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**Nanotechnology - Carbon nanotube probe scanning
microscopy - Measurement of high aspect ratio micro-nano
structures**

(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.

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 by the Chinese Academy of Sciences.

This document is under the jurisdiction of the National Technical Committee on Standardization of Nanotechnology (SAC/TC 279).

Introduction

High aspect ratio micro/nano structures are typical structures in current advanced semiconductor chips, characterized by small critical dimensions and large depth-to-width or

depth-to-diameter ratios.

The three-dimensional morphology is complex, making measurement difficult. Scanning probe microscopy utilizes a probe to reciprocate across the sample surface, measuring the distance between the probe and the sample surface.

Measurements are performed using mechanical, electromagnetic, or chemical forces, and are widely applied in nanotechnology, materials science, and mechatronics engineering. They are used in micro/nanostructures.

Force is used to obtain the morphological characteristics of the sample surface.

However, traditional atomic force microscope probes have a small aspect ratio and a triangular pyramidal tip, limiting their measurement resolution due to the geometry of the tip.

The current morphology is insufficient to meet the measurement requirements of micro/nano structures with large aspect ratios. Carbon nanotubes are typical one-dimensional nanomaterials with large aspect ratio morphology.

Characterized by excellent mechanical properties. Combining carbon nanotubes with conventional scanning probes, such as those at the tip of a conventional atomic force microscope probe, via physical or...

A carbon nanotube is assembled using chemical methods. This carbon nanotube is then used to scan samples in place of the traditional atomic force microscope probe tip, enabling precise scanning.

The three-dimensional morphology of high aspect ratio micro/nano structures was measured. The application of this type of probe in advanced process chip inspection will accelerate semiconductor chip manufacturing.

Technological development.

Nanotechnology. Carbon nanotube probe scanning microscopy Measurement of high aspect ratio micro/nano structures

1 Scope

This document describes a method for measuring high aspect ratio micro/nano structures using carbon nanotube probes, including the basic principles, testing conditions, and required parameters.

The equipment and other specifications define the parameter range of the carbon nanotube probe and the requirements for the sample, and establish the measurement procedure.

This document applies to hard samples with aspect ratios ranging from 1 to 10, and micro/nano junctions with a minimum horizontal linewidth not less than twice the diameter

of carbon nanotubes.

For structural measurements, of other samples should be performed using the same method.

2 Normative references

The contents of the following documents, through normative references within the text, constitute essential provisions of this document. Dated citations are listed below.

For references to documents, only the version corresponding to that date applies to this document; for undated references, the latest version (including all amendments) applies.

document.

GB/T 42659-2023 Surface Chemical Analysis - Scanning Probe Microscopy. Determination of Geometric Quantities Using Scanning Probe Microscopy.

3 Terms and Definitions

The following terms and definitions apply to this document.

carbon nanotubes

Nanomaterials with tubular structures are classified into single-walled carbon nanotubes (single-layer carbon atoms) and double-walled carbon nanotubes based on the number of carbon atom layers in the tube walls.

Rice nanotubes (two layers of carbon atoms) and multi-walled carbon nanotubes (three or more layers of carbon atoms).

[Source. GB/T 26826-2011, 3.1]

4 Abbreviations

The following abbreviations apply to this document.

AFM. Atomic Force Microscope CNT. Carbon Nanotube SEM. Scanning Electron Microscope

5.1 CNT probe structural characteristics

As shown in Figures 1a) and 1b), a traditional AFM probe mainly consists of a base, a microcantilever beam, and a tip. The base portion achieves...

Probe clamping. The microcantilever beam is approximately 100 µm to 500 µm in length and 500 nm to 5 µm in thickness, typically made of silicon or silicon nitride.

Complete. The tip of the microcantilever is a needle used for scanning the sample surface.

Traditional AFM probes have a triangular pyramidal sidewall structure at the tip.