Technical Note: 10000004

Temperature Coefficient of Maxtek Monitor Crystals

The temperature coefficient of quartz crystals is normally specified in units of parts per million per degree of temperature change. In order for this coefficient to be meaningful to us we need to convert the units to units of equivalent drift in the indicated thickness.

A one part per million change in frequency of the sensing crystal corresponds to an indicated thickness change of approximately 7.4 Å for a material with a density of 1.0 gm/cm³. For aluminum with a density of 2.7 gm/cm³, this is equivalent to approximately 2.7 Å.

INFICON specifies the angle of cut of their crystals such that they have a turnaround point of between 40°C and 80°C. The actual angle of cut of the crystal is between 35° 14’ and 35° 22’.

At the turnaround point the temperature coefficient of the crystal is zero. That is, there is no change in indicated thickness due to a change in the temperature of the crystal at the turnaround point.

Over the temperature range of 20°C to 100°C, the worst-case temperature coefficient is equivalent to approximately 2 Å of Al per degree C of crystal temperature change. However, because the temperature coefficient is not constant, the worst case drift in indicated thickness over a crystal temperature range of 20° to 100°C, is approximately ± 100 Å of Al.

The typical worst-case drift in indicated thickness over the range of 20° to 100°C (68° to 212° F) is on the order of 50 Å. The indicated thickness drift may be either positive or negative depending on the actual operating temperature and the actual crystal cut.

Once the turnaround point is exceeded, the temperature coefficient will always be negative with respect to indicated thickness (positive with respect to frequency change). That is, as the temperature of the crystal continues to increase, the indicated thickness will slowly decrease even though the actual thickness is constant.

The temperature induced drift is reversible, which means that, even if the temperature of the crystal is allowed to increase drastically during deposition, as long as the temperature of the crystal is allowed to return to its pre-deposition temperature the resulting indicated thickness will contain no error due to crystal temperature.

There is, however, an upper limit above which the temperature of the crystal should not be allowed to climb. Quartz has a Curie temperature of about 573°C (1063° F). At the Curie temperature the crystallographic structure changes and the quartz loses its piezoelectric nature. The process is irreversible and the structure that supports piezoelectric behavior does not return when the temperature is brought back below the Curie temperature. The crystal is thus irreversibly damaged once the Curie temperature is reached.

The Curie temperature can be significantly lowered by stress so the maximum crystal temperature should be kept well below the 573°C limit.

A practicable upper limit on crystal temperature is probably on the order of 300°C.

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