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TECHNICAL SPECIFICATION

Piezoelectric and dielectric devices for frequency control and selection – Glossary – Part 4-1: Piezoelectric materials – Synthetic quartz crystal

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PIEZOELECTRIC AND DIELECTRIC DEVICES FOR FREQUENCY CONTROL AND SELECTION – GLOSSARY –

Part 4-1: Piezoelectric materials – Synthetic quartz crystal

FOREWORD

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IEC 61994-4-1, which is a technical specification, has been prepared by IEC technical committee 49: Piezoelectric and dielectric devices for frequency control and selection.

This second edition of IEC 61994-4-1 cancels and replaces the first edition published in 2001. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– this second edition takes into account new terms and definitions given in IEC 60758, third edition, published in 2004.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
49/763/DTS	49/767/RVC

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

This publication has been drafted in accordance with the IS0/IEC Directives, Part 2.

IEC 61994 consists of the following parts under the general title, *Piezoelectric and dielectric devices for frequency control and selection – Glossary:*

— Part 1: Piezoelectric and dielectric resonators

— Part 2: Piezoelectric and dielectric filters

— Part 3: Piezoelectric oscillators

— Part 4-1: Piezoelectric materials– Synthetic quartz crystal

— Part 4-2: Piezoelectric and dielectric materials – Piezoelectric ceramics

— Part 4-3: Materials for dielectric devices[1]

— Part 4-4: Materials – Materials for Surface Acoustic Wave (SAW) devices

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

- transformed into an international standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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

[1] To be published.

PIEZOELECTRIC AND DIELECTRIC DEVICES FOR FREQUENCY CONTROL AND SELECTION – GLOSSARY –

Part 4-1: Piezoelectric materials – Synthetic quartz crystal

1 Scope

This technical specification gives the terms and definitions for synthetic quartz single crystals representing the present state-of-the-art, which are intended for manufacturing piezoelectric elements for frequency control and selection.

2 Normative references

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

IEC 60050(561):1991, *International Electrotechnical Vocabulary (IEV) – Chapter 561: Piezoelectric devices for frequency control and selection*

IEC 60758:2004, *Synthetic quartz crystal – Specifications and guide to the use*

3 Terms and definitions

3.1
AT-cut plate
rotated Y-cut crystal plate oriented at an angle of about +35° around the X-axis or of about –3° from the z (minor rhombohedral) -face

[IEC 60758, 3.7.2]

3.2
as-grown Y-bar
crystals which are produced using seeds with the largest dimension in the Y-direction

[IEC 60758, 3.2.2]

3.3
as-grown Z-bar
as-grown Y-bar crystals in which the Z-grown sector is much larger than the X-growth sector.

The relative size of the growth sector is controlled by the X-dimension of the seed

[IEC 60758, 3.2.3 modified]

3.4
as-grown synthetic quartz crystal
single crystal quartz grown hydrothermally. "As-grown" refers to the state of processing and indicates a state prior to mechanical fabrication

[IEC 60758, 3.2.1 modified]

3.5
autoclave
vessel for the high-pressure, high-temperature condition required for growth of synthetic quartz crystal

[IEC 60758, 3.15]

3.6
dislocations
linear defects in the crystal due to misplaced planes of atoms

[IEC 60758, 3.13]

3.7
dopant
any additive used in the growth process which may change the crystal habit, chemical composition, physical or electrical properties of the synthetic quartz batch

[IEC 60758, 3.10]

3.8
effective Z-dimension
as-grown effective Z dimension which is defined as the minimum measure in the Z (Θ = O°) or Z' direction of as-grown crystals

[IEC 60758, 3.8.1.1 modified]

3.9
electrical twins
quartz crystal in which regions with a common Z-axis exist, showing a polarity reversal of the electrical X-axis

[IEC 60758, 3.17]

3.10
etch channel
roughly cylindrical void that is present along a dislocation line after etching a test wafer prepared from a quartz crystal

[IEC 60758, 3.14]

3.11
gross dimensions
maximum dimensions along the X-, Y- or Y'- and Z- or Z'-axes measured along the X-, Y'- and Z'-axes

[IEC 60758, 3.8.1]

3.12
growth zones
regions of a synthetic quartz crystal resulting from growth along different crystallographic directions

[IEC 60758, 3.5]

3.13
hydrothermal crystal growth
literally 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. 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 2000 atmospheres). 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

[IEC 60758,3.1]

3.14
impurity concentration
concentration of impurities relative to silicon atoms

[IEC 60758, 3.12]

3.15
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. A particularly common inclusion is the mineral acmite (sodium iron silicate)

[IEC 60758, 3.9]

3.16
infrared absorption coefficient α -value
coefficient (referred to as the α-value) established by determining the relationship between absorption of two wavelengths: one with minimal absorption due to OH impurity, the other with 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-inducting impurities. The α-value is a measure of OH concentration and is correlated with expected mechanical losses due to material impurities. The infrared absorption coefficient α-value is determined using the following equation:

$$\alpha = \frac{1}{t} \log \frac{T_1}{T_2}$$

where

α is the infrared absorption coefficient;

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

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 3 410 cm^{-1}, 3 500 cm^{-1} or 3 585 cm^{-1}

[IEC 60758, 3.18]

3.17
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

[IEC 60758, 3.19]

3.18
lumbered Y-bar
quartz bars which are lumbered from an as-grown Y-bar

[IEC 60758, 3.19.1]

3.19
lumbered Z-bar
quartz bars which are lumbered from an as-grown Z-bar

[IEC 60758, 3.19.2]

3.20
minimum Z-dimension
minimum distance from seed surface to Z surface

[IEC 60758, 3.8.1.2]

3.21
optical twins
quartz crystal in which regions with the common Z-axis exhibit handedness reversal of the optical Z-axis

[IEC 60758, 3.17]

3.22
orientation of a synthetic quartz crystal
orientation of its seed with respect to the orthogonal axes

[IEC 60758, 3.6]

3.23
pre-dimensioned bar
any bar of as-grown quartz with dimensions altered by sawing, grinding, lapping, etc, to meet a particular dimensional and orientation requirement

[IEC 60758, 3.11 modified]

3.24
orthogonal axial system for quartz
the orthogonal axial system is illustrated in figure 1

[IEC 60758 3.7.1]

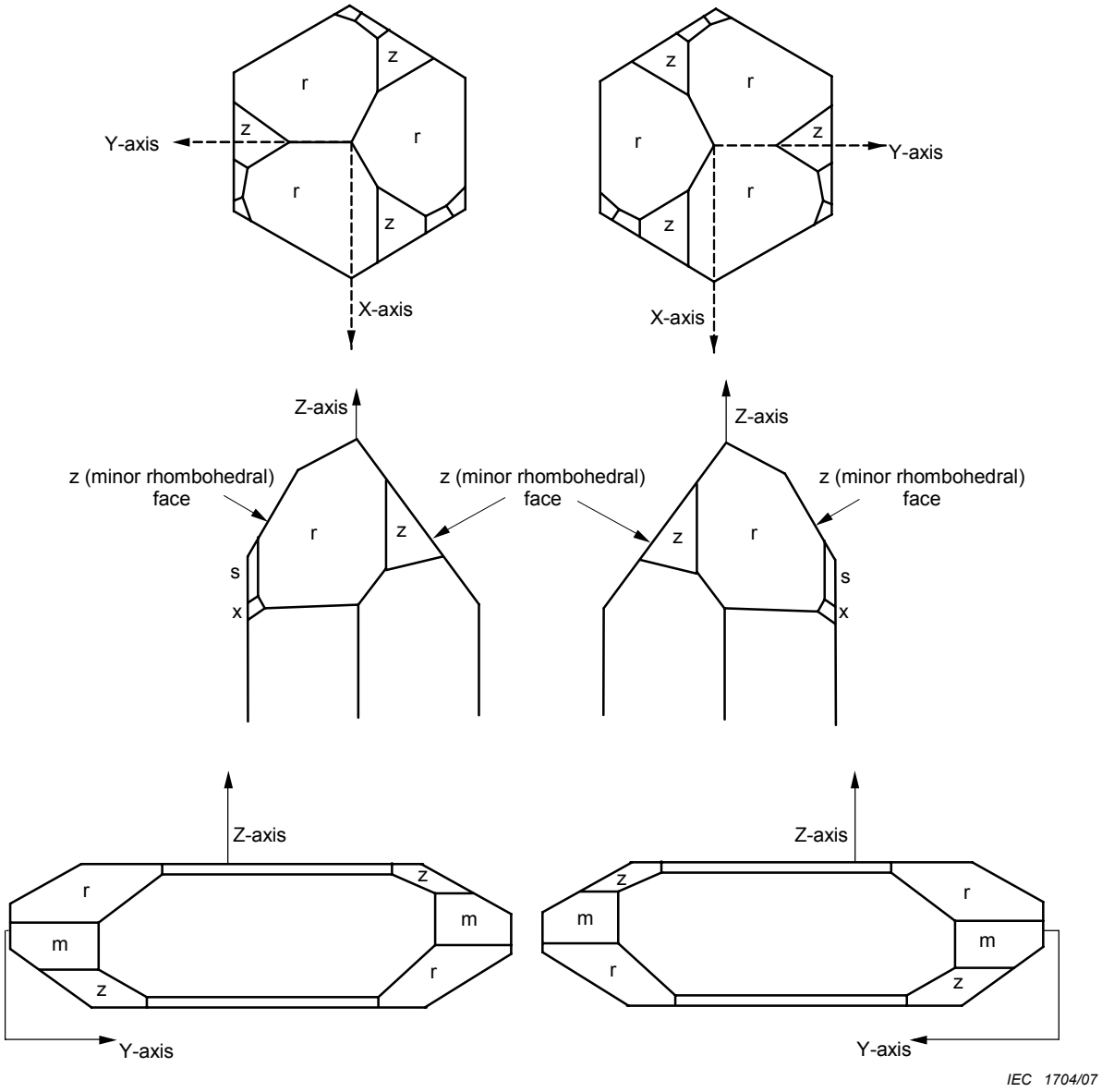

Figure 1 – Orthogonal axial system for quartz

3.25
reference surface
surface of the lumbered bar prepared to specific flatness and orientation with respect to a crystallographic direction (typically the X-direction)

[IEC 60758, 3.20]

3.26
right-handed quartz or left-handed quartz
handedness of a quartz crystal, as determined by observing the sense of handedness of the optical rotation in polarized light. Right handed quartz is the crystal of dextrorotatory and left-handed quartz is the crystal of levorotary.

[IEC 60758,3.16]

3.27
seed
rectangular parallelepiped. quartz plate or bar to be used as a nucleus for crystal growth

[IEC 60758, 3.4]

3.28
seed veil
the array of inclusions or voids at the interface of the seed and the grown crystal

[IEC 60758, 3.9.1 modified]

3.29
synthetic quartz crystal
single crystal of α quartz grown by the hydrothermal method. The crystal is of either handedness and in the "as grown" condition

[IEC 60758, 3.2]

3.30
synthetic quartz crystal batch
synthetic quartz crystals grown at the same time in one autoclave

[IEC 60758, 3.3]

3.31
twins
twins follow laws of crystallography relating symmetrically to specific faces or axes. Common

twins observed in synthetic quartz are optical and electrical twins

[IEC 60758, 3.17]

3.32
X-cut plate
crystal plate perpendicular to the X-axis

[IEC 60758, 3.7.4]

3.33
Y-cut plate
a crystal plate perpendicular to the Y-axis

[IEC 60758, 3.7.5]

3.34
Z-cut plate
a crystal plate perpendicular to the Z-axis

[IEC 60758, 3.7.6]

3.35
z (minor rhombohedral)-cut plate
a crystal plate parallel to the z (minor rhombohedral)-face

[IEC 60758, 3.7.3]

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