

Black ceramics

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1. Introduction

Because of their excellent resistance against corrosion, strength under high temperature, and other properties not found in many other materials, ceramics materials are used commonly as device components. Introduced below are AlN- and SiC-based black ceramics that were developed by our company.

2. Main Features of Black AlN Ceramics

Black AlN ceramics provide excellent resistance against corrosion, a critical requirement for semiconductor production equipment that are subject to plasmas and corrosive gases.

The high thermal conductivity also makes the ceramics ideal material for fabricating heating or cooling susceptors. As dielectrics, electrodes can be built into the black AlN ceramics for use as electrostatic chucks and plasma generators. Table 1 shows the main characteristics of the black AlN ceramics.

Table 1 Characteristics of black AlN ceramics

	Black AlN (I)	Black AlN (II)	White AlN
Material code	ANS101	ANS102	—
Color	Black	Black	White
Relative density (%)	>99	>99	>99
4-point flexural strength(Mpa)	400	400	350
Vickers hardness	1200	1200	1100
Young's modulus (GPa)	310	310	320
Room temperature 500°C	300	310	—
Poisson's ratio	0.20	0.22	0.24
Thermal expansion coefficient (1/k) x 10 ⁻⁶	4.4	4.7	—
Thermal conductivity(W/m•K)	110	60	—
Room temperature 200°C	70	40	—
Resistivity (Ω•m) x 10 ⁻²	10 ¹⁴	10 ¹⁵	10 ¹⁴
Room temperature 200°C	10 ¹³	10 ¹⁴	10 ¹²
Dielectric strength(kV/m) x 10 ³	13.7	18.2	—
Dielectric constant (1MHz)	9.28	9.57	—
Room temperature 200°C	9.44	9.73	—
tanδ (1MHz)	2 x 10 ⁻⁴	<1 x 10 ⁻⁴	—
Room temperature 200°C	6 x 10 ⁻⁴	4 x 10 ⁻³	—

3. Main Features of Black SiC Ceramics

Black SiC ceramics are available in various resistances

from conducting to insulating. The conducting type is used as heater elements because of its excellent thermal characteristics. The insulating type can be used as high-frequency transmitting material for making high-frequency plasma equipment components. As a dense sintering material, the black SiC ceramics has longer life than the CVD coat SiC material, which suggests better plasma resistance against corrosion than the reactive sintering SiC material. The excellent thermal conductivity also promises an action of easing the thermal distribution due to plasma exposure and irradiation. Table 2 shows the main characteristics of the black SiC ceramics.

Table 2 Characteristics of black SiC ceramics

Grade	Conductivity (SSC)		High resistance		Competition
	S311	S451	SC451	SC452	
Material code	S311	S451	SC451	SC452	—
Color	Black	Black	Black	Black	Green
Crystalline form	β-SiC	α-SiC	α-SiC	α-SiC	—
Density(kg/m ³) x 10 ³	3.19	3.18	3.15	2.90	3.15
Flexural strength (Mpa)	510	480	400	180	700
Vickers hardness	2700	2600	2200	1100	2900
Young's modulus (GPa)	420	410	400	400	400
Thermal expansion coefficient(1/k) x 10 ⁻⁶	4.0	4.0	4.0	4.0	4.0
Thermal conductivity (W/m•K)	220	210	130	74	80
Resistivity(Ω • m) x 10 ⁻²	0.008	10	10 ⁶	10 ¹⁰	—
Dielectric strength(kV/m) x10 ³	—	—	—	5.3	—
Dielectric constant (1MHz)	—	—	—	40	—
tanδ (1MHz)	—	—	—	0.27	—

4. Blackness

Blackness is expressed by lightness L* per CIE1976 within the color space recommended by International Commission on Illumination (CIE). L* is a tristimulus value of a color falling anywhere between total diffused reflection (100) and perfect black (0).

The black ceramics developed by our company have lightness L* of no higher than 25, as shown in Table 3, bringing them extremely close to perfect black.

Table 3 Lightness L* of black ceramics

	Material code	Lightness L*
AlN type	ANS101	17
	ANS102	21
SiC type	S311	7.2
	S451	3.8
	SC451	4.9
	SC452	5.1

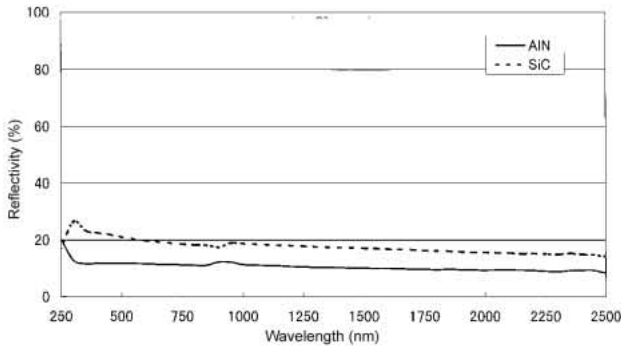


Fig. 1 Reflectivity of black ceramics

Fig. 1 shows the reflectivity measured with an integrating-sphere photometer. Nearly all measurements fell below 20%. Since the light transmission of the 0.3mm thick samples was 1% or lower, the measurements suggest more than 80% of light was absorbed.

5. Concluding Remark

Proprietary AlN- and SiC-based black ceramics were developed by our company. They have unique electric and thermal characteristics that are not found in ordinary SiC or AlN. They give black color with lightness L* value of no higher than 25 while absorbing more than 80% of light ranging from visible to nearly an entire range of near infrared radiation. These suggest excellent thermal efficiency necessary for heating equipment components. As black ceramics, they will also contribute to increasing the positioning accuracy in optical measurements.