



# Maximizing Reactor Performance: The Benefits and Challenges of Zirconia Refractories in Carbon Black Production

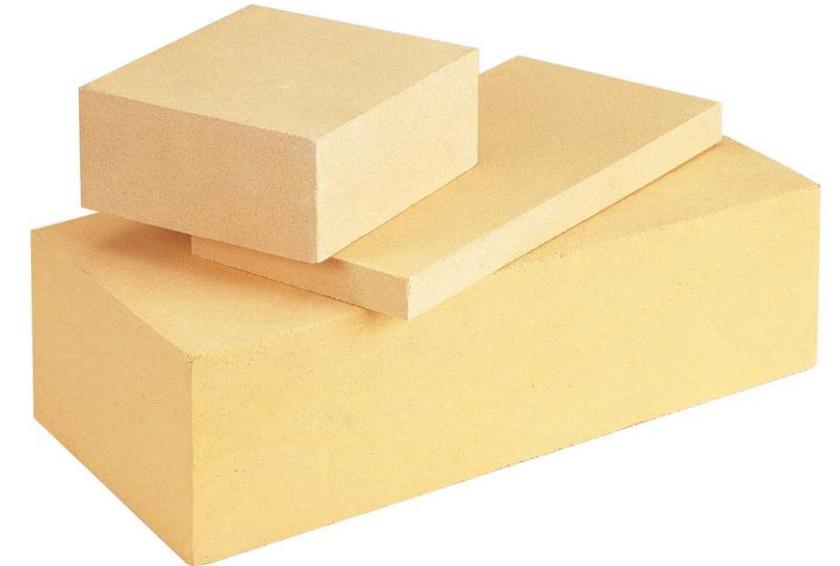
*Carbon Black World 2025*  
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Tayler Perrey  
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# Overview



- Introductions
- What is zirconia?
- Zirconia in carbon black reactors
- Advantages of zirconia
- Zirconia refractory failure modes
- Zircoa in carbon black industry



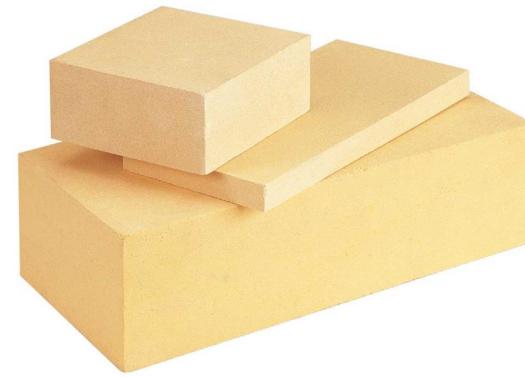
# Introductions



## Tayler Perrey

M.S. Ceramic Engineering  
Application and Development Engineer

- SME – Carbon Black
- SME – Failure Analysis
- New composition development
- 14 years in ceramic industry
  - 6+ years with Zircoa



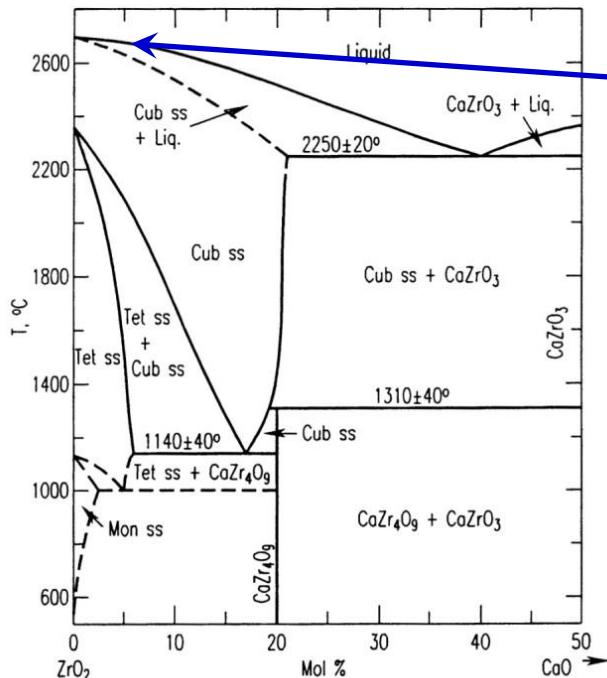
## Zircoa

- Founded in 1952
- Headquarters based in Solon, Ohio (USA)
- Zircoa GmbH, Germany
  - Sales office responsible for EMEA+India
- Specializes in zirconia production for a variety of applications/industries
- ISO 9001:2015 with design

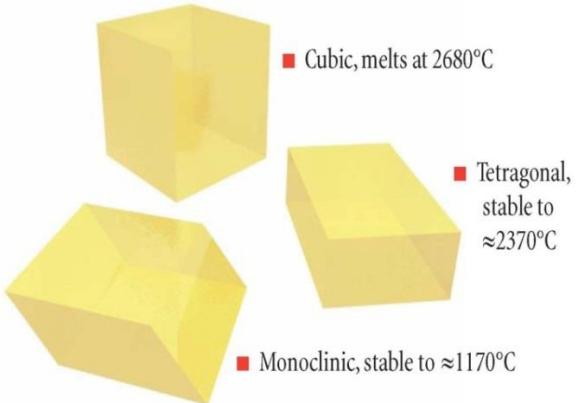
# What is Zirconia ( $ZrO_2$ )?



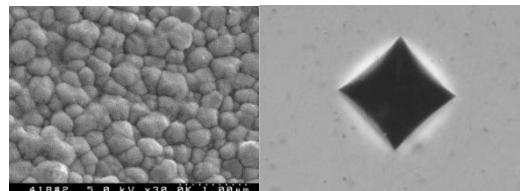
*Unique ceramic material that can be tailored to meet extreme conditions required to enable and/or improve industrial process.*



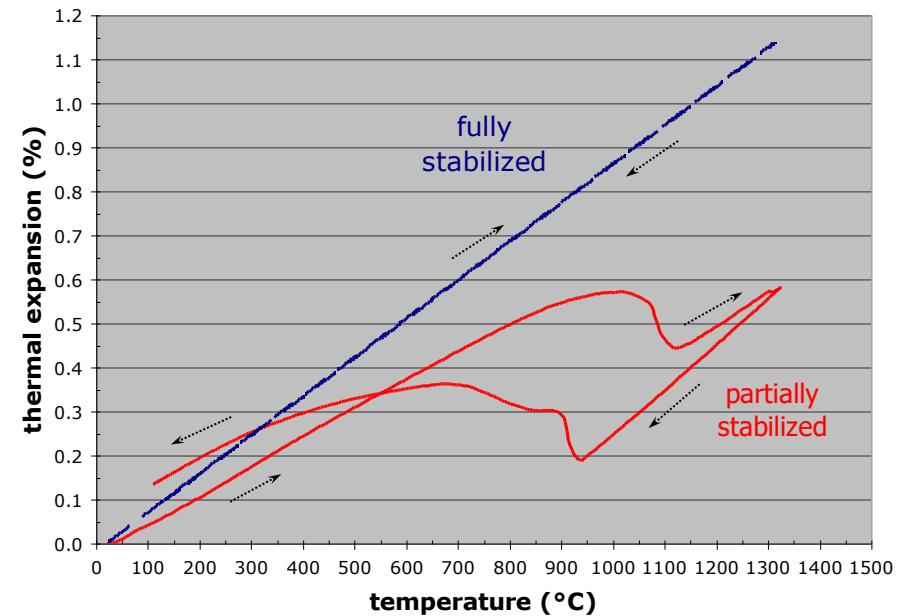
## Very High-Temp Capability



## Low Thermal Conductivity Thermal Insulation



## Thermal Shock Resistance



Texture  
Toughness  
Hardness  
Mechanical Strength

# Zirconia in Carbon Black Reactors

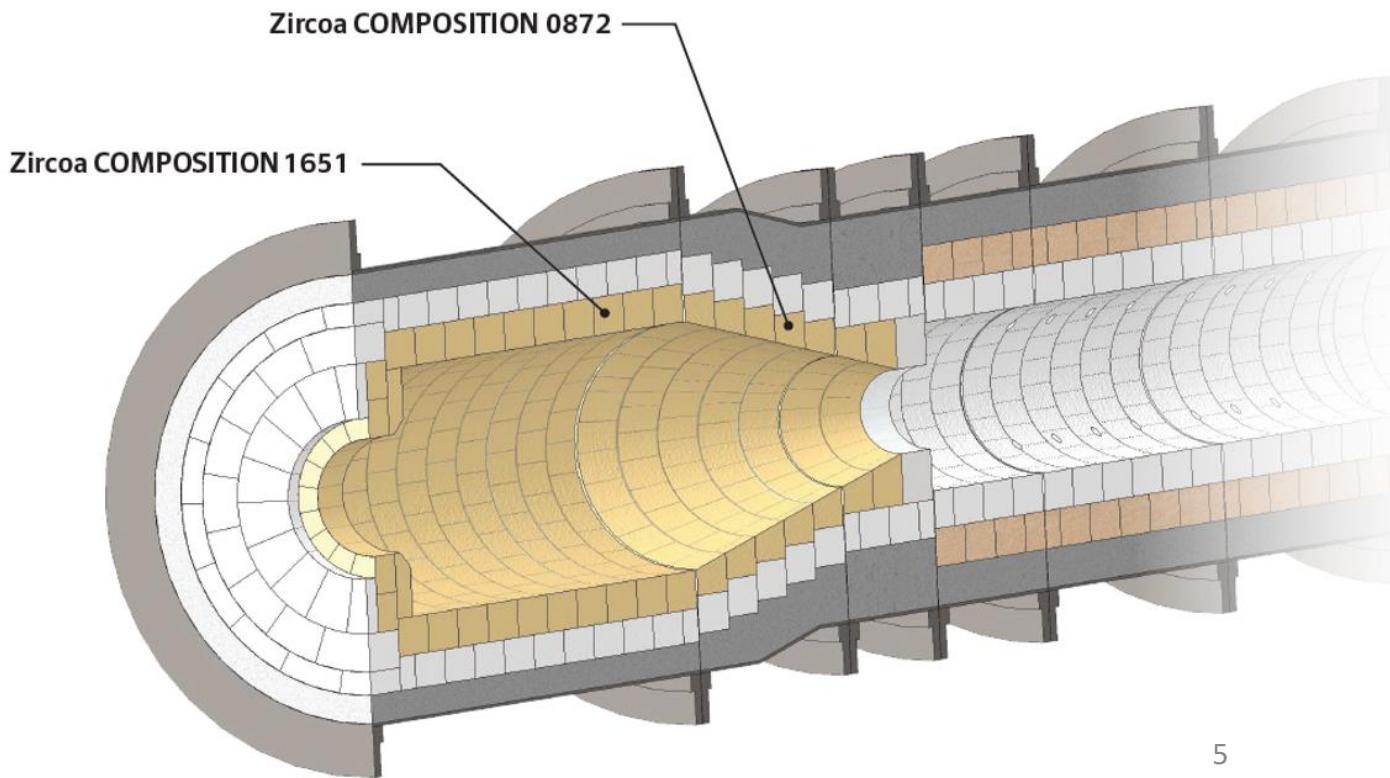


- Unique material properties of zirconia -> most demanding applications
- Hot face lining in combustion chamber

## ZIRCOA PRODUCT OPTIONS

**Zircoa COMPOSITION 1651** — Zircoa's premium calcia-stabilized pressed shape. Stable at temperatures greater than 3800°F (2100°C). With proven refractoriness for extreme temperatures, and 2 times the insulating value of alumina, Zircoa 1651 will take the heat.

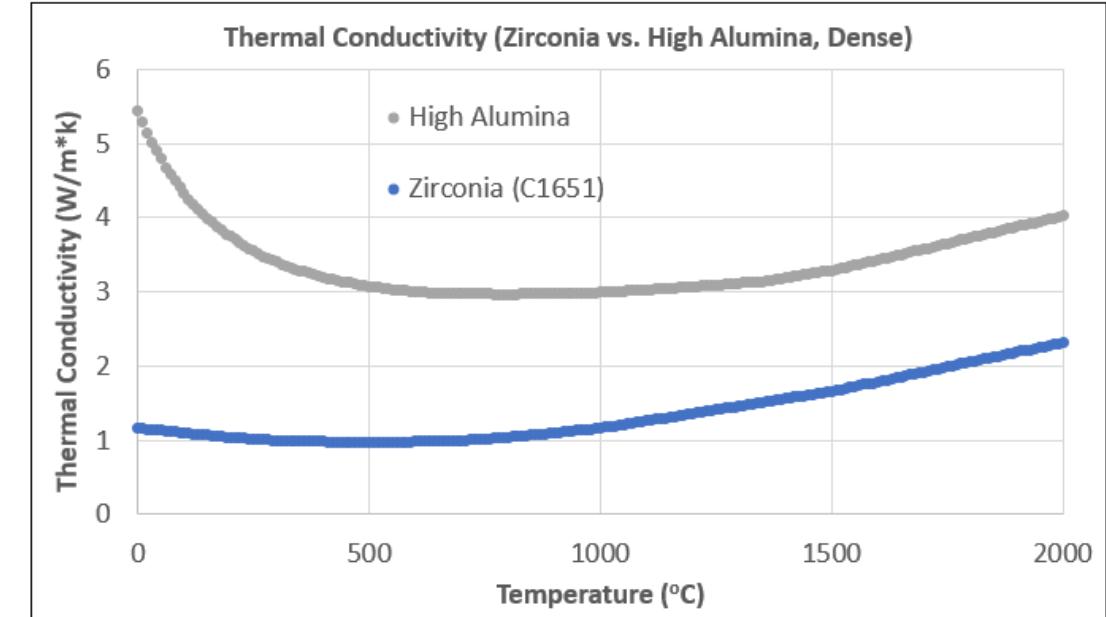
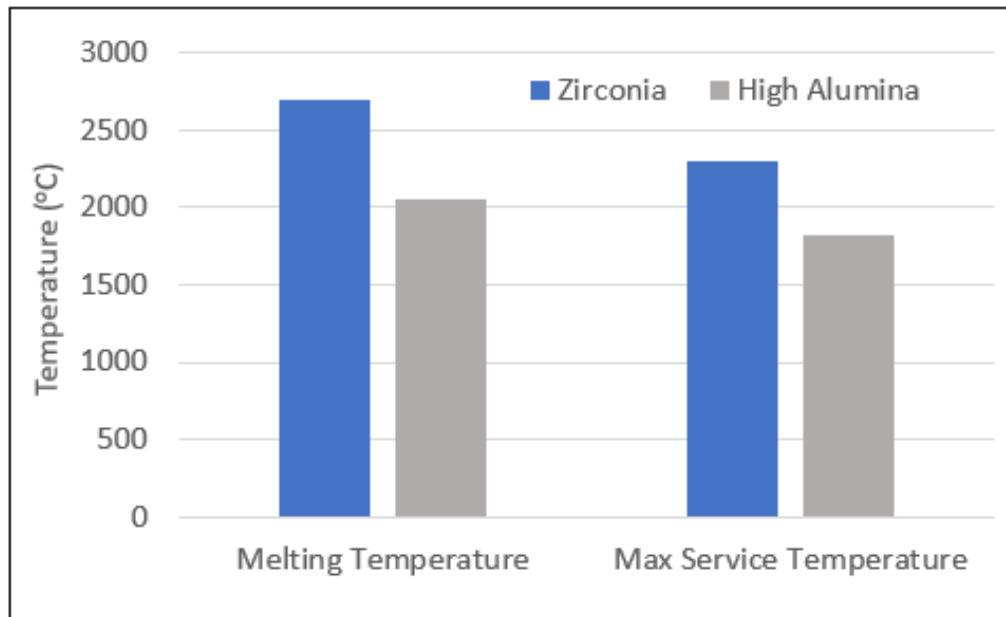
**Zircoa COMPOSITION 0872** — Zircoa's calcia-stabilized, pre-fired, custom shapes formed with performance characteristics of Composition 1651. Frequently used in applications requiring complex geometry where brick installation can be time consuming.



# Advantages of Zirconia in Carbon Black Reactors



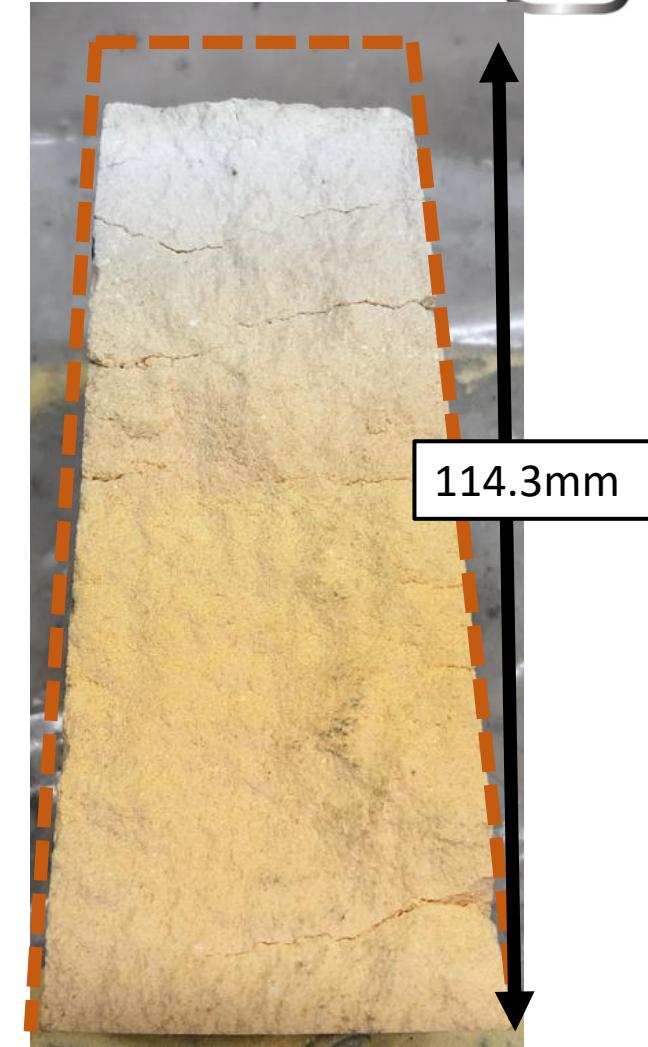
- Enables higher sustained reactor temperature ( $>2150^{\circ}\text{C}$ )
  - Higher reactor efficiency -> increased product yields
- $>40\%$  Lower thermal conductivity than high alumina at  $2000^{\circ}\text{C}$ 
  - Retain more heat in the combustion chamber



# Advantages of Zirconia in Carbon Black Reactors



- Erosion resistant:
  - Minimal loss of material over lining life
- Chemical inertness:
  - Reduced impact from aggressive process gasses
  - Potentially unlocking new products/grades
- Structural stability:
  - Maintains strength integrity at processing temperatures

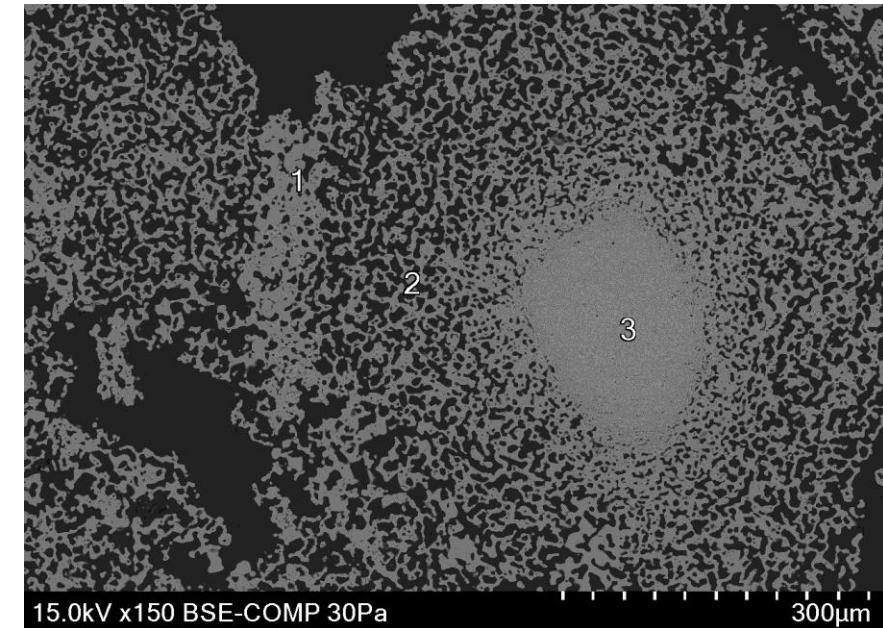


Cross-section of a zirconia brick (C1651)  
after 2 years in carbon black reactor

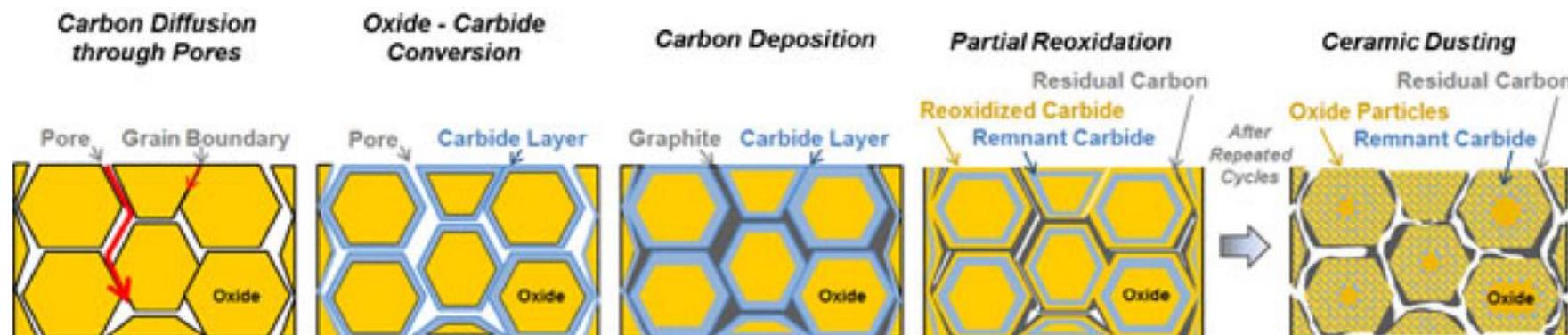
# Zirconia Refractory Failure Modes



- Zirconia refractories do have limitations
- Unique microstructure observed after a failed customer trial
- Numerous cycles between oxidizing and reducing atmospheres, in carbon rich environment, at process temperature cause zirconia degradation



Degradation of fused  $\text{ZrO}_2$  Grain



“Ceramic dusting” degradation mechanism (Chun, et al) [2]

# Zirconia Refractory Failure Modes



## Alkali attack

- Zirconia can degrade when in direct contact with alkali solution (potassium carbonate) at process temperatures
- Injector alignment and placement is critical to maximize lining life

## Thermal shock

- As with all ceramics, sensitive to rapid and excessive temperature changes
- Avoiding hard shutdowns extends lining life



Early failure of zirconia lining due to injector mis-alignment

# Zircoa in Carbon Black Industry



- 15+ years experience in carbon black industry
- Designed hot face linings for multiple reactor designs and customers
- Zircoa lining achieved 4.5 years life in carbon black reactor
- Continuous improvement through Application Engineering and partnerships
  - Thermal modeling software
  - Postmortem Analysis

*Zircoa's Mission: **Innovate** and **manufacture** specialty **zirconia** for the industry*

*“Delivering what Matters”*



# Thank You for your attention!



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