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Microbeam analysis — Scanning electron microscopy — Tagged image file format for scanning electron microscopy(TIFF/SEM)

PROOF/ÉPREUVE

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 202, *Microbeam analysis*, Subcommittee SC 4, *Scanning electron microscopy (SEM)*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Storing an image file as a TIFF (tagged image file format) does not reduce the quality of an image because the image is either not compressed or is compressed using a lossless compression algorithm. A format such as JPEG, which optimises the degree of compression at the expense of reducing some image fidelity, is not recommended, since the necessary information, such as the contrast in a scanning electron microscopy (SEM) image, is changed during compression of the image. Moreover, TIFF is able to embed many kinds of information as "tags" in the image file. Therefore, conditions when acquiring the SEM image (accelerating voltage or magnification or others) can be added.

The purpose in developing this document is to prevent SEM users, who own SEMs from different vendors, from losing the SEM conditional information from when an image is taken, and to standardize what kinds of information must be included in a single SEM image file independently of the make or model of the instrument or detector used to collect the image. The format is based on *TIFF Revision 6.0 Final*[3]. It aims to prevent original image data, including the date when the image was taken, from being overwritten whenever the original image data is processed. This document also explains how related images, such as montage images, sequential images of focused ion beam or microtome cross-sectioning and energy dispersive spectrum mapping images, can be labelled in a TIFF/SEM file.

In this document, new tags are defined to encode image data features which are not included in *TIFF Revision 6.0 Final* as private tags. These new tags conform to the practices specified in *TIFF Revision 6.0 Final*. They have been chosen so as not to overlap with the fields of TIFF/EP (see ISO 12234-2)[1], TIFF/IT (see ISO 12639)[2] or the EXIF (*Exchangeable Image File Format for Digital Still Cameras*)[4].

Microbeam analysis — Scanning electron microscopy — Tagged image file format for scanning electron microscopy(TIFF/SEM)

1 Scope

This document specifies the data file format of digital images generated by a scanning electron microscope (SEM) by adapting the TIFF-based format. The data file includes not only the image data but the SEM conditional information defined in this format. This document does not address the security of the data file.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22493, *Microbeam analysis — Scanning electron microscopy — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22493 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
TIFF/SEM tags
tags described in 5.6 to 5.14 which are commonly used parameters in SEM

3.2
TIFF/SEM file
TIFF file taken by a SEM and saved using the structure shown in Figure 2

3.3
TIFF 6.0
specification defined in *TIFF Revision 6.0 Final*[3]

3.4
EXIF format
specification defined in *Exchangeable Image File Format for Digital Still Cameras*[4]

4 Image data features

4.1 TIFF file encoding structure

The TIFF/SEM header is exactly the same as the TIFF header as indicated in *TIFF Revision 6.0 Final*: 1992, Clause 2, and the structure is shown in Figure 1. It should be noted that Type "II" (0x4949, little-endian) is mandatory for "Byte Order" in a TIFF/SEM file.

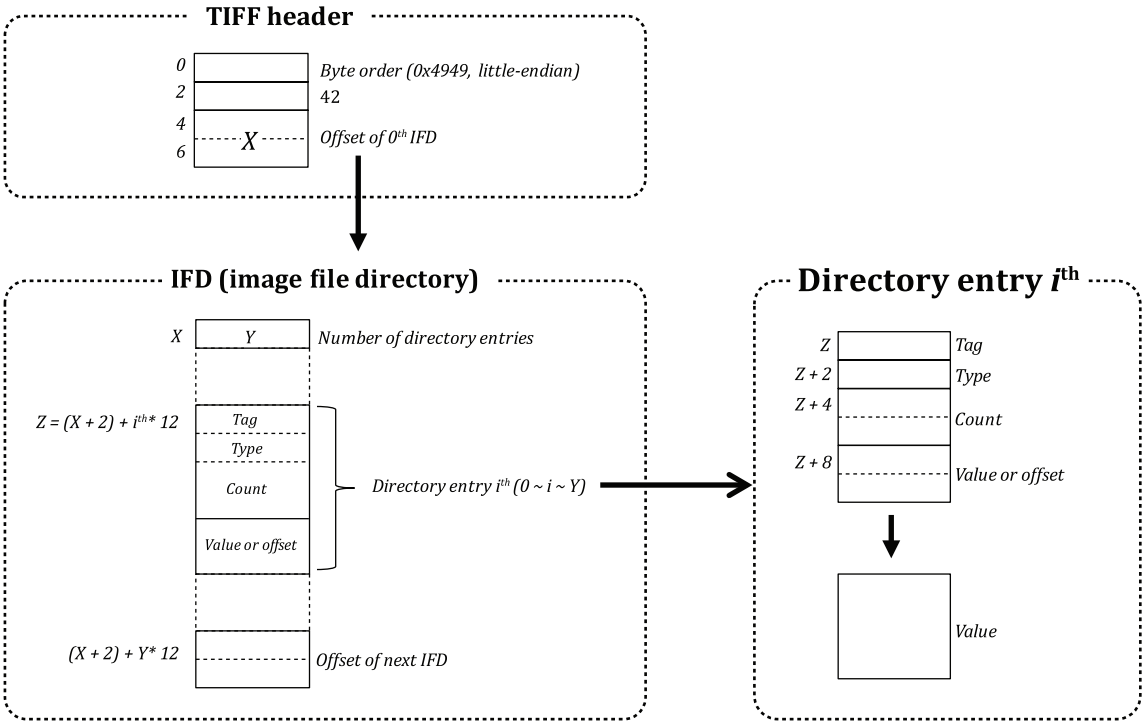

Figure 1 — TIFF file structure

The following subclause describes image file directories (IFDs) for TIFF/SEM in more detail.

4.2 TIFF/SEM file encoding structure

Tags for the TIFF/SEM are identified in the "ToSEMStdIFD" tag-field as shown in Figure 2. In this field, each SEM manufacturer can include SEM specific tags. TIFF/SEM tags are not mandatory in the TIFF/SEM file, unless otherwise stipulated in the tag's specification.

There are some informative parameters that SEM manufacturers might not want to show to rival SEM manufacturers and/or SEM users. SEM manufacturers can define their own tags, not listed in 5.6 to 5.14, related to such parameters. These parameters can be recorded in the "ToSEMMakerNotesIFD" tag-field as shown in Figure 2.

Software using the TIFF/SEM file format shall not overwrite original image data. The "ToProcessedImageIFD" tag gives an offset to store processed image data without losing the original image data. This tag is unique to the TIFF/SEM file format specification; therefore, if users process images using software not conforming to the TIFF/SEM format, original images may be lost. Software conforming with the TIFF/SEM format shall provide an appropriate viewer or an image-processing software which can extract and display both the original and processed images.

SEM specific tags listed from 5.6 onwards are commonly used parameters in SEM. Tags which are not listed but become useful can be added, or existing tags that are no longer useful deleted, in later revisions of the document.

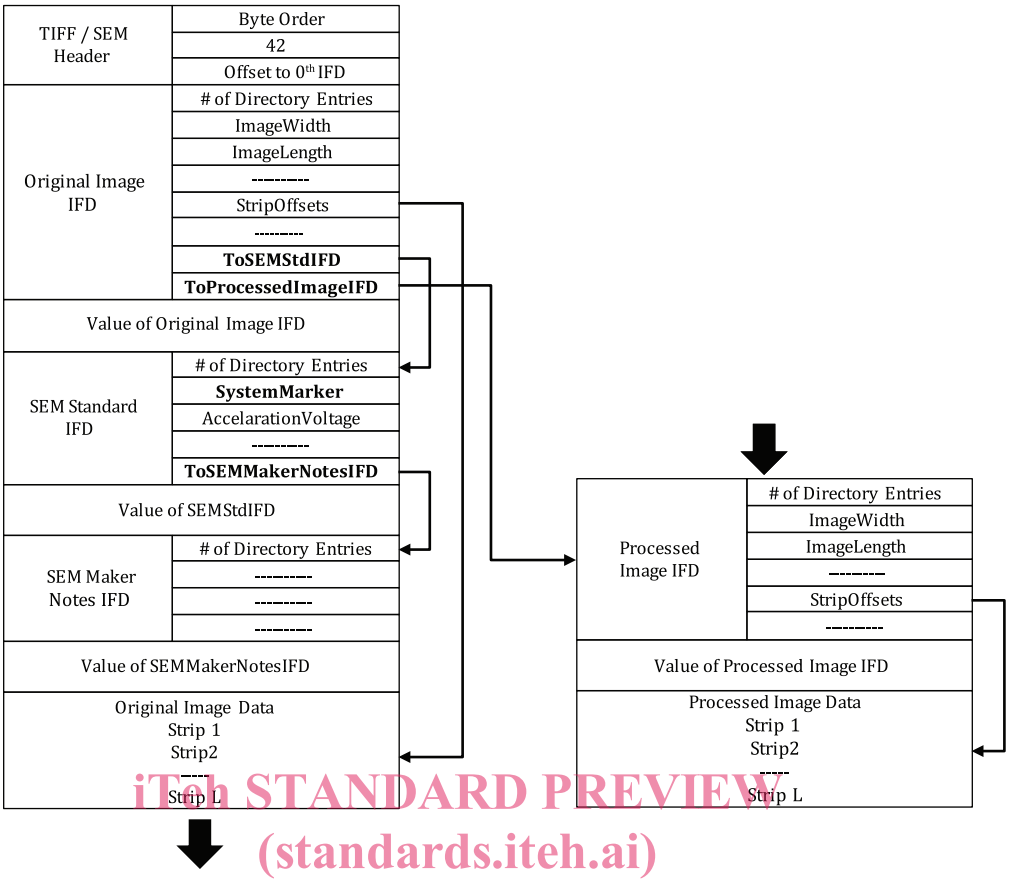

Figure 2 — TIFF/SEM file structure

The following subclauses describe image file tags for TIFF/SEM in more detail. A list of TIFF/SEM and an example of TIFF/SEM are summarized in Annex A and Annex B, respectively.

5 TIFF/SEM tag definitions

5.1 Basic tags in TIFF 6.0

These are required tags for grayscale images generally used in SEM images. These are indicated in TIFF 6.0.

5.2 Usable tags in TIFF 6.0

Some useful tags have been defined in TIFF 6.0. Those tags listed below in TIFF 6.0 can be labelled in files that are saved as the TIFF/SEM. Detailed descriptions are indicated in TIFF 6.0. Tags listed below are also summarized in Annex A.

Tag number	Tag name	Type	Count	Value
271 (0x010F)	Make	ASCII	any	VALUE or OFFSET
272 (0x0110)	Model	ASCII	any	VALUE or OFFSET
305 (0x0131)	Software	ASCII	any	VALUE or OFFSET
306 (0x0132)	DateTime	ASCII	20 "YYYY:MM:DD HH:MM:SS" in 24 h	OFFSET
33432 (0x8298)	Copyright	ASCII	For example, "Copyright, [company or person name], 20xx. All rights reserved."	OFFSET

5.3 Usable tags in EXIF format

Some useful private tags have been defined and standardized in EXIF format used in digital still cameras. Those listed below as the private tags in EXIF format can be labelled in files that are saved in the TIFF/SEM format. Detailed descriptions are indicated in EXIF format. Tags listed below are also summarized in Annex A.

Tag number	Tag name	Type	Count	Value
36867 (0x9003)	DateTimeOriginal	ASCII	20 "YYYY:MM:DD HH:MM:SS" in 24 hours	OFFSET
36868(0x9004)	DateTimeDigitized	ASCII	20 "YYYY:MM:DD HH:MM:SS" in 24 hours	OFFSET
37510(0x9286)	UserComment	UNDEFINED	N	OFFSET

5.4 Offset pointers defined as TIFF/SEM tags

5.4.1 General

Offset pointers are used to specify the area if the file where the TIFF/SEM tags, any SEM manufacturers' private information, and/or information any processing carried out on the image are stored. Tags defined in this subclause are summarized in Annex A.

5.4.2 ToSEMStdIFD

This mandatory tag encodes an offset to the TIFF/SEM standard IFD. The information of tags listed from 5.5 onwards is included in the field where the offset pointer specifies.

Tag Name = **ToSEMStdIFD**

Tag = 65000(0xFDE8)

Type = LONG

$N = 1$

Value = VALUE

5.4.3 ToSEMMakerNotesIFD

Offset to the TIFF/SEM maker notes IFD. Each manufacturer can set their own private tags in this field which they are not willing to show to the public but may wish users to have access to.

Tag Name = **ToSEMMakerNotesIFD**

Tag = 65001(0xFDE9)

Type = LONG

N = 1

Value = VALUE

5.4.4 ToProcessedImageIFD

Offset to the processed image IFD. Digitally processed image data shall be stored after the offset point provided by "ToProcessedImageIFD", in order to not overwrite the original image data. Software conforming to the TIFF/SEM format shall not overwrite original image data. Multiple processed images can be stored by assigning multiple offset values.

Tag Name = **ToProcessedImageIFD**

Tag = 65002(0xFDEA)

Type = LONG

N = 1

Value = VALUE

5.5 System marker tag

5.5.1 General

A unified image file format for other kinds of microscopes may be proposed in the future. To provide for such future development, a system marker tag is defined here. It is mandatory to include this tag in the data file. Tags defined in this subclause are summarized in Annex A.

5.5.2 SystemMarker

The value on TIFF/SEM is "SEM".

Tag Name = **SystemMarker**

Tag = 65003(0xFDEB)

Type = ASCII

N = 1

Value = "SEM "

5.6 SEM basic information defined as TIFF/SEM tags

5.6.1 General

Tags defined in this subclause are summarized in Annex A.