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**Instrumented nanoindentation test - Indentation hardness and  
modulus of thin films**

仪器化纳米压入试验方法 薄膜的压入硬度和弹性模量

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## Table of Contents

- 1 Scope
- 2 Normative references
- 3 Terms and definitions, symbols
  - 3.1 Terms and Definitions
  - 3.2 Symbols and names GB/T 22458-2008 of
- 4 Test principle
- 6 Test Procedure
- 7 Analysis 5
- 9 Test report Reference

## Foreword

Please note that some of the content of this standard may involve patents. The standard release mechanism should not bear the responsibility to identify these patents. This standard was proposed by the Chinese Academy of Sciences. This standard by the National Standardization Technical Committee of nano technology (SAC/TC279) centralized. This standard was drafted. Baoshan Co., Mechanics Institute of Iron and Steel. The main drafters of this standard. Xiu-Fang Wang, Zhang Taihua, Song Hongwei, Yang Xiaoping, Yang Rong, Huan Yong.

Measurement of hardness and elastic modulus of the film is often used as a means to control its quality. For the film micro/nano-scale, often using Compliance Test Method Hardness is difficult to measure accurately the hardness and elastic modulus can not be measured. In recent years, instrumented nanoindentation technology development Quickly becoming one of the most important test methods for characterizing nano-mechanics field, for the determination of hardness and elastic modulus of the film provides a Effective means. When the use of instrumented nanoindentation hardness and elastic modulus Determination of the film, in addition to being the instrument, the environment, methods and testers And so on a number of factors, but also may be affected by the sample itself, such as substrate support film, the film and the substrate matching relations. related How to eliminate the influence of factors such as the instrument and select the appropriate test conditions instrumented nanoindentation test, "GB/T 22458-2008 Instrumented nanoindentation test methods Law "the relevant provisions, has done a detailed provisions. The main purpose of this standard is to provide as much as possible Pressure can exclude the impact of the base film of the hardness and elastic modulus of the test method. Instrumented nanoindentation test methods Film indentation hardness and elastic modulus

## 1 Scope

China's national method for measuring the indentation hardness and the elastic modulus of a thin film by instrumented nanoindentation - the technique that made it possible to measure the mechanical properties of a coating without stripping it off the part, and which underlies the qualification of hard coatings on tools, of the layers in a semiconductor stack and of the films on optical and magnetic media. The standard specifies the test method for determining the indentation hardness and the elastic modulus of thin films by instrumented nanoindentation. It applies to the films attached to a solid substrate, with the indentation made normal to the surface of the specimen and the indentation depth usually of the order of nanometres, although the method can be extended to a few micrometres. In an instrumented indentation the load and the displacement are recorded continuously as the indenter is pushed in and withdrawn, and the hardness and the modulus are extracted from the loading and unloading curves rather than from the size of a residual impression - which is what makes the measurement possible at all at these depths, since an impression that small cannot be reliably imaged. The whole difficulty is that on a thin film the answer is contaminated by the substrate: push in too far and the property measured is a mixture of film and substrate, push in too little and the result is dominated by the surface roughness, the oxide, and the imperfect tip of the indenter. The standard therefore sets the requirements on the specimen and its surface, the calibration of the frame compliance and of the indenter area function, the ratio of indentation depth to film thickness that must be respected, the loading schedule and the hold that allows the creep to be separated, and the analysis by which the contact stiffness and contact area, and from them the hardness and the modulus, are obtained. It sits on the general instrumented nanoindentation method of GB/T 22458-2008 and on the coating provisions of GB/T 21838.4-2008. Issued on 10 January 2011 and in force since 1 May 2011.

This standard specifies the test film indentation hardness and elastic modulus of instrumented nanoindentation test methods. This standard applies to the solid surface attached to the film. Pressed into the direction perpendicular to the direction of the sample surface, the indentation depth range is usually satisfied M order of magnitude, but also can be extended to a few microns.

## 2 Normative references

The following documents for the application of this document is essential. For dated references, only the dated version suitable for use herein Member. For undated references, the latest edition (including any amendments) applies to this document.

GB/T 22458-2008 instrumented nanoindentation General test method GB/T Instrumented indentation test - Part 4 21838.4-2008 metal material hardness and materials parameters. metal and nonmetal Test methods for coating layer ( ISO 14577-4.2007, MOD)

### 3.1 Terms and Definitions

GB/T 22458-2008 defined in

3.1 and the following terms and definitions apply to this standard.

3.1.1 Single stiffness measure single stiffness measurement Quasi-static loading obtained load - unload portion depth curve, determine the bonding material in a single maximum indentation depth at Contact stiffness measurement method.

3.1.2 Continuous stiffness measurement continuous stiffness measurement On the basis of the quasi-static loading superimposed a small dynamic alternating load to the same frequency alternating displacement due to keeping small Constant amplitude, measured alternating load and alternating displacement signal amplitude and phase, thereby determining the material during the loading phase with indentation depth change Measurement of continuous contact stiffness [1,2].

### 3.2 Symbols and names GB/T 22458-2008 of

3.2 symbols and names apply to this standard.

## 4 Test principle

4.1 nano stiffness measurement method based on a single indentation test to obtain the maximum penetration depth in the material at the hardness and elastic modulus Principle, see GB/T 22458-2008

4.1 and 4.2, Appendices C and G.

4.2 nano-based continuous stiffness measurement method indentation test to obtain hardness and elastic modulus of the material with the indentation depth curve The principle, see GB/T 22458-2008 Appendix H.