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EIA STANDARD

Cultured Quartz

EIA-477-A

(Revision of EIA-477 and Inclusion of EIA-477-1-A)

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CULTURED QUARTZ

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REFERENCES

CULTURED QUARTZ

(From EIA Standards Proposal No. 2110 for updating EIA-477 and inclusion of EIA-477-1-A, formulated under the cognizance of EIA P-11 Committee on Piezoelectric Devices.)

1. SCOPE

This document relates to crystalline quartz produced by hydrothermal growth intended to be used as raw material for piezoelectric crystal devices.

2. HISTORICAL PERSPECTIVE

After cultured quartz was introduced commercially (1956), Q capability became and implicitly remains its main quality figure of merit. Inclusions, seed veils, etch channels, dislocations and impurities were all observed then, but their effects on resonator performance were undetected in material whose Q capability was in control.

Q capability of cultured quartz was most sensitively observed in the Warner designed 5 MHz fifth overtone frequency standard resonator, because all the sources of its frictional losses other than the internal friction of the material were minimized. Q's significance in a frequency control device is that it governs the precision of the resonator's frequency response. Cultured quartz users wanted a Q capability greater than the Qs needed in the resonator designs being manufactured. Later it was observed empirically that material meeting a Q minimum test requirement also showed an "in control angle behavior" relationship of its AT cut frequency/temperature curves with respect to cut wafer angles.

In 1965 Fraser showed that the main source of Q-limiting internal friction in cultured quartz, its OH content, could also be measured through its infrared (IR) absorption in the well known OH absorption band. Together with Rudd, he identified wavelengths that serve usefully to indicate OH concentrations in cultured quartz, and they developed an empirical $\alpha_{3500}/5$ MHz Q relationship.

The infrared absorption per cm at 3500 wavenumbers can be measured simply, quickly, inexpensively, and in smaller quartz specimens, than the 5 MHz Qs of fabricated resonators. The IR method soon became the preferred and widely accepted method for obtaining Q indications for use in the quality control of cultured quartz.

In 1985 the EIA chose α_{3500} , measured by the long-used above procedure, to become the main quality indicator for cultured quartz. This bypasses confusion about correlating alphas with 5 MHz Qs, or with Qs at various frequencies. Unlike Q, the α_{3500} measurement, and OH content, are independent of resonator frequency.

The five 5 MHz Q grade test limits that had been accepted in terms of Q indications from α_{3500} measurements, by the EIA in 1981 (and four matching grades by the IEC in 1983) are preserved unchanged in alpha terms. They are restated as their five corresponding α_{3500} grade test limits, together with the letter grade labels (A, B, C, D and E).

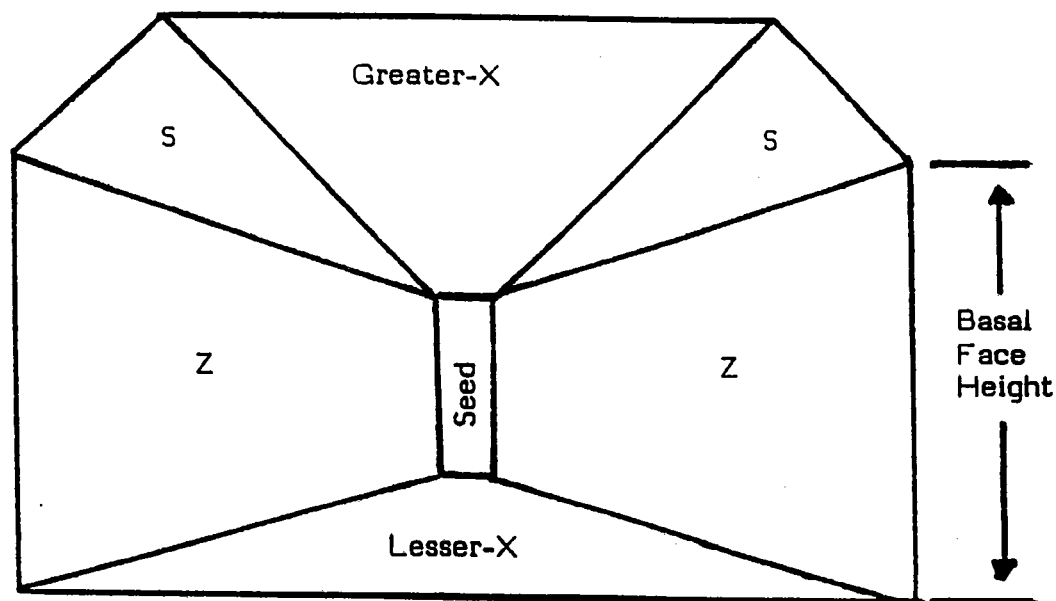


FIGURE 1

GROWTH ZONES OF A CULTURED QUARTZ CRYSTAL
GROWN ON A Z-CUT SEED. VIEW IS OF SECTION
PERPENDICULAR TO Y OR Y-PRIME DIRECTION

It is widely accepted that the α_{3500} also serves as a control of the frequency/temperature curve vs. angle of AT cut behavior of cultured quartz. For most AT applications, Grade C quartz (having an α_{3500} less than 0.06 per cm) yields an f/T behavior closely approximating the range experienced using natural quartz. Grades B and A can be required if tighter control of the f/T behavior and higher quality is needed.

Although they are not ordinarily required, additional testing and grading information included here relates to: inclusion densities, etch channel densities, aluminum content and swept quartz. Each of these tests is pertinent to certain specific application needs - and need not be required for general use. The α_{3500} grade limit will ensure that defects are not present at densities sufficient to increase the OH content beyond its specified grade maximum requirement.

3. TERMS, DEFINITIONS AND PROCEDURES

3.1 Cultured Quartz Crystal; also called Synthetic Quartz Crystal

A single crystal of α SiO_2 grown by a hydrothermal method. The crystal may be of either handedness. The terms and definitions in this section apply to crystals in as grown condition.

3.2 Seed

The quartz crystal substrate upon which growth is induced in the hydrothermal growing process.

3.3 Orientation and Handedness

The orientation and handedness are as defined in IEEE Standard 176-1978.

3.3.1 The orientation and handedness of the cultured quartz crystal are the same as the orientation and handedness of the seed.

3.4 Growth Zones

Growth zones are regions in the quartz deposited on the seed in which the growth is primarily in one crystal direction. Terminology for growth zones is: Z-growth, Greater-X growth, Lesser-X growth, and S-growth. (See Figure 1.)

3.5 Dimensions

3.5.1 As-grown Cultured or Synthetic Crystal

The following dimensions pertain to growth on a Z-cut seed rotated less than 20° around the X-axis, or less than 30° around the Z-axis. Standard dimensions pertaining to growth on a Z-cut seed rotated more than 20° around the X-axis are under consideration.

3.5.1.1 Length

The length of the cultured quartz crystal is in the Y or Y-prime direction and is taken to be the length of the seed.

3.5.1.2 Width

The width of the cultured quartz crystal is in the Z or Z-prime direction and is taken to be the smallest size in the Z-direction excluding regions of natural termination.