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WHITE PAPERS & APPLICATION NOTES

PROPERTIES AND APPLICATIONS OF SAPPHIRE

Sapphire is a tough optical material resistant to chemicals, scratching, and high pressure in many diverse environments and has exceptional transparency. Frequently it is the combination of two, or more, of its properties that make sapphire the only material available to solve complex engineering design problems. Below are some of the properties that set sapphire apart from all other optical materials:

- It has a high modulus of elasticity and high tensile strength that make it extremely wear, abrasion and impact resistant.
- It is an excellent electrical insulator because of its high dielectric constant.
- Due to the thermal stability of sapphire, it does not lose any of its mechanical and optical attributes when exposed to temperatures ranging from cryogenic to over 2000C degrees.
- The thermal conductivity is greater than other optical materials and most dielectrics.
- There is no surface damage or devitrification due to extreme thermal cycling.
- Unlike other optical materials, it does not sag or slump at very elevated temperatures.
- It is highly corrosion resistant and more resistant to corrosive chemicals than most other optical and non-optical hard materials.
- No solarization in high-radiation systems.
- Superior optical transmission span from UV to mid IR. (see Figure 2)

Sapphire has a hexagonal / rhombohedral structure, and there are properties that are dependent on the orientation of the crystal (Figure 1). Sapphire substrates are available in C, R, A, and M plane and random orientations. Random is the least expensive and is generally specified for non-critical optical or mechanical applications.

- C-plane sapphire is the strongest and most mechanically symmetric orientation. C-plane sapphire is usually specified for optical applications to eliminate the inherent birefringent properties of the crystal. Sapphire substrates are used to grow III-V and II-VI compounds such as GaN for blue LED and laser diodes. In addition, it is useful for infrared detector applications.
- A-plane sapphire substrates provide a uniform dielectric constant and high insulation for hybrid microelectronic applications. High Tc superconductors can be grown with a-plane Sapphire substrates.
- R-plane sapphire substrates are used for the hetero-epitaxial deposition of silicon for microelectronic IC applications. Sapphire is an excellent choice for hybrid substrates such as microwave ICs because of its high dielectric constant. In addition, when filmed with an epitaxial silicon process, high speed IC and pressure transducers can be created. Other applications are growing thallium, other superconducting components, high impedance resistors, and GaAs.
- M-plane and R-plane sapphire is used for growing non-polar/semi-polar plane epitaxial layers, which helps in improving luminescence efficiency. Hybrid microelectronics, microelectronic IC applications use sapphire substrates.

Properties and Applications of Sapphire

Sapphire is a tough optical material resistant to chemicals, scratching, and high pressure in many diverse environments and has exceptional transparency. Frequently it is the combination of two, or more, of its properties that make sapphire the only material available to solve complex engineering design problems. This paper will introduce the reader to some of those properties and potential applications that set sapphire apart from all other optical materials.

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