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

微束分析 扫描电子显微术 CD-SEM评定关键尺寸的方法

(English Translation)

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Foreword

This document complies with the provisions of GB/T 1.1-2020 "Standardization Work Guidelines Part 1: Structure and Drafting Rules of Standardization Documents".

Drafting.

This document is equivalent to ISO 21466:2019 "Microbeam analysis scanning electron microscopy (CD-SEM) method for assessing critical dimensions".

Please note that some content in this document may involve patents. The issuing organization of this document assumes no responsibility for identifying patents.

This document was proposed and is under the jurisdiction of the National Technical Committee on Standardization of Microbeam Analysis (SAC/TC38).

Introduction

Nanostructures require stringent dimensional control to meet the demands of the semiconductor industry. Critical Dimension (CD) is crucial for integration.

The smallest geometric feature size in a circuit that affects the electrical properties of a device; its value represents the level of manufacturing complexity. At the nanoscale, as the size increases...

As the dimensions become smaller, controlling measurement uncertainty becomes more difficult. Developing an algorithm-based measurement technique is crucial for accurately assessing critical dimensions.

Important. The length-measuring scanning electron microscope (CD-SEM) is one of the main tools used for CD measurement in the semiconductor manufacturing process, in which secondary...

Electrons (SE) are the signal source for CD-SEM surface structure imaging. CD-SEM images reveal the geometric features of the structure, but image contrast is not...

It cannot perfectly represent the morphology of the structure. The detected SE signal intensity line scan curve contains information about the sample shape and composition, and the electron beam spot.

Size and shape, as well as information generated by electron beam-solid interaction. Limited by the physical mechanisms of SE signal generation and emission.

Edge effects appear on the SE signal intensity curve, making it difficult to accurately determine the CD value based on image contrast. A reliable SE-based...

The CD determination method based on the physical principles of the launch is necessary.

Many factors, such as the chemical composition of the sample, structural geometry parameters, electron beam conditions, and other sample/instrument factors (charge, vibration, and drift), are considered.

All factors can affect the contrast of CD-SEM images, thus affecting the CD measurement results. In SE mode, topographic contrast is determined by the edges and their relative position to the image.

This is due to the enhanced emission of electrons (SE) from a localized surface where the incident beam is tilted. A quantitative description of the contrast or SE intensity curve is crucial in CD measurements.

Crucially, the physical mechanisms underlying quantitative measurements based on CD-SEM have been thoroughly understood. The CD measurement algorithm is based on SE generation.

This document presents a physical model of the emission process and fully considers the influence of various experimental factors during the interaction between the electron beam and the sample.

A Model Database (MBL) approach was used for CD-SEM-based CD assessment. This approach offers advantages over simpler, less refined, and arbitrary methods.

MBL (Meanwhile, the MBL method has an advantage because these methods often ignore the physical mechanisms of signal generation, provide only limited data, and may be accompanied by [unspecified issues].

Unacceptably high deviation. The MBL method utilizes the complete waveform of the signal, thus providing smaller deviations and greater accuracy in size and shape.

High measurement results. Once the database is established, using the MBL method actually incurs no additional time cost. The structure of MBL...

The system relies on a Monte Carlo (MC) simulator, which is widely recognized for its ability to fully account for all possible factors affecting signal strength and line scan curves.

An excellent method for determining the physical factors of line shape. Through a suitable multi-core computing environment and MC software optimized for specific measurement needs, it is possible to...

This greatly accelerates library generation. The obtained MBL can correlate the line scan curve of the measurement signal with the parameters of the sample and the instrument.

Come on. This database contains simulated SE line scan curves, each curve corresponding one-to-one with a specific set of parameter values. By conducting actual measurements...

The SE line scan curve extracted from the CD-SEM image is matched with a pre-simulated curve stored in the MBL database, and the curve is selected from the ones in the CD-SEM

image.

The best-fit CD value used in MC modeling is used to obtain the evaluated CD value.

Microbeam analysis scanning electron microscopy Methods for assessing critical dimensions using CD-SEM

1 Scope

This document specifies a method for measuring wafers and their properties using a model database (MBL) approach via length measurement scanning electron microscopy (CD-SEM) imaging.

The structural model, relevant parameters, file format, and fitting procedure required for the critical dimension (CD) values of a photomask.

This document applies to linewidth determination of samples, such as gates, photomasks, and single isolated or densely packed line feature patterns on wafers, with a minimum...

Reaching 10nm.

2 Normative references

This document has no normative references.

3 Terms and Definitions

The following terms and definitions apply to this document.

Critical dimension; CD the minimum geometric feature size limited by photolithography technology in the manufacturing process of lines.

CD Measurement CDmetrology Measurement of line width and spacing dimensions of trapezoidal line structure model.

Note 1: Extended critical dimension measurements include measurements of the top CD, middle CD, bottom CD, height, side corners, top arc, and bottom arc. Figure 1 illustrates the critical dimension definitions.

A schematic diagram.

Note 2: The term "apex arc" refers to the arc at the vertex, which is tangent to the top and side surfaces of the trapezoid, and its value is expressed by the radius of the arc.

Note 3: The term "bottom arc" refers to the arc of the bottom angle, which is tangent to the bottom and side surfaces of the trapezoid, and its value is expressed by the radius of the arc.

Note 4: More commonly, the critical dimension represents the size of a feature on an integrated circuit or transistor that affects the electrical performance of the device.