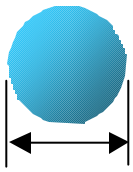
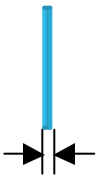
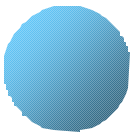
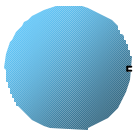
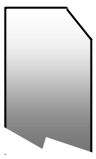
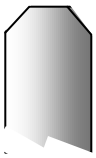
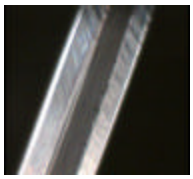
Quartz Unlimited LLC.

Rev.: 2.0

Quartz Wafer & Substrate Specification Guide

The intent of this guide is to assist our customers in the selection and specification of quartz wafers, which will meet the requirements of their applications. In this document we are illustrating a variety of shapes, forms and materials that can be selected from. Although every item is manufactured specifically to our customer requirements this guide lists the most frequently used quartz wafer types.

SIZE	SHAPE	EDGE FORM	EDGE FINISH	SURFACE FINISH	MATERIAL
DIAMETER  75 mm / 2.953” 100 mm / 3.937” 125 mm / 4.921” 150 mm / 5.905” 200 mm / 7.874” 300 mm /11.811” **THICKNESS**  0.50 mm / 0.019” 0.75 mm / 0.029” 1.00 mm / 0.039” 1.50 mm / 0.059”	 ROUND  ROUND W. NOTCH  ROUND W. FLAT  ROUND W. FLATS  OTHER NON-ROUND SHAPES	 STRAIGHT  W. CHAMFER  SINGLE BEVEL  DUAL BEVEL	**MACHINED**  The edge of a Quartz Wafer 1.00 mm thick. **LASER CUT**  The edge of a Quartz Wafer 1.00 mm thick. Dual Bevel **LASER POLISHED**  The edge of a Quartz Wafer 1.00 mm thick. Dual Bevel	♦ OPTICAL GRADE ♦ VIEW PORT GRADE ♦ SEMICONDUCTOR GRADE ♦ COMMERCIAL GRADE **DSP** DOUBLE SIDE POLISHED **OSP** ONE SIDE POLISHED SECOND SIDE HAS A FINE GRIND FINISH	**FUSED QUARTZ** ♦ ELECTRIC FUSED ♦ FLAME FUSED **FUSED SILICA** ♦ Very Dry OH ≤10 ppm ♦ Dry OH ≤100 ppm ♦ Semi Dry OH ≤700 ppm ♦ Standard OH ≤1200 ppm

IN REFERENCE TO SPECIFICATIONS

When you plan to place an order please be prepared to specify the dimensions, tolerances and all, or most, of the characteristic outlined in this document.
If you need assistance, or some of the characteristics are either not applicable or not important for your application, then let us know and we will help you to specify a part, which will be the most apropriate for your particular application.

SIZE

Diameter & Thickness can be specified to comply with standard wafer sizes. We will also cut wafers to custom sizes and thickness to meet your specification.

SHAPE

The shape of the wafer can be specified as: round, round with notch, round with one flat or round with two flats. Other non-round shapes, such as square, rectangle etc. can be specified as well.
Depending on the application the wafer may need some standard form of orientation-reference to fit it into an already existing tool. It is particularly important information when quartz wafers are used for testing or set up where otherwise Silicon wafers are used in the manufacturing process. Although there are standards, in respect to those dimensions, there are also many minor modifications in most equipment on the field; therefore it is necessary to have the location and the dimensions of the notch or the flat(s) to be called out in your specification.

EDGE FORM

It is important to know how the quartz wafers will be handled during processing so the proper edge finish can be specified. Unlike Silicon wafer, which has a crystal structure, quartz is glass (vitreous silica) and it will react to stress and pressure as glass. If it has even a minor crack particularly around the edge, which may be invisible to the naked eye, it may shatter when put under pressure in the processing chamber. It is also important to know about the intended utilization of the quartz wafer, which may be of single use or it may need to go through numerous cycles and are re-used many times over.

- **Straight.**
  This method of cutting is appropriate where the wafer is subject to gentle manual handling only. It is practical and economical method for add sizes, shapes, prototypes when a quick evaluation needed to be done before developing the final specification for the production units.
- **Chamfered edge.**
  This is a simple manual (de-burring) operation. With a fine diamond tool we remove the sharp edges of the wafer after the OD is machined to final dimension.
- **Single bevel**
  The single bevel can be accurately cut at 10 ° to 45 ° of angle / 10 % to 100% of thickness of the wafer.
- **Dual bevel**
  The dual bevel is accurately machined at 45 ° to 33% of thickness from both sides leaving approx. 33% in the center section. Same high quality finish as the single bevel.

EDGE FINISH

In respect to the quality of the edge there are three methods to finish the edge. Since it will have an effect on the reliability and life expectancy of a quartz wafer it must be given a serious consideration.

- ### Machined.
  It is a standard finish where the surface of the edge retains the marks of a fine diamond tool. Some minor voids and chipping may be present.
- ### Laser Cut
  When the wafer is sized with laser the result is a very fine and smooth edge, free of chips and voids.
- ### Laser Polished
  It is our special proprietary process, which provides the finest most resilient edge finish to a quartz wafer. The Laser Polishing of the edge increases the hardness of the edge and become more resistant to chipping during handling, transportation and repeated insertion into the processing chamber. It has been successfully tested up to 100 cycles of metal-deposition, removal of metal-deposition and re-polishing of the same wafer in a fully automated environment.

SURFACE FINISH

In respect to the surface of the wafer there are two major categories of finishes available. For specification see chart on the following page.

- ### Optical Prime Grade
  This high quality finish is for applications where optical qualities, such as flatness, parallelism, surface quality, and etc. is critical and must be of the highest grade.
- ### View Port Window Grade
  This is a ground and polished clear finish appropriate for many applications. The specifications are loosened up in some area depending on the application to lower cost.
- ### Commercial (dummy wafer) Grade
  This finish refers to a “piece of quartz glass” cut to size. Tolerances are fairly “liberal” and are for use as a heat shield in a “boat” and or other non-critical applications where low cost is the primary consideration.

DSP Double Side Polished

Both side polished to the grade as defined above.

OSP One Side Polished

Side one polished to a grade as defined above and side two will have a “Fine Grind” finish.

MATERIAL SELECTION GUIDE

There are two basic types of quartz substrate material available to fabricate Quartz Wafers and there are numerous sources for both type of material. There are also different grades within those two types. The following is the list of the most widely used materials for Quartz Wafers.

Fused Quartz (Natural Silica)

Made out of naturally occurring quartz crystals. The raw crystal crushed into powder and goes through a vigorous purifying process before the fusion process takes place to produce Clear Fused Quartz.
There are two different form of processing.

1. Electrically Fused
   The result is a fairly pure material containing some fine bubbles with a very low OH (Hydroxyl) content. The most widely used material in the semiconductor industry. It is also used in some optical applications where low cost and commercial grade quality is acceptable.
2. Flame Fused
   Fused with Oxygen-Hydrogen flame. This material is extremely purity and contains virtually no bubbles or inclusions. The OH (hydroxyl) content is somewhat higher than the electrically fused quartz. This material is appropriate and economical for almost all but the most demanding optical applications.

Fused Silica (Synthetic Silica)

Unlike Fused Quartz this material is the result of a chemical or various other electro-chemical processes. Most of these processes are proprietary to the manufacturers. Because the availability of information on the processes is limited we call it Dry Process.

1. Flame Fused
   Particular chemicals are fused with Oxygen-Hydrogen flame. We call it the Standard grade Fused Silica. This process produces high quality pure optical grade material suitable for most demanding applications. However its high OH content may limit the use in a very high temperature processing or operating environment.
2. Dry Process
   This technology produces the highest-grade material, which can meet the highest expectations in respect to all parameters. Although the availability is somewhat limited and very expensive it is expected to become competitive on the market as demand increases.

There are many suppliers on the market today and we are constantly updating our information database to help our customers to select the right substrate material.

TABLES OF PROPERTIES

Mechanical Properties						
CHARACTERISTICS	FUSED QUARTZ		FUSED SILICA			
	Electric Fused	Flame Fused	Standard	Semi Dry	Dry	Very Dry
Density 25° C g/cm³	2.200	2,203	2,200	2,202	2,201	2,201
Hardness kg/cm²	750-800	750-800	750-800	600	750-800	750-800
Compressibility kg/cm²	11,500	11,500	11,500	11,300	11,500	11,500
Poisson's Ratio	0.17	0.17	0.17	0.17	0.18	0.18
Rigidity Modulus kg/cm²	320 x 10^3	318 x 10^3	318 x 10^3	320 x 10^3	317 x 10^3	317 x 10^3
Young's Modulus kg/cm²	744 x 10^3	744 x 10^3	744 x 10^3	745 x 10^3	741 x 10^3	741 x 10^3
Tensile Strength kg/cm²	500	500	500	500	500	500
Thermal Properties						
Coefficient of Thermal Expansion (CTE)	5.5 x 10^{-7}	5.0 x 10^{-7}	5.5 x 10^{-7}	5.5 x 10^{-7}	5.5 x 10^{-7}	5.5 x 10^{-7}
Strain Point	1,120 °C	1,090 °C	970 °C	1,000 °C	1,050 °C	1,110 °C
Annealing Point	1,215 °C	1,180 °C	1,080 °C	1,100 °C	1,150 °C	1,200 °C
Softening Point	1,683°C	1,720 °C	1,580 °C	1,600 °C	1,620 °C	1,650 °C
Thermal Conductivity [(cal. cm)/(cm² sec° C)]				3.3 x 10^{-3}		
Thermal Diffusivity cm²/sec				8.5 x 10^{-3}		
Specific Heat Cal/gm ° C				0.177		
Electrical Properties						
Dielectric Constant 25 ° C @ 24Ghz		3.82		3.82	3.71	
Loss Tangent 25 ° C @ 24Ghz				0.00033		
Dielectric Constant 500 °C @ 24Ghz		3.87		3.87	3.75	
Dielectric Constant 500° C @ 24Ghz				0.00020	0.00025	
Dielectric Strength @20 °C, kV/cm		320		400		
Dielectric Strength @ 500 °C, kV/cm		160		200		

Chemical Properties In units of parts per million (ppm)							
ELEMENTS	PT ID	FUSED QUARTZ		FUSED SILICA			
		Electric Fused	Flame Fused	Standard	Semi Dry	Dry	Very Dry
Hydroxyl	OH	≤ 5	≤ 200	≤ 1200	≤ 700	≤ 100	≤ 10
Aluminum	Al	14	9	0.1	0.02	≤10 ppb	≤10 ppb
Antimony	Sb	0.003			0.0004		
Arsenic	As	0.002					
Barium	Ba						
Bismuth	Bi				0.04		
Beryllium	Be				0.03		
Bromine	Br				0.0025		
Boron	B	0.2			1.0		
Cadmium	Cd	0.01			0.08		
Calcium	Ca	0.4	0.6	0.1		≤10 ppb	≤10 ppb
Chlorine	Cl				88.5		
Chromium	Cr	0.05			0.0006	≤10 ppb	≤10 ppb
Cobalt	Co				0.001	≤10 ppb	≤10 ppb
Copper	Cu	0.05	0.03	0.01		≤10 ppb	≤10 ppb
Gallium	Ga				0.02		
Germanium	Ge				0.06		
Gold	Au				0.001		
Hafnium	Hf						
Iron	Fe	0.2	0.4	0.05	0.2	≤10 ppb	≤10 ppb
Lithium	Li	0.6	0.2	0.05	0.21	≤10 ppb	≤10 ppb
Magnesium	Mg	0.1				≤10 ppb	≤10 ppb
Manganese	Mn	0.05					
Molybdenum	Mo						
Nickel	Ni	0.1				≤10 ppb	≤10 ppb
Phosphorus	P	0.2					
Potassium	K	0.6	0.2	0.05		≤10 ppb	≤10 ppb
Silver	Ag						
Sodium	Na	0.7	0.6	0.05	0.023	≤10 ppb	≤10 ppb
Strontium	Sr						
Thallium	Tl				0.05		
Titanium	Ti	1.1				≤10 ppb	≤10 ppb
Uranium	U						
Zirconium	Zr	0.8					
Zinc	Zn					≤10 ppb	≤10 ppb

Optical Properties 1.00 mm thick polished wafer						
Transmittance in %	FUSED QUARTZ		FUSED SILICA			
	Electric Fused	Flame Fused	Standard	Semi Dry	Dry	Very Dry
λ 200 nm	20.0	22.0	96.0			
λ 210 nm	45.0	48.0	97.5			
λ 215 nm	55.0	60.0	97.9			
λ 240 nm	65.0	68.0	99.0			
λ 280 nm	92.0	93.0	99.5			
λ 500 nm	93.0	94.0	99.7			
λ 1000 nm	95.0	96.0	99.8			
λ 2500 nm	95.0	97.0	99.8			

Our Workmanship Standards:

The table below illustrates the major differences between two categories of workmanship tolerances. Be aware of the fact that the call-outs on these features are significantly affecting the production yield thus the price of the final product.

Standard Surface Finish & Dimensional Tolerances.		
FEATURES	Optical PRIME Grade	Semiconductor Grade
Diameter	± 0.05 mm	± 0.10
Thickness	± 0.05 mm	± 0.10
Flatness	≤ 30 microns	≤ 50 microns
Local Thickness Variation	≤ 3.0 microns/20 mm²	≤ 9.0 microns/20 mm²
Total Thickness Variation	≤ 10.0 microns	≤ 25.0 microns
Surface Roughness	≤ 0.5 nm	2 nm
Chips & Voids	NONE 10 x magnification, dark field background	50 micron max.
Open bubbles, inclusions		50 micron max.
Strain		none
Scratch-Dig		60/40
Hill		none
Pits		50 micron max.

PACKAGING

There are three different type of packing available to our customers.

1. Standard - Single Disk - Single Bag

Each disk is placed in special bag and sealed . A label is placed on the outside of each bag. The label may show the part number, serial number (laser scribed into disk, if any), QC. check mark & QC. operator ID., Originator Co. ID. Etc.

This method is a preferred method for many of our customers. It is inexpensive and safe method for shipping fragile quartz wafers long distance by commercial carriers. Also practical for prototypes, small quantities of mixed sizes and types, one of a kind pilot runs and qualifying samples. The customers QC. department can do the qualifying inspection and perform the final cleaning if needed

2. Clean Room - Single Disk - Double Bag

Each disk is placed in a special bag. The bag is purged with inert gas and sealed. A customer specified and designed label is placed on the outside of the bag, placed into a second protective bag and sealed.

Preferred by our regular customer where we are a qualified supplier. When all specifications and procedures are coordinated and we are fully qualified to deliver parts to clean room without inspection by customer's QC. Because quartz wafers are used mostly for test and set up purposes, most customers prefer this type of packing which allow them to move unopened packages from department to department without concern of recontamination or re-packing.

3. Clean Room - Batch of Disks – in a Sealed Cassette

Each disk is placed in the cassette in a clean room. The cassette is vacuum sealed and a customer specified and designed label is placed on the outside of the bag.

ON HANDLING OF QUARTZ WAFERS

Warning: Quartz wafers must be handled lot more gently then silicon wafers in order to avoid cracking and chipping. Unlike silicon wafers, a minute small crack on the edge or a chipped edge. Some cracks may be even invisible for the naked eye. A defective wafer may shatter under pressure in the processing chamber causing major disruption on the production line.

Contact us:

USA
Quartz Unlimited LLC.
Contact:
Ferenc Ledniczky
Sales Engineer
ferenc@quartzunlimited.com
phone: 561 999-4340
fax: 561 982-8836

SOUTH KOREA

Nam Kang Hi-Tech Co. Ltd.
www.namkang.co.kr

Contact:
Yunshic Choi
Phone (82) 2 565-0014
Fax (82) 2 565-3621