

Technical Ceramics Applications

Wear and Corrosion

Greenleaf has been in the advanced ceramic business for 50 years. We have traditionally been known for our ceramic and carbide metal cutting inserts and tooling. However, we also manufacture wear parts for severe service environments. **We manufacture ceramic components that work where exotic metals, carbides and traditional ceramics do not perform well.** Examples of severe service components are deep drawing dies for stainless, red metals and aluminum, bushings, fasteners, seals, valve components, pump parts, battery tooling, wire rollers and more. Our ceramics are used for the worst case applications of wear, corrosion, temperature extremes from cryogenic to 1400°C, friction, abrasion and more.

Electronic and Data Storage

We also have ceramic compositions and shapes for disc drive data storage and electronic industries. Electronic ceramics are generally used for high strength, temperature extremes and either electrical insulation or electrical conductivity. These applications require super precision toleranced, ultra-thin and ultra-flat ceramic plates for disc drives, glide heads, burnishing heads and substrates for the data storage industry. Other electronic applications are high voltage insulators, oil patch insulators and thermal couple block assemblies.

Proprietary ceramic material solutions are made to specific customer requirements.

Lossy or Microwave Absorbing

Greenleaf manufactures lossy or microwave absorbing ceramics that can be tuned to absorb microwave energy in specific frequency ranges based on design, electrical properties (dielectric constant and loss tangent) and other application requirements. We revolutionized the microwave transmission industry by developing ceramic components based on frequency response instead of composition. This allows military and microwave transmission industry leaders to optimize their equipment through more precision wave guides, detection devices, sending and receiving instruments for today's modern microwave uses. Greenleaf offers a complete line of lossy ceramics for use as buttons, wedges, servers, pellets, terminators, slot modes and any custom designs. These materials are made to the highest industry quality and are capable of operating with no outgassing under high vacuum and extremes of temperature. Special ceramic formulations can be developed to meet specific applications.

Medical

We have ceramic components proven to be safe and reliable for medical, pharmaceutical and food service applications. We also have medical applications requiring biocompatibility and the ability to be sterilized without degradation. The applications can include implantable and instrumentation components where the ceramics need to be inert to bodily fluid and yet be fully dense, ultra-smooth, have low frictional rates, and be strong. Our medical ceramics can also withstand all types of sterilization and multiple sterilization cycles.



Greenleaf Corporation Background

Greenleaf Corporation is a leading supplier of cutting tool technology, specializing in the manufacturing of high-performance tungsten carbide and ceramic grade inserts and innovative tool-holding systems. Greenleaf continues to build on over 70 years of innovation and the legacy established by its founder Walter J. Greenleaf, Sr., which centers on supplying customers with productive solutions to every metal cutting situation.

The corporation traces its roots back to the early 1940s when Walter J. Greenleaf, Sr. sold tungsten carbide tooling systems to the steel industry in Western Pennsylvania. Greenleaf Corporation was formed in 1945 and began marketing a diverse line of products for the machine tool industry. Greenleaf Corporation moved into manufacturing in 1960. In 1969, Greenleaf was the first to introduce CVD-coated carbide inserts to the US marketplace.

Over the next 44 years, Greenleaf grew in market share through the development of its technological capabilities and product line. Greenleaf capitalized on its reputable line of carbide products by engineering innovations in the areas of ceramic, ceramic composites and custom designed tool-holding systems. Greenleaf's introduction of WG-300®, a whisker-reinforced ceramic insert that is recognized as one of the most significant advancements in the history of cutting tools, enabled companies to reach previously unachievable machining speeds.

Today, Greenleaf Corporation is positioned to serve the evolving needs of companies in major industries, including aerospace, automotive, bearings, machine tool and rail among others. Greenleaf's products are engineered to provide optimal performance against a wide range of materials under the most rigorous metal cutting conditions. In addition to a comprehensive line of carbide inserts, Greenleaf offers high-quality ceramic and ceramic composite materials, which can be custom designed for specific machining applications.

Currently Greenleaf services its global customer base from a number of locations. Greenleaf's Corporate Headquarters in Saegertown, Pennsylvania and a facility in North Carolina are the mainstays of pioneering breakthroughs in cutting tool technology and manufacturing. On the global front, award winning customer service and technical support is also achieved through offices in the USA, the Netherlands, and China.



Circa 1963



Present Day



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PRODUCT GUIDE TECHNICAL CERAMICS

Properties of Ceramics Materials

Property	GS100™	GEM-7™	PZT	GSN	XSYTIN®-1	WG-50	WG-100	WG-150	WG-300®
Composition	Al ₂ O ₃ (99.9%)	Al ₂ O ₃ + TiC	ZrO ₂ (3%Y ₂ O ₃)	Si ₃ N ₄ (96%)	Si ₃ N ₄	Al ₂ O ₃ + SiC(w)	Al ₂ O ₃ + SiC(w)	Al ₂ O ₃ + SiC(w)	Al ₂ O ₃ + SiC(w)
Color	White (Gray)	Black	Ivory	Light Black	Brown	Light Green	Light Green	Light Green	Green
Average Grain Size (µm)	4.5	0.8							
Mechanical Properties									
Density (g/cm³)	3.98	4.30	6.05	3.21	3.55	3.73	3.78	3.72	3.74
Hardness Hv (500gm Load)	1700	2100	1300	1950	1830	1500	1800	2000	2100
Fracture Toughness (MPa√m)	4.2	3.8	9.0	6.0	7.5	4.5	5.5	6.8	10.0
Flexural Strength (MPa)	585	880	1000	860	1200	450	493	500	690
Young's Modulus (GPa)	400	390	200	310	316	375	380	390	400
Thermal Properties									
Thermal Expansion (10⁻⁶/°C)	6.5	7.5	10.3	3.5	3.5	7.2	7.2	7.0	6.0
Thermal Conductivity (W/mk)	32	23	3	25	26	26	27	31	35
Electrical Properties									
Volume Resistivity (Ω-cm)	>10 ¹⁵	0.002	>10 ¹³	>10 ¹³	>10 ¹³	1 x 10 ¹⁴	1 x 10 ¹⁴	4.8 x 10 ³	1.2 x 10 ³
Applications	Semiconductor Components - Wear Components	Electrical Insulators Ceramic & Metallic Assemblies - Wear & Chemical Environment Resistant Components	Medical Components - Seals - Implants - Pump Shafts - Knife Blades - Bearings & Bushings - Beverage Tooling - Aluminum Forming - Extrusion Dies	Bearings - Seals - High-Temperature, Shock-Resistant Fixtures - Engine Parts - Aerospace - Metal Processing/Forming - Wear Surfaces	Pumps - Valves - Bearings & Bushings - Implants - Battery Dies - Wear Components - Medical Applications	Wear Components - Wire Guides - Machine Wear Surfaces - Microwave Heaters	Wear Components - Metal Forming - Beverage Tooling - Aluminum Forming Dies	Draw Dies - Weld Rolls - Wear Guides - Extrusion Dies - Metal Forming - Valves & Seals	Pumps - Valves - Bearings & Bushings - Implants - Battery Dies - Wear Components - Medical Applications

NOTE: Properties are typical and should not be considered as specifications.

Properties of Electronic Materials

Property	GS 2	GS 4	GS 6	GS 100B
Composition	Al ₂ O ₃ + TiC	Al ₂ O ₃ + TiC	Al ₂ O ₃ + TiC	Al ₂ O ₃
Color	Black	Black	Black	Black
Average Grain Size (µm)	0.80	0.60	0.35	2.20
Mechanical Properties				
Density (g/cm³)	4.30	4.30	4.30	3.98
Hardness Hv (500gm Load) (Kg/mm²)	1950	2050	2050	1830
Fracture Toughness (MPa√m)	3.8	3.9	4.0	4.2
Flexural Strength (MPa)	850	900	600	590
Young's Modulus (GPa)	390	410	420	400
Thermal Properties				
Thermal Expansion (10⁻⁶/°C)	7.5	7.5	7.5	6.3
Thermal Conductivity (W/mk)	24	24	19	32
Electrical Properties				
Volume Resistivity (Ω-cm)	0.002	0.001	0.001	>10 ¹⁵
Sheet Resistance (Ω/□)	17.5	10.5	6.8	N/A
Etch and Lap				
RIE Etch Surface Roughness (Å)	543	102	60*	
Diamond Lap (µ/min)	0.38	0.46	0.59*	
Optical Properties				
n & k @ a wavelength of 546.1 nm	2.25/0.45	2.25/0.44	2.18/0.44	
Applications	- Guide Heads - Burnish Heads - Thin Film Heads - Tape Heads	- Guide Heads - Burnish Heads - Thin Film Heads - Tape Heads	- Guide Heads - Burnish Heads - Thin Film Heads - Tape Heads	- Semiconductor Components - Wear Components

NOTE: Properties are typical and should not be considered as specifications.

* Independent Head Company

Properties of Advanced Technical Ceramics for Microwave Applications

Grade	MS2	MS3	MS5	Fosterite	ANS40	AS40	AS60
Composition	MgO + 2 wt % SiC (particulate)	MgO + 3 wt % SiC	MgO + 5 wt % SiC	2 MgO-SiO ₂ + SiC (0.5-5% SiC)	AlN + 40 wt % SiC	Al ₂ O ₃ + 40 wt % SiC	Al ₂ O ₃ + 60 wt % SiC
Tailored Composition Available	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Processing Route	Hot Pressing	Hot Pressing	Hot Pressing	Cold Press	Hot Pressing	Hot Pressing	Hot Pressing
Density (g/cm³)	3.50	3.50	3.49	3.00	3.22	3.56	3.41
Outgassing	No	No	No	No	No	No	No
Thermal Conductivity (w/mk)	29	29	29	*	60		
Dielectric Constant							
@9.3GHz	9.5	10.6	10.9	*	47.0	30.0	88.0
@12.0 GHz	9.4	10.6	10.4	*	46.7	47.0	105.0
Loss Tangent							
@9.3GHz	0.01	0.01	0.02	*	0.31	0.38	0.59
@12.0 GHz	0.02	0.01	0.02	*	0.33	0.15	0.26
Thermal Expansion Coefficient (RT-1000C)							
	15.3	15.1	14.7		5.1		
Flexural Strength (MPa)							
	120	135	150	*	470	425	515
Applications							
	- Buttons - Absorbers	- Buttons - Absorbers	- Buttons - Absorbers	- Buttons - Absorbers	- High Thermal Conductivity - Terminators - Server Wedges - Absorbers - Load Pellets	- Slot Mode - Absorbers	- Slot Mode - Absorbers

NOTE: Properties are typical and should not be considered as specifications.

* Properties dependent on composition

