

Ceradyne Microwave Ceramic Products

Ceradyne Inc. is a ceramic manufacturing company that specializes in the manufacture of advanced technical ceramic components for the high power microwave tube industry. Ceradyne and its subsidiary, Semicon Associates, have provided ceramics, cathodes and magnets to the industry since the mid 1970s. Ceradyne's Ceralloy® ceramic components continue to provide the enabling technology for innovative material solutions in today's high power microwave applications.

Lossy Ceramics

"Lossy" ceramics are designed to absorb microwave energy in specific frequency ranges based on specific electrical properties (dielectric constant and loss tangent). Ceradyne offers a complete line of "lossy" ceramics for use as absorbers, buttons, terminations, severers, slot mode absorbers and the like. These materials have repeatable electric properties and are capable of operating under high vacuum with no out gassing. The various formulations are composed of a family of compositions that can be tailored to meet specific requirements. **Applications include:**

Absorbers, Buttons

Absorbers (Buttons) are components designed to "tune" the frequency of a coupled cavity microwave tube by absorbing energy in very specific frequency ranges. Ceradyne's Ceralloy® 6700 Series of materials are particulate composites of magnesium oxide and silicon carbide where the absorbed frequency is a function of the composition.



Slot Mode Absorbers

Slot Mode Absorbers are designed to absorb microwave energy over a broad frequency range and the composition is key to obtaining microwave absorption. Ceradyne produces the unique SMA geometry with near net shape processing using Ceralloy® 7712 Series material, a particulate composite of aluminum oxide and silicon carbide.



Severs, Terminations

Severs and Terminations absorb microwave energy over a very broad frequency range while exposed to high energy, requiring high thermal conductivity to dissipate heat and withstand thermal shock during operation. Ceralloy® 13740 Series and Ceralloy® 137 CA and CD1 compositions are proven to meet these requirements through the use of aluminum nitride based materials.



Aluminum Nitride

Ceralloy® 1370DP is a sintered aluminum nitride material developed for thermal management applications. It is an electrical insulator having high thermal conductivity at room temperature (170-190 W/mK). The thermal conductivity at microwave tube use temperature of 150°C is that of toxic BeO making it an ideal replacement (see chart on back). Ceralloy® 1370DP is capable of being formed into complex, three-dimensional components using near net shape fabrication processing techniques for windows, collector rods and collectors in microwave applications.

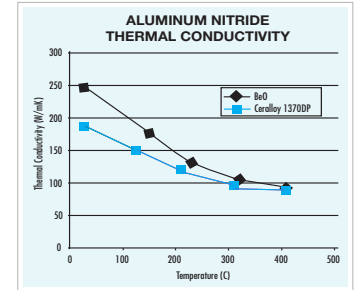


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Innovative Materials

Ceradyne is a complete materials resource with extensive R&D facilities and product development from design through component manufacture. The company has been instrumental in developing a number of unique microwave materials since the 1970s:

- Developed hot pressed “lossy” compositions having a specified composition with no vacuum out gassing. (1970s)
- Formulated BeO-SiC materials (Ceralloy® 2710) for sever and terminations. (1970s)
- Pioneered the use of aluminum nitride compositions as a replacement for BeO compositions. (Mid 1990s)
- Developed Ceralloy® 13740 and Ceralloy® 137CD1 as an aluminum nitride based replacement for Ceralloy® 2710. (1996 / 2001)
- Created Ceralloy® 137CA as an aluminum nitride based material with “lossy” properties independent of temperature to 3°K. (2002)



Stringent Quality Standards

Ceradyne is an innovator in the development of technology required to solve material related problems. Its Ceralloy® ceramic materials are produced using state-of-the-art processing methods and diamond grinding techniques for custom components with exacting tolerances according to ISO9000:2000 quality standards.

Properties of Ceradyne's Advanced Technical Ceramics for Microwave Applications

Property	Ceramic Composition										
	Al ₂ O ₃ -SiC	MgO-SiC		AlN-SiC		AlN Composite		AlN	Al ₂ O ₃	BeO-SiC**	BeO**
Grade	Ceralloy® 7712	Ceralloy® 6703	Ceralloy® 6705	Ceralloy® 13740	Ceralloy® 13740Y*	Ceralloy® 137 CA*	Ceralloy® 137 CD1*	Ceralloy® 1370DP	AICIM	Ceralloy® 2710	
Composition	Al ₂ O ₃ -SiC	MgO-SiC	MgO-SiC	AlN-SiC	AlN-SiC	AlN Composite	AlN Composite	AlN	99.80%	BeO-SiC	99.50%
Tailored Composition Available	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
Processing Route	Hot Pressing	Hot Pressing	Hot Pressing	Hot Pressing	Hot Pressing	Hot Pressing	Hot Pressing	Sintering	Sintering	Hot Pressing	
Density (g/cm ³)	3.36	3.5	3.48	3.19	3.19	2.99	2.99	3.26	3.94	3.02	
Outgassing	No	No	No	No	No	No	No	No	No		
Thermal Conductivity (W/mK)(RT)		30	30	30	53	85	95-105	170-190	35	130	250
Dielectric Constant											
@1.0GHz				22	30	28		8.7		33	7
@8.0GHz	130	11.2	12.8	15	22	18	38			24	
@10.0GHz	83	11.1	12.7	15	21	18	31			23	
@12.0GHz	69	10.9	12.6				27				
Loss Tangent											
@1.0GHz				0.11	0.11	0.2		0.002		0.05	
@8.0GHz	0.4	0.02	0.03	0.3	0.3	0.2	0.45			0.25	
@10.0GHz	0.57	0.02	0.03	0.28	0.28	0.2	0.4			0.25	
@12.0GHz	0.53	0.02	0.03				0.5				
Thermal Expansion Coefficient x10 ⁻⁶ /°C (RT -1000°C)		15.4	14.8	5.1	5.1	5.0	5.0	6.2	6.8	7.0	8.3
Flexural Strength (MPa)	530	200	200	300	300		190	260	415		175
Key Features						Dielectric Loss Independent of Temperature to 3K	Higher Thermal Conductivity than Ceralloy 2710 @ Temperatures >150°C. Close Match in Electrical Properties	Thermal Conductivity Equal to BeO @ Temperatures of about 200°C.		Former Industry Standard for Terminations, etc.	High Thermal Conductivity at RT
Applications	Slot Mode Absorbers	Absorbers, Buttons	Absorbers, Buttons	Replacement for Ceralloy 2710 BeO-SiC, Terminations, Sever Wedges, Load Pellets, Absorbers	Replacement for Ceralloy 2710 BeO-SiC, Terminations, Sever Wedges, Load Pellets, Absorbers	Terminations, Sever Wedges, Load Pellets, Absorbers, Cryogenic Environmental Applications	Replacement for Ceralloy 2710 BeO-SiC, Terminations, Sever Wedges, Load Pellets, Absorbers	Replacement for 99.5 BeO, Collectors, Collector Rods, Helix Support Rods, Windows		Terminations, Sever Wedges, Load Pellets, Absorbers	Collectors, Collector Rods, Helix Support Rods, Windows

Note: properties are typical and should not be considered specifications. * Patent Pending ** BeO and BeO-SiC ceramics are no longer manufactured by Ceradyne. Data is included for reference only.



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4/06 ISO 9001 REGISTERED FIRM

Ceradyne Advanced Technical Ceramics

Ceradyne, Inc. (NASDAQ:CRDN) is a publicly traded corporation specializing in development and vertically integrated production of advanced ceramic materials at facilities based in the United States and Europe. Ceradyne's advanced ceramics are sought for the most demanding applications in automotive/engine, industrial wear, medical/dental, electronic and defense industries.

Ceralloy® components are produced in fully dedicated facilities using patented compositions and processing techniques. Plentiful raw materials are coupled with conventional, time-tested ceramic manufacturing processes that produce high quality, cost effective advanced ceramic solutions.