National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material 476

Optical Microscope Linewidth Measurement Standard

This Standard Reference Material (SRM) is intended for use in calibrating optical microscopes used to make dimensiona measurements on bright-chromium integrated-circuit photomasks. SRM 476 consists of patterns of clear and opaque line with nominal dimensions ranging from 0.9 to 10.8 micrometers and line-spacing (pitch) patterns ranging from 2 to 3 micrometers (see figures 1 to 3). These patterns are on a nominal 63.5 x 63.5 x 1.5 mm (2.5 x 2.5 x 0.06 in.) borosilicate glas substrate. Certified values are given for linewidths (both clear and opaque) and line-spacings (center-to-center) for on of the eight repeated patterns on the SRM as indicated by the pattern number given with the serial number. Al measurements were made within three micrometers of the center of each line feature (at the fiducial line) and th certification applies only to that portion of the feature. The certified values, precision, and estimated accuracy are give in the attached table.

The certification and useful lifetime of the SRM are deemed to be indefinite, and re-certification is not necessary, providin the SRM is not damaged or contaminated. The user is advised, therefore, to be careful to ensure the proper handling an storage of the SRM (e.g., avoid touching the surface with the microscope objective lens while setting-up or focusing). Us of this SRM in a scanning electron microscope is <u>not recommended</u>; the SRM could become contaminated, the materia profile could be changed, and charging and edge effects could invalidate the measurement.

All measurements for certification were made with the NIST optical linewidth measurement system [1,3], which is a photometric transmission microscope with a scanning stage and displacement measuring interferometer. Linewidths ar determined from the image profile using partially coherent optical edge detection. The performance of the system i assessed before and after each calibration by measuring features on a control photomask. These control measurement include center-to-center spacing of line pairs which have been independently calibrated on the NIST Line Scale Interferometer.

The procedures for using this SRM to calibrate optical linewidth measurement systems are described in the accompanyin documents. These procedures have been used successfully in an interlaboratory study using antireflecting-patterned SRM 474 type photomasks [4]. This study showed that, in most cases, using the SRM to calibrate optical linewidth systems lead to improved measurement accuracy. SRM 474 has now been superceeded by SRM 475, which also has antireflecting patter features, but the overall pattern has fewer opaque and clear lines. SRM 476 has the same overall pattern as 475, but i patterned with bright (highly reflective) chromium.

The relative brightness of an image profile at a line edge location is a function of the physical and optical properties of th imaged object (the line) [5]. Therefore, the calibration of a system using a photomask SRM is valid only for measurin artifacts having physical and optical properties similar to the specific SRM used. That is, SRM 474 or SRM 475 should b used to calibrate systems for measuring similar low reflectivity (e.g., AR chromium) artifacts and SRM 476 should be use for high reflectivity (e.g., bright chromium) artifacts. Also, the transmissivity of the artifacts should be low (less than 0. percent) and the thickness of the patterned layer should be small compared to the wavelength of light used.

The underlying theory and the optical equipment used in the certification of the NIST photomask SRMs were develope and initially constructed by D. Nyyssonen. Automation of the measurement process was subsequently designed, constructed, and programmed by J.E. Potzick. Measurement and statistical analysis for this SRM were performed using th automated system by C.F. Vezzetti, J.E. Potzick, and R.N. Varner of the Microelectronics Dimensional Metrology Group with overall supervision by R.D. Larrabee.

Gaithersburg, MD 20899
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William P. Reed, Acting Chie
Standard Reference Materials Progra

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The technical and support aspects involved in the preparation, certification and issuance of this Standard Reference Material were coordinated through the NIST Office of Standard Reference Materials Program by R.L. McKenzie.

References

1. Nyyssonen, D., "Linewidth Measurement with an Optical Microscope: The Effect of Operating Conditions on the Image Profile," App. Opt. 16, 2223-2230 (Aug. 1977).

2. Nyyssonen, D., "Spatial Coherence: The Key to Accurate Optical Micro-metrology," Application of Optical Coherence Vol. 194 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, 1979) pp. 34-44.

3. Potzick, J., "Automated Calibration of Optical Photomask Linewidth Standards at the National Institute of Standards and Technology," SPIE Vol. 1087, Integrated Circuit Metrology, Inspection, and Process Control, Session 23 (Feb. 1980).

4. Jerke, J.M., Croarkin, M.C., and Varner, R.N., "Interlaboratory Study on Linewidth Measurement for Antireflective Chromium Photomasks," NBS Special Publication 400-74 (1982).

5. Nyyssonen, D., Larrabee, R.D., "Submicrometer Linewidth Metrology in the Optical Microscope, NBS J. Res. (May-June issue) 92 (3), 184-204 (1987).

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References

1. Nyyssonen, D., "Linewidth Measurement with an Optical Microscope: The Effect of Operating Conditions on the Image Profile," App. Opt. 16, 2223-2230 (Aug. 1977).

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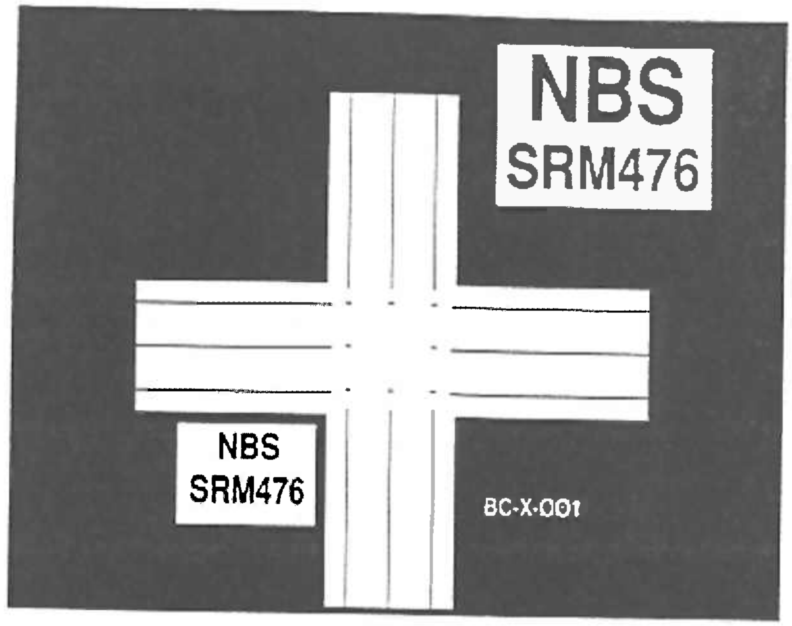


Figure 1. A view of the overall pattern on SRM 476. The basic measurement pattern is repeated eight times about the center. The horizontal and vertical lines help locate the patterns.

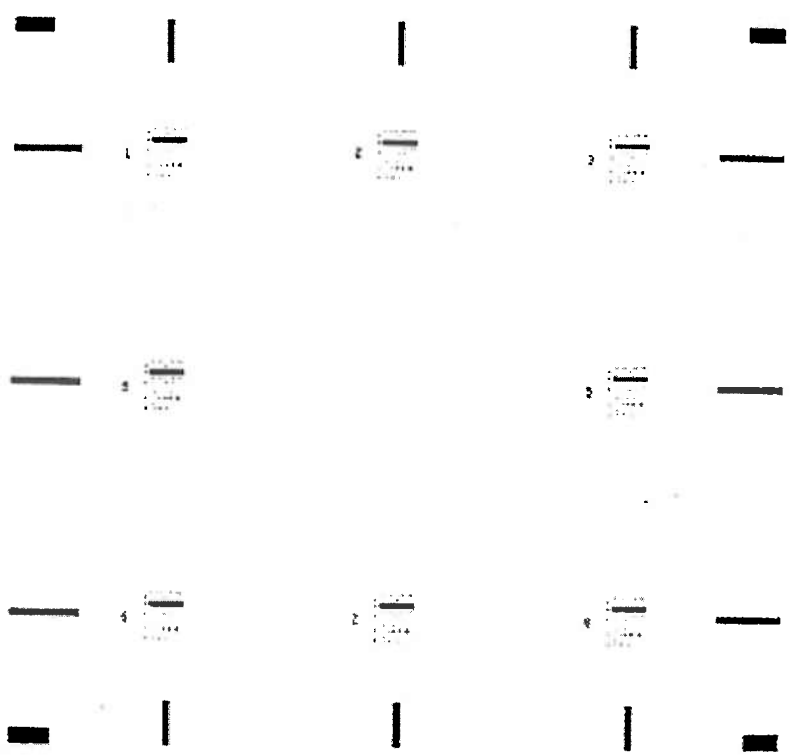


Figure 2. A view of the center of SRM 476. The pattern number given with the serial number identifies which pattern has been certified by NIST. Pattern identification numbers can be seen to the left of each basic measurement pattern.

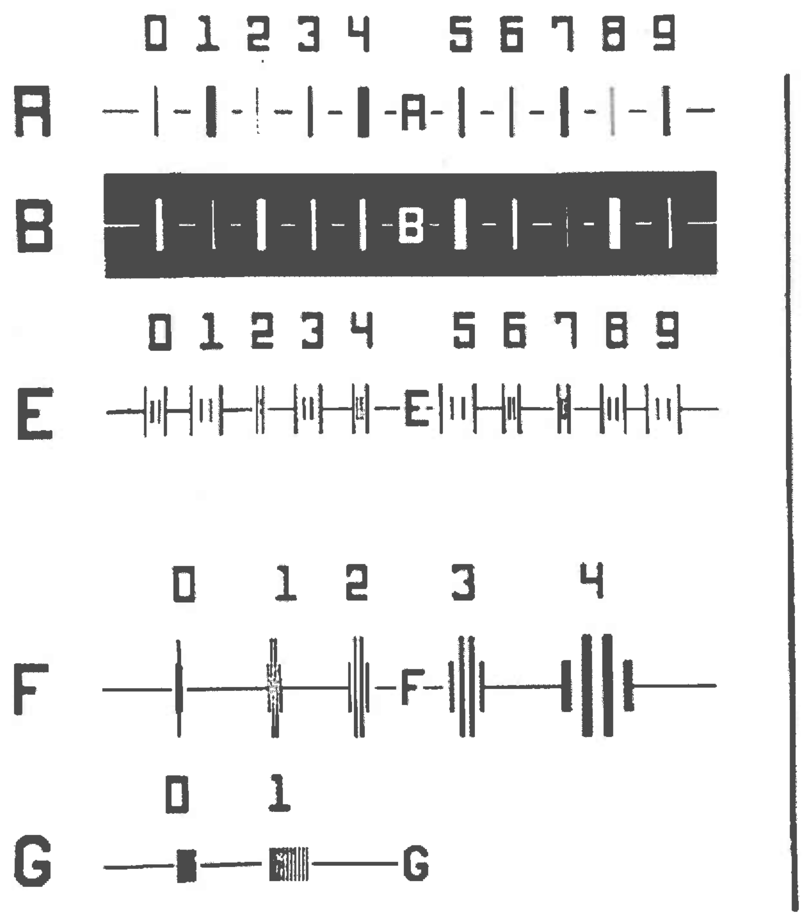
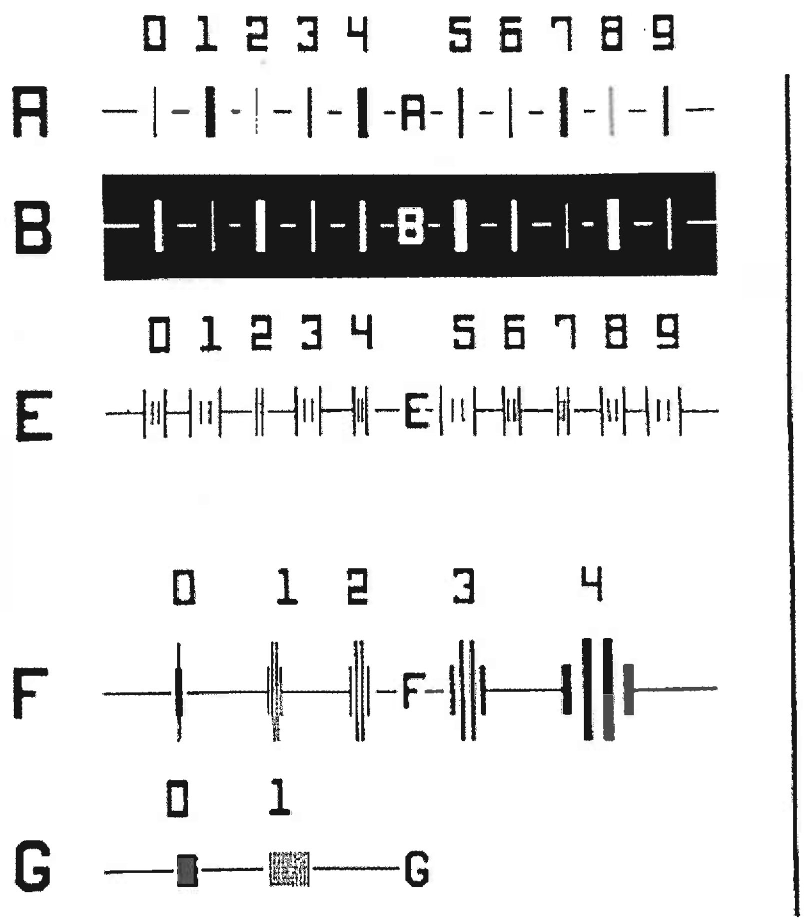


Figure 3. A view of one basic measurement pattern on SRM 476. The individual lines and line patterns are located by reference to an alpha-numeric grid with the letters identifying the row and the numbers identifying the column. The long vertical line on the right is used to align the pattern on the measurement system. The broken horizontal lines mark the central calibrated area of the features.

Calibration values are given for: widths of opaque lines in row A and clear lines in row B; center-to-center spacing of the two inner (short) lines of each line pattern in row E; widths of the left inner (long) line and the space to its right of each line pattern in row F; and center-to-center spacings of lines relative to the first line on the left of each line pattern in row G.



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