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Microbeam analysis — Scanning electron microscopy — Method for evaluating critical dimensions by CD-SEM

Analyse par microfaisceaux — Méthode d'évaluation des dimensions critiques par CD-SEM

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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

Nanostructures need strict dimensional control to meet the demands of the semiconductor industry. Critical dimension (CD) is the minimum size of a feature on an integrated circuit that impacts the electrical properties of the device, whose value represents the level of complexity of manufacturing. At nanometer scale, measurement uncertainty control becomes more difficult with much smaller dimensions. A determination method with algorithm for accurate measurement is a key for CD valuation. CD-SEMs (critical dimension scanning electron microscopes) are one of the main tools for CD measurement in semiconductor manufacturing processes, where secondary electrons (SEs) are the signal source for CD-SEM imaging of surface structure. The CD-SEM image displays the structure geometry, but the image contrast is not a perfect representation of the structure morphology. The detected intensity linescan profile of SE signals carries the information about the sample shape and composition, beam size and shape and the information volume generated by the electron beam-solid interaction. Restricted by the physical mechanism in the processes of SE signal generation and emission, the SE signal profiles show an edge effect which leads to difficulty for accurate CD value determination with image contrast. A reliable CD determination method which bases on physical principle of SE signal emission is necessary.

Many factors, for example the specimen chemical composition, structural geometric parameters, beam conditions and other specimen/instrument factors (charging, vibration and drift), can affect CD-SEM image contrast and hence the CD measurement result. Topographic contrast in the SE mode is resulted from the enhanced SE emission from an edge as well as tilted local surface in relative to the incident beam. The quantitative description of contrast or SE intensity profile is crucial in CD metrology.

The physical mechanisms that dominate quantitative measurements by CD-SEM have been well understood. The CD determination algorithm is based on physical modelling of SE generation and emission and gives adequate consideration of the influence of various experimental factors during electron beam-specimen interaction. This document employs the model-based library (MBL) method for accurate CD determination by CD-SEM. MBL is superior to simpler, unsophisticated, arbitrary methods that disregard the physics of signal generation, and report only a meagre number, potentially with unacceptably high bias. MBL uses the whole waveform of the signal, so it can provide results with less bias and better size and shape accuracy. Once the library is set up, there is essentially no time penalty for using MBL. Construction of MBL is done with a Monte Carlo (MC) simulator which is considered as an excellent approach to take into account of every possible physical factor that may affect signal intensity and shape of linescan profiles. The library generation can be sped up tremendously by suitable multicore computing environment and MC software that is optimized for a specific measurand. Such obtained MBL relates the measured signal linescan profiles to both specimen parameters and instrumental parameters. The library database is consisted of the simulated SE linescan profiles, having a one-to-one correspondence to a specified value of parameter set. By matching the shape of SE linescan profile taking from a measured CD-SEM image with those simulated beforehand and stored in a MBL database, the best fitted CD values used in MC modelling are selected.

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1 Scope

This document specifies the structure model with related parameters, file format and fitting procedure for characterizing critical dimension (CD) values for wafer and photomask by imaging with a critical dimension scanning electron microscope (CD-SEM) by the model-based library (MBL) method. The method is applicable to linewidth determination for specimen, such as, gate on wafer, photomask, single isolated or dense line feature pattern down to size of 10 nm.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
critical dimension
CD
<for a line> minimum geometrical feature size limited by the photolithography technology used for the fabrication process

3.2
CD metrology
measurement of the width of line and space for a trapezoidal line structure model

Note 1 to entry: Extended CD metrology includes the measurement of top CD, middle CD, bottom CD, height, sidewall angle, top rounding and foot rounding. Figure 1 shows schematically the definition of CDs.

Note 2 to entry: The term “top rounding” indicates a circular arc at the top corner, which is tangent to the top surface and side surface of a trapezoidal line, and whose value is represented by the circular radius.

Note 3 to entry: The term “foot rounding” indicates a circular arc at the bottom corner, which is tangent to the bottom surface and side surface of a trapezoidal line, and whose value is represented by the circular radius.

Note 4 to entry: More frequently CD represents the size of a feature on an integrated circuit or transistor that impacts the electrical properties of the device.

Note 5 to entry: Top rounding and foot rounding are not designed parameters.

