Publication guidelines for metrology and masks

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In Vol. 19(3) of JM^3, publication guidelines were provided for papers on materials for lithography. These guidelines were generated to balance the need to provide readers with key data while recognizing that it is often not possible for authors to provide complete descriptions of materials due to their proprietary nature. The guidelines were created to provide common expectations for authors and reviewers alike.

In this editorial, publication guidelines are provided for papers on metrology and mask-making. Since the values of many parameters are available from prior publications or from suppliers of tools or materials, it is often not necessary for authors to provide complete descriptions; a reference or simply stating what material, measurement target, or tool is used is often sufficient, so long as descriptions are publicly available. In some situations, it may not be possible to disclose some information that needs to be kept confidential; in such circumstances the authors should provide an explanation in the submission cover letter, providing the reason for not providing certain information listed in the guidelines. Many of the parameters listed in these guidelines are not expected to involve proprietary concerns, but they have nevertheless been included, since authors should provide them so that readers can properly interpret results in papers. On the other hand, some parameters may not be relevant. For instance, for a paper involving the exploration of a new metrology technique, throughput is not pertinent. Some level of judgment is expected by authors and reviewers in such cases.

In some instances, authors may not know specific information. For example, critical dimensions may be measured using an SEM, and the details of the algorithm that converts secondary electron signals to a dimension may not be known to the user of the SEM. In such an instance, it is sufficient simply to state the make and model of the SEM used. This satisfies requirements for reproducibility, since other people can repeat the measurements using the same type of SEM. On the other hand, if the subject of the paper is a particular SEM or some aspect of e-beam metrology, it is appropriate to provide a greater level of information regarding such algorithms.

1 Publication Guidelines for Metrology

Many contributions to JM^3 include results from metrology equipment. For example, measurements may serve to illustrate the advantages of a new processing method. For other papers, a new metrology tool or technique may be the main subject. Here, we briefly describe guidelines on what should be included so that the reader has enough information to understand fully the key data, and ideally be able to replicate the results of the paper.

The most common metrology tools used by patterning technologists are those for measuring critical dimensions, overlay errors, film thickness, and inspecting patterns for defects. For papers involving the use of metrology tools, it is desirable for authors to state the manufacturer and model of the metrology tools. When this is not possible, it is important for appropriate metrics of tool capability, e.g. total measurement uncertainty (TMU), to be included. Frequently there are a number of adjustable parameters on the tool, some of which are key to a successful result, and the values for these parameters should be included. For many metrology data sets, it is vital to specify the precise target structure which was measured.

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There are some general considerations that are relevant for all papers involving metrology:

- If an aggregate of data is collected, the sampling plan should be described.
  - Across-chip
  - Across-wafer
  - Across-lot
- The number data points used to calculate final statistical numbers should be given.
  - For example, 3 s of 3.89 nm based on 3500 data points.
  - A description should be provided of how outliers were removed.
- For papers in which the subject is a metrology tool, in order to understand throughput, MAM time (move – acquire – measure) should be given.

Concrete details should be provided for specific metrology tool types, and these are listed as follows:

Critical dimension metrology tools:

- Top-down CD-SEM
  - Landing energy (beam voltage)
  - Image mode (typically secondary electrons, sometimes back-scattered)
  - Number of frames to average
  - Data filtering, if any
  - Algorithm(s) used to determine CD, LER, or other attributes from images
  - Any post-image analysis methods, e.g. addressing SEM noise in LER metrology
  - Charge mitigation, if used
- Scatterometer
  - Mode of operation, e.g. reflection versus wavelength
  - Optical configuration, angles, use of polarizers, etc.
  - Range of wavelengths utilized
  - Free parameters and fixed parameters in model
  - Target design and underlying film stack
- AFM
  - Mode of operation, e.g. tapping
  - Tip material and dimensions, e,g. radius of curvature, aspect ratio, etc.
  - Tip calibration
  - Data analysis, such as deconvolution of tip shape
  - Target design and measured area

Overlay error metrology tools:

- Image-based overlay (IBO) tools or diffraction-based overlay (DBO) tools
  - Wavelength range
  - Design of overlay mark
  - Whether every site has TIS correction, or if TIS calibration is used
  - If possible, any use of SRAFs, dummy features for density control, and any other features needed for process compatibility
  - Material stack within measured mark
  - Model fit results –model used (e.g. order of polynomials used), fit parameters, and residuals

Film thickness tools:

- Spectroscopic ellipsometer or reflectance versus wavelength
  - Wavelength range used
  - Film thickness – sometimes more than one film
  - Materials or films underlying the film of main interest
  - Known optical constants (n,k), or data-determined

Wafer inspection tools:

- E-beam type or optical type
- Intended for blank or patterned wafers
- Die-to-die or die-to-database pattern comparison
  - Minimum measurable defect size (may depend on defect type)
- Defect classification scheme
- Aerial throughput, e.g. mm^2/minute (if metrology tool paper)

2 Publication Guidelines for Mask Making

Publications in JM[3] may be directed at a specific mask fabrication technique, material, tool, or characterization method. Authors of mask-specific publications should refer to the following list as guidelines and include any allowable disclosures necessary for readers to understand fully and appreciate the work. If confidentiality prevents sharing of necessary information, please highlight those specific cases.

- Data preparation
  - Hardware and software tools and methods, fracturing, data formats, grid sizes
  - Application of mask process correction and data bias
  - Design layout, feature sizes, and density
- Mask writing
  - Relevant column, switching, and mechanics description
  - For e-beam tools, accelerating voltage and current density
  - For optical tools, wavelength and NA
  - Dose, proximity effect correction, fogging, positional dose, thermal, charging correction methods
  - Exposing sequence number of passes, duration, exposed field size, shot sizes
- Resist processing
  - Develop and coat tools and relevant design information
  - Resist type and process steps including blank preparation
  - Develop and bake parameters
- Etching
  - Etch tool and relevant design information
  - Etching chemistry and process description
  - Etching process bias, uniformity and proximity effects
- Mask blanks
  - Thin film coating design, thicknesses and optical parameters suitable for simulation
  - Blank properties such as flatness and defects

- Metrology (CD SEM, registration, reflectivity, film properties)
  - Tool type, measurement method, repeatability, sample plan, data culling/normalization
  - Data fitting and modeling
- Inspection, repair, printability
  - Inspection setup conditions such as pixel size, wavelength, algorithm
  - Type of repair, material removal and deposition method
  - Imaging verification including AIMS, simulation or wafer based
  - Defectivity descriptions including photo induced defectivity
- Simulation support
  - Input parameters, variables considered, experimental calibration
  - Algorithm descriptions

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