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Evaluation of thickness, density and interface width of thin films by X-ray reflectometry -- Instrumental requirements, alignment and positioning, data collection, data analysis and reporting

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Foreword

This standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This standard uses the translation method equivalent to the use of ISO 16413.2013 "X-ray reflectometry measurement of film thickness, density and interface width

Instrument requirements, alignment and positioning, data acquisition, data analysis and reporting."

Introduction

X-ray reflectometry (XRR) can be widely used to measure thickness on flat substrates at the appropriate wavelengths of thin films, devices and X-rays

Thicknesses, densities, and interface widths of single and multi-layer films between about 1 nm and 1 μm. Interface width is a general term, usually

It refers to the interface or surface roughness and/or the density gradient across the interface. In the X-ray irradiation range, the sample is required to be laterally uniform. Usually, the table

The information on the amount of material provided by the facet chemistry analysis method needs to be converted to estimate the thickness. In contrast, XRR can provide direct traceability to long

Degrees of thickness. XRR is a powerful film thickness measurement method and is traceable to SI units.

Chapter 3 describes the main requirements for equipment that is suitable for acquiring high-quality specular X-ray reflectivity data, as well as useful and accurate

Make sure the required sample collimation and positioning requirements are measured.

Chapter 4 describes the main contents of data acquisition. Its purpose is to obtain high

quality specular X-ray reflectivity data and its application.

For data processing and modeling. Traditional data acquisition is performed in a single measurement with direct data input. However, recent data

Acquisition is usually performed by commanding the instrument for multiple measurements. In addition to the operating mode, if there is a software program that controls the instrument, it can also pass

Dynamic test scripts to collect data.

Chapter 5 describes the basic principles for analyzing specular XRR data for obtaining meaningful information about samples of physical significance. Although the mirror

The XRR fitting process is complicated, but can be carried out to a certain degree and the user's clear simplification on the premise of ensuring quality. There are many patents or non-professional

Lee's XRR data simulation and fitting software packages, their theoretical and algorithmic descriptions are outside the scope of this standard. In the right place

Will provide some references for interested readers.

Chapter 6 lists the information required to report on the XRR experiment and makes a brief description of possible ways to present XRR data and results.

To sum up. When more than one method is available, propose the preferred method.

This standard is not a textbook. It is a standard for conducting XRR measurement and analysis. Technical explanations are available

Appropriate references [eg. "X-RayMetrologyinSemiconductor" by D. Keith Bowen and Brian K. Tanner

Manufacturing (X-ray metrology in semiconductor manufacturing)", Taylor and Francis, London (2006); by M. Tolan

"X-ray Reflectivity from SoftMatterThin Films", SpringerTractsin

ModernPhysicsvol.148 (1999); U. Pietsch, V.Holy, and T.Baumbach co-authored "HighResolutionX-Ray

ScatteringfromThinFilmstoLateralNanostructures (High Resolution X-ray Scattering from Thin Films to Horizontal Nanostructures

(Injection)", Springer (2004); J.Dailant and A.Gibaud, co-author of "X-rayandNeutronReflectivity. Principlesand

Applications (X-Ray and Neutron Reflection. Principles and Applications), Springer (2009)].

This standard does not consider the safety aspects related to the use of X-ray equipment.

In the measurement process, compliance with relevant laws and regulations related to safety

The program is the responsibility of the user.

X-ray reflectometry measures the thickness of the film,

Density and interface width instrument requirements, collimation and positioning,

Data Acquisition, Data Analysis and Reporting

1 Scope

This standard specifies that X-ray reflectometry (XRR) is used to measure single-planar substrates with thicknesses between approximately 1 nm and 1 μm.

Thickness, density, and interface width of layers and multilayers.

The method uses monochromatic parallel light for angle or scattering vector scanning. Similar considerations apply to using distributed detectors

The case of converging beams or scanning wavelengths for parallel data acquisition is not described in this standard. For X-ray diffuse reflectance

In terms of surgery, the experimental requirements are similar, but this standard does not include this part.

Measurements can be performed on devices with different configurations. These devices include laboratory instruments, reflectometers on synchrotron beam lines

And industrial automation systems.

It should be noted that, during data acquisition, the possible instability of the film will cause the accuracy of the measurement results to decrease. XRR single use

The incident X-ray beam at a wavelength does not provide the chemical information of the film, so care should be taken that the surface of the sample may be contaminated or reacted. Surface change

Chemicals can seriously affect the accuracy of the outermost film measurements.

2.1 Terms and Definitions

The following terms and definitions apply to this document.

2.1.1

Incidence angle

The angle between the incident beam and the sample surface.

2.1.2

Critical angle criticalangle

Thetac

The angle between the incident beam and the surface of the sample. Below this angle, the X-rays undergo total reflection of the surface, above which x-rays penetrate.

Below the sample surface.

Note. The critical angle of the known sample material or structure can be obtained by simulation software or the approximate formula thetac ~ 2delta, where 1-delta is a complex X-ray refraction.

The real part of the rate n=1-delta-ibeta.

2.1.3

Sample length specimenlength

The sample size at the incident and reflected X-ray planes and in the sample plane.

2.1.4

Sample width specimenwidth

The sample size perpendicular to the incident and reflected X-ray planes and in the sample plane.