# GE Materials

## Semiconductor Grade Fused Quartz Tubing

Globally in the semiconductor industry a combination of extreme purity and excellent high temperature properties make fused quartz tubing an ideal furnace chamber for processing silicon wafers. The material can tolerate the wide range of temperature gradients and high heat rates of the process. And its purity creates the low contamination environment required for achieving high wafer yields. The advent of eight inch wafers combined with today's smaller chip sizes has increased chip production by a factor of four compared to technology in place just a few years ago. These developments have impacted heavily on quartz produced, requiring both large diameter tubing and significantly higher levels of purity. GE Quartz has responded on both counts. Quartz tubing is available in a full range of sizes, including diameters of 400mm and larger. Diameter and wall thickness dimensions are tightly controlled. Special heavy wall thicknesses are available on request. By finding new and better sources of raw material, expanding and modernizing our production facilities, and upgrading our quality control functions, GE has reduced contaminants levels in its fused quartz tubing to less than 25 ppm, with alkali levels below 1 ppm.

### Grade 214LD

This is a larger diameter grade of industry standard 214 quartz tubing. For all but the highly specialized operations, this low cost tubing offers the levels of purity, sag resistance, furnace life and other properties that diffusion and CVD processes require. For superior performance at elevated temperatures GE type 214 LD furnace tubing gives process engineers a better balance between the effects of higher temperatures and heavier wafer loads.

### Fused Quartz Rod & Solids

We supply GE materials in two forms of high purity fused quartz solid shapes for fabricators of quartzware. Type 214 rod has the high purity, elevated temperature characteristics and low coefficient of thermal expansion required for wafer carriers and push rods used in semiconductor wafer processing. The material is available in diameters of 1 to 20 mm. Very tight quality control and special processing of raw materials is used to achieve low levels of trace element contamination. When larger sizes and different shaped starting materials are required, we supply GE materials to fabricators with pieces cut from fused quartz ingots. They are up to 72 inches in diameter, two feet thick, and weigh up to 9000 pounds.

### Large Ingots

GE Type 124 ingots have been the semiconductor industry's material of choice for fabricating diffusion and CVD furnace components for a number of years. The advent of larger wafer sizes, tighter device geometries, and the drive for lower contaminant levels has stimulated GE's development of an even higher purity grade. Type 144 is specially processed to reduce alkali content by up to 90%. Sodium is held to 0.2 ppm or lower, potassium is significantly reduced while lithium is about 0.2 ppm. Type 012 provides the ultra high purity of synthetic fused silica, while maintaining low (OH) at < 5 ppm.

## Table of Typical Physical Properties, Type 214 Fused Quartz

| Property | Typical Values |
|---|---|
| Density | 2.2x10 3 kg/m3 |
| Hardness | 5.5 - 6.5 Mohs' Scale 570 KHN 100 |
| Design Tensile Strength | 4.8x10 7 Pa (N/m2) (7000 psi) |
| Design Compressive Strength | Greater than 1.1 x l0 9 Pa (160,000 psi) |
| Bulk Modulus | 3.7x10 10 Pa (5.3x10 6 psi) |
| Rigidity Modulus | 3.1x10 10 Pa (4.5x10 6 psi) |
| Young's Modulus | 7.2x1 -10 Pa (10.5x10 6 psi) |
| Poisson's Ratio | .17 |
| Coefficient of Thermal Expansion | 5.5x10 -7 cm/cm . øC (20øC-320øC) |
| Thermal Conductivity | 1.4 W/m . øC |
| Specific Heat | 670 J/kg . øC |
| Softening Point | 1683 øC |
| Annealing Point | 1215 øC |
| Strain Point | 1120 øC |
| Electrical Resistivity | 7x10 7 ohm cm (350øC) |
| Dielectric Properties | (20øC and 1 MHz) |
| Constant | 3.75 |
| Strength | 5x10 7 V/m |
| Loss Factor | Less than 4x10 -4 |
| Dissipation Factor | Less than 1x10 -4 |
| Index of Refraction | 1.4585 |
| Constringence (Nu) | 67.56 |
| Velocity of Sound-Shear Wave | 3.75x10 3 m/s |
| Velocity of Sound/Compression Wave | 5.90X10 3 m/s |
| Sonic Attenuation | Less than 11 db/m MHz |
| Permeability Constants (700øC) | (cm3 mm/cm2 sec cm of Hg) |
| Helium | 210x10 -10 |
| Hydrogen | 21x10 -10 |
| Deuterium | 17x10 -10 |
| Neon | 9.5x10 -10 |

## Typical Trace Element Composition (ppm by weight)

| Type | Al | As | B | Ca | Cd | Cr | Cu | Fe | K | Li | Mg | Mn | Na | Ni | P | Sb | Ti | Zr | OH | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 214 | 14 | <0.002 | <0.2 | 0.4 | <0.01 | <0.05 | <0.05 | 0.2 | 0.6 | 0.6 | 0.1 | <0.05 | 0.7 | <0.1 | <0.2 | <0.003 | 1.1 | 0.8 | <5 | 214 |
| 219 | 14 | <0.01 | <0.2 | 0.4 | <0.01 | <0.05 | <0.05 | 0.2 | 0.6 | 0.6 | 0.1 | <0.05 | 0.7 | <0.1 | <0.2 | <0.003 | 100 | 0.8 | <5 | 219 |
| 214A | 14 | <0.002 | <0.2 | 0.4 | <0.01 | <0.05 | <0.05 | 0.2 | 0.6 | 0.6 | 0.1 | <0.05 | 0.7 | <0.1 | <0.2 | <0.003 | 1.1 | 0.8 | <1 | 214A |
| 214Rod/LD | 14 | <0.002 | <0.2 | 0.4 | <0.01 | <0.05 | <0.05 | 0.2 | 0.6 | 0.6 | 0.1 | <0.05 | 0.7 | <0.1 | <0.2 | <0.003 | 1.1 | 0.8 | 10 | 214Rod/LD |
| 224/Rod | 14 | <0.002 | <0.2 | 0.4 | <0.01 | <0.05 | <0.03 | 0.2 | <0.2 | <0.2 | 0.1 | <0.03 | <0.2 | <0.1 | <0.2 | 0.003 | 1.4 | 0.8 | 10 | 224/Rod |
| 224LD | 14 | <0.002 | <0.2 | 0.4 | <0.01 | <0.05 | <0.01 | 0.2 | <0.2 | 0.001 | 0.1 | <0.05 | <0.1 | <0.1 | <0.2 | 0.003 | 1.1 | 0.8 | 10 | 224LD |
| 244/Rod | 8 | <0.002 | <0.1 | 0.6 | <0.01 | <0.05 | <0.03 | 0.2 | <0.2 | <0.2 | <0.1 | <0.03 | <0.2 | <0.1 | <0.2 | <0.03 | 1.4 | 0.3 | 10 | 244/Rod |
| 244LD | 8 | <0.02 | <0.1 | 0.6 | <0.01 | <0.05 | <0.01 | 0.2 | <0.2 | 0.001 | <0.1 | <0.03 | 0.1 | <0.1 | <0.2 | <0.003 | 1.4 | 0.3 | 10 | 244LD |
| 124 | 14 | <0.002 | <0.2 | 0.6 | <0.01 | <0.05 | <0.05 | 0.2 | 0.6 | 0.6 | 0.1 | <0.05 | 0.7 | <0.1 | <0.2 | <0.003 | 1.1 | 0.8 | <5 | 124 |
| 144 | 8 | <0.002 | <0.1 | 0.6 | <0.01 | <0.05 | <0.05 | 0.2 | <0.2 | <0.2 | <0.1 | <0.03 | <0.2 | <0.1 | <0.2 | <0.03 | 1.4 | 0.3 | <5 | 144 |