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|  QUARZ (GERMANY) GmbH | Product Specification RQ 200 DSC / RSC over 60 mm dia. | SPEC_Z_LW_02 page 1 of 10 |
| Authors: 09.06.2008 Ludwig Stier Dr. Sigrun Rakus | Approved: 09.06.2008 Frithjof Raesch | Released: 10.06.2008 Frithjof Raesch |


Introduction:

This kind of quartz is made from 99.99% of pure quartz (SiO₂). **RQ 200 DSC / RSC** is a high temperature and high viscosity melting quartz glass. RQ 200 **DSC** are **d**irect drawn tubes and RQ 200 **RSC** are **r**esized tubes.

These products are typically used for semiconductor applications to fabricate high purity components for processing of silicon wafers.

Physical Properties:

| | | | |
|--------------------------------------------|-----------------|-------------------------------------|-------------|
| Linear thermal expansion coefficient | (20 - 320) °C | [10 ⁻⁶ K ⁻¹] | 0.54 |
| Modulus of elasticity | | [GPa] | 66 |
| Poisson-Number | | [1] | 0.17 |
| Density | | [gcm ⁻³] | 2.2 |
| Transformation temperature | | [°C] | ca. 1200 |
| Viscosity | | [dPas] | [°C] |
| Strain point | | 10 ^{14.7} | 1167 |
| Annealing point | | 10 ^{13.2} | 1255 |
| Softening temperature | | 10 ^{7.6} | 1760 |
| Working temperature | | 10 ⁴ | 1990 |
| Devitrification range | | [°C] | 1000 - 1700 |
| Max. working temperature | | | [°C] |
| Permanent with cooling to room temperature | | | 1000 |
| Permanent with cooling to 300 °C | | | 1200 |
| Short time | | | 1300 |
| Electrical resistance | | [Ωcm] | [°C] |
| | | 10 ⁴ | 1660 |
| | | 10 ⁶ | 1000 |
| | | 10 ⁸ | 510 |
| Dielectric constant | at 20 °C, 1 MHz | [1] | 3.7 |
| Dielectric loss factor | at 20 °C, 1MHz | [10 ⁻⁴] | < 1 |
| Refractive index | at λ = 587,6 nm | [1] | 1.459 |
| Thermal conductivity | at 20 °C | [Wm ⁻¹ K ⁻¹] | 1.4 |

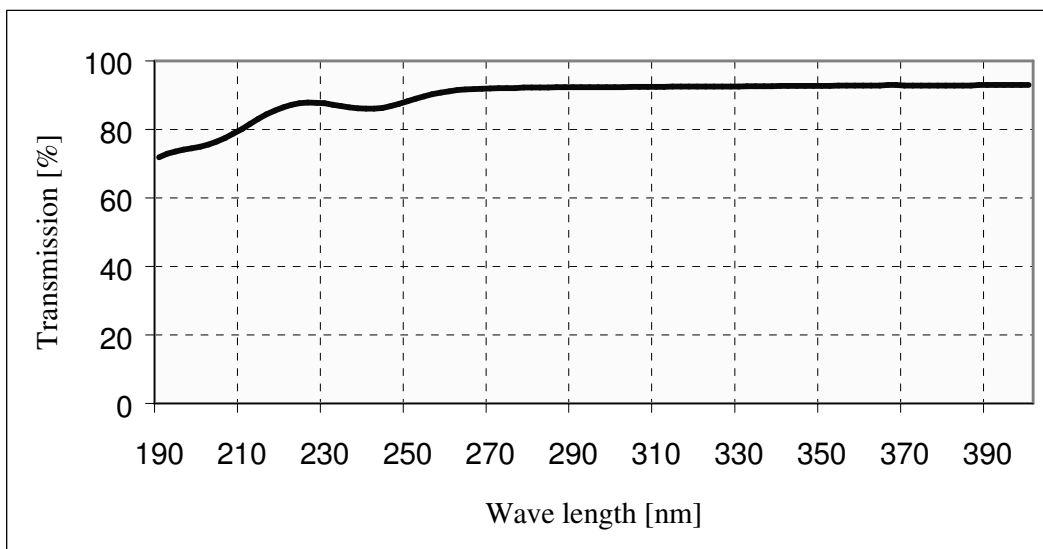
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Transmission Properties:

Limits for transmission values of 1 [mm] wall thickness:

| | | | | |
|----------------------------|------|------|------|------|
| wave length λ [nm] | 200 | 250 | 360 | 400 |
| transmission T [%] | > 65 | > 85 | > 90 | > 91 |

Transmission curve RQ 200 DSC / RSC



Chemical Composition:

SiO₂ [%] 99.99

RQ 200 DSC / RSC contains the following impurities in ppm:

| Elements | Typical | Elements | Typical |
|----------|---------|----------|---------|
| Al | 13.0 | Mg | < 0.1 |
| Ca | 0.4 | Na | 0.7 |
| Fe | 0.2 | Ti | < 1 |
| K | 0.5 | Zr | 0.6 |
| Li | 0.5 | P | < 0.2 |

The OH⁻ content of **RQ 200 DSC / RSC** is ≤ 5 ppm (excluding surface).

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Visual Characteristics:

Airlines / Bubbles

A1: Airlines / Bubbles (enclosed):

Definition:

A void, wholly within the tube wall. (Note: Collapsed portions are covered under "Surface Voids")

- Bubbles are primarily spherical.
- Airlines are elongated and parallel to the tube length.
- Stringers are a short series (3 or more end to end) of airlines or bubbles, parallel to the tube length.
- Arrowheads are partially collapsed airlines, with the remaining enclosed void resembling a flattened Indian arrowhead shape.

Limits:

-Max volume for any enclosed void to be no more than that of a 1 mm diameter bubble. The table below is to be used:

| Width [mm] | Maximum Length [mm] | | |
|---------------|---------------------|---------|----------------------|
| | Shape: | | |
| | Bubble | Airline | Arrowhead (RSC only) |
| <0.250 | 1.0 | 15 | 15 |
| 0.250 – 0.500 | 1.0 | 8 | 8 |
| 0.500 – 0.750 | 1.0 | 4 | 4 |
| 0.750 – 1.000 | 1.0 | 2 | 2 |

- Max number of enclosed voids ≤ 0.5 mm wide is an average of three per 300 mm.
- Max number of enclosed voids > 0.5 mm wide is an average of one per 300 mm.
- A stringer must be contained within a 2 mm x 100 mm area. Each void within a stringer is judged individually in the table above for max size and for max number.
- All enclosed voids, including bumpy must have sufficient wall strength/thickness to withstand fingernail pressure if applied over the void. Failures must be judged as though they were open airlines or bubbles.


A2: Surface voids (RSC only):

Definition:

Surface voids are depressions on the surface left by healed or collapsed airlines, causing an optical distortion. (Distinct from open airlines in that these depressions have rounded edges). This applies also to repair areas, in conjunction with defect "machine marks" limits.

Limits:

- No depression having an estimated depth of 0.4 mm or more.
- No wall reduced beyond dimensional thickness limit.
- Judge size and frequency of surface depressions (collapsed airlines) the same length as airlines in the table above. Because of optical distortion, the width may appear wider than the original airline. Therefore, collapsed airlines are rejected on the basis of length only.

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B: Bumpy ID or OD Airlines / Bubble:

Definition:

A raised area in the wall of the tubing, directly over an enclosed void near the surface, on the ID or OD.

Limits:

Same as Airline / Bubbles (enclosed), except stringers: Max ID area is 1.5 mm x 37 mm for bumpy stringers.

C: Open ID or OD Airlines / Bubble:

Definition:

A void, open to the wall surface, which has sharp, knifelike edges, on the ID or OD.

Limits:

None allowed on the ID or OD (above visual detection of 0.1 mm diameter or width).

D: Bubble Clusters:

Definition:

More than one bubble connected.

Limits:

-OD or enclosed cluster: Judge the whole cluster to the limits of a single large bubble.

-ID cluster: Judge the whole cluster to the limits of a single white spot. Note: Consider a cluster to be an ID cluster if close enough to disrupt the ID smooth surface.

Check

Definition:

A very small fissure in the glass surface, which extends part way through the tube wall, recognizable by a bright spot reflection under end lighting.

Limits:

None.


Orange Peel (RSC only)

Definition:

General area surface distortions, minor in depth, uniformly distributed and transparent, looking mildly like the outside texture of an orange skin. This defect category includes the effect of other optical distortions in the same area of view.

Limits:

Optical distortion is not to exceed the reasonable ability to read a Print Limit Sample Card when viewed through both tube walls. The Print Limit Sample card is available on customers request.

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Water spots

Definition:

Whitish surface deposit left by washing residue (visible to unaided eye, general illumination, black background).

Limits:

None visible to the unaided eye on the ID or OD.

Scratch

Definition:

A fine line abrasion of the surface (line wider than 0.1 mm), visible to the unaided eye under general illumination with a black background.

Limits:

-OD scratches: Total lengths of scratches on the OD, added together, are to be no more than half the tube length. No individual OD scratch is to be longer than 150 mm.

-ID scratches: No scratches are permitted on the ID.

Scuff

Definition:

A broad surface abrasion (series or group of lines with individual lines wider than 0.1 mm), visible to the unaided eye under general illumination with a black background.

Limits:

-OD scuffs: Total area of scuffs on the OD, added together, are to be no more than 2% of tube surface OD area. No individual OD scuff wider than 12.5 mm and longer than 150 mm.

-ID scratches: No scuffs are permitted on the ID.

Machine marks (RSC only)

Definition:

An obvious distortion of the surface caused by mechanical means or tools.

Limits:

OD and wall dimensional limits must be maintained at all marks, plus special criteria below:


Roller mark (RSC only)

Definition:

A type of Machine mark caused by the roller, visible as a group or band of line variations around (or partly around) the tube OD. These marks can be detected with a fingernail on the OD.

Limits:

Total area of all roller marks, added together, is to be no more than the equivalent area of 50 mm all around the OD. No individual roller mark should be wider than 25 mm.

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Pad marks (RSC only)

Definition:

Marks on the tube the size and location where lathe chuck pads held the tube.

Limits:

None visible to the unaided eye.

Repairs (RSC only)

Definition:

A local Machine mark on the tube wall (e.g. scratch or sanded spot) firepolished to a glaze and annealed.

Limits:

- No standard (distinct) repair area larger than 500 sq.mm (e.g. 25 mm circle, or 10 mm x 50 mm, or 20 mm x 25 mm, etc.).
- No variation of the OD or wall by more than 0.4 mm, from the repaired area to the nearest unrepaired area.
- Max number of allowed standard (distinct) repairs is:

| Tube length | Max allowed per tube |
|--------------------|-----------------------------|
| Under 1830 mm | 2 |
| 1830 mm to 2135 mm | 3 |
| 2135 mm to 2440 mm | 4 |
| 2440 mm & above | 5 |

- No limit on the number of blemish free repairs (well blended with negligible surface distortion < 0.1 mm depth).

Pitted (RSC only)

Definition:

Very fine dimpling of the tube on the OD surface.

Limits:

- No adhered foreign material permitted in a pit.
- Depth of any pit not to exceed 0.4 mm.
- Appearance not to exceed limit samples. Regardless of the number of pits, a change in pit level per equipment, operator or size is flagged for corrective action.


Vapour

Definition:

A broad area ore band of white haze in the ID or OD surface visible to the unaided eye on a black background.

Limits:

None permitted.

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Adhered material

Definition:

Quartz particles fused into the surface causing a protrusion.

Limits:

- None with any sharp edges allowed.
- 0.25 mm max diameter if fully smooth, glazed and clear.

Optical distortions

Definition:

Optical distortions caused by general variations in wall surface. Clear discontinuity from the designed smooth contour. The tube is designed to be clear and homogenous from end to end around the circumference (exclude machine marks).

Miscellaneous Distortions Limits:

Shallow OD surface distortions referred to as OD "teardrops" due to their shape, may be passed if no more than one is in the tube and it is less than 12 mm diameter.
ID "teardrops" inside DSC tubes are rejectable if larger than "Adhered material" limits.

OD-Wavy / Dip

Definition:

Consider wavy to be readily visible changes in the OD that make the tube appear wavy along its length. Consider dip to be a sudden change in OD, readily visible for a short length.

Limits:

- All OD dimensional limits must be maintained.
- Variation of OD is not to exceed 0.4 mm max, along any 75 mm length.

Ripple (RSC only)

Definition:

A regular pattern of circumferential rings created by the resizing process. These rings normally occur on tubes with a wall thickness greater than 6 mm, but can be seen on other sizes. This minor variation in wall thickness is seen on the inside surface. Although ripple can be seen visually, the wall thickness variation is < 0.1 mm.


Limits:

- All OD dimensional limits must be maintained.
- Ripple specific measurement and limits are not yet formalized.

Wall-pulse

Limits:

- All wall dimensional limits must be maintained.
- Variation of wall is not to exceed 0.4 mm max, along any 75 mm length, excluding the 150 mm at each end.
- Ends (150 mm each end): Allow 0.8 mm wall variation along any 75 mm in the end.

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- Tubes larger than 200 mm diameter and shorter than 1500 mm will be pulse free.

Striations

Limits:

-Striations (line variations along the tube length) are to be less than 0.05 mm as measured with a 0.25 mm profilometer probe, from peak to valley.

White spot (devitrification spot)

Definition:

Surface spot, white in appearance (not an inclusion). Visible to the unaided eye on an inspection "light table" (special illumination, black background, with verge of visibility over 0.1 mm).

Limits:

| | Max. diameter | Max. average count over tube length | Max. count (frequency) over a short length (300 mm) |
|----|---------------|-------------------------------------|-----------------------------------------------------|
| OD | 1.0 mm | 1 / 300 mm | Not specified. |
| ID | 0.25 mm | 1 / 300 mm | 3 / 300 mm |

Devitrification band

Definition:

A white area or streak on the ID or OD surface visible to the unaided eye on a black background.

Limits:

None permitted.

Stress


Limits:

Stresses are permanent forces of tension and compression contained within the quartz part. Stress is observed as a bright blue or yellow coloration beyond the neutral (blue magenta) background when viewed under a polariscope.

Discoloration (Tinting)

Definition:

A tint other than clear. Note: It is possible for tubes to have some visible tint in the wall when viewed from the end of the tube. Inspecting the tube in this manner is a very critical method of inspection. A very slight tint is amplified by the tube length. It is important that the background used be white. The color of the background or surrounding materials may be picked up and amplified by the tube. Some degree of tint is commonly seen when inspecting tubes in this manner.

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Limits:

- None that fail chemical purity as specified.
- None readily visible when viewed perpendicularly through the sidewall of the tube.
- Tint specific measurement and limits when viewed through the length of the tube are not yet formalized.

Inclusions

Definition:

Foreign matter wholly enclosed within the wall (visible to the unaided eye, under general illumination, with a black & white background).

Limits:

- 0.7 mm max diameter and none closer than 50 mm apart.

| | |
|-------------------------------------|-----------------------------------------------------|
| Max. average count over tube length | Max. count (frequency) over a short length (300 mm) |
| 1 / 300 mm | 2 / 300 mm |

Exposed ID Inclusion

Definition:

Approximately spherical foreign matter exposed to the ID (visible to the unaided eye, under general illumination, with a black & white background).

Limit:

None visible to the unaided eye.

Exposed OD Inclusion

Definition:

Approximately spherical foreign matter exposed to the ID (visible to the unaided eye, under general illumination, with a black & white background). Consider the inclusion exposed if it can be detected with the fingernail or some other mechanical means.

Limit:

None visible to the unaided eye.


Line

Definition:

A dark or discoloured line, running lengthwise in the tube wall (visible to the unaided eye, under general illumination, with a black & white background).

Limits:

None allowed.

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Other

Broken: None.

Dirty: No visible foreign material.

Dimensional Characteristics:

Outside diameter: + / - 2.0 % of nominal value

Wall thickness: on request,
+ / - 15% of nominal value

Other dimensions/tolerances: might be available upon request

Length: ≤ 2450 mm (furnace cut) ± 25 mm
> 2450 to 3000 mm on request, ± 40 mm
fine cut is possible on request, ± 1mm

Ovality: max. 2 % of nominal OD

Siding: max. 18 % of nominal WT
Wall thickness tolerances have to be maintained.

Bow: over 1200 mm length: 2 mm acceptable

Company adress:

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Effective documents:

Sortierkriterien USC / DSC (RK_Z_LW_010)