INTERNATIONAL STANDARD

ISO 22278

First edition
2020-08

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for crystalline quality of single-crystal thin film (wafer) using XRD method with parallel X-ray beam

Reference number
ISO 22278:2020(E)

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Published in Switzerland

Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

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

Single crystals are important in many applications ranging from synthetic gemstones for jewellery to hosts for solid-state lasers. For some applications, ceramic materials are prepared as single crystals. When used as substrates for thin film growth (such as gallium-on-sapphire technology or the growth of superconductor thin films) it is the crystalline perfection of a single crystal that is important. Wide bandgap semiconductors such as silicon carbide (SiC) and gallium nitride (GaN) have drawn a lot of attention in power applications due to their superior material properties such as high critical electric field resulting in a minimum of 10 times higher breakdown voltage or a 100 times smaller on-resistance than Si. These unique properties of SiC and GaN materials have made them promising candidates for future high-power, high-frequency semiconductor devices. In optical applications, such as the use of ruby and yttrium–aluminium–garnet (YAG) for laser hosts and quartz and sapphire for optical windows, single crystals are used to minimize scattering or absorption of energy. In piezoelectric materials, such as quartz, the optimum properties are obtained in single-domain single crystals. In addition, there are many other applications that require the optical, electrical, magnetic or mechanical properties of ceramic single crystals.

Substrate diameters for the single crystal have been steadily increasing since the commercial introduction of substrates in 1990 and crystal defects have been greatly reduced in the past 15 years. Commercial devices are available, but their widespread use will depend on the ability of growers to make large, inexpensive, defect-free materials available.

While various methods for measuring the defect of single-crystal thin films have been presented until now, the most typical method for measuring the crystalline quality (degree of average defect) of single-crystal thin films that have a wide area (e.g. 2 inches, 4 inches, 6 inches) is the X-ray diffraction (XRD) method with parallel X-ray beam. However, this method can easily create a great error margin as the result value is analysed to be very different depending on the measuring process and conditions of the user or the pre-treatment of samples, for example. A standard on universal measurement methods and conditions, therefore, is absolutely necessary.

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1 Scope

This document specifies the test method for measuring the crystalline quality of single-crystal thin film (wafer) using the XRD method with parallel X-ray beam. This document is applicable to all of the single-crystal thin film (wafer) as bulk or epitaxial layer structure.

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
single crystal
crystalline material having identical atomic arrangement on all areas of the material

3.2
off-cut angle
angle that a specific crystallographic orientation forms with surface in a single-crystal thin film (wafer)

Note 1 to entry: Off-cut angle is a key condition determining the growth behaviour of thin film during epitaxial growth on a single-crystal thin film (wafer).

3.3
chemical mechanical polishing
CMP
process to planarize the thin film surface using a combination of chemical action by a slurry composed of chemical liquid or abrasive particles and the mechanical action of a grinder

3.4
Bragg diffraction
width between the wavelength of light and the width of crystal structure, or relationship between the reflecting surface and the angle formed by the ray

Note 1 to entry: The formula is $2d \cdot \sin\theta = n \cdot \lambda$

where