



- ◆ 先进陶瓷材料
Advanced ceramic material
- ◆ 精密陶瓷部件
Precision ceramic parts
- ◆ 应用解决方案
Solution of application



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广东夏阳精细陶瓷科技有限公司
GUANGDONG XY FINE CERAMIC TECHNOLOGY CO.,LTD

广东夏阳精细陶瓷科技有限公司位于广东省东莞市,2012年开始投入研发测试先进陶瓷,投资金额1000万人民币,专注于先进精细陶瓷材料的研发、制造、精密加工、应用方案。是精细陶瓷领域的制造商、供应商和方案提供商。

公司拥有多名材料博士和陶瓷工程师;并且拥有设备齐全的实验室和全套先进的制造检测设备:气炉烧结炉,真空烧结炉,冷等静压,干式压力机,注塑成型机、泥压设备等;并拥有成熟的干压成形、冷等静压成形、注塑成形、热压铸成形技术;同时拥有夏阳精密加工设备:光学曲线磨、CNC外圆磨床、CNC精密铣床等。是中国国内少有从材料实验、造粒到成型、烧结、精密制造全产业链的先进精细陶瓷公司。

公司凭借科研院所雄厚的研发力量支持,和夏阳精密近20年精密制造经验,以及管理层对国际市场成熟运作经验,先进陶瓷材料和精密陶瓷零部件的品质与国际同步,使我们先进陶瓷材料主要的性能指标达到或接近欧洲同行水平。公司配备多名陶瓷应用工程师,可以为全世界用户提供中、英、德三种语言的工程陶瓷应用解决方案。致力成为全球超硬材料应用的领航者。

XY Fine Ceramics Technology Co., Ltd. is located in Dongguan City, Guangdong Province. It began to invest in research and development and testing of advanced ceramics in 2012, with an investment of 10 million RMB, focusing on the research and development, manufacturing, precision processing and application of advanced ceramic materials. Who is a manufacturer, supplier and solution provider in the field of fine ceramics.

The company has a number of materials doctors and ceramic engineers; and has a well-equipped laboratory and a full set of advanced manufacturing and testing equipment: pneumatic sintering furnace, vacuum sintering furnace, cold isostatic pressing, dry press, injection molding machine, mud making equipment, etc.; and has mature dry pressing forming, cold isostatic pressing, injection molding, hot die-casting forming technology; at the same time. It has precision processing equipment: optical curve grinding, CNC cylindrical grinding machine, CNC precision milling machine, etc.

It is one of the best advanced fine ceramics companies in China that has a complete industrial chain from material experimentation, granulation, molding, sintering, and precision manufacturing.

The company relies on strong R&D support from scientific research institutes, has nearly 20 years of precision manufacturing experience, and the management is mature in the international market. Operational experience, the quality of advanced ceramic materials and precision ceramic parts are synchronized with the international level, so that the main performance indicators of our advanced ceramic materials can reach or close to the level of European counterparts. The company is equipped with a number of ceramic application engineers, which can provide engineering ceramics in Chinese, English and German languages to users all over the world. And committed to becoming a leader in the application of super-hard materials in the world.

先进材料检测仪器

Advanced Material Testing Instruments

洛氏硬度计



材料检测仪



三次元检测仪



圆度仪



公司现主营产品有:增韧氧化锆、氧化镁锆、氧化铝锆、氧化铝、氮化硅、碳化硅,蓝色氧化锆;陶瓷柱塞、陶瓷泵阀、陶瓷焊接辊、陶瓷焊接垫片、陶瓷压延轮、陶瓷辊轮、陶瓷坩埚、陶瓷拉深模具、陶瓷挤压模具、陶瓷量规、量块、陶瓷刀片等。

Company main products:Toughened zirconia, zirconium oxide, zirconium oxide, alumina, silicon nitride, silicon carbide, blue zirconia.Ceramic plunger, ceramic valve, ceramic welding roller, ceramic welding gasket, ceramic rolling wheel, ceramic roller, ceramiccrucible, ceramic drawing die, ceramic extrusion die, ceramic gauge, measuring block, ceramic blade, Ceramic shaped parts.

先进精细陶瓷是近年兴起的新型材料,具有耐超高温、高硬度、耐酸碱腐蚀,不导磁、不导电,特殊光学效果,在航天航空、通信、汽车、化工、医疗、电子、精密机械等军工民用行业有广泛的用途。正成为未来最具前途的新材料之一。

Advanced fine ceramic is a new material in recent years. It' s non-magnetic and non-conductive and has special light color effect , with characteristics of ultra-high temperature resistance, high hardness, resistance to acid and alkali corrosion. It has a wide range of uses in military and civilian industry, like aerospace, communication, automotive, chemical industry, medical care, electronic, precision machinery etc. It' s becoming one of the most promising new materials in the future.

材料制造设备

Material Manufacturing Equipments



立式注射机
Injection Molding Machine



隧道炉 Tunnel Kiln



烧结炉
Sintering Furnace



等静压机
Isostatic Press Machine



开合式密炼机
Pressurized Mixer



液压机
Hydraulic Press Machine

精密加工设备

Precision Processing Equipments



光学曲线磨
Profile Grinding Machine



CNC 磨床
CNC Carving Machines



超精密外圆磨床
High Precision Cylindrical Grinding Machine

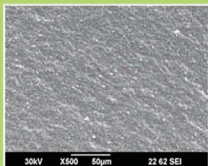


五轴精雕机
Five-axis CNC Machine



阿奇夏米尔慢走丝
Agie Charmilles E.D.M Wire Cutting Machine

氧化锆 (ZrO_2) —— 韧性最好的陶瓷材料



氧化锆不仅具有高硬度、高耐磨性，也是精细陶瓷中韧性非常好的材料，因此它常用于结构件，耐磨件。它还具有与钢材接近的热膨胀系数，因此也是常用于连接陶瓷和钢的材料，氧化锆除了常用于工业结构件领域，因其具有玉石般的质感，在生活陶瓷中也有着广泛的应用。

Zirconia not only has good feature of a high hardness, high wear resistance, but also is excellent in toughness among fine ceramic material, so it is commonly used for structural parts and wear parts. As thermal expansion coefficient is close to the steel, it is also always used to connect ceramic and steel. Except commonly used in the field of industrial structural parts Zirconia is also widely used in daily-used ceramic because of its jade-like texture.

应用领域:

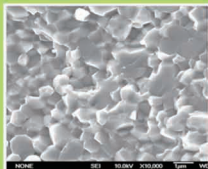
- ◆ 光通信用品 (插芯、套管)
- ◆ 柱塞 (阀芯、阀套、灌装泵)
- ◆ 手机部件 (指纹识别、后盖)
- ◆ 智能穿戴 (表壳, 饰品)
- ◆ 特种结构件 ◆ 燃料电池 ◆ 汽车氧传感器

Application areas:

- ◆ Optical communication parts (ceramic core pin, ceramic tube)
- ◆ Medical plunger (valve core, valve sleeve, filling pump)
- ◆ Mobile phone parts (Fingerprint recognition, Back cover)
- ◆ Smart wear (watch case, accessories)
- ◆ Special structural parts ◆ Fuel Cell ◆ Automotive oxygen sensor



氧化铝 (Al_2O_3) —— 价格与价值最优的材料



氧化铝具有硬度高，熔点高、耐腐蚀、电阻率高、成本低、适中的表面活性、良好的附着力、耐热震性以及屏蔽效应。较厚的多用于磨料或抛光行业。片状氧化铝用于陶瓷增强材料，化妆品，高级涂料等领域。

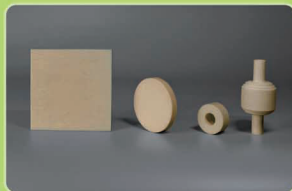
Alumina has high hardness, high melting point, corrosion resistance, high resistivity, low cost, moderate surface activity, good adhesion, thermal shock resistance and shielding effect. Thicker ones are mostly used in abrasive or polishing industry. Flake alumina is used in ceramic reinforcing materials, cosmetics, advanced coatings and other fields.

应用领域:

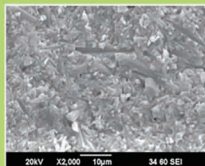
- ◆ 冶炼 (坩埚、理化器皿)
- ◆ 电子行业 (电路基板、管座、外壳)
- ◆ 机械行业 (轴承)

Application areas:

- ◆ Smelting (Crucible, Physicochemical containers)
- ◆ Electronics industry (circuit board, tube-socket, outer casing)
- ◆ Machinery industry (bearing)



氮化硅 (Si_3N_4) —— 综合性能优异陶瓷材料



它的微观结构由互锁成微棒的细长晶体组成，其互相结合成微棒。优异的耐磨性能，优异的断裂韧性以及非常高的热稳定性，使得氮化硅陶瓷用于轻、高速和高精度的轴承，以及重型陶瓷成形工具和汽车部件承受高应力的滚珠和滚动元件，并且在焊接工艺中利用良好的耐热冲击性和耐高温性。

The microstructure consists of elongated crystals that interlock into micro-rods. Silicon nitride ceramics has excellent wear resistance, outstanding fracture toughness and good thermal stability. It's these features that make it suitable for applications as following: Light bearings; high-speed bearings, high precision bearings; tools for heavy-type ceramic forming; automotive components subject to high stress. And the good thermal shock resistance and high temperature resistance is exploited in welding processes.

应用领域:

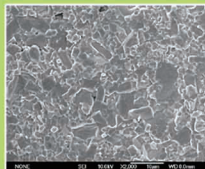
- ◆ 机械行业 (电机轴承、电主轴)
- ◆ 冶金行业 (焊接辊、阻水圈)
- ◆ 汽车部件 (涡轮转子、凸轮挺杆)
- ◆ 工业耐磨件 (金属成型、剪切刀具, 喷砂喷嘴)
- ◆ 航天、航空 ◆ 半导体

Application areas:

- ◆ Machinery Industry (Electric machinery bearing, Electric Spindle)
- ◆ Metallurgical industry (welding roller, Water-Resistant Ring)
- ◆ Auto parts (Turbine rotor, Cam tappet)
- ◆ Industrial wear parts (Metal forming, cutting tools, sand blasting nozzle)
- ◆ Aerospace ◆ Semiconductor



碳化硅 (SiC) —— 超硬的陶瓷材料



碳化硅几乎像钻石一样。它不仅是最轻的，也是最硬的陶瓷材料，具有优异的导热性，低热膨胀性，非常耐酸和碱，并且在急冷急热的环境下不易开裂。

Silicon carbide behaves almost like a diamond. It is not only the lightest, but also the hardest ceramic material and has excellent thermal conductivity, low thermal expansion, high resistant to acids and lyes and it's not crack easily in the environment of sudden cold or hot.

应用领域:

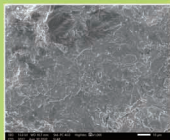
- ◆ 石油 (阀门、喷嘴) ◆ 化工 (密封件)
- ◆ 机械行业 (轴承、滚珠)
- ◆ 航天 (燃气涡轮机叶片, 涡轮增压器转子)

Application areas:

- ◆ Oil (valves, nozzles) ◆ Chemical industry (sealing parts)
- ◆ Machinery industry (ball bearing)
- ◆ Aerospace (Gas turbine blades, Turbocharger rotor)

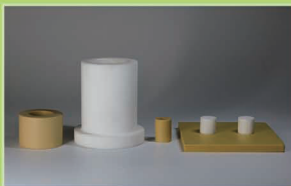


镁锆 (MG-PSZ) —— 抗弯强度最佳材料



镁锆陶瓷通过氧化镁作为稳定剂而制备的氧化锆增韧陶瓷, 可拥有抗弯强度和断裂韧性最佳的镁锆陶瓷。具有更好的抗热震性。广泛应用于冶金、钢铁和石化工业。而高品质的镁稳定氧化锆陶瓷, 更适用于食品工业, 医药工业, 高精密封工业, 高精密封仪器。

Magnesium zirconium ceramics are zirconia toughened ceramics made by using magnesia as a stabilizer, which can have magnesia zirconium ceramics with the best flexural strength and fracture toughness. With have better thermal shock resistance. It is widely used in metallurgy, steel and petrochemical industries. The high-quality magnesium stabilized zirconia ceramics are more suitable for the food industry, pharmaceutical industry, high-precision canning industry, high-precision instruments.



应用领域:

- ◆ 冶金
- ◆ 石化
- ◆ 纺织
- ◆ 密封
- ◆ 食品
- ◆ 医药
- ◆ 高精密封
- ◆ 高精密封仪器等等

Application areas:

- ◆ Metallurgy
- ◆ Petrochemical
- ◆ Textile
- ◆ Sealing
- ◆ Food
- ◆ Medicine
- ◆ High-precision canning
- ◆ High-precision instruments

陶瓷泵阀

Ceramic Fluid Valve

- * 增韧结构陶瓷材料制造, 机械强度高, 使用寿命长
- * 具备耐磨损、耐腐蚀、抗高温及化学稳定性稳定等卓越性能。
- * 具有隔热性好、热膨胀小
- * 产品尺寸精度高, 圆度0.001mm、密封性能好
- * 绿色环保无污染



- * Made of toughened structural ceramic materials, high mechanical strength, long service life
- * With wear resistance, corrosion resistance, high temperature stability, chemical stability and other superior performance
- * With good thermal insulation, thermal expansion
- * High precision dimension, roundness reaches 0.001mm, good sealing performance
- * Green pollution-free

精密陶瓷零件

Precision Ceramic Parts

- * 可做异形精细加工, 加工范围可达250mmx200mmx200mm
- * 公差达到±0.002mm
- * 精密密度达±0.001mm
- * 光洁度Ra0.08



- * Can do special shaped fine processing, range can up to 250mm X 200mm X 200mm
- * The precision can reach ±0.002mm
- * Roundness can be ±0.001mm
- * Roughness can reach Ra 0.08

陶瓷模具

Ceramic Mold

- * 耐高温、耐酸碱腐蚀、高抗压
- * 拥有良好的电绝缘性、导热性、抗热震性
- * 优异附着强度、热循环能力
- * 产品尺寸精度高, 圆度0.001mm、密封性好
- * 绿色环保无污染



- * High temperature resistance, acid and alkali corrosion resistance, high pressure resistance
- * Good electrical insulation, thermal conductivity, thermal shock resistance
- * Excellent adhesion strength, thermal cycling capacity
- * High dimensional accuracy, roundness 0.001 mm, good sealing performance
- * Green, environmentally and non-polluting

陶瓷轧辊/焊接棍

Ceramic Roller /Welding Roller

- * 具有非常高的硬度, 高耐磨性, 以及它不导磁不导电。
- * 具有非常高的热稳定性, 在高温工作情况下也能保持其性能。
- * 高精密度, R精度可达±0.002mm。
- * 跳动度、圆度精度可达±0.002mm。
- * 绿色环保, 在金属成型工作中可节省30%以上的能源



- * It has characteristics of high hardness, wear resistance, non-magnetism and non-conducting.
- * It also has good thermal stability, which enable it maintain its performance in the case of high temperature.
- * High precision, the precision of R can up to ±0.002mm
- * Vibration, roundness accuracy up to ±0.002mm
- * Environmental protection, it can save more than 30% of energy in the metal forming field.

半导体工装夹具

Semiconductor fixture

- * 具有优异的耐磨、耐高温、耐腐蚀、抗热冲击、绝缘等特性
- * 相比传统材料性价比优越。
- * 拥有其他材料无法达到的强度和破坏韧性, 适用于高腐蚀性, 高强度环境。
- * 绿色环保



- * Excellent wear resistance, high temperature resistance, corrosion resistance, thermal shock resistance, insulation and other characteristics
- * Good price Compared with traditional materials,
- * It has the strength and fracture toughness that other materials can't reach, and is suitable for high corrosiveness and high-intensity environment.
- * Green environment



精密仪器 Precision Equipments

行业性能要求:

耐高温、耐酸碱腐蚀、高抗压、拥有良好的电绝缘性、导热性、抗热震性,以及优异附着强度、热循环能力。

产品:

光伏轧辊、热流道喷嘴、导柱导套、汽车拉伸模具
金属冶金隔热导热材料管、柱塞高压泵

Industry performance requirements:

high temperature, acid and alkali corrosion resistance, high pressure resistance, and good electrical insulation, thermal conductivity, thermal shock resistance, and excellent adhesion strength, thermal cycling capacity.

Products:

PI roller, Hot runner nozzle, guide column guide sleeve, automobile tensile die metallurgical thermal insulation material tube, plunger high pressure pump

化妆品/医疗/食品 Cosmetic /Medical/ Food

特种陶瓷具有超强化学稳定性,良好的耐磨性、耐高温、耐腐蚀、极强的耐酸碱性、机械性能好和密封性能佳,自润滑使灰尘不易粘附,清洁更为容易。

产品种类:

陶瓷缸筒柱塞、陶瓷流量阀、陶瓷泵芯柱塞定量泵、陶瓷活塞等;

Special ceramics have super strong chemical stability, good wear resistance, High Temperature, corrosion resistance, strong acid alkaline resistance, good mechanical properties and sealing performance is good, self-lubricating makes dust not easy to adhere to, and cleaning is easier.

Products: Ceramic cylinder plunger, ceramic flow valve, ceramic pump core, Plunger metering pump, ceramic pistons, etc..



环保新能源 Green Energy

将煤气在高温下直接净化,比常温净化热效率大大提高,将净化后的煤气用于燃气轮机发电,提高供电效率,减低有害物的排量,节约用水。内燃机解决能大的空调、取暖、除霜等纯电动汽车遇到的难题。

产品:

隔膜切刀、陶瓷转子、加热器、粉体处理泵

The gas is directly purified at a high temperature, and the heat efficiency is greatly improved compared with the normal temperature. The purified gas is used for gas turbine power generation, the power supply efficiency is improved, the discharge of harmful substances is reduced, and water is saved. The internal combustion engine solves the problems encountered in pure electric vehicles such as air conditioners, heating, and defrosting.

Products:

Diaphragm cutter, Ceramic rotor, Heater, Powder processing pump



航空航天 Aerospace

陶瓷热膨胀系数低于常用金属,优良的电气隔离、介电特性;导热性好,耐磨性、机械强度高,在高频下的低损耗老化慢。抗EUV等离子体和离子辐射,以及在高真空中几乎不排气。

应用:

EUV半导体设备的传感器。

The coefficient of thermal expansion of ceramics is lower than that of common metals, excellent electrical isolation and dielectric properties; good thermal conductivity, high wear resistance, high mechanical strength, and lower loss at high frequencies.

Anti-EUV plasma and ionizing radiation, and almost no deflation in high vacuum. Application: Sensors for EUV semiconductor devices.



石油化工行业 Petrochemical Industry

耐磨陶瓷用于保护基底材料,达到隔热、抗氧化、防腐蚀的目的。石油化工行业有许多操作温度很高的设备,在这些设备的高温部件应用后,不仅可以使设备的制造成本降低、生产效率提高,而且设备庞大的体积也将相应的减小。

Wear resistant ceramics are used to protect substrate materials to achieve thermal insulation, oxidation resistance, and corrosion resistance. petrochemical industry has many equipments with high operating temperatures. After the application of the high-temperature components, it can not only reduce the manufacturing cost of the equipment, but also increase the productivity, and the huge volume of the equipment will be correspondingly reduced. according to.

半导体 Semiconductor

特种陶瓷是微晶晶体的烧结体,它与单晶材料不同,是由晶粒及晶界构成的,正是由于陶瓷内部晶界的存在和利用,使得陶瓷半导体具有一些优于单晶半导体的性能,因此被广泛应用于电子科技领域!

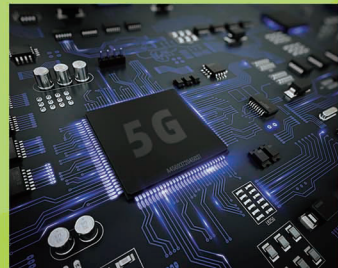
应用:

集成电子、消费电子、芯片、通讯系统、照明

Special ceramics are sintered bodies of fine crystals. It is different from single crystal materials. It is composed of grains and grain boundaries. It is precisely due to the existence and benefits of grain boundaries inside ceramics, so that ceramic semiconductors have some better performance than single crystal semiconductors, so it is widely used in the field of electronic technology!

Application:

Integrated electronics, consumer electronics, chips, communication systems, lighting.





机械自动化 Machinery Automation

结构陶瓷零部件陶瓷硬度高,在机械中高速运转不易受磨损、不受助剂和加工时降解物的腐蚀,不粘着磨损,大大延长模具寿命。

产品:

挤塑机筒内衬、螺杆部件、注嘴和模具、热电偶套管涡轮叶片、机械密封环、高温轴承、高速切削工具

The structural ceramic parts have high hardness, are not easily worn by the high-speed operation in the machine, are not corroded by the additives and the degraded materials during processing, and are not sticky and wear, which greatly prolongs the life of the mold.

Products: Extrusion barrel liners, screw components, nozzles and molds, thermowells, turbine blades, mechanical seal rings, high temperature bearings, high speed cutting tools

封装电子 Electronic Package

寻常电池组在高温中使用腐蚀性强的电解质,为使电池能在1000°的高温工作,要求稳定的薄状电解质。陶瓷即使在1000°也是稳定的,可以避免电池结构材料的腐蚀和电解质的逸散。

应用种类:

电容器、热敏电阻、光电器件、陶瓷基板电解质、变阻器、传感器、陶瓷金属印刷头

Conventional battery packs use a highly corrosive electrolyte at high temperatures, and a stable thin electrolyte is required to operate the battery at a high temperature of 1000°. The ceramic is stable even at 1000°, and corrosion of the battery structural material and escape of the electrolyte can be avoided.

Applications:

Capacitors, Thermistors, Optoelectronic devices, Ceramic substrate electrolyte, Rheostat, Sensor, Ceramic metal print head



通讯 Communication

蜂窝程序控制要求通讯系统高性能化、小型化,微波介质陶瓷介质损耗要小、频率温度系数小、介电常数高、低热膨胀系数、高机械强度,工作稳定性好,无需宽带倍频器,体积小重量轻,可以胜任。

应用:

滤波器、带通滤波器、频率振荡器、光纤插芯、光纤通信系统、印刷线路板

Cellular program control requires high performance and miniaturization of communication system. Microwave dielectric ceramic dielectric loss is small, frequency temperature coefficient is small, dielectric constant is high, low thermal expansion coefficient, high mechanical strength, good working stability, no need for broadband frequency multiplier. Small size and light weight, it can be competent.

Applications:

Filters, Bandpass filters, Frequency oscillators, Fiber ferrules, Optical fiber communication system, Printed circuit boards



Type(类型)	Unit 单位	Alumina (氧化铝)				Zirconium (氧化锆)				Silicon Carbide (碳化硅)		Silicon Nitride (氮化硅)		
XY Grade(编号)	\	A-100	A-200	A-300	AZ-100	Z-100	Z-200	Z-300	ZM-100	ZB-100	SC-200	SN-200	SN-300	SN-1000
Material(材料)	\	(Al2O3) 97%	(Al2O3) 99.5%	(Al2O3) 99.7%	(Al2O3)-ZrO2	ZrO2-Y2O3	ZrO2-Y2O3	ZrO2-MgO	ZrO2-Y2O3	(SiC)	(Si3N4)	(Si3N4)	(Si3N4)	
colour(颜色)	\	White, Ivory	White	Ivory, White	White	White	White	White	Yellow	Blue	Black	Gray, Black	Gray, Black	Yellow
Density(密度)	g/cm ³	3.7	3.85	3.9	4.2	6	6.03	6.04	5.62	6.03	3.2	3.2	3.2	3.2
Flexural Strength (抗弯强度)	Mpa	360	360	400	480	900	1050	1200	450	1100	400	850	1050	750
Compressive Strength (抗压强度)	Mpa	2250	2300	2450	2700	2100	2200	2300	1600	2300	2000	3000	3800	3000
Modules of Elasticity(young) (弹性模量)	Gpa	330	370	380	350	200	210	220	210	220	430	290	300	300
Fracture Toughness (断裂韧性)	MPam ^{1/2}	3	4	4.5	5.5	6	\	8	5.5	7	\	6	7	7.5
Poisson's Ratio (维泊尔系数)	\	0.23	0.22	0.22	0.24	0.3	0.3	0.3	0.3	0.3	0.16	0.28	0.28	0.28
Hardness HRA	HRA	90	91	91	91	89	90	90	88	90	94	91.5	92	92
Vickers Hardness (维氏硬度)	HV1	1450	1550	1600	1600	1250	1450	1450	1240	1450	2100	1600	1650	1650
Thermal Expansion Coefficient (热膨胀系数)	10 ⁻⁶ /K	7.1	6.8	6.8	9.2	11	10	10	10	10	4.5	3.2	3.2	3.2
Thermal Conductivity (导热系数)	W/mk	25	32	32	8	3	3	3	3	3	80	30	30	70
Thermal Shock Resistance (热震稳定性)	△T°C	200	220	220	470	400	400	400	\	400	400	600	800	800
Maximum Use Temperature (最高使用温度) in Oxidizing Atmosphere	°C	1200	1400	1500	1000	1000	1000	1000	850	1000	1350	1300	1300	1300
Max Use Temperature (最高使用温度) in Reducing or Inert Atmosphere	°C	1200	1400	1500	1000	1000	1000	1000	850	1000	1350	1400	1400	1400
Volume Resistivity at 20°C (20°C体积电阻)	Ωcm	10 ¹⁴	10 ¹⁵	10 ¹⁵	10 ¹⁴	10 ¹³	10 ¹²	10 ¹²	5X10 ¹³	10 ¹²	10 ⁸	10 ¹⁴	10 ¹⁴	10 ¹⁴
Dielectric Strength (介电强度)	kV/mm	16	20	20	16.5	19	15	17	19	17	0	15	19	19
Dielectric Constant (1MHz)(介电常数)	\	9.5	9.5	9.5	10	28	30	30	27	30	\	9	9	9
Dielectric Loss Angle at 20°C, 1MHz20°C, 兆赫介质损耗角	tan δ	3x10 ⁻⁴	1x10 ⁻⁴	1x10 ⁻⁴	2x10 ⁻² (9GHz)	2x10 ⁻³	2x10 ⁻³	2x10 ⁻³	2x10 ⁻³ (1GHz)	2x10 ⁻³	\	4x10 ⁻³ (1GHz)	5x10 ⁻³ (1GHz)	3x10 ⁻³ (1GHz)