Technical Bulletin

Low-K & Novel Chemistry Thermal Barrier Coatings

Thermal barrier materials with lower thermal conductivity, higher fracture toughness, or a combination of both

Introduction

Thermal Barrier Coatings (TBCs) are designed to provide thermal protection in high temperature environments. The most widely used material for TBCs is 7% Yttria-stabilized Zirconia (7YSZ), due to its relatively high fracture toughness and low thermal conductivity. TBCs are essential in industrial gas turbines and jet engines, where they protect combustion and turbine components, allowing turbines to operate at higher inlet temperatures. This, in turn, boosts efficiency, reduces costs, and lowers emissions. However, the push for further increases in efficiency and reductions in NOx and CO2 emissions has led to operating temperatures that exceed the capability of 7YSZ alone.

7YSZ is partially stabilized, meaning it can undergo a phase change [figure 1] under certain conditions or at temperatures above approximately 1200 °C. This phase change involves a volumetric expansion, which reduces the coating's lifespan. Fully stabilized Zirconates can withstand higher temperatures without undergoing this detrimental phase change, making them suitable for more demanding applications. However, fully stabilized Zirconates may suffer from lower fracture toughness and higher thermal conductivity. It's important to apply oxide materials or rare-earth-stabilized Zirconates that offer lower thermal conductivity. This allows for either thinner coatings that provide the same thermal protection or greater protection at equivalent thicknesses.

Powder Properties and Typical Applications

Low-k materials (with lower thermal conductivity than 7YSZ) or novel chemistry materials are typically applied in the most aggressive high-temperature jet engine or industrial gas turbine applications. Intentional adjustments in Yttria or other rare earth element content control whether the Zirconate materials are partially or fully stabilized, thus managing their stability to phase changes during high-temperature exposure. These changes can also affect sintering resistance, fracture toughness, and thermal conductivity. Many low-k materials are preferred to be applied as a bilayer structure using 7YSZ as the underlayer.

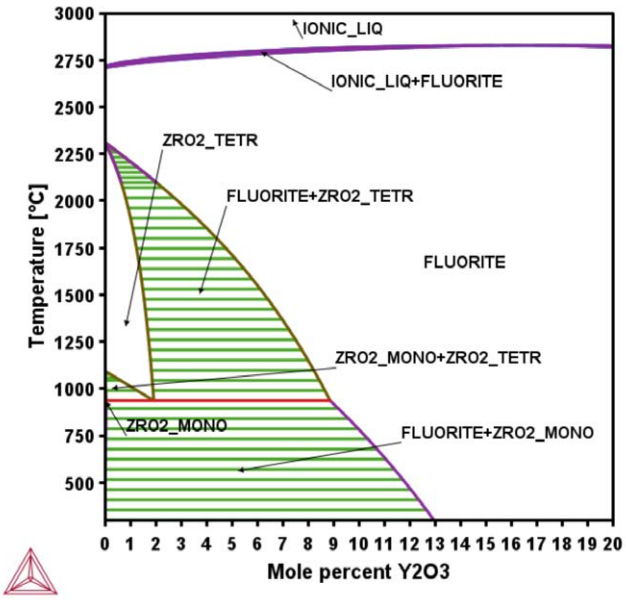

Figure 1: Phase diagram of YSZ

Amperit 808 is an Agglomerated and Sintered, multi-rare earth, fully stabilized Zirconate [figure 3] with a higher temperature capability than 7YSZ. It exhibits 30% lower thermal conductivity compared to 7YSZ [figure 2] and is commonly applied as a bilayer coating, with 7YSZ or another YSZ material as the underlayer.

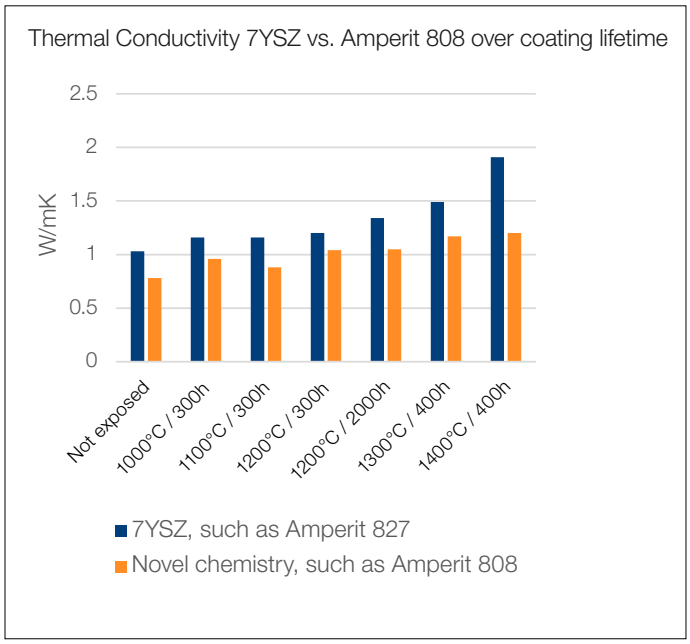

Figure 2. Thermal conductivity of different TBC chemistries after exposure to high temperatures.

Amperit 828 is a 12% Yttria-stabilized Zirconia, while **Amperit 817** is a fully stabilized Zirconate with 20% Yttria (20YSZ). The Yttria content offers a balance between higher temperature capability and minimal change in fracture toughness and thermal conductivity. Some studies have shown that 20YSZ can be used as a standalone coating like 7YSZ, but it can also be part of a multilayer system.

Other high-Yttria-stabilized Zirconate materials (up to and above 50%) can be produced, allowing for tailored properties in fracture toughness and thermal conductivity.

Amperit 835 is an Agglomerated and Sintered Gadolinium Zirconate powder that can be applied either as a bilayer or as part of a multilayer structure. It has lower thermal conductivity than 7YSZ but also lower fracture toughness. It is particularly effective in mitigating the effects of CMAS (Calcium-Magnesium-Aluminosilicate) deposits.

Höganäs' TBC portfolio contains various grades of Agglomerated and Sintered, Fused and Crushed, and HOSP powders. Using our state-of-the-art Integrated Computational Materials Engineering (ICME) tool and oxide database, we have developed TBC powders with different chemistries, particle size distributions, and powder morphologies. Customized materials are also available upon request.

Particle Morphologies

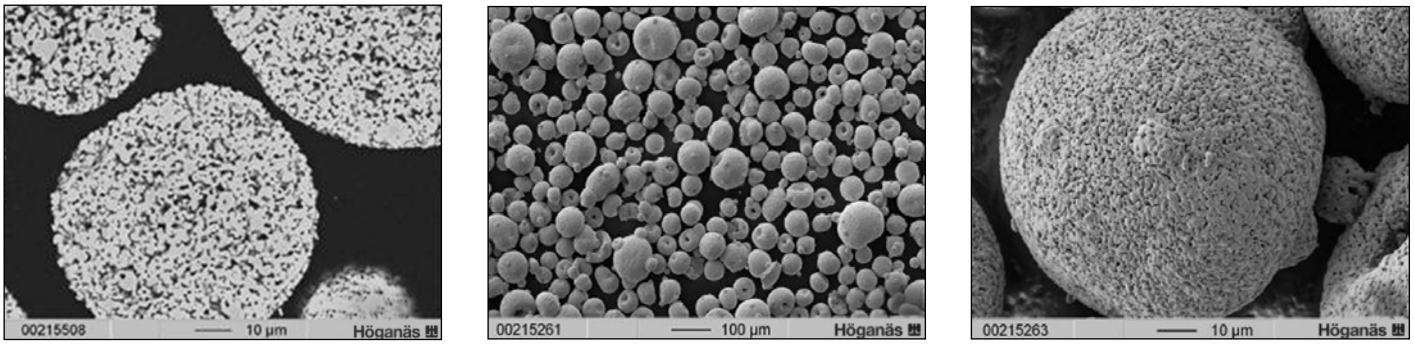

Figure 3: SEM, powder morphology of Amperit 808.006

Höganäs' Low-K and Noval Chemistry Portfolio, Customized Materials Available

Composition	Amperit	Particle Size (µm)	Powder Morphology	Special Features and Typical Applications
12YSZ	Amperit 828	Custom PSD	Agglomerated and Sintered	• OEM approved
14YSZ	Proprietary	Custom PSD others on request	Agglomerated and Sintered	• OEM approved
			Fused and Crushed	• In the process of OEM approval • Blocky and dense powder morphology • For Dense Vertically Cracked (DVC) coatings
20YSZ	Amperit 817	Custom PSD	Plasma Spherodized/HOSP	• OEM approved • For Dense Vertically Cracked (DVC) coatings
38YSZ	Amperit 819	Custom PSD	Agglomerated and Sintered	• OEM approved • For porous Thermal Barrier Coatings
48YSZ	Proprietary	Custom PSD	Fused and Crushed	• OEM approved • Blocky and dense powder morphology
			Agglomerated and Sintered	• OEM approved • For porous Thermal Barrier Coatings
55YSZ	Proprietary	Custom PSD others on request	Fused and Crushed	• OEM approved • Blocky and dense powder morphology
			Agglomerated and Sintered	• OEM approved • For porous Thermal Barrier Coatings
GdZrO	Amperit 808.006	125/45 others on request	Agglomerated and Sintered	• Höganäs' Advanced low-K TBC solution 10wt% Gd 10wt% Yb 2wt% Y ZrO – balance • For porous Thermal Barrier Coatings • Improved sintering resistance and phase stability for longer cycling lifetime and better thermal shock resistance
	Amperit 835.006	125/45		• Ratio: 59wt% Gd ZrO – balance • For porous Thermal Barrier Coatings
	Amperit 835	Custom PSD		• OEM approved
YbSZ	Several proprietary products	Custom PSD others on request	Agglomerated and Sintered	• OEM approved 10–40wt% Yb ZrO – balance

OEM Approvals

Höganäs' low-K and novel TBC chemistries are qualified and approved by many OEMs including:

Industrial Gas Turbine OEMs:

- Ansaldo Energia
- General Electric Vernova
- Siemens Energy
- Others

Aviation Engine OEMs:

- General Electric Aviation
- Rolls-Royce
- Pratt & Whitney

Approval list is available upon request

Related Products

- A range of partially stabilized 7YSZ powders is available in different morphologies and purities. These powders come in various sieve sizes to help achieve the desired coating structure with optimal deposit efficiency.

Amperit 816 is high purity, Agglomerated and Sintered powder.

Amperit 825 is a Fused and Crushed material perfect for denser structures.

Amperit 827 is a yellow Agglomerated and Sintered option.

Amperit 831 is a white Agglomerated and Sintered powder.

EBC powders with different chemistries, such as YbDS, YbMS, and others, are available upon special request.

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