SOFC IC Workshop
Bulk Alloy Breakout Team

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Bulk Alloys - Technology Status

- Basic categories of alloys
  - Fe-base (430, Crofer 22 APU)
    - Chromia forming
    - Ferritic or austenitic
  - Ni-base
    - Conventional chromia forming alloys
    - Low CTE Ni-base alloys
  - Cr-base (Ducralloy)
  - Other exotics (Co, Ti, or precious metal base chemistries)
- Constitutive relations (predictive equations)
- Designed scale chemistries
  - Single scale
  - Dual scale (Mn rich chromia over chromia layer)
  - Alternative scale chemistries

Bulk Alloys - Pros✓/Cons✗

- Fe base ferritic
  - ✓ Low cost, CTE match, ASR
  - ✗ Creep resistance, lifetime, chromia volatility
- Fe base austenitic
  - ✓ ASR, mechanical properties, ease of fabrication
  - ✗ CTE, chromia volatility, carburizing resistance, cost
- Conventional Ni-base alloys
  - ✓ Reduced dual atmosphere issues, ASR, lifetime, mechanical properties
  - ✗ Cost, CTE, sulfur interactions, Cr volatility, phase stability
- Low CTE Ni-base alloys
  - ✓ CTE decrease may be sufficient
  - ✗ Lifetime, ASR, cost

Bulk Alloys - Pros✓/Cons✗

- Cr base alloys
  - ✓ CTE match, ASR
  - ✗ Fabrication, cost, chromia volatility
- Other exotic alloy systems (Co, Ti, Precious metals)
  - ✗ Will require coatings or other enabling technology
- Constitutive Relationships
  - ✓ Provide understanding of property relationships
  - ✗ Extrapolation dangerous

Technological Needs

- ASR (<10 mOhm starting, 0.1% degredation per 1000 hours)
- CTE
- Low Cr Volatility (cell poisoning, environmental regulations for emission)
- Mechanical properties
  - Thermal stability
  - Mechanical integrity
- Chemical Compatibility w/ adjacent components
- Chemical Stability w/ environment
- Thermal cycling stability (Scheduled and unscheduled)
- Fabricability
- Cost
- From Coatings Breakout Group
  - Continuous variation in properties from surface to bulk, compatible substrate and/or oxides
- From Interface Breakout Group

Approach

Continue to develop and/or engineer Fe and Ni base alloy systems such as:

- Conventional Ferritic
  - Commercially available 18-26 Cr Ferritic (430 to E-BRITE)
- Optimized Ferritic
  - SOFC specific alloys: rare earth, titanium, Mn (Crofer22APU; ZMG232; new Plansee)
- Conventional Austenitic
  - Commercially available (3xx series; 2025; HR120;etc)
- Optimized Austenitic
  - Low Si; optimized rare earth (no examples)
- Chromium base Alloys
  - ODS or rare earth modified (Plansee, Russian alloys)
- Conventional Ni base alloys
  - Commercially available (Haynes 230)
- Optimized Ni base alloys
  - Mn modified Haynes 230
  - Low CTE Ni base alloys (242, 42)

Other Potential Approaches for Long Range Research

- Ni oxide scales
  - Modified Cr-free NiO forming system (doped Ni)
- Co oxide scales
  - Modified Cr-free Co-O forming system (doped Co)
- Ti oxide scales
  - Modified Cr-free Ti-O forming system (doped Ti)
- Multi-cation oxide scales
  - *In-situ* perovskite or spinel formation
  - Optimized substrate for coating
- Precious metals
  - Platinum or gold
- Dispersion modified surfaces*
  - Conducting vias through oxide
- Copper*
  - Anode cladding

Bulk Alloys - Summary

- Status
  - Current technology focuses on chromia forming alloys
- Review of Technological Needs
- Approach
  - Continue to develop/engineer Fe-base and Ni-base alloy systems for bulk interconnect materials
  - Show proof of concept for alternate approaches