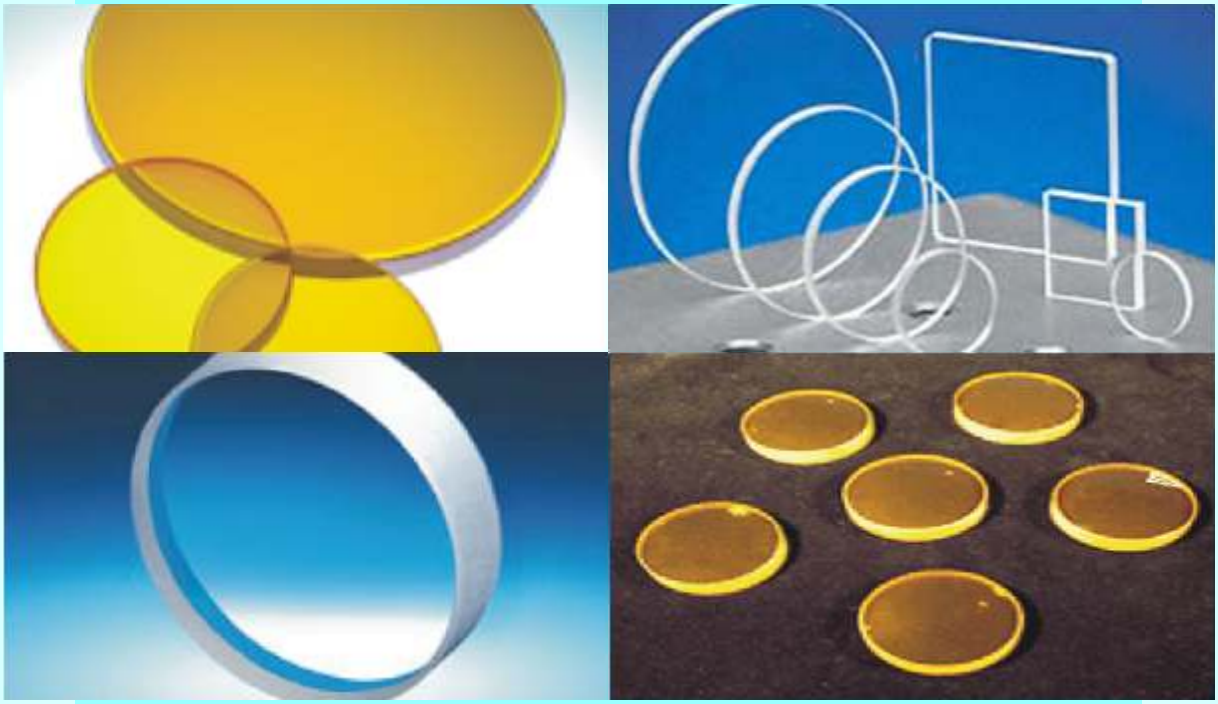
# OPTICAL WINDOWS



HHV supplies precision grade and commercial quality windows from a wide range of optical materials to support different applications in the ultraviolet (UV), visible, and infrared (IR) wavelength ranges. Standard optical glasses include BK-7, B-270 and synthetic fused silica (UVFS), in addition, specialty optical materials like sapphire, germanium (Ge), silicon (Si), zinc selenide (ZnSe), and zinc sulfide (ZnS) are in-house fabricated.

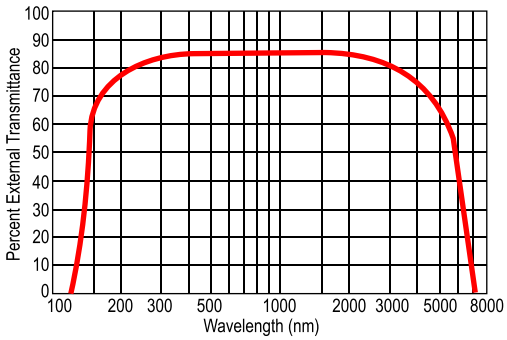
## Infrared optical Substrates:

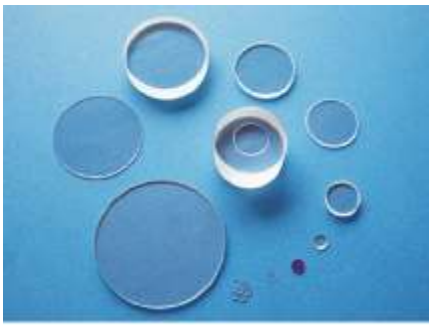
There are two major far infrared (FIR) applications: imaging applications (FLIR/ thermal) and CO2 laser processing. Imaging devices that operate at 3-5 and 8-12 µm regions, and CO2 laser devices operate at 10.6 µm require IR transmitting materials like ZnSe, ZnS, Cleartran, Si, Ge, Sapphire etc. In general, processing IR substrates requires special fabrication techniques that are different from those of UV and Visible substrates. M/s. HHV has the capability to fabricate and supply of the IR optics.

## Sapphire:

Sapphire is chemically very stable, insoluble, resistant to acids and alkaline. It only reacts with hydrofluoric acid, phosphoric acid and potassium hydroxide at high temperature of above 300 degree celsius. Sapphire has over 95% light transmission rate on natural light ray and over 85% on infrared ray. Because of its excellent transmission for infrared ray, it is also widely used as infrared filters in military and industrial applications. Because of its great strength, windows made from sapphire can be much thinner than windows of other glass types, and therefore are useful even at wavelengths that are very close to their transmission limits. It has very high thermal conductivity.

The hardness of sapphire is extremely high which is scale 9 of moh's scale, only second to diamond. This also explains why watch crystals made of sapphire have a very good mechanical strength, wear and weather resistance. Sapphire is commonly used in high-class watches. HHV is capable of supplying sapphire to the required shapes and dimensions.



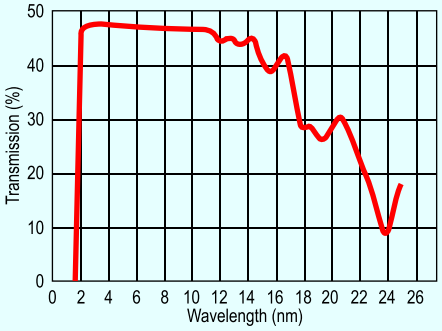



**Specification:**

| | |
|---|---|
| Material | : Sapphire |
| Dimension | |
| Diameter | : 2 to 200 mm |
| Square/Rectangle | : 2 to 200 mm |
| Thickness | : > 1mm |
| Edges | : Fine ground |
| Surfaces | : 60/40 |
| Flatness | : ≤ 10 Fringes |
| Paralleslism | : ≤ 3 arc minutes |

## Germanium (Ge):

Germanium is transparent in the infrared from 2 to 16 microns. It is a chemical element with atomic number 32. Pure germanium is a hard, lustrous, gray-white, brittle metalloid. It has a diamond like crystalline structure and it is similar in chemical and physical properties to silicon. Because germanium is transparent in the infrared it is a very important infrared optical material that can be readily cut and polished. It is especially used as the front optic in thermal imaging cameras working in 8-14 micron range for passive thermal imaging, forward looking infrared (FLIR) system and for hot-spot detection in military and night vision system in cars.

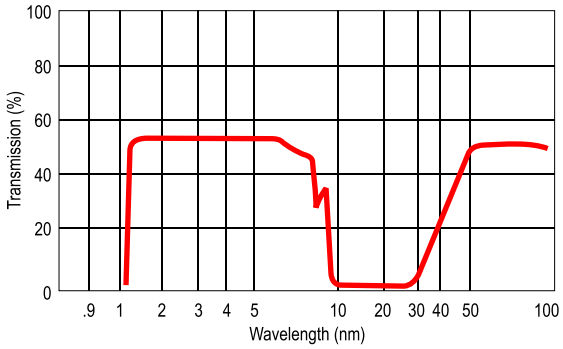


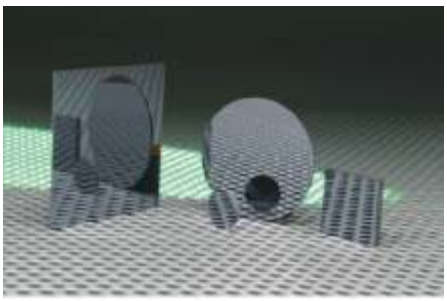

**Specification:**

| | |
|---|---|
| Material | : Germanium |
| Dimension | |
| Diameter | : 3 to 100 mm |
| Square/Rectangle | : 3 to 100 mm |
| Thickness | : > 1mm |
| Type | : n-type monocrystalline |
| Resistivity | : 5-30 ohm-cm |
| Surfaces | : 40/20 |
| Paralleslism | : ≤ 3 arc minutes |

## Silicon:

Silicon (Si) is commonly used for 3-5 µm imaging applications. Widespread use of this material in the semiconductor industry has driven the price of silicon down, making it the least expensive of IR materials. It is readily available, lightweight and possesses very good thermal and mechanical durability. Although silicon has some absorption in the 8-12 µm range, the low power levels of these imaging applications make it a suitable choice. Silicon is not used for CO2 transmitting optics because of high absorption characteristics, however, it is widely used in mirror applications due to its high thermal conductivity and mechanical characteristics. It is also useful as a transmitter in the 20 micron range It is ideal for weight sensitive applications, especially those in the 3 - 5µm region. Density is 2.329 g/cm3 and Knoop Hardness is 1150, making it harder and less brittle than Germanium.



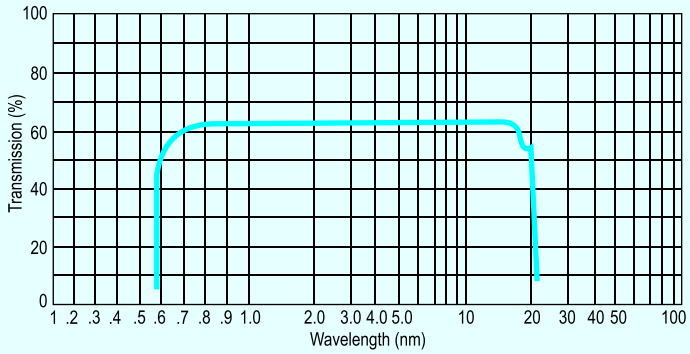



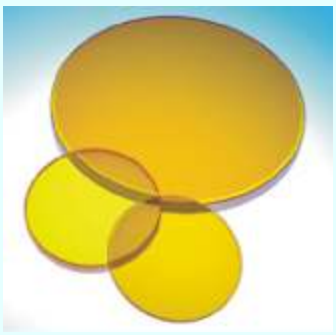
**Specification:**

| | |
|---|---|
| Material | : Silicon |
| Dimension | |
| Diameter | : 3 to 100 mm |
| Square/Rectangle | : 3 to 100 mm |
| Thickness | : > 1mm |
| Type | : p/n-type mono/ polycrystalline-FZ |
| Surfaces | : 40/20 |
| Paralleslism | : ≤ 3 arc minutes |

## Zinc Selenide (ZnSe):

Zinc Selenide (ZnSe) has the transmission range 0.6 µm - 20 µm and is widely used in both imaging and CO2 laser applications. ZnSe is one of the most commonly used IR substrates because of wide availability, good mechanical strength and ease of processing. It is the industry standard for CO2 laser optics because of lower absorption at 10.6 µm. It is also used for chromatic correction in predominantly germanium FLIR lens systems. It has found use for multispectral windows, which permits it to be used in any one of the three atmospheric transmission windows as well as in the upper portion of the visible spectrum above 0.5µm. Since ZnSe has fairly good transmission in visible, permits the testing and lenses in transmission with HeNe lasers or with interferometers that use a HeNe laser as the light source. Unlike germanium, ZnSe can be used as IR component at elevated temperatures. Because of its very low absorption (<0.0005/ cm at 10.6 µm), thermal runaway can become a problem only at temperatures of 300 deg C. This good temperature performance makes ZnSe a good choice for IR windows on high- performance aircraft. Zinc selenide has the density 5.27 g/ cm 3 and its hardness is less than the zinc sulphide.



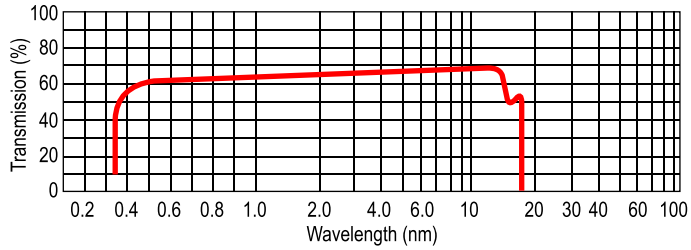



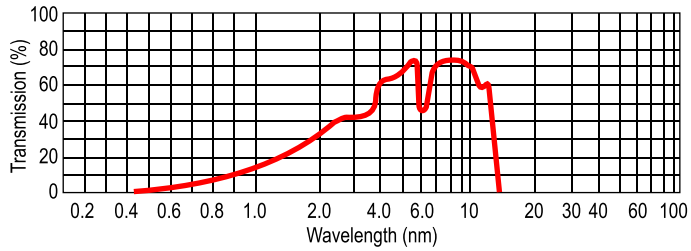
**Specification:**

| | |
|---|---|
| Material | : CVD-Zinc selenide |
| Dimension | |
| Diameter | : 3 to 100 mm |
| Square/Rectangle | : 3 to 100 mm |
| Thickness | : > 1mm |
| Accuracy | : 1/20 @ 10.6 µm |
| Surfaces | : 40/20 |
| Paralleslism | : ≤ 3 arc minutes |

## Zinc Sulphide:

Zinc Sulfide (ZnS) has good transmission characteristics in the 3-5 / 8-12 µm regions and its mechanical strength makes it a common choice for FLIR and thermal imaging applications. Unlike ZnSe, ZnS has poor transmitting characteristics in the visible region. ZnS is also a polycrystal zinc chalcogenide with better mechanical strength than ZnSe. ZnS is typically used for windows or domes in FLIR systems. Because of its greater strength, it is better suited to serve as window material for IR light in high-speed aircraft. It also provides an adequate rain erosion resistance. Cleartran is a special type of multi-spectral ZnS (chemically identical) that is clear in appearance. This means that it has the same IR transmitting properties as ZnS with the added benefit of transmitting the full VIS/NIR spectrum as well. Cleartran is a more expensive optical material (comparable to ZnSe) and is generally used in special applications requiring multiple wavelength regions.




**Specification:**

| | |
|---|---|
| Material | : Cleartron/CVD-ZnC |
| Dimension | |
| Diameter | : 3 to 100 mm |
| Square/Rectangle | : 3 to 100 mm |
| Thickness | : > 1mm |
| Accuracy | : 1/20 @ 10.6 µm |
| Surfaces | : 40/20 |
| Paralleslism | : ≤ 3 arc minutes |

## Ultraviolet Fused Silica (UVFS):

Fused Silica is a high purity synthetic amorphous silicon dioxide. This noncrystalline, colorless, silica glass combines a very low thermal expansion coefficient with excellent optical qualities and exceptional transmittance over a wide spectral range, especially in the ultraviolet. It is resistant to scratching and thermal shock. Its refractive index varies from 1.55 to 1.40 through the transmission range. It can withstand temperatures upto 1500 degree C.

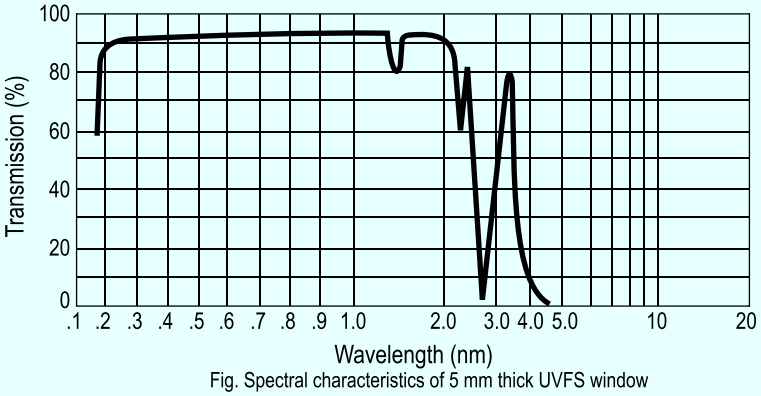
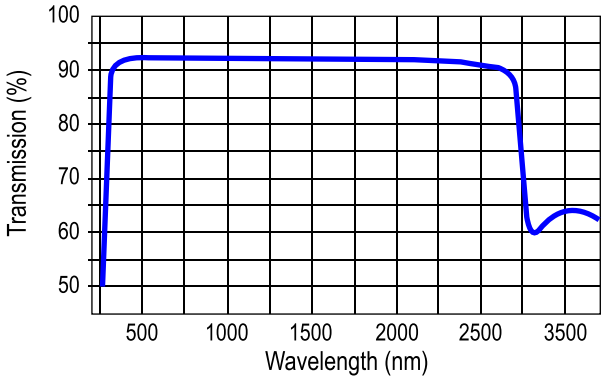



Fig. Spectral characteristics of 5 mm thick UVFS window

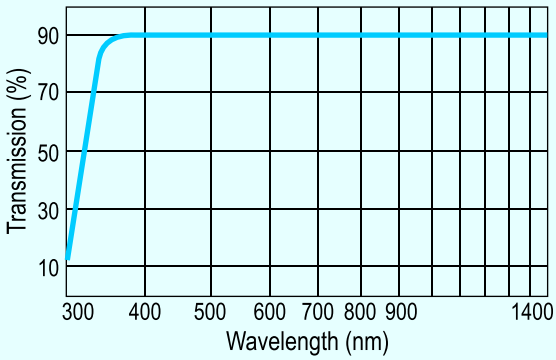
## BK-7 Glass:

BK7 is the most widely used Vis/NIR substrate because of its transmission characteristics, low price, wide availability and ease of processing. Although BK7 is only one of many different types of glass, it is considered as the standard optical material for precision optics. Only for those systems which work in visible and at temperature beyond 500 O C, UVFS replaces BK7. It has the stable index through out the region of transparency.




## B-270 Glass:

Another class of glass, which is at the lower end of borosilicate type is B-270. This glass can replace BK-7 in few of the optical applications. This glass has the same index and less costlier than BK-7. It is used as optical windows and as eyepiece lenses in optical systems. B-270 is widely used as substrates for telescope mirrors and in watch industry. HHV is one of few companies in the world that manufactures different types of watch glass to cater the needs of Horological industries.




**Specification:**

| | |
|---|---|
| Material | : UVFS/BK-7/B-270 |
| Dimension | |
| Diameter | : 2 to 200 mm |
| Square/Rectangle | : 2 to 300 mm |
| Thickness | : > 1mm |
| Edges | : Fine ground |
| Surfaces | : 60/40 |
| Flatness | : ≤ 10 Fringes |
| Paralleslism | : ≤ 3 arc minutes |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