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INTERNATIONAL STANDARD

Synthetic quartz crystal – Specifications and guidelines for use

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SYNTHETIC QUARTZ CRYSTAL –
SPECIFICATIONS AND GUIDELINES FOR USE

FOREWORD

International Standard IEC 60758 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

This fifth edition cancels and replaces the fourth edition, published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- order rearrangement and review of terms and definitions;
- abolition as a standard of the infrared absorbance coefficient $\alpha_{3\,410}$;
- addition of the α value measurement explanation by FT-IR equipment in annex;
- addition of the synthetic quartz crystal standards for optical applications.

The text of this standard is based on the following documents:

FDIS	Report on voting
49/1185/FDIS	49/1190/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The reason for adding synthetic quartz crystal for optical application to this International Standard is as follows.

Quartz crystal produced for optical applications is produced by many of the same suppliers manufacturing quartz for electronic applications. The equipment and methods to produce optical quartz are similar to those used in the production of electronic quartz. Also, with a few exceptions the characterization methods of electronic and optical material are similar. Therefore, IEC 60758 serves as the proper basis for including addenda related to quartz crystal for optical applications.

SYNTHETIC QUARTZ CRYSTAL – SPECIFICATIONS AND GUIDELINES FOR USE

1 Scope

This International Standard applies to synthetic quartz single crystals intended for manufacturing piezoelectric elements for frequency control, selection and optical applications.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60122-1:2002, *Quartz crystal units of assessed quality – Part 1: Generic specification*

IEC 60410*, Sampling plans and procedures for inspection by attributes*

IEC 61994 (all parts), *Piezoelectric and dielectric devices for frequency control and selection – Glossary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61994 and the following apply.

3.1
hydrothermal crystal growth
crystal growth in the presence of water, elevated temperatures and pressures by a crystal growth process believed to proceed geologically within the earth's crust

Note 1 to entry: The industrial synthetic quartz growth processes utilize alkaline water solutions confined within autoclaves at supercritical temperatures (330 °C to 400 °C) and pressures (700 to 2 000 atmospheres).

Note 2 to entry: The autoclave is divided into two chambers: the dissolving chamber, containing raw quartz chips at the higher temperature; the growing chamber, containing cut seeds at the lower temperature (see 7.1.2).

3.2
synthetic quartz crystal
single crystal of α quartz grown by the hydrothermal method

Note 1 to entry: Cultured quartz has the same meaning as synthetic quartz crystal.

3.3
as-grown synthetic quartz crystal
state of synthetic quartz crystal prior to grinding or cutting

3.4
as-grown Y-bar
crystals which are grown by using long stick seed in the Y-direction

3.5
as-grown Z-bar
crystals which are grown by using Z-cut seed

3.6
synthetic quartz crystal batch
synthetic quartz crystals grown at the same time in one autoclave

3.7
seed
rectangular parallelepiped quartz plate or bar to be used as a nucleus for crystal growth

3.8
growth zones
regions of a synthetic quartz crystal resulting from growth along different crystallographic directions

SEE: Figure 2.

3.9
orientation of a synthetic quartz crystal
orientation of the seed of a synthetic quartz crystal with respect to the orthogonal axes specified in 3.7

3.10
orthogonal axial system of α quartz crystal
orthogonal axis system consisting of three axes with a mutually vertical X axis, Y axis and Z axis as illustrated in Figure 1

Note 1 to entry: The z-cut seed may be oriented at an angle of less than 20°to the Y-axis, in this case the axial system becomes X, Y', Z'.

3.11
AT-cut plate
rotated Y-cut crystal plate oriented at an angle of about +35° around the X-axis or about −3° from the z (minor rhombohedral)-face

SEE: Figure 3

3.12
X-cut plate
crystal plate perpendicular to the X-axis

SEE: Figure 3b

3.13
Y-cut plate
crystal plate perpendicular to the Y-axis

SEE:Figure 3b

3.14
Z-cut plate
crystal plate perpendicular to the Z-axis

SEE:Figure 3b

3.15
z (minor rhombohedral)-cut plate
crystal plate parallel to the z (minor rhombohedral)-face

SEE: Figure 3a

3.16
dimensions
dimensions pertaining to growth on Z-cut seed rotated less than 20°from the Y-axis

3.17
effective Z-dimension
as-grown effective Z dimension defined as the minimum measure in the Z $(\theta = 0^{\circ})$ or Z' direction in usable Y or Y' area of an as-grown crystal and described by Z_{eff}

SEE: Figure 2

3.18
minimum Z-dimension
minimum distance from seed surface to Z-surface described by Z_{min}

SEE: Figure 2d

3.19
inclusions
any foreign material within a synthetic quartz crystal, visible by examination of scattered light from a bright source with the crystal immersed in a refractive index-matching liquid

Note 1 to entry: A particularly common inclusion is mainly the minerals called acmite and emeleusite.

3.20
seed veil
array of inclusions or voids at the surface of the seed upon which a crystal has been grown

3.21
etch channel
roughly cylindrical void that is present along the dislocation line after etching a quartz crystal

3.22
dopant
additive used in the growth process which may change the crystal habit, chemical composition, physical or electrical properties of the synthetic quartz batch

3.23
pre-dimensioned bar
bar whose as-grown dimensions have been altered by sawing, grinding, lapping, etc., to meet a particular dimensional requirement

3.24
impurity concentration
concentration of impurities relative to silicon atoms

3.25
dislocations
linear defects in the crystal due to misplaced planes of atoms

3.26
autoclave
vessel for the high-pressure and high-temperature condition required for growth of a synthetic quartz crystal

3.27
right-handed quartz or left-handed quartz
handedness of quartz crystal as determined by observing the sense of handedness of the optical rotation in the polarized light

Note 1 to entry: Right-handed quartz is the crystal of dextrorotatory and left-handed quartz is the crystal of levorotary

3.28
twins
two or more same single crystals which are combined together by the low of symmetrical plane or axis

Note 1 to entry: The following twin types have been identified in synthetic quartz crystals:

a) Electrical twins

Quartz crystal in which regions with the common Z-axis exist showing a polarity reversal of the electrical X-axis.

b) Optical twins

Quartz crystal in which regions with the common Z-axis exhibit handedness reversal of the optical Z-axis.

3.29
infrared absorption coefficient α value
coefficient (referred to as the α value) established by determining the relationship between absorption of two wave numbers

Note 1 to entry: One wave number is minimal absorption due to OH impurity, the other is high absorption due to presence of OH impurities in the crystal lattice. The OH impurity creates mechanical loss in resonators and its presence is correlated to the presence of other loss-inducing impurities. The α value is a measure of OH concentration and is correlated with expected mechanical losses due to material impurities.

Note 2 to entry: For the coefficient defined here, the logarithm base 10 is used. The infrared absorption coefficient value α is determined using the following equation:

$$\alpha = \frac{1}{t} log_{10}\left(\frac{T_1}{T_2}\right)$$

where

α is the infrared absorption coefficient;

t is the thickness of Y-cut sample, in cm;

T_1 is the per cent transmission at a wave number of 3 800 cm^{-1} or 3 979 cm^{-1};

T_2 is the per cent transmission at a wave number of 3 500 cm^{-1}, or 3 585 cm^{-1}.

3.30
lumbered synthetic quartz crystal
synthetic quartz crystal whose X- and Z- or Z'- surfaces in the as-grown condition have been processed flat and parallel by sawing, grinding, lapping, etc., to meet specified dimensions and orientation

3.31
reference surface
surface of the lumbered bar prepared to specific flatness and orientation with respect to a crystallographic direction (typically the X-direction)

3.32
synthetic quartz for optical applications
synthetic quartz which satisfies the requirements for the use of optical pickups, optical lowpass filters (OLPF) and wave plates for digital single-lens reflex camera, monitoring camera, digital video camera and optical communication module operating in the 300 nm – 1 700 nm wave length (5 882 cm^{-1}-33 333 cm^{-1})