



Designation: F 728 – 81 (Reapproved 2003)

Standard Practice for Preparing An Optical Microscope for Dimensional Measurements¹

This standard is issued under the fixed designation F 728; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the preparation of an optical microscope for dimensional measurements. It is intended for preparing an optical microscope to measure the width of lines, in the range from 0.5 to 12 μm, inclusive, on hard surface photomasks and processed silicon wafers.

1.2 This practice is applicable for a microscope equipped with a micrometer attachment, such as an optical filar, video filar, optical image-shearing with optical or video display, optical image-scanning, or video image-scanning micrometer. Adjustment and calibration of the micrometer attachment is not included in this practice.

1.3 This practice is intended for observing optically transparent specimens in bright-field transmitted illumination or optically opaque specimens in bright-field reflected illumination. It is not intended for dark-field illumination.

1.4 This practice is limited to an optical microscope with an illumination system that is an integral part of the microscope body and includes a condenser lens.

1.5 No useful figure capable of showing the arrangement of components for all microscope designs is available; therefore, this practice does not contain illustrations and procedures which would suggest a specific microscope.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For more specific hazard statements, see Note 7, Note 8, and Note 17.

2. Referenced Documents

2.1 ASTM Standards:

E 175 Terminology of Microscopy²

F 127 Definitions of Terms Relating to Photomasking Technology for Microelectronics³

3. Terminology

3.1 Definitions:

3.1.1 Other terms used in this practice are defined in Terminology E 175 and Definitions F 127.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *coherence—in optics*, a measure of the ability of light to interfere.

3.2.1.1 *Discussion*—Coherence arising from the finite extent of the light source is spatial coherence. Coherence arising from the finite spectral width of the light source is temporal coherence.

3.2.2 *coherence parameter—in microscopy*, the ratio of the condenser numerical aperture to the objective numerical aperture for wide-field, bright-field, Kohler illumination.

3.2.3 *condenser aperture diaphragm—in microscopy*, a fixed or variable opening that controls the light passing through the condenser and determines the value of the condenser numerical aperture.

3.2.4 *condenser lens or substage condenser—in microscopy*, a lens that collects light for the purpose of illuminating the specimen.

3.2.5 *condenser numerical aperture—in microscopy*, the product of the index of refraction in object space multiplied by the sine of half the angular aperture of the condenser.

3.2.6 *condenser system—in microscopy*, lenses and mirrors that collect light for the purpose of illuminating the specimen.

3.2.6.1 *Discussion*—A condenser system usually consists of mirrors, a lamp collector, relay lenses, and a condenser lens.

3.2.7 *contrast—in microscopy*, the ratio of the transmittance or reflectance of two different areas on the specimen.

3.2.8 *cover glass—in microscopy*, a thin glass plate that is placed over the specimen.

3.2.8.1 *Discussion*—Some microscope objectives are designed for use with a cover glass of a specified thickness, and use of these objectives without a cover glass or with a cover glass of a different thickness from the specified thickness introduces spherical aberration in the observed image.

3.2.9 *epi-objective—in microscopy*, an objective with an annular mirror that acts as a lens to illuminate the specimen.

¹ This practice is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.06 on Silicon Materials and Process Control.

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² *Annual Book of ASTM Standards*, Vol 14.02.

³ Discontinued; see 1992 *Annual Book of ASTM Standards*, Vol 10.05.



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3.2.9.1 *Discussion*—An epi-objective is commonly used in dark-field reflected illumination, but it is also useful in bright-field illumination.

3.2.10 *field diaphragm—in optics*, a usually variable opening that controls the field of view.

3.2.11 *field of view—in microscopy*, the area or solid angle viewed through the microscope.

3.2.11.1 *Discussion*—Field of view is often expressed as the diameter of the largest image which the eyepiece can cover.

3.2.12 *filar micrometer, optical*—for the purposes of this practice, a micrometer equipped with a movable fiducial line imaged in the eyepiece.

3.2.13 *filar micrometer, video*—for the purposes of this practice, a micrometer equipped with movable, electronically generated fiducial lines that appear, along with an image of the specimen, on a television monitor.

3.2.14 *illumination, bright-field—in microscopy*, a method of illumination in which the image appears against a bright background generally produced by uniformly illuminating a circular and unobstructed condenser aperture diaphragm.

3.2.15 *illumination, dark-field—in microscopy*, a method of illumination in which the image appears as self-luminous against a dark background generally produced by illuminating the specimen with an annular cone of light so that only scattered light enters the objective.

3.2.15.1 *Discussion*—In dark-field transmitted illumination, the condenser has an opaque center stop. In dark-field reflected illumination, the objective has a reflective annular surface that surrounds the lenses and serves as a condenser.

3.2.16 *illumination, Kohler—in microscopy*, a method of illumination in which an image of the light source is focused on the condenser aperture diaphragm located at or near the back focal plane of the condenser lens and an image of the lamp collector is focused on the specimen plane.

3.2.17 *image-scanning micrometer, optical*—for the purposes of this practice, a micrometer that uses a phototube and scanning slit to generate an optical image profile from which the specimen dimension is determined by means of an optical threshold.

3.2.18 *image-scanning micrometer, video*—for the purposes of this practice, a micrometer that uses a television camera to generate an electronic image profile from which the specimen dimension is determined by means of an electronic threshold.

3.2.18.1 *Discussion*—In semiautomatic image-scanning micrometers, the operator sets an electronic window in the vicinity of the boundaries of the specimen image, and the edge locations are determined automatically by electronic thresholding techniques.

3.2.19 *image-shearing micrometer, optical*—for the purposes of this practice, a micrometer that optically shears, or splits, the image of the specimen into two identical images whose separation can be continuously adjusted while being viewed in the eyepiece.

3.2.20 *image-shearing micrometer, video*—for the purposes of this practice, a micrometer that optically shears, or splits, the image of the specimen into two identical images whose separation can be continuously adjusted while being viewed on a television monitor.

3.2.21 *lamp collector or lamp condenser—in microscopy*, a lens that collects light from the lamp and usually focuses the light either on the specimen or on the condenser aperture diaphragm.

3.2.22 *lamp diffuser—in microscopy*, a ground-glass plate or other light-diffusing material used to improve the uniformity of the illumination.

3.2.23 *mechanical tube length—in microscopy*, the distance between the shoulder or flange of the objective and the eyepiece seating face.

3.2.24 *micrometer attachment*—for the purposes of this practice, an instrument used with an optical microscope for measuring small distances.

3.2.25 *objective aperture—in microscopy*, a fixed opening that controls the light passing through the objective and determines the value of the objective numerical aperture.

3.2.26 *objective, flat-field—in microscopy*, an objective that is designed to show little or no field curvature over the useful field of view.

3.2.27 *objective numerical aperture—in microscopy*, the product of the index of refraction in object space multiplied by the sine of half the angular aperture of the objective.

3.2.28 *relay lens—in optics*, a lens that transfers an image from one location to another along the optical axis.

3.2.29 *vertical illuminator—in microscopy*, an illumination system used with reflected light in which the objective both illuminates and images the specimen.

3.2.29.1 *Discussion*—It usually consists of the objective (condenser), beam splitter, relay optics, field diaphragm, condenser aperture diaphragm, and filter holder.

4. Summary of Practice

4.1 An objective, eyepiece, condenser lens, and green filter are inserted into the microscope, and a representative specimen is placed on the mechanical stage.

4.2 The lamp is switched on and the image of the lamp filament or arc lamp is centered and focused on the condenser aperture diaphragm.

4.3 The microscope is adjusted to give a focused image of the representative specimen within the field of view.

4.4 For transmitted illumination, the condenser lens is adjusted to give a focused and centered image of the field diaphragm within the field of view. For reflected illumination, a relay lens and centering controls are adjusted to give a focused and centered image of the field diaphragm within the field of view.

4.5 The condenser aperture diaphragm is adjusted to give a numerical aperture that is approximately two thirds of the objective numerical aperture.

4.6 The illumination observed in the field of view is adjusted to equal the room illumination.

5. Significance and Use

5.1 Dimensional measurements made with an optical microscope are made on the optical image of the specimen and not directly on the specimen itself. The method of illuminating the specimen affects the image content, including the appearance of edges which are used in defining the size of the specimen.