Designation: E1635 − 06 (Reapproved 2011)

Standard Practice for Reporting Imaging Data in Secondary Ion Mass Spectrometry (SIMS)[1]

This standard is issued under the fixed designation E1635; 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 lists the minimum information necessary to describe the instrumental, experimental, and data reduction procedures used in acquiring and reporting images generated by secondary ion mass spectrometry (SIMS).

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E673 Terminology Relating to Surface Analysis (Withdrawn 2012)[3]

E1504 Practice for Reporting Mass Spectral Data in Secondary Ion Mass Spectrometry (SIMS)

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology E673.

4. Summary of Practice

4.1 Experimental conditions and reporting procedures that affect SIMS imaging data are presented in order to standardize the reporting of such data and to facilitate comparisons with other laboratories and analytical techniques.

5. Significance and Use

5.1 This practice is to be used for reporting the experimental and data reduction procedures to be described with the publication of the data.

6. Information to be Reported

6.1 Standard information to be reported may be found in Practice E1504. This information pertains to the type of SIMS instrumentation used, the mounting of the specimen, and the experimental conditions. For imaging SIMS analysis, additional information is required on the acquisition and display parameters for each image. The information reported will depend primarily on the type of SIMS instrumentation used. Two distinct instrumental configurations are used for ion imaging: the ion microscope and the ion microprobe.

6.2 *Experimental Conditions for Acquisition of Ion Microscope Images*—For stigmatic ion imaging, the mass spectrometer ion optics project a mass resolved secondary ion image that preserves the lateral relationship between ions sputtered from the sample onto the plane of an imaging detector. Whenever stigmatic ion images are recorded the configuration of the secondary ion optics should be reported, including the use and settings of contrast apertures, energy resolving slits, mass resolution, and so forth. All information regarding the condition of the mass spectrometer that influences the spatial resolution of the image should be reported.

6.2.1 *Camera Based Systems*—Camera-based systems image photons that are produced from the impact of ions onto an appropriate conversion device. In many cases, the secondary ion image is visualized via ion-to-electron conversion at a micro-channel plate placed in front of a fluorescent screen.[4] The image resolution (typically 0.5 to 1 μm) depends on the configuration of the ion optics and the energy and angular distribution of the sputtered ions. The ion image is recorded from the fluorescent screen by a variety of camera systems, including but not limited to vidicon cameras, intensified cameras such as the SIT camera, charge-coupled device (CCD) cameras and slow-scan scientific grade CCD cameras. The design of the micro-channel plate assembly and camera system

[1] This practice is under the jurisdiction of ASTM Committee E42 on Surface Analysis and is the direct responsibility of Subcommittee E42.06 on SIMS.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Lapareur, M., *Rev. Tech. Thomson-CSF*, Vol 12, No. 1, 1980, p. 225.

used will define the sensitivity and dynamic range of the acquired images. Minimum parameters to be specified in addition to that stated in Practice E1504 should include the integration time for each mass, number of pixels in the image, field-of-view, and the number of bits used to digitize the image. A description of the micro-channel plate assembly (or other ion-to-photon conversion device) used should be stated (that is, for micro-channel plates: single, double, curved, and so forth, and for photon conversion: phosphor plate, scintillator, and so forth). Information pertinent to the operation of the camera or image acquisition system should also be specified. This could include manufacturer and model number and the use of any accessory or auxiliary equipment that would affect the acquisition or display of an image. If long integration times are used information about the dark-current should be specified in a statistically meaningful way (that is, bits/pixel/sec along with a standard deviation). Any non-standard modifications made to the equipment should be described in detail.

6.2.2 *Position-Sensitive, Pulse-Counting Detectors*—A position-sensitive pulse-counting detector produces single electrical pulses for each incident ion. In addition to the detection of the ions, the position of the ion impact is able to be determined by some method. An example of such a detector is the resistive anode encoder (RAE), which consists of a double channel plate array followed by a resistive anode. Secondary ions that impact the front of the micro-channel plate produce electrons that strike the resistive anode. The position of the centroid of each electron-pulse is calculated from the quantity of charge collected at each of four electrodes placed at the corners of the anode. Many of the parameters reported for RAE-acquired images should be the same as those listed above for camera-based systems. The dead-time of the position-sensitive pulse-counting detector should be specified, in addition the nature of the dead-time correction should be specified (that is, whether the count rate affects the entire detector or just single pixels). It is also important to report whether a static or rastered primary beam was used. If a rastered beam was used, the size of the beam relative to the raster size will affect the count rate at which dead-time effects become significant.

6.3 *Experimental Conditions for Acquisition of Scanning Ion Images*—The spatial resolution of scanning ion images depends only on the size of the primary beam on the sample surface. The primary ion beam may be pulsed, or continuous, depending upon the mass spectrometer used. Continuous primary beams are typically used with quadrupole and magnetic sector instruments, and modulated primary beams are used with time-of-flight SIMS instruments. Experimental parameters to be reported are similar to those used for camera-based systems. In addition, the approximate primary beam size, the method by which it was determined, the scan frequency (or dwell time per pixel), the intrapixel sequence of the scan (interlaced, random, flyback, and so forth), the type of secondary ion detector, and the degree of electronic gating used shall also be reported. For time-of-flight (TOF) analysis, details of the pulsing should be described (that is, pulse width, repetition rate, extent of beam bunching, and so forth). In addition, any special alignment or tuning of the primary column should be specified or referenced.

6.4 *Display of Ion Image Data:*

6.4.1 *False Color or Gray-Scale Image Display*—Secondary ion images are often displayed via a look-up table (LUT) representation that codes a range of pixel intensities with a given color or gray level. This LUT should be visible in the image (particularly with the use of pseudo color displays) and the numerical values, or scale (secondary ion counts or pixel intensities) for the different colors should be specified. The field-of-view of the image, the mass or mass range of the analyzed species, and the image acquisition time (or the primary ion dose in ions/cm^2) should be visible in the image or stated in the image caption.

6.4.2 *Image Processing*—Any image processing performed on the reported data should be specified. If the processing algorithm is commonly used then the method used must be stated and a reference given. If a novel processing method has been employed then the mathematics of the transform must be specified. This must include any processing performed to remove imaging artifacts. For example, when using camera-based systems, it is common practice to divide the analytical image by a uniformly illuminated reference to remove the influence of spatial variation in the response of the imaging system.

6.4.3 *Quantitative Imaging*—If a concentration scale is generated for the image, the full quantitative imaging procedure should be specified. This includes the preparation and characterization of imaging standards and the calibration and characterization of the detector system response. If the image contains pixels with few or no counts, or if negative counts could be assigned to pixels then the method with which these are treated must be stated (that is, are negative pixel values set to zero? Are computed ratios where zero would be in the denominator set to zero?). In addition, some indication should be presented as to the uncertainty that should be ascribed to pixel values in the quantitative image.

7. Keywords

7.1 imaging; secondary ion mass spectrometry