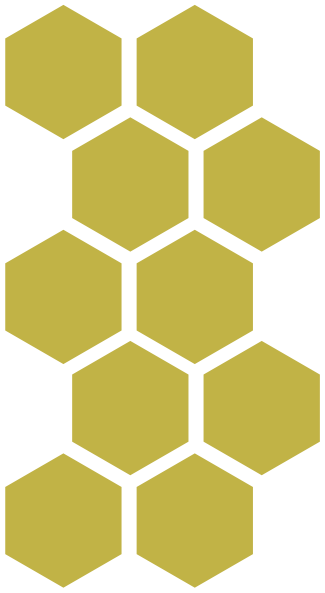


J

# MATERIALS
# SUBSTRATES

**NEYCO has a complete range of crystal substrates for a wide variety of applications, including Semiconductor, Biotechnology, Nanotechnology, and MEMS. NEYCO is your one stop source for advanced materials for both R&D laboratory use and industry production. We can help you to locate, specify, and purchase unique materials in an efficient and cost effective manner.**

# STANDARD SUBSTRATE PARAMETERS

**Substrates and wafers are manufactured by a technology, which is specially adapted to the respective material. Additionally we produce substrates and wafers customer-specific in all possible orientations, sizes and geometries and with smaller tolerance.**

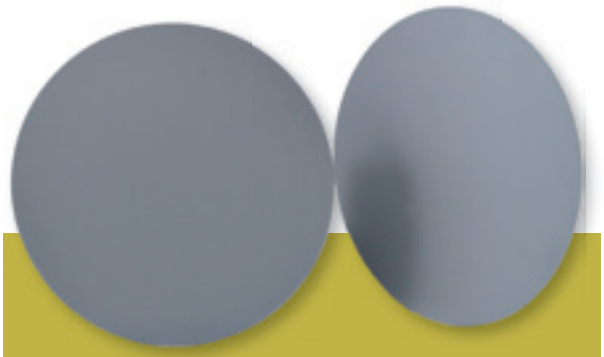
| | |
|---|---|
| **Orientations** | (100), (111), (110) for cubic crystals<br>(110), (001) for tetragonal crystals<br>(0001), (1-102), (11-20), (10-10)<br>for hexagonal crystals<br>(110), (001) for orthorhombic crystals<br>other orientations on request<br>Standard: edges are oriented |
| **Tolerance of orientation** | Maximum 30' ; typical < 20'<br>higher precision on request |
| **Standard sizes** | 10x10 mm, 10x5 mm, 12.7x12.7 mm, 15x15 mm,<br>20x20 mm, 25x25 mm, ø 1", ø 2", ø 3"<br>other sizes on request |
| **Tolerance of sizes** | +0/-0.05 mm |
| **Thickness** | 0.5 mm, 1.0 mm (standard)<br>other thicknesses down to 0.1 mm on request |
| **Tolerance of thickness** | +0.05/-0.05 mm |
| **Polish** | One side, two sides<br>optical polish of lateral sides (cylinders) on request |
| **Surface quality** | Scratchfree at magnification of 50 |
| **Roughness: (at $\lambda_{Cutoff}$ = 0.08 mm)** | Ra: typ. better than 0.5 nm<br>Rq: typ. better than 1 .0 nm<br>Rt: typ. better than 2.0 nm |
| **Parallelity** | Typ. better than 10' |
| **Flatness** | Max. 1 µm/10 mm (test region 98%<br>of the wafer area) |

Micro-roughness measured with Kugler Interferometermicroscope (lateral resolution: 0.64 µm, vertical resolution (theoretically): 0.01 nm).

# Silicon Wafers

## MATERIALS CHARACTERISTICS

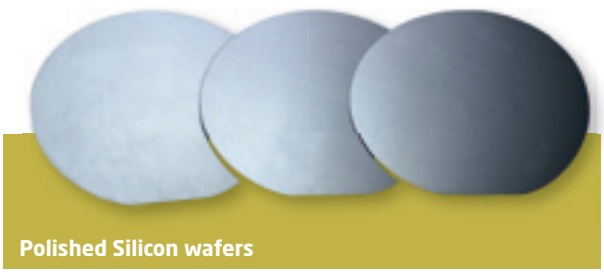
Silicon wafers are cut from silicon single crystal using internal diameter diamond discs. Silicon wafers are lapped of both sides with abrasive mixture. After cutting or lapping the wafers are washed in ultrasonic washers or undergo active washing. The wafers' edges are mechanically rounded. Silicon wafers are etched in acid mixture or alkaline. Wafers surface is alkaline or acid etched according to the customer's request. Active sides of the wafers (for single side polished wafers) or both sides (for two sides polished wafers) are chemo-mechanically polished.



Etched Silicon wafers

## APPLICATIONS

Wafers are used for production of silicon substrates and membranes.
The below mentioned parameters are dealing with our standard production. On the customer's request we are ready to discuss orders for wafers with some other parameters, for instance:



Polished Silicon wafers

- Low radial resistivity variation (RRV) combined with the uniform distribution of dopants in the crystal (this parameter depends on shape of phase boundary and the phenomena in the boundary layer during monocrystalization process).
- Perfect crystallographic structure of material (free from swirls, with dislocations density lower than recommended by SEMI standard - 500/cm$^2$).
- Low oxygen concentration ($O_2$ < 30 ppm).
- Tolerance of orientation better than 0.10°.
- Very good polished surface (one or both sides polished depending on technology and the type of products).

## STANDARD SPECIFICATIONS

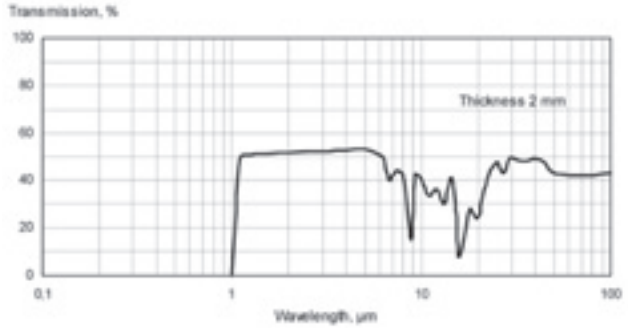
| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| **Growth method** | Czochralski (CZ)<br>Floating zone (FZ) | | | | | |
| **Orientation** | <111>, <100> | | | | | |
| **Diameters** | 1" to 300 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| **Crystal structure** | Cubic a = 0.543 nm | | | | | |
| **Dopant available** | P-type: Boron<br>N-type: Phosphorus, Antimony or Arsenic | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Density** | 2.329 $g.cm^{-3}$ | | | | | |
| **Melting point** | 1417°C | | | | | |
| **Hardness** | 7 Mohs | | | | | |
| **Thermal expansion** | $2.3.10^{-6} K^{-1}$ | | | | | |
| **Resistivity range** | 0.001 - 10 000 Ω.cm | | | | | |
| **Band gap (at 273 K)** | 1.106 eV | | | | | |
| **Thermal conductivity** | 147 $W.m^{-1}.K^{-1}$ | | | | | |
| **Carrier mobility** | $\mu_e$ = 1350 $cm^2.V^{-1}.s^{-1}$<br>$\mu_h$ = 480 $cm^2.V^{-1}.s^{-1}$ | | | | | |
| **Conductivity type** | P-type or N-type | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | 0.005 g/100 $cm^3$ | | | | | |
| **Solubility in acids** | Soluble | | | | | |
| **Solubility in organic solvents** | Insoluble | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Absorption coefficient** | 0.01 $cm^{-1}$ at 5 µm | | | | | |
| **Transmission range (thickness 2 mm)** | 1.2 - 15.0 µm | | | | | |
| **Refractive index n** | 3.0 µm | 5.0 µm | 6.0 µm | 7.0 µm | 8.0 µm | 10.0 µm |
| | 3.432 | 3.422 | 3.420 | 3.419 | 3.418 | 3.417 |

## TECHNICAL DATA : AS CUT, LAPPED, ETCHED, POLISHED

| **Diameter (mm)** | 50.8 ± 0.3 | 76.0 ± 0.5 | 100 ± 0.5 | 125 ± 0.5 | 150 ± 0.5 |
|---|---|---|---|---|---|
| **Orientation** | <100> | <100> | <100> | <100> | <100> |
| **Thickness (µm)** | 40 to 25000 | 60 to 25000 | 70 to 25000 | 100 to 5000 | 150 to 5000 |
| **Thickness tolerance (µm)**<br>**Standard**<br>**Typical** | ± 25<br>± 10 | ± 25<br>± 10 | ± 25<br>± 15 | ± 25<br>± 20 | ± 25<br>± 20 |
| **Total thickness variation**<br>**TTV max** | 10 | 15 | 15 | 20 | 25 |

| **Diameter (mm)** | 50.8 ± 0.3 | 76.0 ± 0.5 | 100 ± 0.5 | 125 ± 0.5 | 150 ± 0.5 |
|---|---|---|---|---|---|
| **Orientation** | <111> | <111> | <111> | <111> | <111> |
| **Thickness (µm)** | 100 to 25000 | 150 to 25000 | 200 to 25000 | 250 to 5000 | 350 to 5000 |
| **Thickness tolerance (µm)**<br>**Standard**<br>**Typical** | ± 25<br>± 10 | ± 25<br>± 10 | ± 25<br>± 15 | ± 25<br>± 20 | ± 25<br>± 25 |
| **Total thickness variation**<br>**TTV max** | 10 | 15 | 15 | 20 | 25 |

## TRANSMISSION SPECTRUM (high resistivity Si)




## RECOMMENDED APPLICATIONS

| Wafer Resistivity (ohm.cm) | < 0.05 | 1 - 5 | 6 - 12 | > 30 |
|---|---|---|---|---|
| Application | Epitaxial substrate | Solar cell | IC, OE devices or sensors | Special device or component |

## THERMAL OXIDATION

On request, a thermal oxidation can be grown on our Silicon wafers.

- Oxidation thickness: 100 nm to max. 2 µm.
- Wafer sizes: up to 4".

## OTHER SERVICE

We can made special vacuum coatings on wafers: for example, we can deposit a precoating of Chromium or Titanium before a thin film of Gold, or any other evaporated or sputtered material. Contact us for your specific needs.

# Single Crystal Substrates

# SAPPHIRE $Al_2O_3$ SUBSTRATE

Sapphire (single crystal of $Al_2O_3$) is being used extensively as a substrate for III-V nitrides and for many other epitaxial films. Single crystal sapphire wafer plays an increasingly important role as a material for blue LED, high Tc superconductor and microwave applications, due to its high strength, high anti-corrosion, high anti-abrasion, low dielectric loss and good electrical insulation.

NEYCO provides sapphire substrates with complete orientation options including C plane, A plane, R plane and M plane, in diameter range from 1" to 4", square substrate is also available as well, size from 10 x 10 mm to 100 x 100 mm. NEYCO can offer EPI ready grade sapphire wafer for your epitaxial growth.

## FEATURES

- High working temperature
- Good thermal conductivity
- Superior mechanical properties
- High anti corrosion
- Stable dielectric constant & low dielectric loss
- Excellent light transmission

## APPLICATIONS

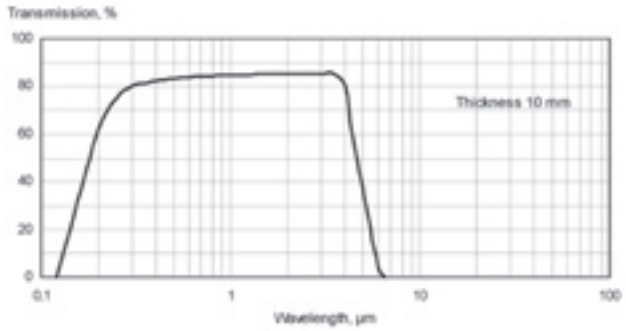
- Blue LED substrate
- Superconductor substrate
- Electronics and optoelectronics
- UV and IR optics

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **CRYSTAL GROWTH** | |
| **Growth method** | Czochralski (CZ) |
| **Maximum size** | Ø 4" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Hexagonal<br>a = 0.477 nm  c = 1.304 nm |
| **Color** | Colourless |
| **PHYSICAL PROPERTIES** | |
| **Density** | 3.98 $g.cm^{-3}$ |
| **Melting point** | 2052°C |
| **Hardness** | 9 Mohs |
| **Thermal expansion** | Vertical c-axis: $6.2.10^{-6}$ $K^{-1}$<br>Parallel c-axis: $5.4.10^{-6}$ $K^{-1}$ |
| **Thermal conductivity** | Vertical c-axis: 23.1 $W.m^{-1}.K^{-1}$<br>Parallel c-axis: 25.2 $W.m^{-1}.K^{-1}$ |
| **Heat capacity** | 761 $J.kg^{-1}.K^{-1}$ |
| **Dielectric constant** | Vertical c-axis: 9.4<br>Parallel c-axis: 11.5 |
| **Loss Tangent at 10 GHz** | Vertical c-axis: $8.6.10^{-8}$<br>Parallel c-axis: $3.10^{-8}$ |
| **CHEMICAL PROPERTIES** | |
| **Solubility in water** | $98.10^{-6}$ g/100 $cm^3$ |
| **Solubility in acids** | Insoluble |
| **Solubility in organic solvents** | Not declarate |

| OPTICAL PROPERTIES | | | | |
|---|---|---|---|---|
| Absorption coefficient | 0.2 $cm^{-1}$ at 0.2 µm<br>0.02 $cm^{-1}$ at 0.4 µm<br>0.46 $cm^{-1}$ at 5 µm | | | |
| Transmission range (thickness 10 mm) | 0.17 - 5.0 µm | | | |
| Refractive index n | 1 µm | 2 µm | 3 µm | 4 µm |
| | 1.7545 | 1.7374 | 1.7015 | 1.6748 |

## TRANSMISSION SPECTRUM




# BARIUM FLUORIDE $BaF_2$ SUBSTRATE

## APPLICATIONS

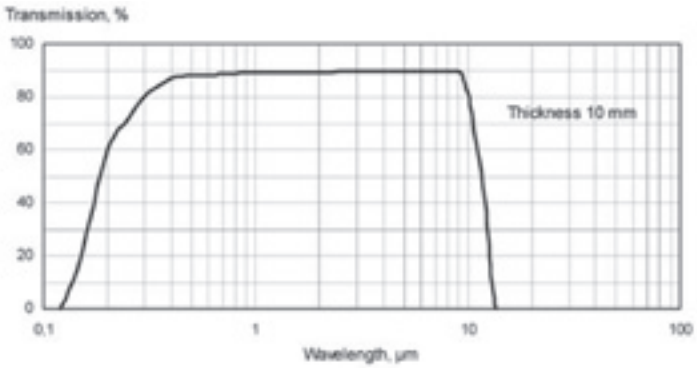
IR and UV window, prism, substrate.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Stockbarger technique |
| Maximum size | Ø 150 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.6196 nm |
| Cleavage plane | <111> |
| **PHYSICAL PROPERTIES** | |
| Density | 4.83 $g.cm^{-3}$ |
| Melting point | 1354°C |
| **PHYSICAL PROPERTIES** | |
| Hardness | 3 Mohs |
| Thermal expansion | 16.5 - 19.2 x $10^{-6}$ $K^{-1}$ |

| PHYSICAL PROPERTIES | | | | | | |
|---|---|---|---|---|---|---|
| Thermal conductivity | 7.1 $W.m^{-1}.K^{-1}$ | | | | | |
| Specific heat capacity | 456 $J.kg^{-1}.K^{-1}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| Solubility in water | 0.17 g/100 $cm^3$ | | | | | |
| Solubility in acids | Soluble | | | | | |
| Solubility in organic solvents | Not declarate | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| Absorption coefficient | 0.20 $cm^{-1}$ at 0.2 µm<br>0.08 $cm^{-1}$ at 0.4 µm<br>0.13 $cm^{-1}$ at 10.6 µm | | | | | |
| Refractive index n | 0.2 µm | 0.5 µm | 1.0 µm | 5.0 µm | 10.0 µm | 12.0 µm |
| | 1.5573 | 1.4779 | 1.4686 | 1.4511 | 1.4014 | 1.3696 |

## TRANSMISSION SPECTRUM




# BARIUM TITANATE $BaTiO_3$ SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | 10 x 10 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Tetragonal<br>a = 0.3992 nm c = 0.4036 nm |
| **PHYSICAL PROPERTIES** | |
| Density | 8.82 $g.cm^{-3}$ |
| Melting point | 1600°C |
| Hardness | 5 Mohs |

# CALCIUM FLUORIDE $CaF_2$ SUBSTRATE

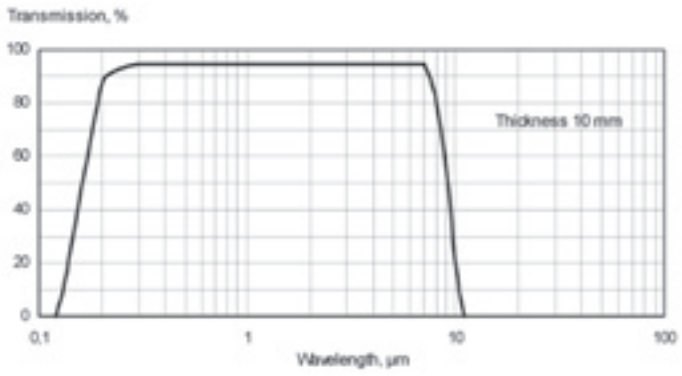
## APPLICATIONS

IR windows and lens, prism.

## STANDARD SPECIFICATIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| **Growth method** | Stockbarger technique | | | | | |
| **Maximum size** | Ø 200 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| **Crystal structure** | Cubic a = 0.5462 nm | | | | | |
| **Cleavage plane** | <111> | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Density** | 3.18 $g.cm^{-3}$ | | | | | |
| **Melting point** | 1418°C | | | | | |
| **Hardness** | 4 Mohs | | | | | |
| **Thermal expansion** | 16.2 - 19.4 x $10^{-6}$ $K^{-1}$ | | | | | |
| **Thermal conductivity** | 9.17 $W.m^{-1}.K^{-1}$ | | | | | |
| **Specific heat capacity** | 888 $J.kg^{-1}.K^{-1}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | 0.0016 g/ 100 $cm^3$ | | | | | |
| **Solubility in acids** | Unessential | | | | | |
| **Solubility in organic solvents** | Insoluble in acetone | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Transmission range (Thickness 10 mm)** | 0.15 - 9.0 µm | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Refractive index** | 0.2 µm | 0.5 µm | 1.0 µm | 5.0 µm | 10.0 µm | 12.0 µm |
| | 1.4951 | 1.4365 | 1.4289 | 1.3990 | 1.3002 | 1.2299 |
| **Absorption coefficient** | 0.10 $cm^{-1}$ at 0.2 µm<br>0.01 $cm^{-1}$ at 0.4 µm<br>0.03 $cm^{-1}$ at 2.6-2.9 µm | | | | | |

## TRANSMISSION SPECTRUM



# CALCIUM NEODYMIUM ALUMINATE $CaNdAlO_4$ (CNAO) SUBSTRATE

## MATERIAL CHARACTERISTICS

High quality YBaCuo, BiSrCaCuO, Bi(Pb)CaCuO and TlBaCaCuO thin films have been grown on $CaNdAlO_4$ substrates by different techniques.

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **CRYSTAL GROWTH** | |
| **Growth method** | Czochralski (CZ) |
| **Maximum size** | Ø 18 - 20 mm |
| **Standard thickness** | 0.5 to 1 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Tetragonal<br>a = 0.369 nm  c = 2.215 nm |
| **Color** | Violet |
| **Twin structure** | No |
| **PHYSICAL PROPERTIES** | |
| **Density** | 5.527 $g.cm^{-3}$ |
| **Melting point** | 1860°C |
| **Thermal expansion** | Along a-axis: $8.67.10^{-6}$ $K^{-1}$<br>Along c-axis: $1.57.10^{-5}$ $K^{-1}$ |
| **Dielectric constant** | 20 |
| **Loss tangent (at 10 GHz)** | $2.10^{-3}$ |
| **OPTICAL PROPERTIES** | |
| **Transmission range** | 220 to 6670 nm (excluding Nd range) |
| **Refractive index n** | 1.941 |

# CADMIUM SULFIDE CdS SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Seeded vapour phase growth |
| Maximum size | Ø 50 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Hexagonal<br>a = 0.4135 nm c = 0.6749 nm |
| **PHYSICAL PROPERTIES** | |
| Density | 4.82 $g.cm^{-3}$ |
| Melting point | 1475°C |
| Hardness | 4 Mohs |
| Thermal expansion | $4.2.10^{-6}$ $K^{-1}$ |
| Resistivity range | > $10^{8}$ Ω.cm (high resistivity)<br>< $10^{1}$ Ω.cm (low resistivity) |
| Band gap at 300 K | 2.53 eV |
| Thermal conductivity | 15.9 $W.m^{-1}.K^{-1}$ |
| Conductivity type | N-type |
| Carrier concentration | $10^{9}$ - $10^{18}$ $cm^{-3}$ |
| Dielectric constant | Vertical c-axis: 8.28<br>Parallel c-axis: 8.64 |

# CADMIUM SELENIDE CdSe SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Seeded vapour phase growth |
| Maximum size | Ø 50 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Hexagonal<br>a = 0.431 nm c = 0.7021nm |
| **PHYSICAL PROPERTIES** | |
| Density | 5.816 $g.cm^{-3}$ |
| Melting point | 1268°C |
| Hardness | 4 Mohs |
| Thermal expansion | $2.9.10^{-6}$ $K^{-1}$ |
| Resistivity range | > $10^{7}$ Ω.cm (high resistivity)<br>< $10^{1}$ Ω.cm (low resistivity) |
| Thermal conductivity | 3.49 $W.m^{-1}.K^{-1}$ |
| Band gap at 300 K | 1.74 eV |
| Conductivity type | N-type |

# CADMIUM TELLURIDE CdTe SUBSTRATE

## STANDARD SPECIFICATIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| **Growth method** | Modified Bridgman (with Cd-reservoir) | | | | | |
| **Maximum size** | Ø 60 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| **Crystal structure** | Cubic a = 0.6481 nm | | | | | |
| **Cleavage** | <110> | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Density** | 5.855 $g.cm^{-3}$ | | | | | |
| **Melting point** | 1092°C | | | | | |
| **Hardness** | 3 Mohs | | | | | |
| **Thermal expansion** | $5.7.10^{-6}$ $K^{-1}$ | | | | | |
| **Thermal conductivity** | 6.28 $W.m^{-1}.K^{-1}$ | | | | | |
| **Resistivity range** | > $10^{9}$ Ω.cm | | | | | |
| **Band gap at 300 K** | 1.5 eV | | | | | |
| **Conductivity type** | N-type, P-type | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | Insoluble | | | | | |
| **Solubility in acids** | Insoluble | | | | | |
| **Solubility in organic solvents** | Insoluble | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Absorption coefficient** | 0.001 $cm^{-1}$ at 10.6 µm | | | | | |
| **Transmission range (thickness 2 mm)** | 0.9 µm to 24 µm | | | | | |
| **Refractive index n** | 1 µm | 5 µm | 10 µm | 15 µm | 20 µm | 30 µm |
| | 2.831 | 2.692 | 2.679 | 2.659 | 2.632 | 2.559 |

# COBALT OXIDE CoO SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Verneuil |
| Maximum size | Ø 15mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.4267 nm |
| Color | Black |
| **PHYSICAL PROPERTIES** | |
| Density | 6.4 $g.cm^{-3}$ |
| Melting point | 1935°C |
| Hardness (Knoop test) | 310 to 345 |

# CHROMIUM OXIDE $Cr_2O_3$ SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Verneuil |
| Maximum size | Ø 15 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Hexagonal<br>a = 0.496 nm c = 1.3599 nm |
| Color | Black |
| **PHYSICAL PROPERTIES** | |
| Density | 5.2 $g.cm^{-3}$ |
| Melting point | 2275°C |

# GALLIUM ARSENIDE GaAs SUBSTRATE

Gallium Arsenide used for lenses and beam splitters provides an alternative to ZnSe in medium and high power CW CO2 laser systems. It is most useful in applications where toughness and durability are important. Its hardness and strength make it a good choice where dust or abrasive particles tend to build up on or bombard the optical surfaces. When frequent cleaning by wiping is required, GaAs is excellent. The material is nonhygroscopic, safe to use in laboratory and field conditions and is chemically stable except when in contact with strong acids.

## FEATURES

- High mobility
- High frequency
- Low power consumption

## APPLICATIONS

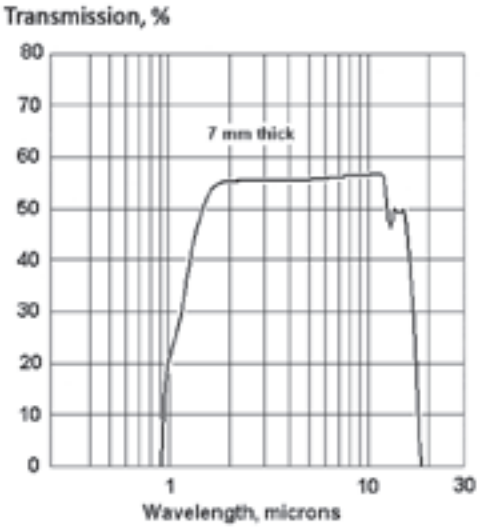
- Visible and infrared LED
- Light emitting diodes
- Laser diodes

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Growth method | Czochralski (CZ) or Vertical Gradient Freeze | | | | | | | | | |
| Maximum size | Ø 4" | | | | | | | | | |
| Standard thickness | 350 - 625 µm | | | | | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | | | | | |
| Crystal structure | Cubic a = 0.565 nm | | | | | | | | | |
| Dopant available | Silicon, Tellurium, Zinc, Chromium | | | | | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | | | | | |
| Density | 5.32 $g.cm^{-3}$ | | | | | | | | | |
| Melting point | 1238°C | | | | | | | | | |
| Hardness (Knoop test) | 750 | | | | | | | | | |
| Thermal expansion | $5.8.10^{-6}$ $K^{-1}$ | | | | | | | | | |
| Dielectric constant | 12.85 | | | | | | | | | |
| Band gap | 1.42 eV | | | | | | | | | |
| Thermal conductivity | 0.55 $W.cm^{-1}.K^{-1}$ | | | | | | | | | |
| Specific heat capacity | 0.327 $J.g^{-1}.K^{-1}$ | | | | | | | | | |
| Conductivity | Semi-conducting or semi-insulating | | | | | | | | | |
| Conductivity type | P-type or N-type | | | | | | | | | |
| **OPTICAL PROPERTIES** | | | | | | | | | | |
| Absorption coefficient | < 0.02 $cm^{-1}$ at 10.6 µm | | | | | | | | | |
| Transmission range (thickness 7 µm) | 1.0 to 22 µm | | | | | | | | | |
| Solubility in water | None | | | | | | | | | |
| Refractive index n | 8 µm | 10 µm | 11 µm | 13 µm | 13.7 µm | 14.5 µm | 15 µm | 17 µm | 19 µm | 21.9 µm |
| | 3.34 | 3.13 | 3.04 | 2.97 | 2.89 | 2.82 | 2.73 | 2.59 | 2.41 | 2.12 |

| Parameters | Undoped GaAs | Si Doped GaAs | Zn Doped GaAs | Cr Doped GaAs | Te Doped GaAs |
|---|---|---|---|---|---|
| Doping | Undoped | Si | Zn | Cr | Te |
| Conductor type | N, (SI) | N | P | SI | N |
| Carrier concentration ($cm^{-3}$) | - | $(5 - 15).10^{17}$ | $> 5.10^{18}$ | - | $5 - 20.10^{17}$ |
| Resistivity (Ω.cm) | $> 1.10^{-7}$ | - | - | $> 5.10^{7}$ | - |
| Mobility ($cm^2.V^{-1}.s^{-1}$) | > 4500 | 3000 - 1800 | > 50 | > 3000 | > 1500 |
| E.P.D. ($cm^{-2}$) | $< 5.10^{4}$ | $1.10^{4} - 3.10^{3}$ | $< 5.10^{4}$ | $> 8.10^{4}$ | < 3000 |

## TRANSMISSION SPECTRUM




# GALLIUM PHOSPHIDE GaP SUBSTRATE

GaP single crystals are grown by the Czochralski technique and are widely used for red, yellow and green LED substrates. NEYCO provides high quality as-cut GaP wafers for LPE in mass production, and also supplies EPI polished wafers for CVD and MBE applications.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 2" |
| Standard thickness | 500 µm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.545 nm |
| **PHYSICAL PROPERTIES** | |
| Conductivity | Semi-conducting (SI) |
| Conductivity type | N-type |
| Dopant available | Silicon |

| Dopant | Si doped | Undoped |
|---|---|---|
| Carrier concentration | 2 - 8.$10^{17}$ $cm^{-3}$ | 4 - 6.$10^{16}$ $cm^{-3}$ |
| EPD | < 3.$10^{5}$ $cm^{-2}$ | < 3.$10^{5}$ $cm^{-2}$ |
| Resistivity range | ~ 0.03 Ω.cm | ~ 0.3 Ω.cm |
| Density | 4.13 $g.cm^{-3}$ | |
| Melting point | 1480°C | |
| Thermal expansion | 5.3.$10^{-6}$ $K^{-1}$ | |
| Band gap | 2.26 eV | |
| Thermal conductivity | 1.1 $W.cm^{-1}.K^{-1}$ at 300 K | |

# GADOLINIUM GALLIUM GARNET $Gd_3Ga_5O_{12}$ (GGG) SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 3" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 1.2382 nm |
| Color | Pale yellow |
| **PHYSICAL PROPERTIES** | |
| Density | 7.02 $g.cm^{-3}$ |
| Melting point | 1730°C |
| Thermal expansion | 9.7.$10^{-6}$ $K^{-1}$ |

# GERMANIUM Ge SUBSTRATE

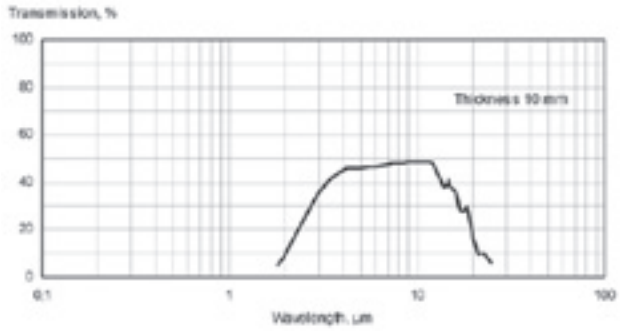
## APPLICATIONS

- IR optics
- Solar cell application
- Optical fiber production
- Semiconductor and electronics device

## STANDARD SPECIFICATIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| **Growth method** | Czochralski (CZ) | | | | | |
| **Maximum size** | Ø 3" | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| **Crystal structure** | Cubic a = 0.565 nm | | | | | |
| **Dopant available** | Antimony (N), Gallium (P) | | | | | |
| **Cleavage** | <111> | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Density** | 5.32 $g.cm^{-3}$ | | | | | |
| **Melting point** | 937°C | | | | | |
| **Hardness** | 6 Mohs | | | | | |
| **Thermal expansion** | $5.75.10^{-6}\ K^{-1}$ | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Resistivity range** | N-type: < 0.4 Ω.cm<br>P-type: 0.005 - 30 Ω.cm<br>Undoped: > 30 Ω.cm | | | | | |
| **Specificity heat capacity** | 310 $J.kg^{-1}.K^{-1}$ | | | | | |
| **Band gap at 273 K** | 0.67 eV | | | | | |
| **Thermal conductivity** | 58.6 $W.m^{-1}.K^{-1}$ | | | | | |
| **Carrier mobility** | $\mu_e$ = 3900 $cm^2.V^{-1}.s^{-1}$<br>$\mu_h$ = 1900 $cm^2.V^{-1}.s^{-1}$ | | | | | |
| **Conductivity type** | P-type or N-type | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | Insoluble | | | | | |
| **Solubility in acids** | Soluble in mixture of HCl and $HNO_3$ and $H_2O_2$ | | | | | |
| **Solubility in organic solvents** | Insoluble | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Absorption coefficient** | 0.02 $cm^{-1}$ at 10.6 µm | | | | | |
| **Transmission range (thickness 10 mm)** | 2 to 18 µm | | | | | |
| **Refractive index n** | 2.0 µm | 5.0 µm | 8.0 µm | 10.0 µm | 11.0 µm | 15.0 µm |
| | 4.1079 | 4.0153 | 4.0053 | 4.0040 | 4.0031 | 4.0017 |

## TRANSMISSION SPECTRUM




# INDIUM ARSENIDE InAs SUBSTRATE

NEYCO provides InAs wafers (Indium Arsenide) to optoelectronics in diameter up to 2 inch. InAs crystal has high uniformity of electrical parameters and low defect density, suitable for MBE or MOCVD epitaxial growth.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Czochralski (CZ) |
| **Maximum size** | Ø 2" |
| **Standard thickness** | 500 µm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Cubic |
| **PHYSICAL PROPERTIES** | |
| **Band gap** | 0.4 eV |
| **Conductivity** | Semi-conducting (SI) |
| **Conductivity type** | P-type or N-type |
| **Dopant available** | Silicon, Zinc |

| DOPANT AVAILABLE | TYPE | CARRIER CONCENTRATION ($cm^{-3}$) | MOBILITY ($cm^2.V^{-1}.s^{-1}$) |
|---|---|---|---|
| **Undoped** | N | - | > 20000 |
| **Si** | N | $1.10^{17}$ - $3.10^{18}$ $cm^{-3}$ | 10000 - 25000 |
| **Zn** | P | $1.10^{17}$ - $5.10^{18}$ $cm^{-3}$ | 100 - 500 |

# INDIUM PHOSPHIDE InP SUBSTRATE

NEYCO supplies high quality InP single crystal substrates for semiconductor industries. The wafers are cut along precise orientation and highly EPI polished.

## APPLICATIONS

InP has been a focus of development since the early 1980s, and today the material is being used as a platform for a wide variety of fiber communications components, including lasers, LEDs, semiconductor optical amplifiers, modulators and photo-detectors.

InP applications for discrete active devices are widespread in communications networking, making it the natural starting place for wholesale integration of passive devices for a complete system on a chip. As a semiconductor material, InP can provide all-in-one integrated functionality that includes light generation, detection, amplification, high-speed modulation and switching, as well as passive splitting, combining and routing. The same material can be used to make high-speed modulators, switches, amplifiers and detectors, or just passive wave guides for interconnecting these diverse devices.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Czochralski (CZ) |
| **Standard thickness** | 500 µm |
| **Maximum size** | Ø 2" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Face-centered cubic (Zinc blende) |
| **PHYSICAL PROPERTIES** | |
| **Band gap** | 1.344 eV |
| **Conductivity** | Semi-conducting or semi-insulating (SI) |
| **Conductivity type** | P-type or N-type |
| **Dopant available** | Silicon, Tin, Zinc, Iron |
| **Density** | 4.81 $g.cm^{-3}$ |
| **Melting point** | 1082°C |
| **Thermal conductivity** | 0.68 $W.cm^{-1}.K^{-1}$ at 300 K |

| DOPANT AVAILABLE | TYPE | CARRIER CONCENTRATION ($cm^{-3}$) | MOBILITY ($cm^2 .V^{-1}.s^{-1}$) | RESISTIVITY (Ω.cm) | EPD ($cm^{-2}$) |
|---|---|---|---|---|---|
| **Undoped** | N | 0.8 - 2.0 $.10^{15}$ | 3600 - 4000 | 0.03 - 0.2 | 5-6.$10^4$ |
| **Sn, Si** | N | 0.5 - 1.0 $.10^{18}$ | 200 - 2400 | 0.001 - 0.002 | 3-5.$10^4$ |
| | | 0.5 - 1.0 $.10^{18}$ | 1500 - 2000 | 0.0025 - 0.007 | |
| **Zn** | P | 0.8 - 2.0 $.10^{18}$ | 2500 - 3500 | 0.0025 - 0.006 | 1-3.$10^4$ |
| | | 2.5 - 4.0 $.10^{18}$ | 1300 - 1600 | | |
| **Fe** | SI | 0.1 - 1.0 | 2000 | $10^7$ - $10^8$ | 4-5.$10^4$ |

# LANTANUM ALUMINATE $LaAlO_3$ SUBSTRATE

$LaAlO_3$ single crystal provides a good lattice match to many materials with perovskite structure. It is an excellent substrate for epitaxial growth of high Tc superconductors, magnetic and ferro-electric thin films. The dielectric properties of $LaAlO_3$ crystal are well suitable for low loss microwave and dielectric resonance applications.

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **CRYSTAL GROWTH** | |
| **Growth method** | Czochralski (CZ) |
| **Max. size** | Ø 3" |
| **Standard thickness** | 0.5 to 1 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Rhombohedral at 25°C<br>a = 0.5357 nm |
| | Cubic at > 435°C<br>a = 0.379 nm |
| **Twin structure** | Twins // to the <100>-planes of the pseudocubic cell |
| **Color** | Tan to brown based on annealing condition |
| **PHYSICAL PROPERTIES** | |
| **Density** | 6.52 $g.cm^{-3}$ |
| **Melting point** | 2180°C |
| **Thermal expansion** | $9.2.10^{-6}$ $K^{-1}$ |
| **Dielectric constant** | 24.5 |
| **Loss tangent (at 10 GHz)** | ~ $3.10^{-4}$ at 300 K<br>~ $6.10^{-5}$ at 77 K |
| **CHEMICAL PROPERTIES** | |
| **Chemical stability** | Insoluble in mineral acids at 25°C and soluble in $H_3PO_3$ at > 150°C |

# LITHIUM ALUMINATE $LiAlO_2$ SUBSTRATE

$LiAlO_2$ is a potential substrate for III-V nitride thin films due to its excellent lattice mismatch to GaN (<0.2% at <100>), chemical stability at high temperature and cost effective.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Czochralski (CZ) |
| **Maximum size** | Ø 2'' |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Tetragonal<br>a = 0.517 nm c = 0.626 nm |
| **Color** | Transparent |
| **PHYSICAL PROPERTIES** | |
| **Density** | 2.2 $g.cm^{-3}$ |
| **Melting point** | 1900°C |
| **Hardness** | 7.5 Mohs |

# LITHIUM FLUORIDE LiF SUBSTRATE

## APPLICATION

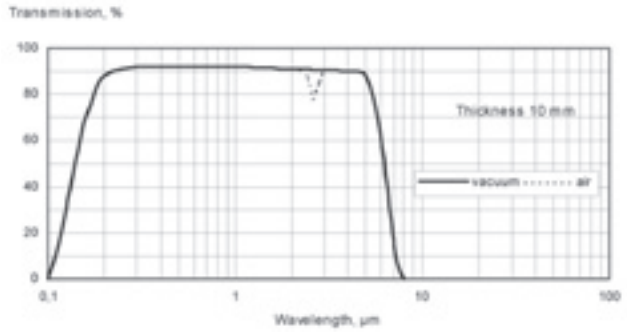
UV window and prism, without deliquescence.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Stockbarger technique |
| **Maximum size** | Ø 150 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Cubic a = 0.4026 nm |
| **Cleavage plane** | <100> |
| **PHYSICAL PROPERTIES** | |
| **Density** | 2.60 $g.cm^{-3}$ |
| **Melting point** | 870°C |

| PHYSICAL PROPERTIES | | | | | | |
|---|---|---|---|---|---|---|
| **Hardness** | 4 Mohs | | | | | |
| **Thermal expansion** | 28.1 - 34.8.$10^{-6}$ $K^{-1}$ | | | | | |
| **Thermal conductivity** | 14.2 $W.m^{-1}.K^{-1}$ | | | | | |
| **Specific heat capacity** | 1562 $J.kg^{-1}.K^{-1}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | 0.27 g/100 $cm^3$ | | | | | |
| **Solubility in acids** | Soluble | | | | | |
| **Solubility in organic solvents** | Insoluble in acetone and ethylalcohol | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Absorption coefficient** | 0.05 $cm^{-1}$ at 0.2 µm<br>0.02 $cm^{-1}$ at 0.4 µm<br>0.03 $cm^{-1}$ at 2.6-2.9 µm | | | | | |
| **Transmission range (thickness 10 mm)** | 0.12 - 6.5 µm | | | | | |
| **Refractive index n** | 0.2 µm | 0.5 µm | 1.0 µm | 3.0 µm | 5.0 µm | 6.0 µm |
| | 1.4390 | 1.3943 | 1.3871 | 1.3666 | 1.3266 | 1.2975 |

## TRANSMISSION SPECTRUM



# LITHIUM GALLATE $LiGaO_2$ SUBSTRATE

$LiGaO_2$ single crystal was grown in 1960's for laser application. However, it is found out that $LiGaO_2$ is a potential substrate for III-V nitride thin films due to its excellent lattice mismatch to GaN (<0.2%), chemical stability at high temperature and cost effective.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 20 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Orthorhombic<br>a = 0.54 nm b = 0.6379 nm c = 0.5012 nm |
| Color | White to brown |
| Twin structure | No twins and inclusion |
| **PHYSICAL PROPERTIES** | |
| Density | 4.18 $g.cm^{-3}$ |
| Melting Point | 1600°C |

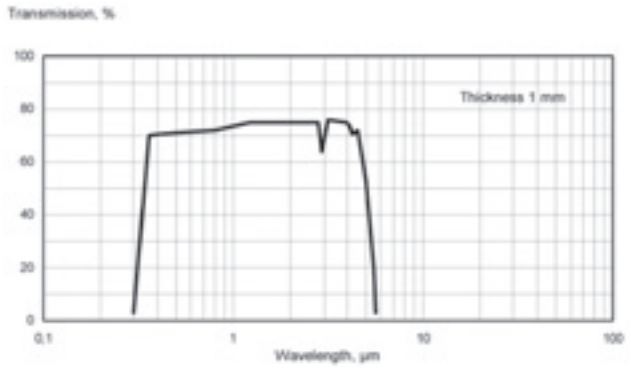
# LITHIUM NIOBATE $LiNbO_3$ SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Hexagonal<br>a = 0.5148 nm c = 1.3863 nm |
| **PHYSICAL PROPERTIES** | |
| Density | 4.64 $g.cm^{-3}$ |
| Melting point | 1250°C |
| Hardness | 5 Mohs |
| Thermal expansion | Vertical c-axis: $15.4.10^{-6}$ $K^{-1}$<br>Parallel c-axis: $7.5.10^{-6}$ $K^{-1}$ |

| OPTICAL PROPERTIES | | | |
|---|---|---|---|
| Transmission range | 0.4 - 2.90 µm | | |
| Refractive index: | 0.633 µm | 1.064 µm | 1.30 µm |
| $n_o$ | 2.286 | 2.232 | 2.220 |
| $n_e$ | 2.203 | 2.156 | 2.146 |

## TRANSMISSION SPECTRUM




# LANTHANUM-STRONTIUM-ALUMINUM-TANTALUM-OXIDE (LSAT) SUBSTRATE

LSAT $(LaAlO_3)_{0.3}$ $(Sr_2AlTaO_6)_{0.7}$ is a newly developing crystal with peroviskite structure and twin-free. LSAT has excellent lattice match with high Tc superconductors and many oxide materials. LSAT has lower melting point and can be grown by CZ technology at lower cost, therefore, it is expected to replace $LaAlO_3$ and $SrTiO_3$ as a common single crystal substrate for epitaxial oxide thin films for gain magnetic ferro-electronic and superconductive devices.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 2" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.7737 nm |
| Twin structure | No twin and domain visible |
| Color | Colorless to light brown based on annealing condition |
| **PHYSICAL PROPERTIES** | |
| Density | 6.74 $g.cm^{-3}$ |
| Melting point | 1840°C |

| PHYSICAL PROPERTIES | |
|---|---|
| Thermal expansion | $10.10^{-6}$ $K^{-1}$ |
| Dielectric constant | ~ 22 |
| Loss tangent (at 8.8 GHz) | $2.10^{-4}$ at 77 K |

# MAGNESIUM ALUMINUM OXIDE $MgAl_2O_4$ SUBSTRATE

$MgAl_2O_4$ (spinel) single crystals are widely used for bulk acoustic wave and microwave devices and fast IC epitaxial substrates. It is also found that $MgAl_2O_4$ is a good substrate for III-V nitrides device. $MgAl_2O_4$ crystal is very difficult to grow, due to the difficulty in maintaining a single phase structure.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 30 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.8083 nm |
| Color | Colourless |
| **PHYSICAL PROPERTIES** | |
| Density | 3.64 $g.cm^{-3}$ |
| Melting Point | 2130°C |
| Hardness | 8.0 Mohs |
| Thermal expansion | $7.10^{-6}$ $K^{-1}$ |

# MAGNESIUM FLUORIDE $MgF_2$ SUBSTRATE

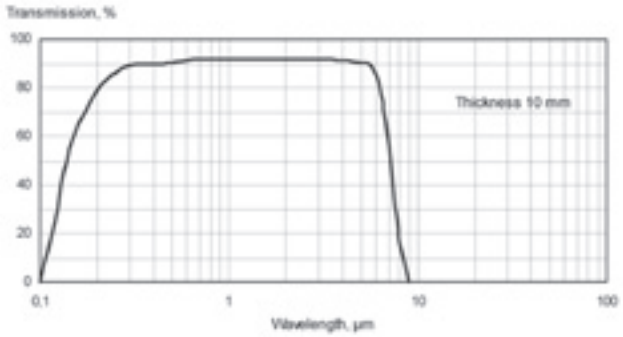
## APPLICATIONS

VUV window and mirror, lens.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | | | | | | |
|---|---|---|---|---|---|---|
| Growth method | Stockbarger technique | | | | | |
| Cleavage | <100>, <110> | | | | | |
| Maximum size | Ø 90 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| Crystal structure | Tetragonal<br>a = 0.464 nm c = 0.306 nm | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| Density | 3.18 $g.cm^{-3}$ | | | | | |
| Melting point | 1255°C | | | | | |
| Hardness | 6 Mohs | | | | | |
| Thermal expansion | Parallel c-axis: 10.86 - 14.54.$10^{-6}$ $K^{-1}$<br>Vertical c-axis: 6.23 - 9.25.$10^{-6}$ $K^{-1}$ | | | | | |
| Specific heat capacity | 920 $J.kg^{-1}.K^{-1}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| Solubility in water | 0.0076 g/100 $cm^3$ | | | | | |
| Solubility in acids | Soluble | | | | | |
| Solubility in organic solvents | Insoluble in alcohol | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| Absorption coefficient ($cm^{-1}$) | 0.07 $cm^{-1}$ at 0.2 µm<br>0.02 $cm^{-1}$ at 5.0 µm | | | | | |
| Refractive index: | 0.2 µm | 0.5 µm | 1.0 µm | 3.0 µm | 5.0 µm | 7.0 µm |
| $n_o$ | 1.4231 | 1.3797 | 1.3736 | 1.3618 | 1.3400 | 1.3044 |
| $n_e$ | 1.4367 | 1.3916 | 1.3852 | 1.3724 | 1.3487 | 1.3101 |

## TRANSMISSION SPECTRUM



# MAGNESIUM OXIDE MgO SUBSTRATE

MgO is an excellent single crystal substrate for thin films of ferro-magnetic, photo-electronic and high Tc superconductor materials.

## FEATURES

- Low dielectric loss
- Cleavage plane on the <100>

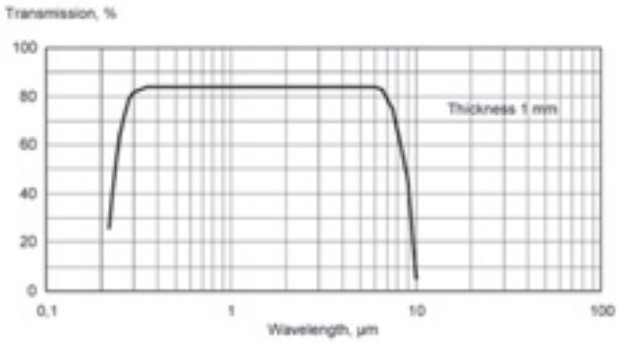
## APPLICATIONS

- High Tc Superconductor
- Electronics and optoelectronics
- Microwave device

## STANDARD SPECIFICATIONS

| | | | | |
|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | |
| **Growth method** | Flux melt | | | |
| **Standard thickness** | 0.5 to 1 mm | | | |
| **Maximum size** | Ø 2" | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | |
| **Crystal structure** | Cubic a = 0.4216 nm | | | |
| **Cleavage** | <100> | | | |
| **Twin structure** | Without twins | | | |
| **Color** | Colorless | | | |
| **PHYSICAL PROPERTIES** | | | | |
| **Density** | 3.58 $g.cm^{-3}$ | | | |
| **Melting point** | 2800°C | | | |
| **Hardness** | 5.8 Mohs | | | |
| **Thermal expansion** | $8.10^{-6}$ $K^{-1}$ | | | |
| **Thermal conductivity** | 40.6 $W.m^{-1}$ $K^{-1}$ | | | |
| **Specific heat capacity** | 837 $J.kg^{-1}.K^{-1}$ | | | |
| **Dielectric constant** | 8.1 | | | |
| **Loss tangent (at 10 GHz)** | ~ $9.10^{-3}$ at 77 K | | | |
| **CHEMICAL PROPERTIES** | | | | |
| **Chemical stability** | Insoluble in mineral acids at 25 °C and soluble in $H_3PO_3$ at > 150 °C | | | |
| **Solubility in water** | 0.00062 g/100 $cm^3$ | | | |
| **OPTICAL PROPERTIES** | | | | |
| **Transmission range (thickness 1 mm)** | 0.3 - 7.0 µm | | | |
| **Refractive index n** | 0.5 µm | 1 µm | 3 µm | 5 µm |
| | 1.74 | 1.72 | 1.68 | 1.63 |

## TRANSMISSION SPECTRUM




# MANGANESE OXIDE MnO SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Verneuil |
| Maximum size | Ø 15 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.4445 nm |
| Color | Black |
| **PHYSICAL PROPERTIES** | |
| Density | 5.4 $g.cm^{-3}$ |
| Melting point | 1650°C |
| Hardness (Knoop test) | 300 |

# SODIUM CHLORIDE NaCl SUBSTRATE

Use only these crystals for fine research work requiring minimum 10 mm square uninterrupted areas.

- Formula: NaCl
- Appearance: Cubic clear (nearly transparent) crystals
- Density: 2.165 $g.cm^{-3}$
- Solubility in water: a thin "wafer" that is 0.05" (1.27 mm) will dissolve in water at room temperature in roughly 30 seconds

## GROW EPITAXIAL FILMS

These high quality research grade sodium chloride single crystal substrates offer a major advantage: the ability to grow epitaxial films on a featureless substrate.

The orientation of the film is related to the orientation of the substrate, producing areas of single crystal film.

This feature is ideal for boundary diffusion studies and applications where a single crystal thin film is required. The film is easily removed by floating it off on water or by dissolving away the underlying substrate.

| SIZES | PACKAGING | P/N |
|---|---|---|
| 25 mm cubes | 1 | 01817-AB |
| 10 mm cubes | 5 | 01807-AF |
| 25 mm cubes | 5 | 01817-AF |

## OFF-CUTS

- Use for class experiments and for the teaching of cleaving techniques
- Approximate size range: 20 mm to 45 mm
- Note: Some "fines" will be present as well

| PACKAGING | P/N |
|---|---|
| 100 g | 01779-AB |

# NEODYMIUM GALLATE $NdGAO_3$ (NGO) SUBSTRATE

## MATERIAL CHARACTERISTICS

- Excellent lattice matches to the typical HTSC composition
- Low dielectric constant and low dielectric loss tangent, which makes it attractive for microwave applications
- Good thermal properties
- No destructive phase transformations

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 2" |
| Standard thickness | 0.5 to 1 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Orthorhombic to > 1000°C<br>a = 0.5426 nm b = 0.5496 nm c = 0.7707 nm<br>Second order phase transformation at 950°C |
| Twin structure | Without twins |
| Color | Deep red to green |
| **PHYSICAL PROPERTIES** | |
| Density | 7.56 $g.cm^{-3}$ |
| Melting point | 1750°C |
| Hardness | 5.9 Mohs |
| Thermal expansion | 11.$10^{-6}$ $K^{-1}$ |
| Dielectric constant (1 MHz) | 20 at 300 K |

# NICKEL OXIDE NiO SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Verneuil |
| Maximum size | Ø 15 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.419 nm |
| Color | Black |
| **PHYSICAL PROPERTIES** | |
| Density | 6.96 $g.cm^{-3}$ |
| Melting point | 1998°C |
| Hardness (Knoop test) | 560 - 590 |

# QUARTZ $SiO_2$ SUBSTRATE

## FEATURES

- High working temperature
- Good thermal conductivity
- High stability
- High anti corrosion
- Superior mechanical properties
- Stable dielectric constant & low dielectric loss
- High optical transmission

## APPLICATIONS

- Photo mask blank
- Sensors
- High frequency circuit (Microwave circuit)
- Biotech arrays
- Laser Optics
- Optical windows and lenses

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Hydrothermal synthesis |
| **Maximum size** | 100 x 100 mm |
| **Standard thickness** | 0.5 mm to 4 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Hexagonal<br>a = 0.490 nm c = 0.539 nm |
| **Color** | Colourless |
| **PHYSICAL PROPERTIES** | |
| **Density** | 2.65 $g.cm^{-3}$ |
| **Melting Point** | 1700°C |
| **Hardness** | 5.5 - 6.5 Mohs |
| **Thermal expansion** | Vertical c-axis: $13.37.10^{-6}$ $K^{-1}$<br>Parallel c-axis: $7.97.10^{-6}$ $K^{-1}$ |
| **Resistivity** | $7.10^{7}$ Ω.cm |
| **Dielectric constant** | 3.7 - 3.9 |

# STRONTIUM LANTHANUM ALUMINATE $SrLaAlO_4$ SUBSTRATE

SrLaAlO4 crystal is a promising substrate material for high Tc superconductor film and other oxide films. It has similar lattice constant to $SrTiO_3$, but better quality and lower cost because of CZ growth and lower melting point.

## APPLICATIONS

High quality YBaCu, BiSrCaCuO, Bi(Pb)CaCuO and TlBaCaCuO thin films have been grown on $SrLaAlO_4$ substrates by different techniques.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 18 - 20 mm |
| Standard thickness | 0.5 to 1 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Tetragonal<br>a = 0.3754 nm c = 1.2630 nm |
| Twin structure | No |
| Color | Light yellow |
| **PHYSICAL PROPERTIES** | |
| Density | 5.924 $g.cm^{-3}$ |
| Melting point | 1650°C |
| Hardness | 7 Mohs |
| Thermal expansion | Along a-axis: $7.55.10^{-6}$ $K^{-1}$<br>Along c-axis: $1.71.10^{-6}$ $K^{-1}$ |
| Dielectric constant | 17 |
| Thermal conductivity | At 12 K: 360 $W.m^{-1}.K^{-1}$<br>At 300 K: 8.82 $W.m^{-1}.K^{-1}$<br>At 450 K: 7.50 $W.m^{-1}.K^{-1}$ |
| Dielectric loss tangent (at 10 GHz) | $8.10^{-4}$ at 77 K |
| **OPTICAL PROPERTIES** | |
| Transmission range | 240 to 6670 nm |

# STRONTIUM LANTHANUM GALLATE $SrLaGA_3O_7$ SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 18 - 20 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Tetragonal<br>a = 0.806 nm c = 0.534 nm |

| CRYSTALLOGRAPHIC PROPERTIES | |
|---|---|
| Color | Orange |
| **PHYSICAL PROPERTIES** | |
| Density | 5.2 $g.cm^{-3}$ |
| Melting point | 1760°C |
| Dielectric constant | 22 |
| Loss tangent (at 1 MHz) | $5.7.10^{-5}$ at 300 K |

# STRONTIUM LANTHANUM GALLATE $SrLaGaO_4$ SUBSTRATE

## APPLICATIONS

High quality YBaCuO, BiSrCaCuO, Bi(Pb)CaCuO and TlBaCaCuO thin films have been grown on $SrLaGaO_4$ substrates by different techniques.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 18 - 20 mm |
| Standard thickness | 0.5 to 1 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Tetragonal<br>a = 0.3843 nm  c = 1.2680 nm |
| Twin structure | No |
| Color | Colorless to yellow |
| **PHYSICAL PROPERTIES** | |
| Density | 6.389 $g.cm^{-3}$ |
| Melting point | 1520°C |
| Thermal expansion | Along a-axis: $10.1.10^{-6}$ $K^{-1}$<br>Along c-axis: $1890.10^{-5}$ $K^{-1}$ |
| Dielectric constant | 22 |
| Loss tangent (at 10 GHz) | $5.7.10^{-3}$ at 77 K |

# STRONTIUM TITANATE $SrTiO_3$ SUBSTRATE

$SrTiO_3$ single crystal provides a good lattice match to most materials with Perovskite structure. It is an excellent substrate for epitaxial growth of HTS and many oxide thin films. $SrTiO_3$ single crystal has also been used widely for special optical windows and as high quality sputtering target.

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| **Growth method** | Verneuil |
| **Maximum size** | Ø 2" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Cubic a = 0.3905 nm |
| **Twin structure** | Without twins |
| **Color** | Colorless to pale yellow |
| **PHYSICAL PROPERTIES** | |
| **Density** | 5.175 $g.cm^{-3}$ |
| **Melting point** | 2080°C |
| **Hardness** | 6 Mohs |
| **Thermal expansion** | $9.10^{-6}$ $K^{-1}$ |
| **Dielectric constant** | ~ 300 |
| **Loss Tangent (at 10 GHz)** | $2.10^{-2}$ at 77 K |
| **CHEMICAL PROPERTIES** | |
| **Chemical stability** | Insoluble in water |

Doped $SrTiO_3$ is used in the basic research and is applied as conducting material [e.g. back side contacting, application of certain surface sensitive measurements (STM)].

| DOPANDS | Nb | | La | |
|---|---|---|---|---|
| CONCENTRATION AT % | AVAILABLE | RESISTIVITY (Ω.cm) | AVAILABLE | RESISTIVITY (Ω.cm) |
| 0.02 | X | - | - | - |
| 0.05 | X | 0.08 | X | 0.12 |
| 0.1 | X | 0.03 | X | - |
| 0.2 | X | - | - | - |
| 0.5 | X | 0.005 | X | 0.006 |
| 1.0 | X | 0.003 | X | - |
| 2.0 | X | - | - | - |
| 5.0 | - | - | X | 0.0007 |

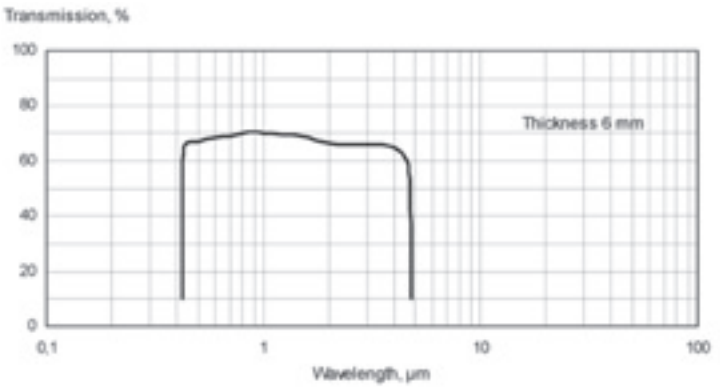
# TITANIUM OXIDE (RUTILE) $TiO_2$ SUBSTRATE

Rutile ($TiO_2$) single crystal is one of the most suitable materials for spectral prisms and polarizing devices such as optical isolators and beam displacers because it has a large birefringence with a high refractive index. Compared to $YVO_4$, $TiO_2$ crystal is more stable chemically and physically.

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **CRYSTAL GROWTH** | |
| **Growth method** | Floating zone (FZ) |
| **Maximum size** | Ø 1" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Tetragonal<br>a = 0.459 nm c = 0.296 nm |
| **Color** | Pal |
| **PHYSICAL PROPERTIES** | |
| **Density** | 4.26 $g.cm^{-3}$ |
| **Melting point** | 1825°C |
| **Hardness** | 7 Mohs |
| **Thermal expansion** | Vertical c-axis: $7.2.10^{-6}$ $K^{-1}$<br>Parallel c-axis: $9.19.10^{-6}$ $K^{-1}$ |
| **Specific heat capacity** | 710 $J.kg^{-1}.K^{-1}$ |
| **Thermal conductivity** | 12.56 $W.m^{-1}.K^{-1}$ |
| **Resistivity** | $7.10^{7}$ Ω.cm |
| **Dielectric constant** | Vertical c-axis: 170<br>Parallel c-axis: 88 |
| **OPTICAL PROPERTIES** | |
| **Transmission range (thickness 6 mm)** | 0.43 - 6.0 µm |
| **Refractive index:** | 0.6 µm |
| **$n_o$** | 2.61 |
| **$n_e$** | 2.90 |

## TRANSMISSION SPECTRUM

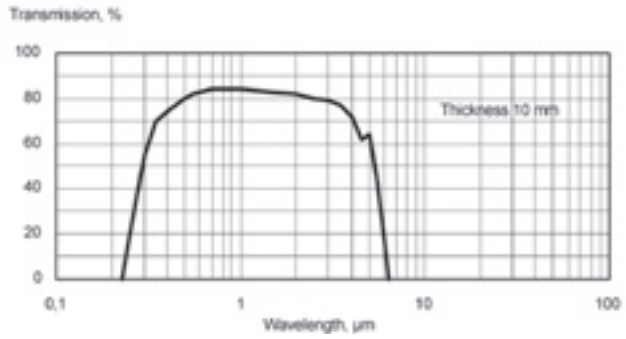


# YTTRIUM ALUMINIUM GARNET $Y_3AL_5O_{12}$ (YAG) SUBSTRATE

## STANDARD SPECIFICATIONS

| | | | | | |
|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | |
| **Growth method** | Czochralski (CZ) | | | | |
| **Maximum size** | Ø 2" | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | |
| **Crystal structure** | Cubic a = 1.2005 nm | | | | |
| **Color** | Colorless | | | | |
| **PHYSICAL PROPERTIES** | | | | | |
| **Density** | 4.55 $g.cm^{-3}$ | | | | |
| **Melting point** | 1940°C | | | | |
| **Hardness** | 8.5 Mohs | | | | |
| **Thermal expansion** | $6.9.10^{-6}$ $K^{-1}$ | | | | |
| **Transmission range (thickness 1 mm)** | 0.3 - 0.5 µm | | | | |
| **Solubility in water** | Insoluble | | | | |
| **Solubility in acids** | Unessential | | | | |
| **Refractive index n** | 0.5 µm | 1.0 µm | 2.0 µm | 3.0 µm | 4.0 µm |
| | 1.845 | 1.8197 | 1.8035 | 1.7855 | 1.7602 |

## TRANSMISSION SPECTRUM



# YTTRIUM ALUMINATE $YAlO_3$ (YAP) SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Czochralski (CZ) |
| Maximum size | Ø 1.5" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Orthorombic<br>a = 0.517 nm b = 0.5307 nm c = 0.7355 nm |
| Twin structure | No |
| Color | Colorless |
| **PHYSICAL PROPERTIES** | |
| Density | 4.88 $g.cm^{-3}$ |
| Melting point | 1870°C |
| Thermal expansion | 2 - 10.$10^{-6}$ $K^{-1}$ |
| Dielectric constant | 16 - 20 |

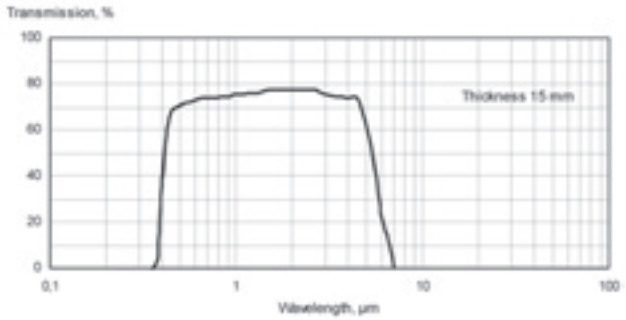
# YTTRIA STABILIZED ZIRCONIA (YSZ) SUBSTRATE

## STANDARD SPECIFICATIONS

| CRYSTAL GROWTH | |
|---|---|
| Growth method | Skull melting ($ZrO_2/Y_2O_3$ 92-8 % wt) |
| Maximum size | Ø 2" |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Cubic a = 0.5125 nm |
| Color | Colourless |
| **PHYSICAL PROPERTIES** | |
| Density | 5.92 $g.cm^{-3}$ |
| Melting point | 2780°C |
| Hardness | 7.5 - 8 Mohs |
| Thermal expansion | 8.$10^{-6}$ $K^{-1}$ |
| Dielectric constant | 27 |
| Thermal conductivity | 31.8 $W.m^{-1}.K^{-1}$ |
| **CHEMICAL PROPERTIES** | |
| Solubility in water (g/100 $cm^3$) | Not declarate |
| Solubility in acids | Not declarate |
| Solubility in organic solvents | Not declarate |

| OPTICAL PROPERTIES | |
|---|---|
| Refractive index n | 4 µm |
| | 2.24 |

## TRANSMISSION SPECTRUM




# ZINC OXIDE ZnO SUBSTRATE

## STANDARD SPECIFICATIONS

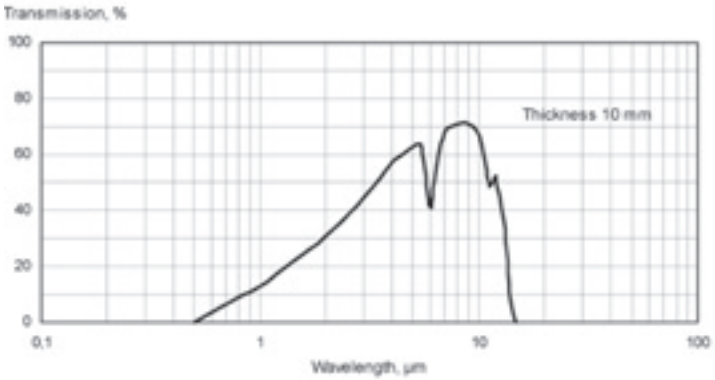
| CRYSTAL GROWTH | |
|---|---|
| Growth method | Hydrothermal, seeded vapor phase growth |
| Maximum size | Ø 35 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| Crystal structure | Hexagonal<br>a = 0.3252 nm c = 0.5213 nm |
| **PHYSICAL PROPERTIES** | |
| Density | 5.7 $g.cm^{-3}$ |
| Melting point | 1975°C |
| Hardness | 4 Mohs |
| Thermal expansion | $3.16.10^{-6}$ $K^{-1}$ |
| Resistivity range | > $10^{2}$ - $10^{4}$ Ω.cm |
| Band gap at 300 K | 3.2 eV |
| Thermal conductivity | 2.5 $W.m^{-1}.K^{-1}$ |
| Conductivity type | N-type |
| Carrier concentration | $10^{10}$ to $10^{18}$ $cm^{-3}$ |
| Dielectric constant | 8.5 |
| **OPTICAL PROPERTIES** | |
| Refractive index n | $n_0$ = 2.026, $n_e$ = 2.041 |

# ZINC SULFIDE ZnS SUBSTRATE

## STANDARD SPECIFICATIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| Growth method | Seeded vapour phase growth | | | | | |
| Maximum size | Ø 40 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| Crystal structure | Cubic a = 0.5411 nm | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| Density | 4.09 $g.cm^{-3}$ | | | | | |
| Melting point | 1830°C | | | | | |
| Hardness | 3 Mohs | | | | | |
| Thermal expansion | $7.9.10^{-6}$ $K^{-1}$ | | | | | |
| Resistivity range | > $10^{2}$-$10^{4}$ Ω.cm | | | | | |
| Band Gap (at 300 K) | 3.66 eV | | | | | |
| Thermal conductivity | 1.73 W $m^{-1}.K^{-1}$ | | | | | |
| Conductivity type | N-type | | | | | |
| Carrier concentration | $10^{5}$ to $10^{16}$ $cm^{-3}$ | | | | | |
| Dielectric constant | 9.67<br>5.13 | | | | | |
| Specific heat capacity | 530 J.$kg^{-1}.K^{-1}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| Solubility in water | Insoluble | | | | | |
| Solubility in acids | Unessential | | | | | |
| Solubility in organic solvents | Insoluble | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| Absorption coefficient | 0.001 $cm^{-1}$ at 2.7 µm<br>0.2 $cm^{-1}$ at 10 µm | | | | | |
| Transmission range (thickness 10 mm) | 0.4 - 12.5 µm | | | | | |
| Refractive index n | 0.5 µm | 0.7 µm | 1.0 µm | 10.0 µm | 11.0 µm | 12.0 µm |
| | 2.419 | 2.332 | 2.292 | 2.201 | 2.186 | 2.161 |

## TRANSMISSION SPECTRUM

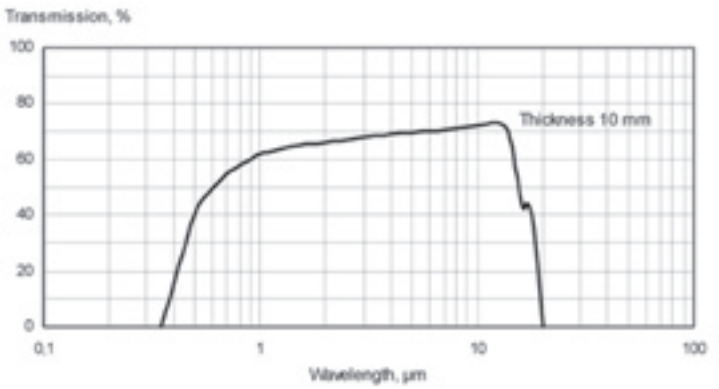


# ZINC SELENIDE ZnSe SUBSTRATE

## STANDARD SPECIFICATIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRYSTAL GROWTH** | | | | | | |
| **Growth method** | Seeded vapour phase growth | | | | | |
| **Maximum size** | Ø 40 mm | | | | | |
| **CRYSTALLOGRAPHIC PROPERTIES** | | | | | | |
| **Crystal structure** | Cubic a = 0.5668 nm | | | | | |
| **Cleavage** | <110> | | | | | |
| **PHYSICAL PROPERTIES** | | | | | | |
| **Density** | 5.26 $g.cm^{-3}$ | | | | | |
| **Melting point** | 1520°C | | | | | |
| **Hardness** | 4 Mohs | | | | | |
| **Thermal expansion** | $7.6.10^{-6}$ $K^{-1}$ | | | | | |
| **Thermal conductivity** | 12.97 $W.m^{-1}.K^{-1}$ | | | | | |
| **Specific heat capacity** | 355 $J.kg^{-1}.K^{-1}$ | | | | | |
| **Resistivity range** | > $10^{8}$ Ω.cm | | | | | |
| **Band Gap (at 300 K)** | 3.66 eV | | | | | |
| **Conductivity type** | N-type | | | | | |
| **Carrier concentration** | $10^{5}$ to $10^{17}$ $cm^{-3}$ | | | | | |
| **CHEMICAL PROPERTIES** | | | | | | |
| **Solubility in water** | Insoluble | | | | | |
| **Solubility in acids** | Soluble | | | | | |
| **Solubility in organic solvents** | Insoluble | | | | | |
| **OPTICAL PROPERTIES** | | | | | | |
| **Absorption coefficient** | 0.005 $cm^{-1}$ at 10.6 µm | | | | | |
| **Transmission range (thickness 10mm)** | 0.55 - 18.0 µm | | | | | |
| **Refractive index n** | 1.0 µm | 3.0 µm | 5.0 µm | 10.0 µm | 12.0 µm | 15.0 µm |
| | 2.4894 | 2.4376 | 2.4296 | 2.4067 | 2.3936 | 2.3662 |

## TRANSMISSION SPECTRUM



# ZINC TELLURIDE ZnTe SUBSTRATE

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **CRYSTAL GROWTH** | |
| **Growth method** | Seeded vapour phase growth |
| **Maximum size** | Ø 40 mm |
| **CRYSTALLOGRAPHIC PROPERTIES** | |
| **Crystal structure** | Cubic a = 0.6089 nm |
| **PHYSICAL PROPERTIES** | |
| **Density** | 5.636 $g.cm^{-3}$ |
| **Melting point** | 1290°C |
| **Hardness** | 4 Mohs |
| **Thermal expansion** | $8.36.10^{-6}$ $K^{-1}$ |
| **Resistivity range** | > $10^{5}$ Ω.cm |
| **Band gap (at 300 K)** | 2.28 eV |
| **Thermal conductivity** | 12.39 $W.m^{-1}.K^{-1}$ |
| **Conductivity type** | P-type |
| **Carrier concentration** | $10^{10}$ to $10^{17}$ $cm^{-3}$ |
| **Dielectric constant** | 8.1<br>7.28 |
| **OPTICAL PROPERTIES** | |
| **Refractive index n** | 2.68 |

# Glass & Fused Quartz Substrates

## BOROSILICATE GLASS

Borosilicate glass, known under trade names such as Pyrex® and Duran®, is widely used in chemical and engineering applications.

This glass is chemically resistant, has a low thermal expansion coefficient and can be used at relatively high temperatures. Our high quality borosilicate glass substrates are optically polished on both surfaces. The excellent flatness and a low warp of our borosilicate wafers and the thermal coefficient of expansion close to the one of silicon, facilitate sophisticated applications in the semiconductor industry such as anodic bonding to silicon and various micro optical applications.

On request, our borosilicate glass wafers can be made with a ground SEMI standard flat or a notch.

### APPLICATIONS

- Semiconductor applications
- Micro lithography
- Substrates for anodic bonding
- Optical substrates
- Micro system technology
- Micro mechanics
- Microstructure applications

### STANDARD SPECIFICATIONS

| GENERAL PROPERTIES | |
|---|---|
| **Density** | 2.23 $g.cm^{-3}$ |
| **MECHANICAL PROPERTIES** | |
| **Young's modulus** | 64 GPa |
| **Hardness (Knoop test)** | 480 |

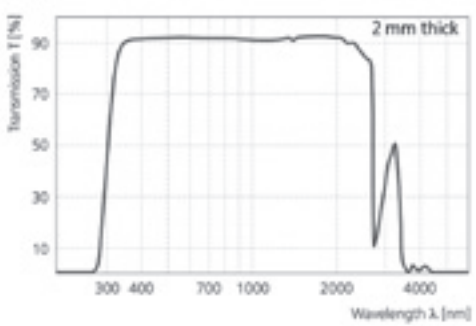
| THERMAL PROPERTIES | |
|---|---|
| Max. use temperature | 500°C |
| Thermal conductivity | 1.14 $W.m^{-1}.K^{-1}$ |
| Coefficient of linear expansion | $3.3.10^{-6}K^{-1}$ |
| **ELECTRICAL PROPERTIES** | |
| Volume resistance | $10^{15}$ Ω.cm |
| Dielectric constant | 4.6 (20°C, 1 MHz) |
| Dielectric strength | 30 $kV.mm^{-1}$ |
| **OPTICAL PROPERTIES** | |
| Refractive index n | 1.474 at 588 nm |

## AVAILABLE THICKNESS

| THICKNESS (mm) | TOLERANCE (mm) |
|---|---|
| 0.7 | +/- 0.07 |
| 1.1 | +/- 0.1 |
| 1.75 | +/- 0.2 |
| 2 | +/- 0.2 |
| 2.25 | +/- 0.2 |
| 2.75 | +/- 0.2 |
| 3.3 | +/- 0.2 |
| 3.8 | +/- 0.2 |
| 5 | +/- 0.2 |
| 6.5 | +/- 0.2 |
| 7.5 | +/- 0.3 |
| 9 | +/- 0.3 |
| 11 | +/- 0.3 |
| 13 | +/- 0.3 |
| 15 | +/- 0.3 |
| 17 | +/- 0.5 |
| 19 | +/- 0.5 |
| 21 | +/- 0.7 |
| 25.4 | +/- 1.0 |

Other thickness are available on request.

## TRANSMISSION SPECTRUM



# QUARTZ/SILICA SUBSTRATE

Quartz glass is an extremely versatile material used in a range of different applications. It has outstanding thermal properties, excellent optical transmission, with good electrical and corrosion performance.

There are two basic ways of making quartz / silica glass:

- By melting silica grains either by gas or electrical heating (the type of heating affects some optical properties). This material can be transparent or, for some applications, opaque.
- By synthesising the glass from chemicals.

This synthetic material, normally referred to as synthetic fused silica, has better optical properties and is somewhat more expensive than the other type.

## ADVANTAGES

- Incredibly thermally shock resistant (can be taken from red heat and plunged into water without cracking)
- Low coefficient of thermal expansion
- Optical transmission properties from ultra violet to infra red
- Good chemical resistance
- Excellent electrical insulator

## APPLICATIONS

- Windows
- Lenses
- Mirror substrates
- Crucibles, trays and boats
- UV transmitting optics (synthetic fused silica)
- IR transmitting optics
- Metrology components

## DIFFERENCES BETWEEN FUSED SILICA AND QUARTZ WAFER

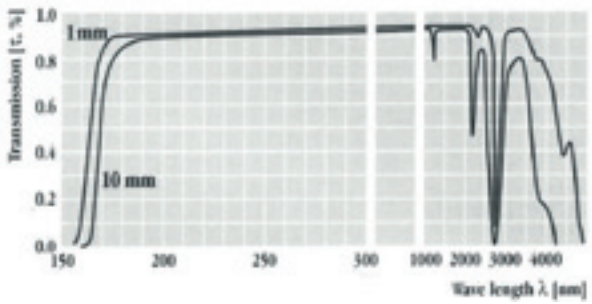
Very often terms such as quartz, silica, fused quartz and fused silica tend to be used interchangeably.

| FUSED SILICA WAFER (SYNTHETIC SILICA) | FUSED QUARTZ WAFER (NATURAL SILICA) |
|---|---|
| • High OH content >1200 | • Low OH content > 150 |
| • Excellent optical properties | • Excellent thermal properties |
| • Higher transmission in the UV range | • Contain some bubbles, inclusions and contaminants |
| • Free bubbles, inclusions and contaminants | • High fluorescence |
| • Very low fluorescence | • Impurity 20 - 40 ppm |
| • Impurity 5 ppm | |

## STANDARD SPECIFICATIONS

| | |
|---|---|
| **GENERAL PROPERTIES** | |
| Density | 2.2 $g.cm^{-3}$ |
| **MECHANICAL PROPERTIES** | |
| Young's modulus | 72 Gpa |
| Design tensile strength | 48 Mpa |
| Design compressive strength | 1100 Mpa |
| **THERMAL PROPERTIES** | |
| Max. Use temperature | 950 - 1300°C |
| Thermal conductivity | 1.4 $W.m^{-1}.K^{-1}$ |
| Coefficient of linear expansion | $0.55.10^{-6}K^{-1}$ |
| **ELECTRICAL PROPERTIES** | |
| Volume resistance | 1016 Ω.cm |
| Dielectric constant | 3.7 (20°C, 1 MHz) |
| Dielectric strength | 40 $kV.mm^{-1}$ |

## TRANSMISSION SPECTRUM




## OPTICAL TRANSMISSION

| WAVELENGTH (nm) | FUSED SILICA (SYNTHETIC SILICA) | FUSED QUARTZ (NATURAL SILICA) |
|---|---|---|
| 190 | 86.42 | 73.84 |
| 200 | 86.88 | 75.16 |
| 210 | 88.51 | 79.90 |
| 220 | 89.09 | 85.69 |
| 230 | 89.58 | 87.57 |
| 240 | 89.90 | 87.58 |
| 250 | 90.12 | 88.64 |
| 260 | 90.46 | 90.11 |
| 280 | 90.89 | 90.82 |
| 300 | 91.14 | 91.15 |
| 350 | 91.49 | 91.45 |
| 400 | 91.72 | 91.75 |
| 500 | 92.08 | 91.99 |
| 750 | 92.26 | 92.32 |
| 1000 | 92.52 | 92.48 |
| 2000 | 93.25 | 93.48 |
| 2500 | 91.58 | 93.56 |

# Ceramic Substrates

## ALUMINA $Al_2O_3$ SUBSTRATE (MICROPOLISHED)

Pure alumina ceramics due to their high insulation resistance at elevated temperatures, high dielectric strength, low dielectric loss tangent at high frequencies is one of the best dielectric materials available for use in applications requiring electrical insulation.

The mechanical strength of pure alumina ceramics may be extremely high if properly controlled by the size and homogeneity of the constituent crystallites. It is recommended to use ceramics in compression because compressive strength is nearly 10 times that of the flexural strength. This may be achieved through design or by the establishment of operating conditions.

Thermal and chemical properties of pure alumina ceramics are always of great interest. Thermal conductivity is nearly equivalent to stainless steel. Pure alumina ceramics is inert to oxidation, not corroded by chemical agents and not subjected to radiation damage.

### APPLICATIONS

- Mechanical seal faces
- Nozzles for abrasives spraying corrosive reagents
- High pressure liquid media
- Laboratory apparatus components
- Metalized parts of high vacuum and high-voltage feed-through, and many other applications

### STANDARD SPECIFICATIONS

| | |
|---|---|
| **Purity** | 96% |
| **Color** | White |
| **Density** | 3.72 $g.cm^{-3}$ |
| **Thermal expansion** | $8.10^{-6}$ $°C^{-1}$ |
| **Loss tangent** | $4.10^{-4}$ at 1 MHz |

| | |
|---|---|
| **Thermal conductivity** | 24 $W.m^{-1}.K^{-1}$ |
| **Dielectric constant (at 1 MHz)** | 9.8 |
| **Volume resistivity (Ω.m)** | > $10^{13}$ at 20°C<br>> $3.10^{7}$ at 500°C |
| **Flexural strength** | 350 $N.mm^{-2}$ |

# Glassy Carbon Substrates

Glassy carbon, also called vitreous carbon, is an advanced material of pure carbon combining glassy and ceramic properties with these of graphite. Unlike graphite, glassy carbon has a fullerene-related microstructure. This leads to a great variety of unique material properties.

## SPECIAL PROPERTIES

- High temperature resistance in inert gas or vacuum up to 3000°C
- High purity
- Extreme corrosion resistance
- Impermeability to gas and liquids, no open porosity
- No wetting by melts
- High hardness and strength
- Low density
- High surface quality, no particle generation
- Low thermal expansion
- Extreme resistance to thermal shock
- Isotropy of physical and chemical properties
- Good electrical conductivity
- Biocompatibility

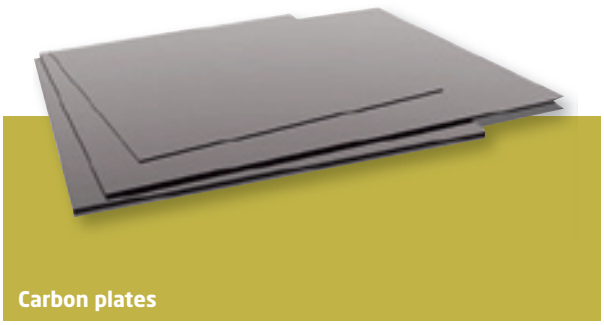
## STANDARD SPECIFICATIONS

| | PLATES | PLATES / FILMS |
|---|---|---|
| **Maximum service temperature (vacuum or inert gas)** | 3000°C | 1000°C |
| **Density** | 1.42 $g.cm^{-3}$ | 1.54 $g.cm^{-3}$ |
| **Open porosity** | 0% | 0% |
| **Permeability coefficient** | $10^{-9}$ $cm^2.s^{-1}$ | $10^{-11}$ $cm^2.s^{-1}$ |
| **Vickers hardness** | 230 HV1 | 340 HV1 |
| **Flexural strength (4 point)** | 260 $N.mm^{-2}$ | 210 $N.mm^{-2}$ |
| **Young's modulus** | 35 $kN.mm^{-2}$ | 35 $kN.mm^{-2}$ |
| **Compressive strength** | 480 $N.mm^{-2}$ | 580 $N.mm^{-2}$ |
| **Specific electrical resistance (RT)** | 45 Ω.µm | 50 Ω.µm |
| **Thermal conductivity (RT)** | 6.3 $J.K^{-1}.m^{-1}.s^{-1}$ | 4.6 $J.K^{-1}.m^{-1}.s^{-1}$ |
| **Median linear coefficient of expansion (20-200°C)** | $2.6.10^{-6}$ $K^{-1}$ | $3.5.10^{-6}$ $K^{-1}$ |

## AVAILABLE DIMENSIONS

| | THICKNESS | DIMENSIONS |
|---|---|---|
| PLATES | 0.3 mm<br>0.5 mm | 25 x 25 mm<br>50 x 50 mm<br>100 x 100 mm |
| | 1 to 6 mm | 25 x 25 mm<br>50 x 50 mm<br>100 x 100 mm<br>200 x 200 mm |
| FILMS | 60 µm<br>100 µm<br>140 µm<br>180 µm | 25 x 25 mm<br>50 x 50 mm<br>100 x 100 mm |

Other dimensions and custom made parts are available on request.



Carbon plates

Carbon films

# HOPG & Mica Substrates

## HIGHLY ORDERED PYROLYTIC GRAPHITE HOPG

HOPG, is a relatively new form of high purity carbon and provides microscopists with a renewable and smooth surface. Unlike mica, HOPG is completely non-polar, and for samples where elemental analysis will also be done, it provides a background with only carbon in the elemental signature. The extreme smoothness of HOPG gives results in a featureless background, except at atomic levels of resolution.

The structure is strictly columnar, that is, the columns run vertically within the flat slab of the material. The grain boundaries can be seen on the lateral surfaces. The mosaic spread is the angle of deviation of the grain's boundary from this perpendicular axis (of the columnar structure).

### USE AT ELEVATED TEMPERATURES

As more and more applications are found for HOPG in research and technology, more and more applications are requiring good high temperature characteristics. We can report the following information which should be useful for those contemplating such usage:

- Air: 500°C (Starts to burn)
- Vacuum at 0.1 Torr: 2500°C
- Inert atmosphere ($N_2$, Ar, He): 3500°C

### DENSITY OF HOPG

The density for all three grades (SPI-1, SPI-2, and SPI-3) is 2.27 $g.cm^{-3}$.

### GRADE SPI-1

Comparable to the very best "calibration grade" HOPG and exhibiting a 0.4° +/- 0.1°. This is the most highly ordered, lateral grain size is typically up to about 3 mm but can be as large as 10 mm, and is used primarily for instrument calibration purposes or for research experiments where for some reason, the very ultimate in HOPG order is needed.

### GRADE SPI-2

This grade exhibits a mosaic angle as small as 0.8° +/- 0.2°. This grade is slightly less highly ordered than SPI-1 but is acceptable for most users. The lateral grain size can be up to 0.5 mm but can be as large as 1 mm.

### GRADE SPI-3

Exhibits a mosaic angle as small as 3.5° +/- 1.5°. This grade is much less highly ordered and has a grain size not larger than the range of 30-40 nm.

### SQUARES & RECTANGLES

| DIMENSIONS (mm) | P/N SPI-1 GRADE | P/N SPI-2 GRADE | P/N SPI-3 GRADE |
|---|---|---|---|
| 5 x 5 x 1 | 476HP-AB | 479HP-AB | 490HP-AB |
| 7 x 7 x 1 | 498HP-AB | 480HP-AB | 491HP-AB |
| 10 x 10 x 1 | 439HP-AB | 436HP-AB | 429HP-AB |
| 10 x 10 x 2 | 438HP-AB | 446HP-AB | 440HP-AB |
| 12 x 12 x 1 | 426HP-AB | - | - |
| 10 x 10 x 0.2 | 424HP-AB | - | - |
| 10 x 10 x 3 | - | 456HP-AB | 443HP-AB |
| 20 x 20 x 1 | - | 466HP-AB | 449HP-AB |
| 20 x 20 x 2 | - | 444HP-AB | 448HP-AB |
| 20 x 20 x 3 | - | 447HP-AB | 451HP-AB |

### DISCS

3 mm diameter to fit into a standard TEM grid holder, 50-75 µm thick, shipped in a BEEM Dial-A-Grid box.

| Packaging | P/N |
|---|---|
| Pack of 20 discs | 423HP-CA |
| Pack of 100 discs | 423HP-MB |

## MICA SHEETS, STRIPS AND DISCS

The only mica offered by Neyco is of the muscovite type and indeed, we offer only the highest qualities of the mineral.

### APPLICATIONS

For AFM studies, and for those making either carbon films or doing thin film coating research and wanting a higher quality mica as defined as having fewer "steps" on a freshly cleaved surface, we would recommend grade V-4. This grade is also great for use with AFM where a polar substrate is desired or where polarity of the substrate just does not matter.

For AFM calibration studies or perhaps the ultimate substrate for carbon film production, we offer the grade V-1. Mica can also be used as a substrate for binding cells to be characterized by TEM.

- Chemical Formula: $K_2OAl_2O_3SiO_2$
- Appearance: Semi clear to gray translucent sheets, strips, and discs
- Specific Gravity: 2.7 $g.cm^{-3}$
- Hardness on Mohs scale of hardness: 2 - 2.25

- Grade V-1 Muscovite: Highest possible quality
- Grade V-4 Muscovite: Premium research quality
- Grade V-5 Muscovite: Research quality

## SQUARES & RECTANGLES

| THICKNESS | LATERAL SIZE (mm) | PACKAGING | GRADE V-1 | GRADE V-4 | GRADE V-5 |
|---|---|---|---|---|---|
| 0.15 mm | 50 x 25 | Pkg of 1 | 01792-AB | - | - |
| | 50 x 25 | Pkg of 20 | 01792-CA | 01876-CA | - |
| | 50 x 25 | Pkg of 100 | 01792-MB | 01876-MB | - |
| | 25 x 25 | Pkg of 1 | 01872-AB | - | - |
| | 25 x 25 | Pkg of 20 | 01872-CA | - | - |
| | 25 x 25 | Pkg of 100 | 01872-MB | - | - |
| | 15 x 15 | Pkg of 20 | 01868-CA | 01869-CA | - |
| | 15 x 15 | Pkg of 100 | 01868-MB | 01869-MB | - |
| | 75 x 50 | Pkg of 20 | - | - | 01804-CA |
| | 75 x 25 | Pkg of 20 | - | - | 01805-CA |
| | 75 x 25 | Pkg of 100 | - | - | 01805-MB |
| | 40 x 10 | Pkg of 100 | - | - | 01806-MB |
| 0.26 mm | 25 x 25 | Pkg of 20 | - | 01870-CA | - |
| | 25 x 25 | Pkg of 100 | - | 01870-MB | - |
| | 50 x 25 | Pkg of 20 | - | 01791-CA | - |
| | 50 x 25 | Pkg of 100 | - | 01791-MB | - |
| | 75 x 25 | Pkg of 20 | - | 01875-CA | - |
| | 75 x 25 | Pkg of 100 | - | 01875-MB | - |
| | 80 x 40 | Pkg of 25 | - | 01918-CF | - |
| | 40 x 10 | Pkg of 10 | - | - | 01806A-BA |
| | 40 x 10 | Pkg of 100 | - | - | 01806A-MB |

## DISCS

| THICKNESS | DIAMETER (mm) | PACKAGING | GRADE V-1 | GRADE V-4 | GRADE V-5 |
|---|---|---|---|---|---|
| 0.05 mm | 3.05 | Pkg of 100 | 01900-MB | - | - |
| | 3.05 | Pkg of 20 | 01900-CA | - | - |
| 0.15 mm | 9.5 | Pkg of 100 | 01873-MB | 01874-MB | - |
| | 9.5 | Pkg of 20 | 01873-CA | 01874-CA | - |
| | 12 | Pkg of 100 | 01877-MB | 01879-MB | - |
| | 15 | Pkg of 100 | 01878-MB | 01880-MB | - |
| | 22 | Pkg of 100 | 01920-MB | 01921-MB | - |
| 0.26 mm | 9.9 | Pkg of 20 | - | - | 01871-CA |
| | 9.9 | Pkg of 100 | - | - | 01871-MB |
| 0.275 to 0.325 mm | 12 | Pkg of 100 | 01925-MB | - | - |
| | 25 | Pkg of 100 | 01926-MB | - | - |
| 0.05 mm | 3.05 | Pkg of 100 | - | 01923-MB | - |
| | 3.05 | Pkg of 20 | - | 01923-CA | - |

# Thin Film Deposition

## THIN FILM DEPOSITION ON REQUEST

Neyco offers thin films deposition on request on the various substrates such as: Platinum, Gold, ITO, Titanium, Chromium.

***See Silicon Wafers** in this section about **Thermal Oxidation of Si wafers***

## ITO-COATINGS ON GLASS SUBSTRATE

Whenever an electrically conductive surface that at the same time offers a high optical transparency is required, ITO-coating glass series are used. ITO-coating glass is achieved by sputter-coating a thin conductive layer of indium-tin-oxide onto high quality glass substrates.

Because of the low electrical sheet resistances we have available, our ITO-coatings have often be used to shield electromagnetic fields while still transmitting most of the visible light.

Our series of conductive transparent oxide coatings feature a $SiO_2$ passivation layer. This quartz barrier layer is only a few nanometers thick, and is located between the substrate and the ITO-coating. This offers an increased electrical insulation performance and minimizes possible leaching of alkali-oxides from the glass into liquid crystals. The process of coating this $SiO_2$ passivation layer between the ITO thin film coating and the glass substrate, is advantageous for most electronic applications and is efficiently integrated into the production process.

## APPLICATIONS

- Display technology
- Transparent ITO electrode
- ITO coated microscope slide
- Circuit substrate
- Micro structuring application
- Transparent EMF/EMI/EMC/RFI/HF shielding glass
- Flat antennas for mobile communication
- Conducting glass
- De-Icing applications
- Heatable ITO slide & cover slip

## SPECIAL PROPERTIES

- Electrically conductive and optically transparent
- High VIS-NIR light transmission
- High quality glass substrate
- $SiO_2$ barrier layer
- Low roughness
- High sheet resistance homogeneity
- Uniform transmission homogeneity
- Reflecting in the infrared range

## REFRACTIVE INDEX

We present the refractive index data for the ITO coating. It is the refractive index value used for calculating our ITO film performances. Remember that the ITO coatings made are sputtered and therefore are denser than coatings made by vacuum evaporation.

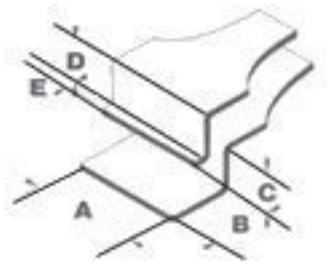
| WAVELENGTH (nm) | REFRACTIVE INDEX | EXTINCTION COEFFICIENT |
|---|---|---|
| 400 | 2.15 | 0.025 |
| 425 | 2.1 | 0.018 |
| 450 | 2 | 0.01 |
| 506 | 2 | 0.0087 |
| 600 | 2 | 0.0065 |
| 650 | 2 | 0.0044 |
| 700 | 2 | 0.0042 |
| 750 | 2 | 0.0042 |
| 800 | 2 | 0.004 |
| 1065 | 2 | 0.004 |

## RESISTIVITY RANGE

Resistivity range: 10 - 15, 15 - 30, 30 - 60, 70 - 100 Ω.cm according ITO thickness.

# Wafer Tweezers

We offer 18 different tweezers styles, mostly from the SPI-Swiss collection.




| STYLE | DIMENSIONS (in mm) | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Style #2W | 6.5 | 5 | 2.5 | 4 | - |
| Style 2WF | 6.5 | 9 | 2.5 | 4 | 2.5 |
| Style 2WFG | 6.5 | 9 | 2.5 | 4 | 2.5 |
| Style 3W | 9.5 | 10 | 2.5 | 4 | - |
| Style 3WF | 9.5 | 10 | 2.5 | 4 | 2.5 |
| Style 3WFG | 9.5 | 10 | 2.5 | 4 | 2.5 |
| Style 4W | 12 | 9 | 2.5 | 4 | - |
| Style 4WF | 12 | 9 | 2.5 | 4 | 2.5 |
| Style 4WFG | 12 | 9 | 2.5 | 4 | 2.5 |

| | STYLE | DESCRIPTION | P/N |
|---|---|---|---|
|  | **Style #2W<br>Length: 120 mm** | Antimagnetic<br>Stainless Steel | 0S2W0-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S2W0T-XD |
|  | **Style 2WF<br>Length: 119 mm** | Antimagnetic<br>Stainless Steel | 0S2WF-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S2WFT-XD |
|  | **Style 2WFG<br>Length: 120 mm** | Antimagnetic<br>Stainless Steel | S2WFG-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S2WFGT-XD |
|  | **Style 3W<br>Length: 125 mm** | Antimagnetic<br>Stainless Steel | 0S3W0-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S3W0T-XD |
|  | **Style 3WF<br>Length: 125 mm** | Antimagnetic<br>Stainless Steel | 0S3WF-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S3WFT-XD |
|  | **Style 3WFG<br>Length: 125 mm** | Antimagnetic<br>Stainless Steel | S3WFG-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S3WFGT-XD |
| | **Style 4W<br>Length: 133 mm** | Antimagnetic<br>Stainless Steel | 0S04W-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S04WT-XD |
|  | **Style 4WF<br>Length: 133 mm** | Antimagnetic<br>Stainless Steel | 0S4WF-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S4WFT-XD |
|  | **Style 4WFG<br>Length: 125 mm** | Antimagnetic<br>Stainless Steel | S4WFG-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S4WFGT-XD |
|  | **Style 33A<br>Length: 112 mm<br>Width at end: 6.5 mm** | Antimagnetic<br>Stainless Steel | 0S33A-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S33AT-XD |
|  | **Style 34A<br>Length: 127 mm<br>Width at end: 6.2 mm** | Antimagnetic<br>Stainless Steel | 0S34A-XD |
| | | PTFE Coated Antimagnetic<br>Stainless Steel | S34AT-XD |

| | STYLE | DESCRIPTION | P/N |
|---|---|---|---|
|  | **Style 35A**<br>**Length: 121 mm**<br>**Width at end: 6.5 mm** | Antimagnetic Stainless Steel | 0S35A-XD |
| | | PTFE Coated Antimagnetic Stainless Steel | S35AT-XD |
|  | **Style 36A**<br>**Length: 124 mm**<br>**Width at end: 6.2 mm** | Antimagnetic Stainless Steel | 0S36A-XD |
| | | PTFE Coated Antimagnetic Stainless Steel | S36AT-XD |
|  | **Style 37S**<br>**Length: 124 mm**<br>**Width at end: 6.5 mm** | Antimagnetic Stainless Steel | 0S37S-XD |
| | | PTFE Coated Antimagnetic Stainless Steel | S37ST-XD |
|  | **Style 84A**<br>**Length (Total): 121 mm**<br>**Width of pick up: 2 mm**<br>**Length of top pick up:**<br>**Top: 5 mm**<br>**Bottom: 6 mm** | Antimagnetic Stainless Steel | 0S84A-XD |
| | | PTFE Coated Antimagnetic Stainless Steel | S84AT-XD |
|  | **Style 85C**<br>**Length: 121 mm**<br>**Width at end: 7.0 mm** | Antimagnetic Stainless Steel | 0S85C-XD |
| | | PTFE Coated Antimagnetic Stainless Steel | S85CT-XD |
|  | **Style 86B**<br>**Length: 121 mm**<br>**Width at end: 2.7 mm** | Antimagnetic Stainless Steel | 0S86B-XD |

***See Section L - Sample Preparation*** *in this catalogue for other* ***tweezers****.*