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Single Crystal Sapphire

Introduction

$A1_2O_3$ single crystal, also known as sapphire or corundum, is a simple coordination type oxide, often blue color due to the trace element titanium (Ti) or iron (Fe). Sapphire single crystal has excellent mechanical properties, chemical stability and high temperature resistance, and has high strength and high hardness. It can work under the harsh conditions of high temperature of 1900 ℃. Therefore, it is widely used in infrared military equipment, satellite space technology, and the window material for high-intensity lasers.Sapphire is also an important technical crystal. With its unique lattice structure, good physical and chemical properties and price advantages, it has become the most ideal substrate material for large-scale integrated circuit SOI and SOS and superconducting nanostructured films; light-emitting diode (LED) substrate; can be made into optical sensors, and other optical communication and optical waveguide devices, such as observation windows of high temperature and high pressure or vacuum containers, heat sinks of liquid crystal display projectors, monitor windows of harmful gas detectors and fire monitor, optical fiber communication connector box, etc.

Properties

Molecular Formula	Al_2O_3
Density	3.95-4.1 g/cm^3
Crystal Structure	Hexagonal Lattice
Crystal Structure	a =4.758Å , c =12.991Å
Number of molecules in unit cell	2
Mohs Hardness	9
Melting point	2050 ℃
Boiling Point	3500 ℃
Thermal Expansion	5.8×10-6 /K
Specific Heat	0.418 W.s/g/k
Thermal Conductivity	25.12 W/m/k (@ 100℃)
Refractive Index	no =1.768 ne =1.760
dn/dt	13x10 -6 /K(@633nm)
Transmittance	T≈80% (0.3 ~ 5μm)
Dielectric Constant	11.5(∥c), 9.3(⊥c)

Application Types of Sapphire Substrate

The sapphire substrates used by the majority of epitaxial wafer manufacturers are divided into three types.

1, C-Plane sapphire substrate

This is the sapphire substrate surface widely used by many manufacturers for GaN growth. This is mainly because the sapphire crystal growing along the C axis is relatively mature, relatively low in cost, and stable in physicochemical properties. The technology of epitaxy on C surface is mature and stable.

C-Plane sapphire substrate is a widely used sapphire substrate. Professor Akasaki Yong and Dr. Nakamura Shuji at Nichia et al in Japan in 1993, broke the InGaN and sapphire substrate lattice mismatch (buffer layer), the activation of P type material and so on, finally to develop the first Blu ray LED at the end of 1993, nichia. A few years later Liriya chemical on sapphire substrate, using InGaN materials, by MOCVD technology, and continue to be improved sapphire and epitaxial technology, improve the luminous efficiency of blue light, and in 1997 developed the UV LED, 1999 blue purple LED samples start shipping in 2001 to provide white LED. Which laid the leading Nichia in the field of LED.

Taiwan follow Japan's LED technology, the development of Taiwan LED is the first to buy wafers from Japan and processing, bought MOCVD machine and the sapphire substrate for epitaxy, Taiwan local manufacturers of sapphire crystal growth and processing technology of production, through independent research and development, LED patent licensing and other ways to achieve sapphire crystal substrate, and epitaxial wafer production, epitaxial wafer processing and so on our own production technology, step by step, Taiwan laid an important position in the upstream business in LED. At present most of the blue / Green / white LED products are used in Japan as the representative of Taiwan sapphire substrate for MOCVD epitaxial production. The sapphire substrate has great universality, by American Cree company using SiC as the substrate as the representative of the LED products are followed.

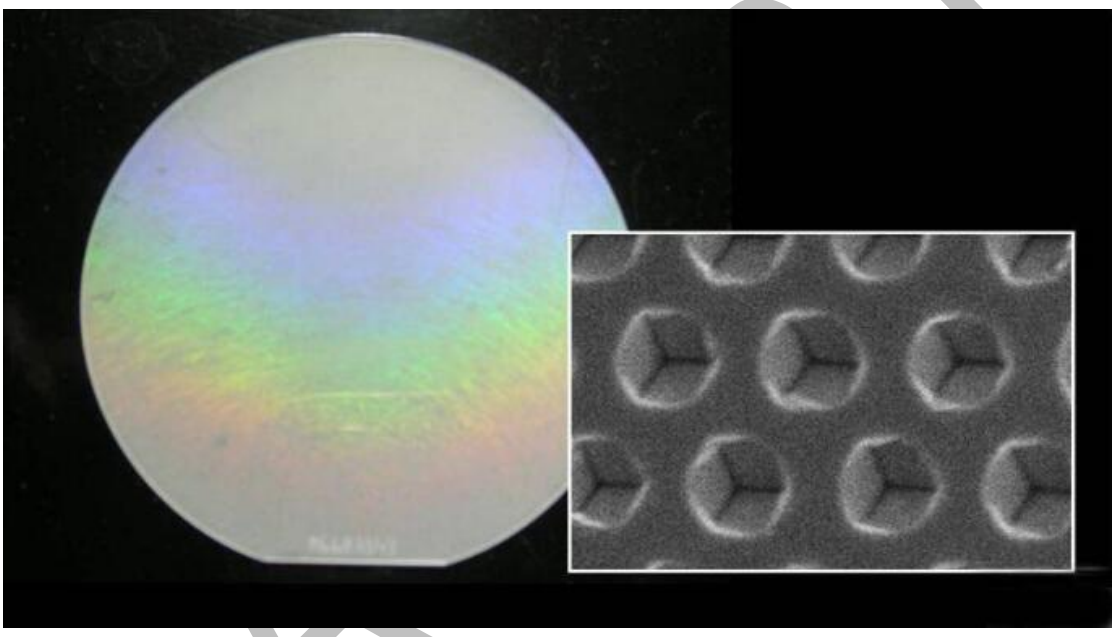
2, R-Plane or M-Plane sapphire substrate

Mainly used for growth of nonpolar / semipolar GaN epitaxial films, to improve the luminous efficiency. GaN films prepared on sapphire substrates usually grow along the c axis, and C axis is the axis of polarity GaN, resulting in GaN based devices in active layer quantum well in the construction of a strong electric field in the therefore, the luminous efficiency will be reduced, the development of non polar GaN extension, overcome the physical phenomenon, the luminous efficiency is improved.

By etching (in C / sapphire surface dry etching and wet etching) way, designed to produce micron or nano level with micro structure specific regular pattern on the sapphire substrate, so

as to control the LED light output form (concave convex pattern on the sapphire substrate will produce light scattering or refraction effects increase the removal rate of light at the same time), GaN film grown on patterned sapphire substrate will produce lateral epitaxial effect, reduce the growth on sapphire GaN dislocation defects, improve and enhance the quality of epitaxial, LED internal quantum efficiency, increase the light extraction efficiency. Compared with the general growth in the sapphire substrate LED, the brightness increased by more than 70%. At present Taiwan production of patterned sapphire and crystal silicon with the United States, Zhaojing, Shaoda. 2/4 inch sapphire substrate is a mature product, prices gradually stabilized, and the large size (6/8 inches) and ordinary sapphire substrate the 2 inch patterned sapphire substrate in the growth stage, the price is high, the manufacturer is the main push of large size and patterned sapphire substrate, but also actively

There is no manufacturer in the mainland to produce a patterned sapphire substrate.



Nanoscale patterned sapphire substrate (source: toon Technology)

3. Patterned sapphire substrate (Pattern Sapphire Substrate for short, PSS)

To grow (Growth) or etching (Etching) method, design the micro structure of nano pattern specific rules to control the LED light output in the form of sapphire substrate, and can also reduce growth on sapphire substrates GaN dislocation defects, improve and enhance the amount of crystalline Lei, internal quantum efficiency, LED increase the light extraction efficiency.

Usually, C sapphire substrates GaN thin film growth is along the polar axis is the growth of the c axis, the film has spontaneous and piezoelectric polarization effects, resulting in the film (active layer quantum well) have a strong built-in electric field (Quantum Confine, Stark Effect, QCSE; the history of tank effect) greatly. Reduce the luminous efficiency of GaN thin film. In some non C sapphire substrate surface (such as R or M) and some other special substrates (such as lithium aluminate; LiAlO2) GaN thin film growth is nonpolar and semipolar, caused by

the polarization field generated in the light emitting device in the negative effect will be partially or even completely improved. The traditional 35 nitride semiconductor growth on sapphire substrates were C-plane, if this kind of compound growth in R-plane or M-Plane, can produce the built-in electric field parallel to the epitaxial layer, in order to increase the electron The probability of a hole to compound. Therefore, the growth of LED structure based on nitride epitaxial thin films on R-plane or M-Plane sapphire substrate, compared with the traditional C surface sapphire, will effectively solve the problem of LED's internal quantum efficiency and low efficiency, and increase the luminous intensity of components. The latest news is that non polar LED can increase the luminous efficiency of white light by two times.

Because GaN has no polarity has the potential to make more efficient components than the traditional C axis GaNN, and many international companies and research institutions have increased the research and production of such epitaxial technology. So for the needs and requirements of R-plane or M-Plane is also a corresponding increase in the sapphire substrate.

Customization

We can provide sapphire crystal window/plate, ruby window/plate, sapphire crystal dome, sapphire crystal fairing, sapphire crystal prism, sapphire crystal lens, sapphire crystal rod, sapphire crystal tube, sapphire crystal shaped components etc.