Technical Bulletin

TBC – 7% Yttria-Stabilized Zirconia

High quality thermal barrier materials for all desired microstructures

Introduction

Thermal Barrier Coating (TBC) is a generic name for coatings that provide thermal protection in hot environments. With the unique properties of a relatively high fracture toughness and low thermal conductivity, 7% Yttria-stabilized Zirconia (YSZ) is the most widely used and established material for thermal barrier coatings based on the findings of Dr. Stephan Stecura in 1978 at NASA. It is applied in the hot sections of industrial gas turbines and jet engines to protect both combustion and turbine components, allowing the turbine to operate at higher inlet temperatures and thereby increasing efficiency, saving costs, and reducing emissions.

Porosity and thickness are the key variables, beyond the chemistry, which control the thermal conductivity, compliance, and lifetime of the TBC coating. In addition to being applied to create coatings with various structures and a wide range of thicknesses (200–2000 microns), 7% YSZ can be applied in high temperature conditions up to 1150 °C, and possibly even higher.

Powder Properties and Typical Applications

Besides particle size distribution our customers can also choose between different powder morphologies to find the best solution for their specific application. Höganäs' TBC portfolio contains various grades of agglomerated and sintered, fused and crushed, as well as HOSP 7% YSZ powders (Figure 1). Secondly, intentional changes in the purity level optimize the coatings for different turbine uses and types.

Particle Morphologies

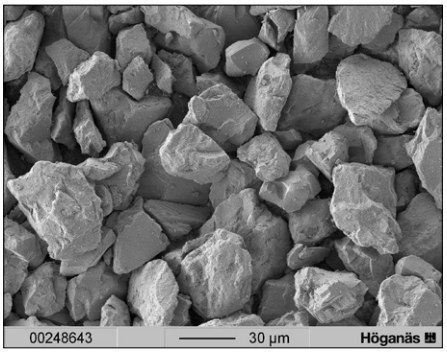
Agglomerated and sintered powders (e.g., **Amperit 827**, Figure 1) are produced from primary particles that are in the range of a few micrometers. The particles are spherical and highly porous. When combined with a wide range of particle size distributions, these powder materials can be used to manufacture coatings with various porosity levels ranging from 6–20% or higher, with the addition of sacrificial polymeric pore formers (Figure 2).

Fused and Crushed powders (**Amperit 825**) are solid and irregular in shape, making them ideal for producing dense TBC structures. These structures exhibit better erosion and cavitation resistance, albeit at the expense of some thermal conductivity. High coating compliance is achieved when cracks form vertically through the coating (Figure 1).

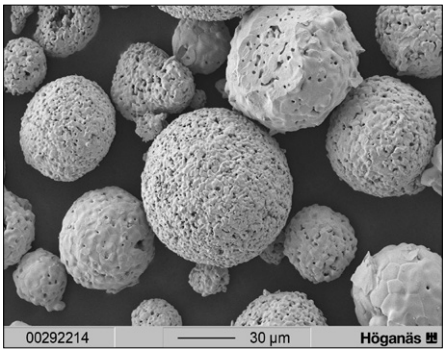
HOSP, or Hollow Spherical Particle powders (**Amperit 831**) are spherical with a smooth surface allowing optimal flowability. The coating porosity ranges from 5 to 15%, depending on spray conditions and particle size distribution, with comparably larger pores. In some cases, this allows further control of thermal conductivity and compliance of the coatings (Figure 1).

The high purity materials **Amperit 816** and **Amperit 831** contain very low amounts of impurities to enhance the sinter resistance of the coatings. The colours yellow and white mentioned in the product overview table refer to the optical appearance of the powder material and the coating.

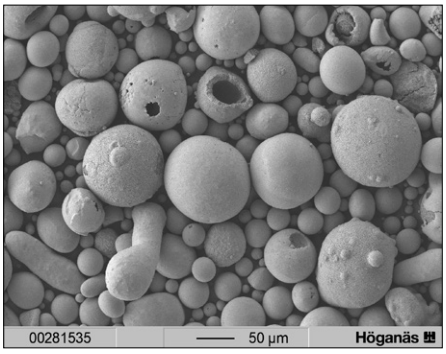
Figure 1: Typical Powder Morphology



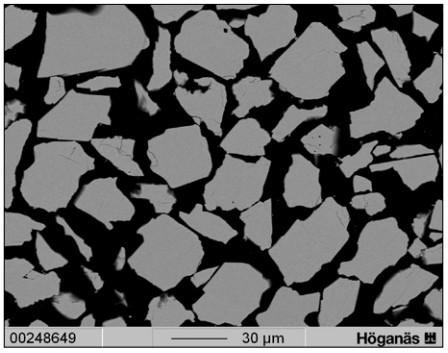
Amperit 825
Fused and Crushed,
blocky and dense particles

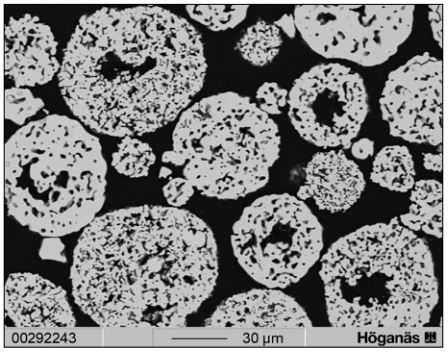


Amperit 827
Agglomerated and Sintered,
spherical particle shape



Amperit 831
Plasma Spherodized/HOSP





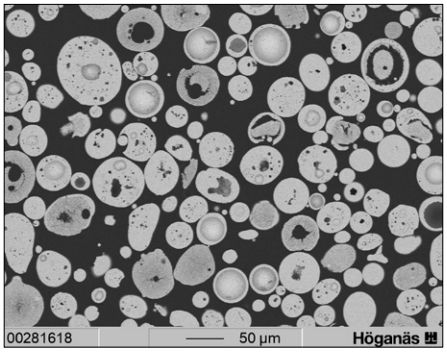
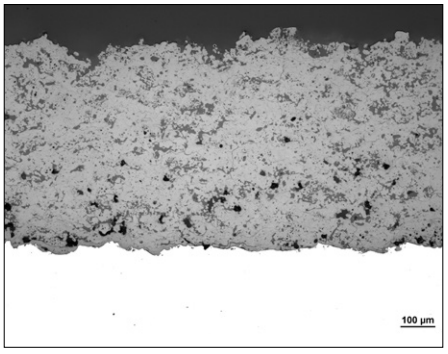
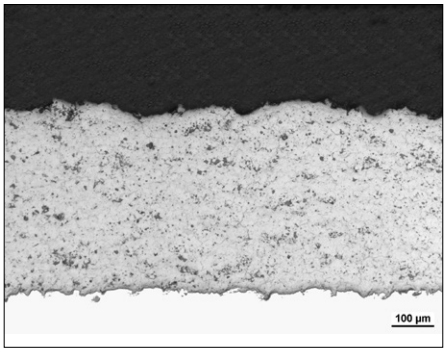


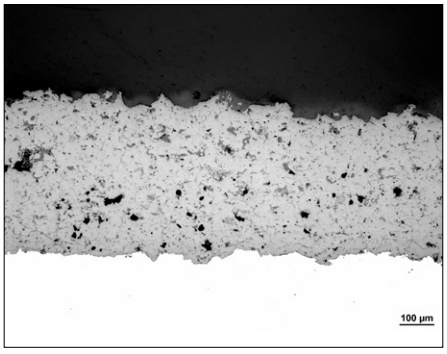
Figure 2: Microstructures (LOM) of Typical Coatings of Amperit 7YSZ materials



Amperit 827.007
porosity level: 6%



Amperit 827.006
porosity level: 15%



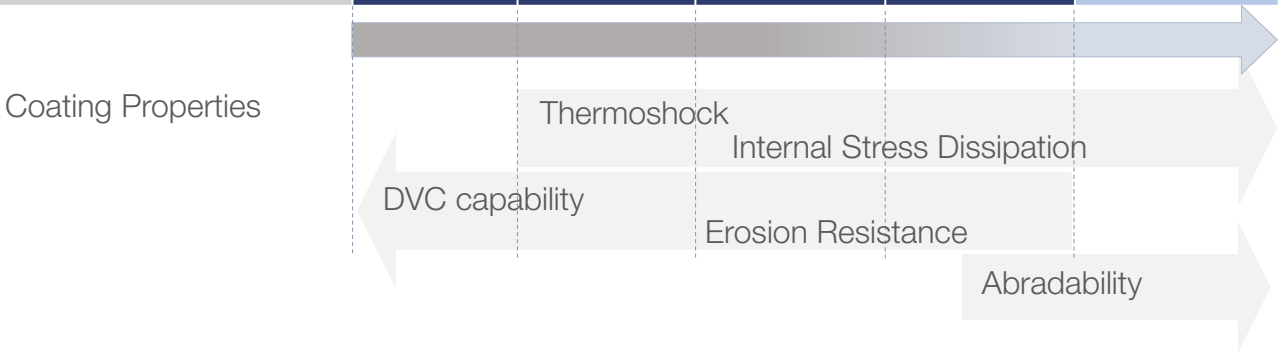
Amperit 831.006
porosity level: 9%

Application Guidelines

- Particle Size of agglomerated & sintered and HOSP materials pre-determine the accessible porosity range.
- High porosity coatings possess lower thermal conductivity and thereby improve the thermal insulation of the component.
- Thermal shock resistance is in general improved with increasing porosity.
- The erosion resistance of the coatings is higher with decreasing porosity. Dense Vertically Cracked (DVC) coatings are used on components that are exposed to high erosive wear. Due to the denser structure of DVCs, thermal conductivity is higher compared to porous structures.
- Fused and crushed materials, such as Amperit 825 type, are most suitable for generating Dense Vertically Cracked (DVC) coatings.
- YSZ spray powders with large porous particles designed for high porosity, such as Amperit 827 type, can be processed using high enthalpy APS conditions to generate dense coatings. However, such dense coatings cannot be produced under normal APS conditions due to insufficient cohesion.

Figure 3: Porosity Range and Coating Properties of Amperit 7YSZYSZ

Porosity range	0 – 6	6 – 10	10 – 15	15 – 25	> 25
Fused/Crushed (A 825)					
Plasma Spherodized (A 831)					
Agglomerated/Sintered (A 827)	45/10µm			125/63µm	With organic placeholders



**Typical data. For more details, please contact us at: www.hoganas.com/contact*

Table 1: Höganäs Standard 7YSZ Portfolio, Customized Materials Available on Request

Amperit	Particle Size (µm)	Composition ZrO_2-Y_2O_3	Powder Morphology	Special Features and Typical Applications
816.006	125/45	93-7	Agglomerated and Sintered	• Colour 'white' • High purity, low in Al_2O_3 and SiO_2, and very low in monoclinic phases for longer cycling lifetime and better thermal shock resistance • Low NORM (Naturally Occurring Radioactive Material) content for better environmental compatibility
825.000	22/5	93-7	Fused and Crushed	• Colour 'white' • Blocky and dense powder morphology • For Dense Vertically Cracked coatings (DVCs)
825.001	45/22			
827.006	125/45	93-7	Agglomerated and Sintered	• Colour 'yellow' • Very good thermal shock resistance and thermal insulating properties • Hot corrosion resistance • Used for thermal barrier coatings in aero engines and stationary gas turbines • Highest achievabe coating porosity (A827.006 recomemmended) • For DVCs (non-columnar) A827.054 recommended • Low Apparent Density
827.007	90/16			
827.054	45/10			
827.083	125/38			
831.006	125/45	93-7	Plasma Spherodized /HOSP	• Colour 'white' • High purity • Hollow and spherical particles • Improved sinter resistance and phase stability for longer cycling lifetime and better thermal shock resistance
831.007	90/16			
831.054	45/10			
831.063	75/45			
831.082	125/10			

OEM Approvals

OEM	Specification	Amperit
GE Power (former Alstom)	HTCT 650564	Amperit 827
		Amperit 831
GE Power	GE A50A557	Amperit 827.772
		Amperit 831.772
	GE A50A558	Amperit 827.773
		Amperit 831.773
	GE A50AG1	Amperit 825.998
		Amperit 825.999
GE Aviation	GE A50TF278 CLASS A	Amperit 827.289
		Amperit 831.289
		Amperit 825.289
	GE Aviation	Amperit 827.290
		Amperit 825.290
		Amperit 831.290
	GE A50TF278 CLASS C	Amperit 831.774
		Amperit 827.774
		Amperit 825.774
	GE A50TF278 CLASS D	Amperit 831.967
GKN	PM 819-20	Amperit 827.853
	PM 819-57	Amperit 827.864
	PM 819-84	Amperit 827.873
Honeywell	EMS 57750	Amperit 827.943
MHI/MHPS	GXX-0025	Amperit 827.883
MTU	MTS 1198	Amperit 825.218
	MTS 1342	Amperit 825.242
	MTS 1352	Amperit 827.238
PWA	PWA 1375	Amperit 827.423
	PWA 36375	Amperit 828.405
Rolls Royce	RRMS 40042	Amperit 825.381
	RRMS 40000 (former MSRR 9707/46)	Amperit831.359
SAFRAN/Helicopters	LA657 PQ0	Amperit 831.733
SAFRAN	DMR 33-098	Amperit 831.733
Siemens Sweden	MAT 870011	Amperit 827
Siemens	DPTLV-00000912	Amperit 825
	DPTLV-70000633 00	Amperit 816
	DGTLV-504009001	Amperit 827
	DGTLV-504009001	Amperit 831

Related Products

- Amperit 808 is a YSZ-based material with lower thermal conductivity compared to 7YSZ materials. It is designed for applications at very high service temperatures.
- Materials with high yttria content, containing more than 7% weight of Y_2O_3, are used to enhance the sinter resistance of the coatings. However, this improvement comes at the expense of erosion resistance. Amperit 809 (40YSZ), Amperit 813 (48YSZ), Amperit 814 (55YSZ), Amperit 815 (55YSZ), Amperit 817 (20YSZ), Amperit 818 (14YSZ), Amperit 819 (38YSZ), and Amperit 828 (12YSZ) are in this category.
- Amperit 835 is a Gd $2Zr_2O_7$ material. It is mainly used as a CMAS-resistant top layer in combination with YSZ coatings.
- Amperit 845 and Amperit 846 are ytterbia-stabilized zirconium oxides.

Handling and Safety Recommendations

- Store in dry location.
- Open containers should be stored in a drying oven to prevent moisture pickup.
- Tumble powder prior to use to prevent segregation.
- For information related to health, safety and the environment, please refer to the respective Safety Data Sheets.

More info: scan or click the QR Code