

SEMI HB8-0217

TEST METHOD FOR DETERMINING ORIENTATION OF A SAPPHIRE SINGLE CRYSTAL

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NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

1.1 The purpose of this Standard is to standardize a test method for sapphire single crystal orientation measurement which includes sapphire cylinder, sapphire ingot, sapphire wafer, etc. It will improve the standardization of sapphire single crystal process from coring sapphire ingot, rolling cylindrical ingot to cutting wafer and provide solutions to improve sapphire products as well. Similar processes are defined in ASTM E82.

2 Scope

2.1 The test method of this Specification is X-ray diffraction orientation.

2.2 This Test Method is applied to determine the crystallographic orientation of a surface which is substantially parallel to the low index planes for sapphire single crystal materials.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 *ASTM® Standards*¹

ASTM E82 — Standard Test Method for Determining the Orientation of a Metal Crystal

3.2 *Other Documents*

Code of Federal Regulations, Title 10, Part 20, Standards for Protection Against Radiation

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 *Definitions*

4.1.1 *error* — the difference between the theoretical quality level and the level that could be received.

4.1.2 *ingot* — a cylinder or rectangular solid of polycrystalline or single crystal, generally of slightly irregular dimensions.

4.1.3 *Miller indices, of a crystallographic plane* — the smallest integers proportional to the reciprocals of the intercepts of the plane on the three crystal axes of unit length.

4.1.4 *orientation, of a single crystal surface* — the crystallographic plane, described in terms of its Miller indices, with which the surface is ideally coincident.

4.1.5 *prepared plane* — the plane to be tested.

4.1.6 *reference plane* — the theoretical plane from which deviations are measured.

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, <http://www.astm.org>. ASTM trademark is owned by ASTM International.

4.1.7 *sapphire* — single crystal aluminum oxide (Al_2O_3) having a definite orientation that allows epitaxial compound semiconductor deposition.

4.1.8 *surface normal* — in the three-dimensional case a surface normal, or simply normal, to a surface at a point P is a vector that is perpendicular to the tangent plane to that surface at P.

5 Hazards

5.1 It is of great importance to avoid personal exposure to X-ray.

5.1.1 Keep hands or fingers out of the path of X-ray and protect the eyes from scattered secondary radiation.

5.1.2 Use of commercial film badge or dosimeter service is recommended, together with periodic checks of the radiation level at the hand and body positions with a Geiger-Muller counter calibrated with a standard nuclear source.

5.2 The present maximum permissible dose for total body exposure of an individual to external X-radiation of quantum energy less than 3 MeV over an indefinite period is 1.25 R (3.22×10^{-4} C/kg) per calendar quarter (equivalent to 0.6 mR/h [1.5×10^{-7} C/kg·h]) as established in the Code of Federal Regulations, Title 10, Part 20. The present maximum permissible dose for hand and forearm exposure under the same conditions is 18.75 R (4.85×10^{-4} C/kg) per calendar quarter (equivalent to 9.3 mR/h [2.4×10^{-6} C/kg·h]).

6 Test Method

6.1 Summary of Test Method

6.1.1 Crystal orientation measurement is based on X-ray diffraction theory. Single crystal is made up of atoms arranged in three-dimensional periodic structure, which can be seen as formed by a series of parallel crystal planes with vertical distance d in Figure 1. When a bunch of parallel monochromatic X-rays incident on the crystal surface, diffraction (reflection) will occur provided that optical path difference of X-ray between adjacent crystal faces is an integer multiple n of the wavelength. By detecting the diffraction lines with the counter, single crystal orientation can be determined, as shown in Figure 1.

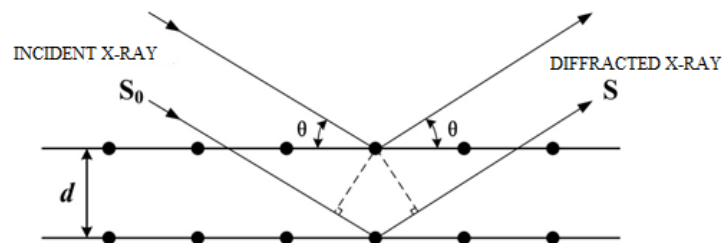


Figure 1
Geometrical Reflection Conditions for X-Rays from a Single Crystal

6.1.2 When θ , λ , d and n satisfy the following Bragg Equation 1 at the same time, X-ray diffraction intensity of the beam is maximized:

$$n\lambda = 2d\sin\theta \quad (1)$$

where:

θ = the angle between the incident beam and the reflecting planes (refer to Figure 1).

λ = the X-ray wavelength.

d = the interplanar spacing (refer to Figure 1).

n = the diffraction order.