF A SCANNING ELECTRON MICROSCOPE**
- **ISO 16700:1994 MICROBEAM ANALYSIS — SCANNING ELECTRON MICROSCOPY — GUIDELINES FOR CALIBRATING IMAGE MAGNIFICATION**
- **THERE ARE NO INTERNATIONAL STANDARDS FOR SPM MAGNIFICATION CALIBRATION AT THIS TIME**

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