Argonne Activity Overview

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Nothing Is Permanent But Change

Completed: -Cathode Development

Continuing: -Exploration of alloy composition for bipolar plates

New: -Investigate Cr Poisoning

-Develop diesel reforming catalysts

-Review detection methods for defects

Technical Issues

Bipolar Plate Materials

- Stainless steels are protected by a Cr_2O_3 layer, but in flowing moist air the Cr_2O_3 becomes volatile

$$Cr_2O_3 + {}^{3}/{}_{2}O_2 + 2H_2O \longrightarrow 2\,CrO_2(OH)_2$$

- Composition of steels cannot be easily changed

Technical Issues (2)

Chromium Volatization

- Poisoning of the cathode has been observed to be more rapid at 700ºC than 800ºC.

Diesel Reforming

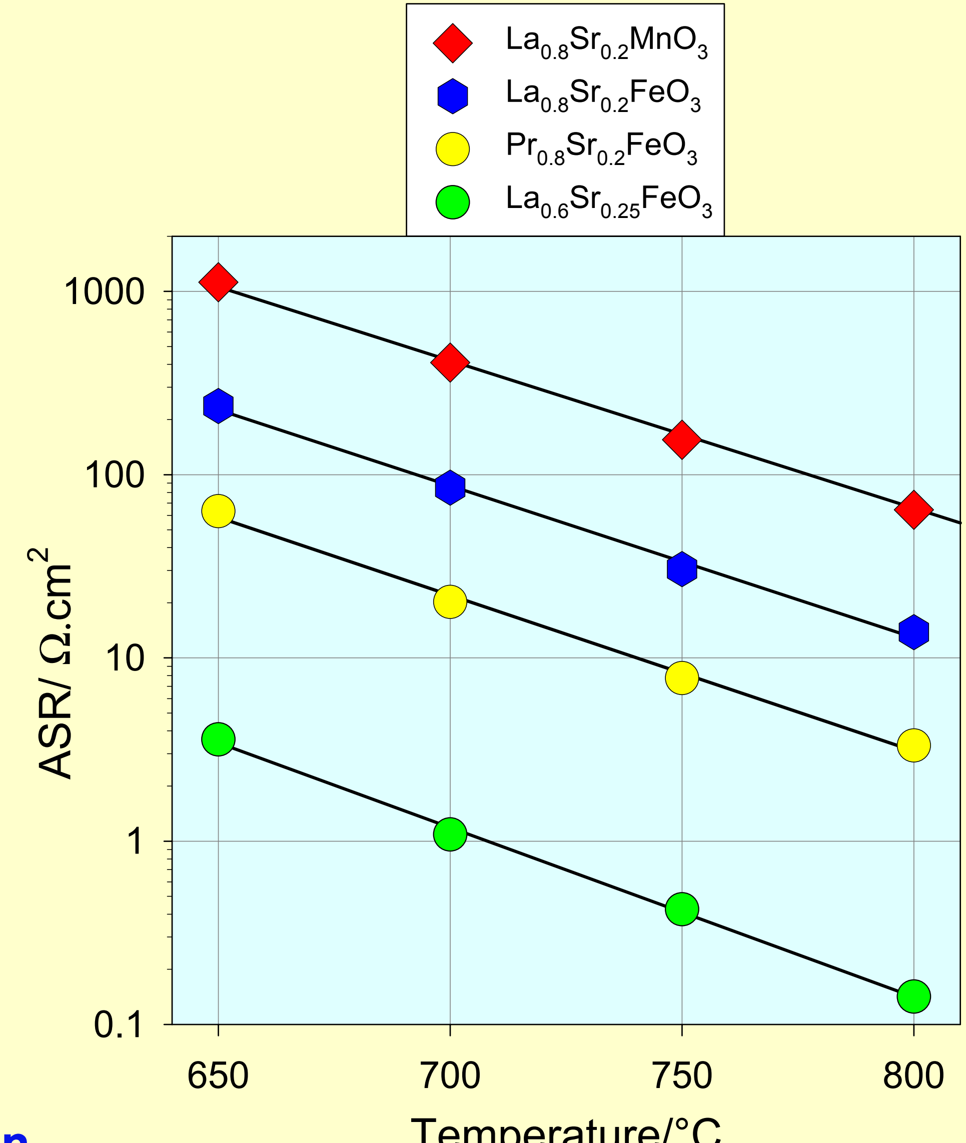
- Catalysts are poisoned by sulfur and loose activity
- Avoiding carbon formation

Results: Cathodes

LSF better than LSM

PrSF shows further improvement over LSM

La-deficient $La_{0.6}Sr_{0.25}FeO_3$ displays significant improvement over stoichiometric LSF

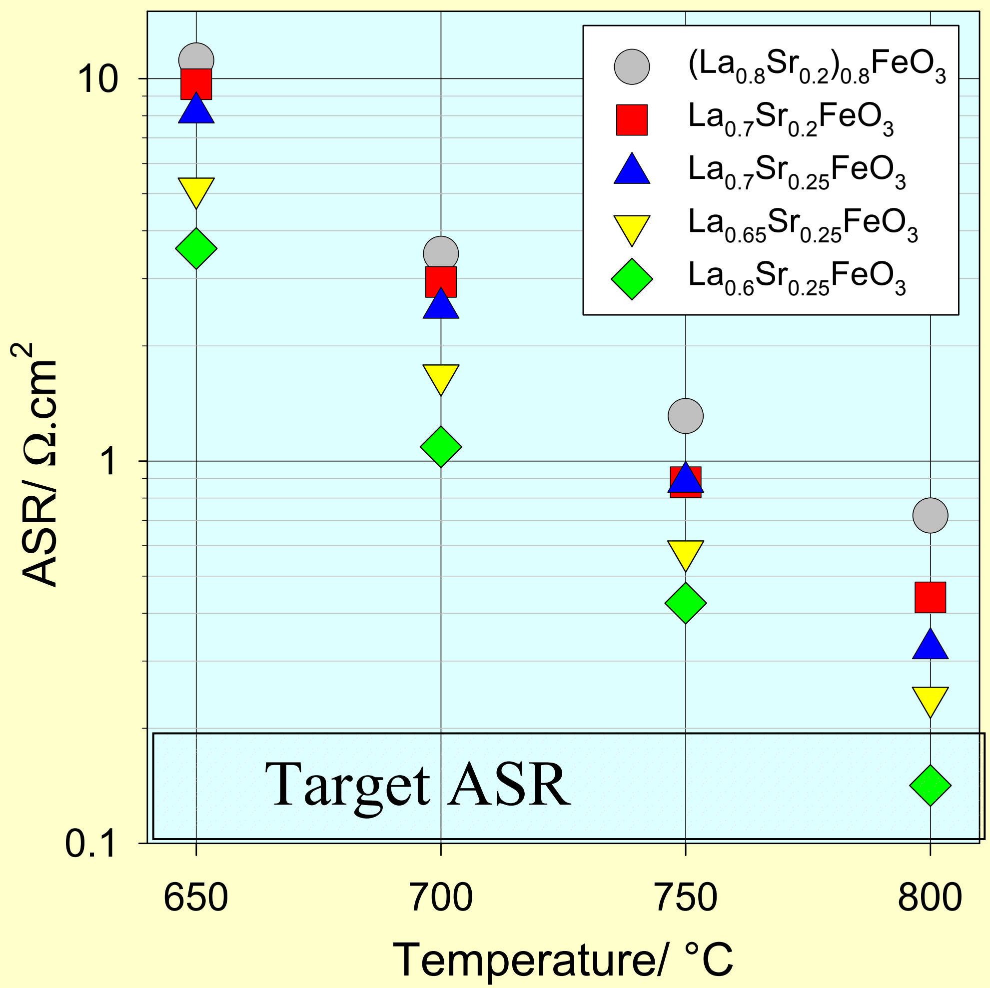


La-Deficient Ferrite Cathodes

La- and total A-site-deficiency between 5-20 mol% achieve significantly lower ASR values compared to stoichiometric LSF

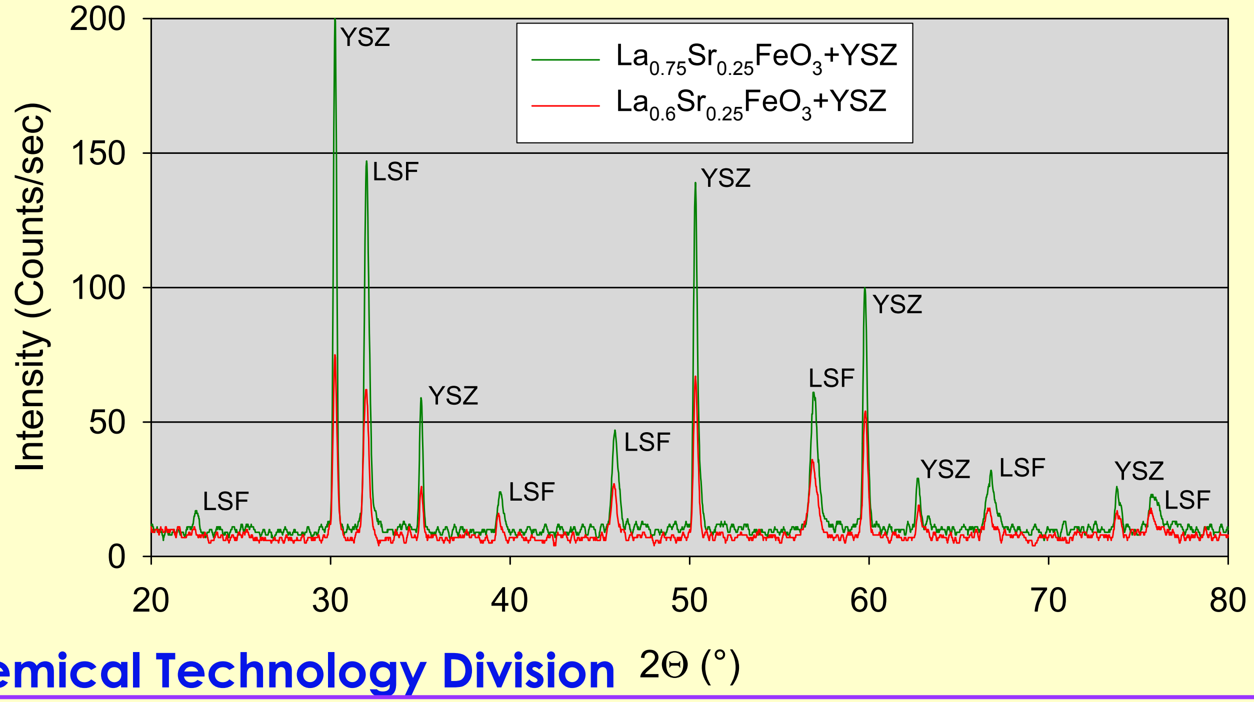
Increasing Sr-doping in La-deficient LSF further improves ASR

Target ASR obtained at 800°C using $La_{0.6}Sr_{0.25}FeO_3$



Stability of Argonne LSF Cathodes

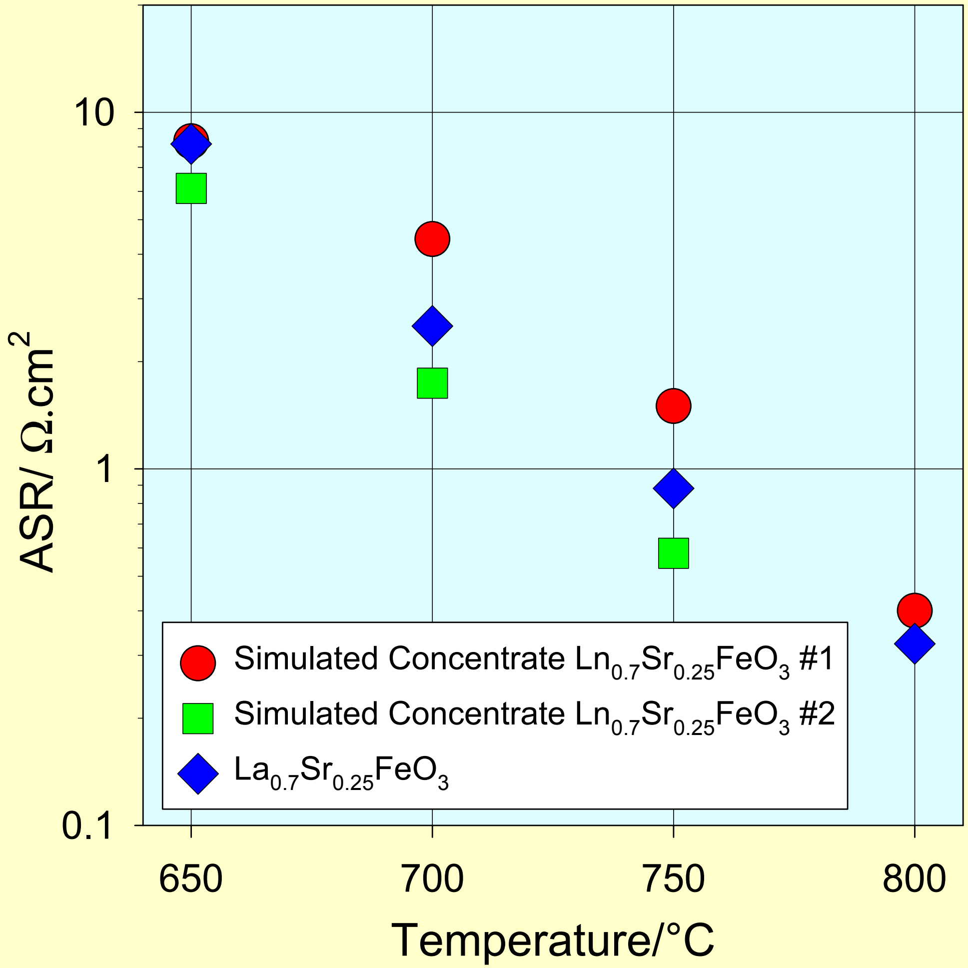
No reactivity observed between stoichiometric or non-stoichiometric LSF and YSZ using XRD: *Reactivity experiment performed at 1200°C for 1 week on compacted powders*



Lower Cost Ferrite Cathodes

Switching La for other rare earths has shown further improvements

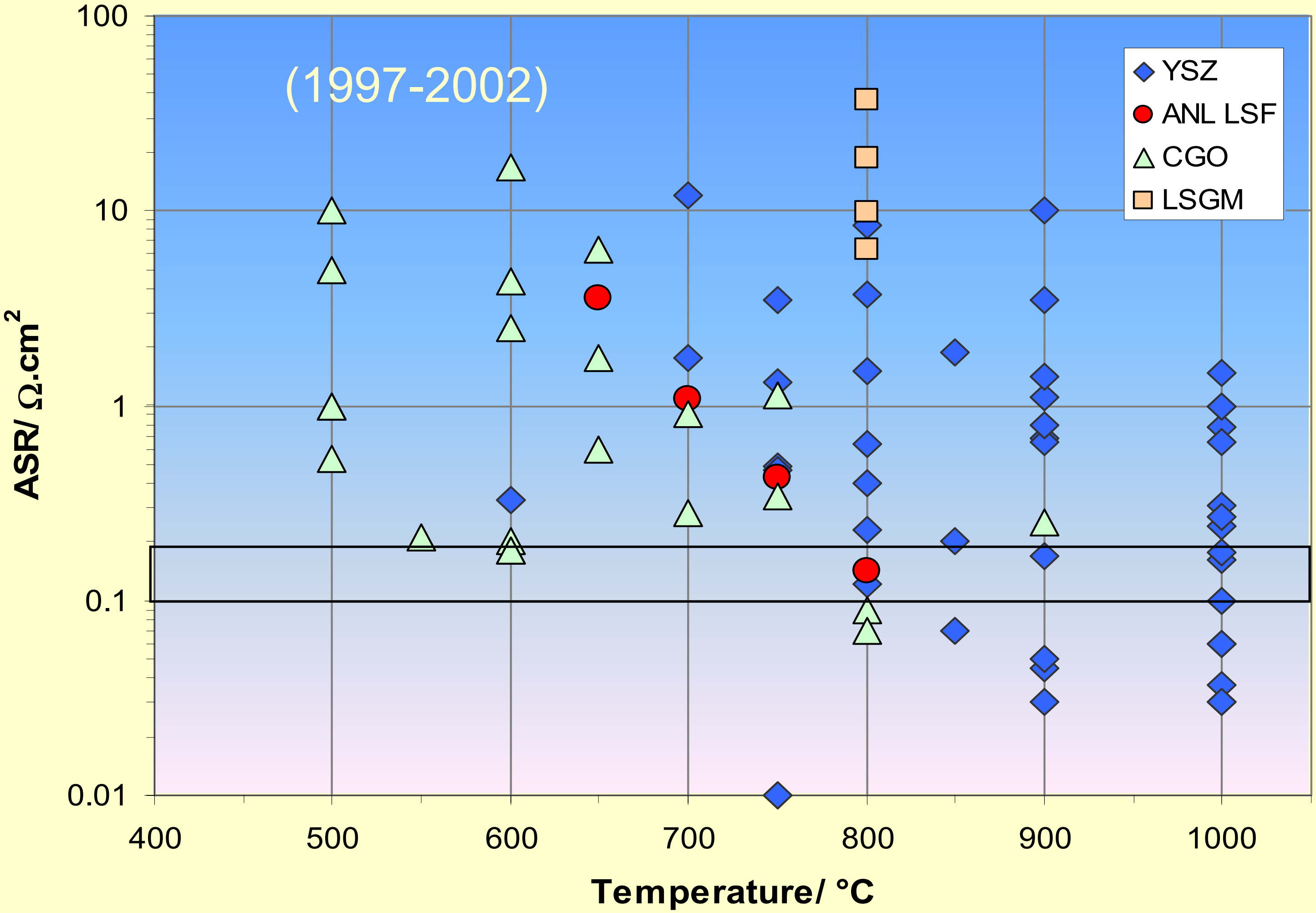
Replacing pure lanthanum with a cheaper but less pure lanthanum concentrate resulted in similar ASR values



#1 – La(68.7%), Ce(3.4%), Pr(4.7%), Nd(23.2%)

#2 - La(63.5%), Ce(6.35%), Pr(8.73%), Nd(22.5%)

Cathode ASR Comparison



Benefits of Argonne LSF Cathodes

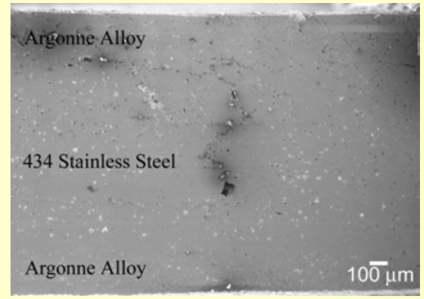
Iron is cheapest of transition metals normally considered on the B-site of the perovskite

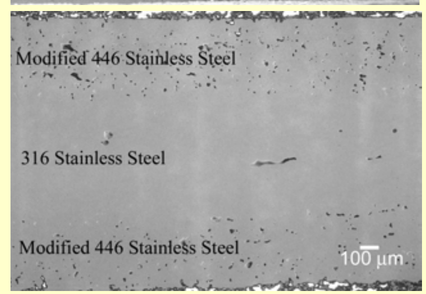
Slurry coated cathodes are simple and cheap

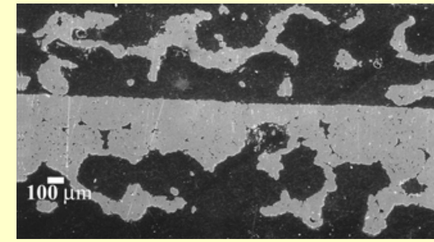
NO additional processing steps are used to obtain acceptable performance, e.g. interlayers, impregnation, graded structures

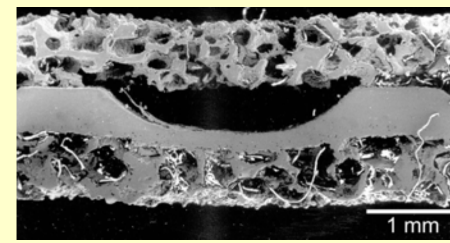
Argonne's Approach

Powder metallurgy approach offers the ability to quickly make unique alloy compositions, a wide range of structures and compositionally graded materials allowing for different alloys under both environments.





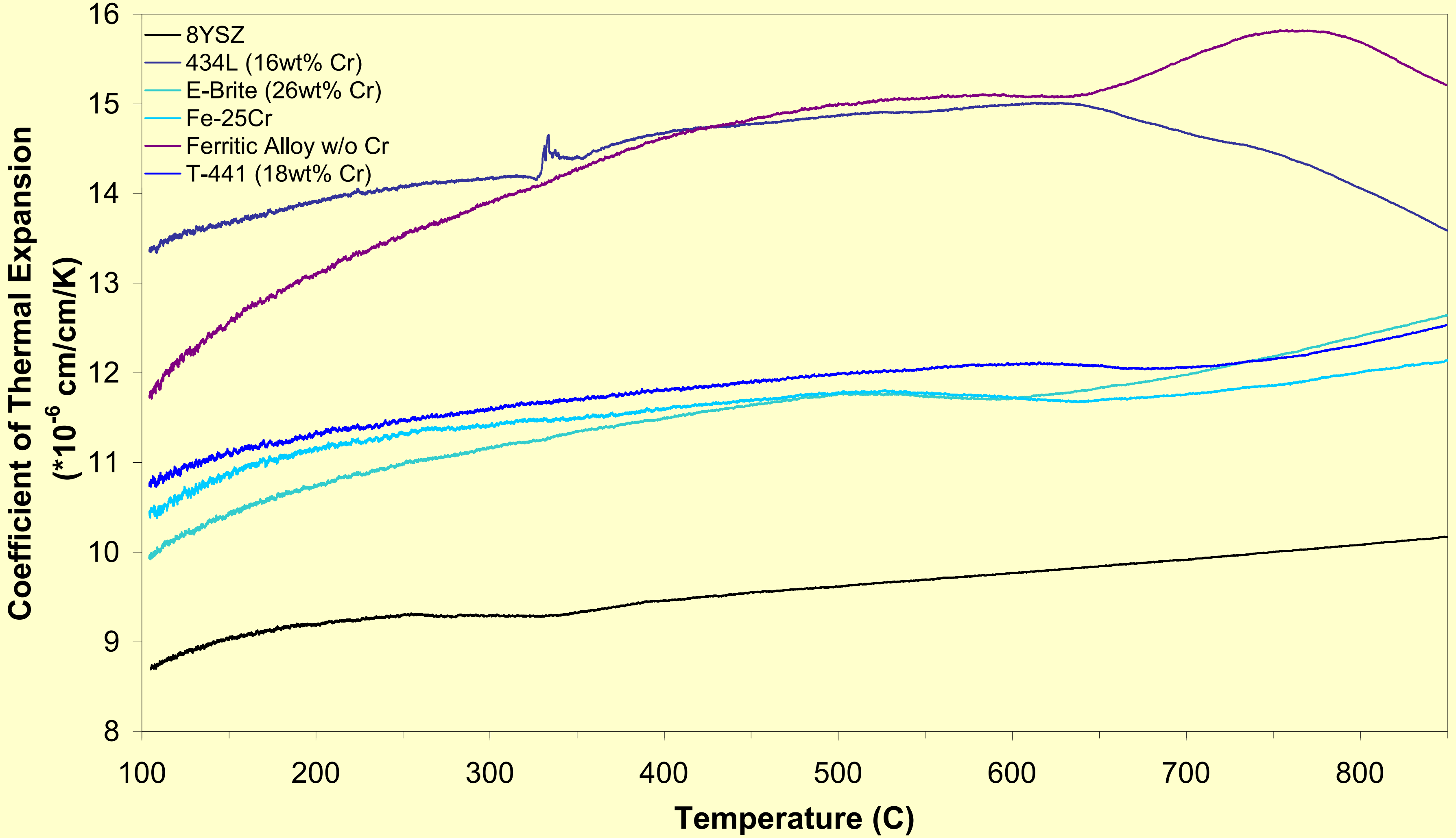




Argonne's 3 Primary Groups of Focus

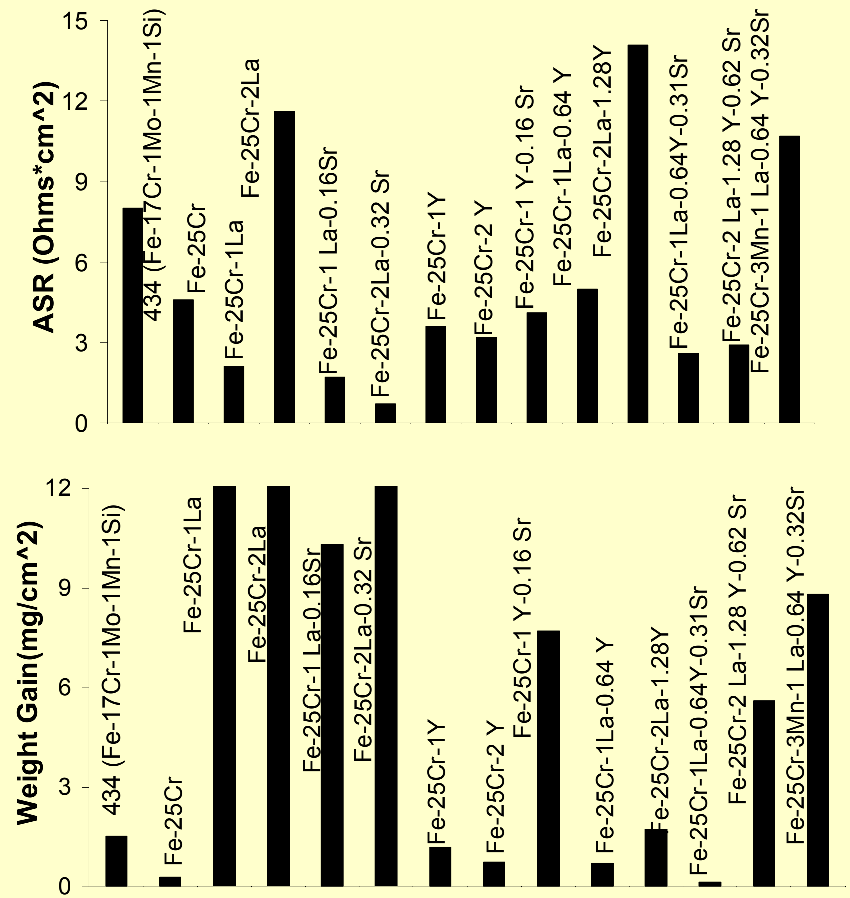
- Fe-Cr Alloys With Rare Earth Additions
- Ferritic Alloys Without Chromium
- Compositionally Graded Cermets

Thermal Expansion of Alloys Compared to 8YSZ



Ferritic Stainless Steels

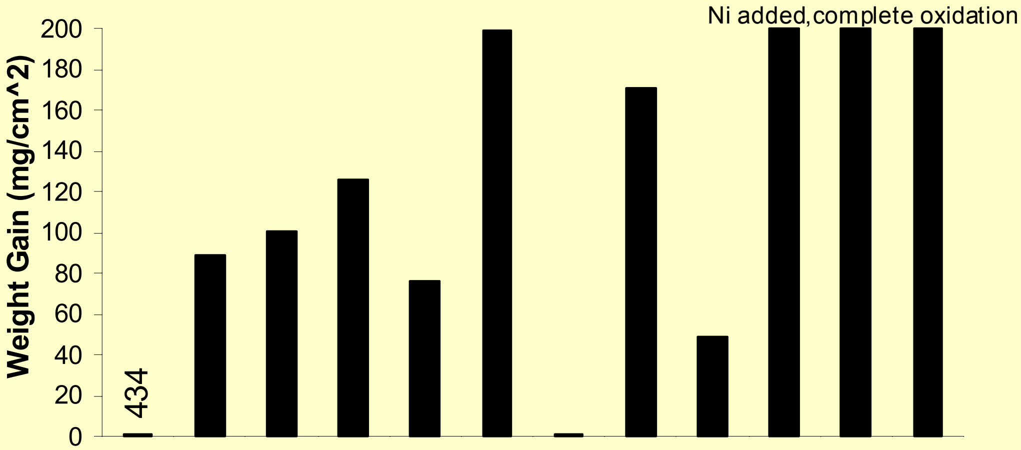
- Rare earth additions improve ASR and should stabilize oxide scale
- La appears more effective at improving ASR
- Y appears more effective at improving oxidation resistance
- Sr enhances electrical conductivity

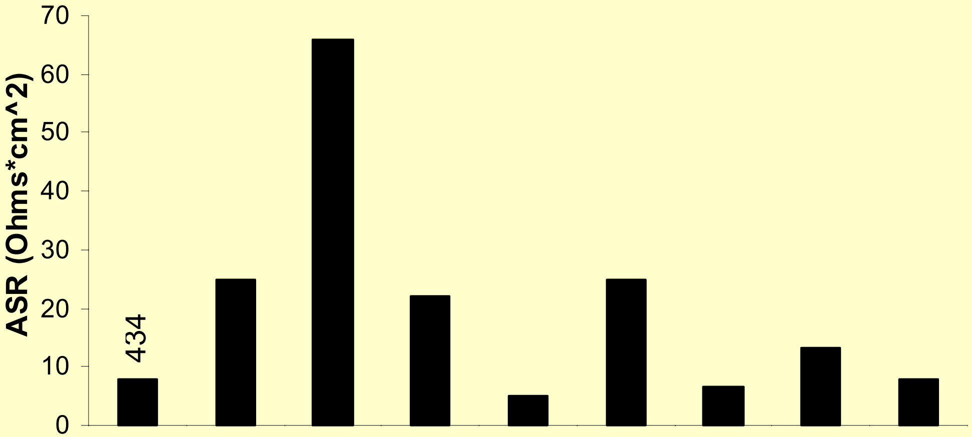


Compositions in weight percent

Ferritic Alloys Without Chromium

- Limited Selection of Elements that stabilize ferritic phase.
- Possible Mixed Oxide Scales
  - $FeXO_4$ (wolframite structure).
  - $FeXO_4$ (rutile structure)
  - FeX_2O_6 (trirutile structure)
- Addition of Ni
  - Possible Formation of NiX_2O_6 (trirutile structure).
- Addition of Ni with La or Y
  - Possible Formation of $XNiO_3$ (perovskite structure).
- Consider additions and oxides other than those of ferritic stabilizers
- Produce a stable oxide
- Dope to enhance electrical conductivity





$LaSrCrO_3$-Ferritic Stainless Steel Composites

- Simple mixing: some segregation during processing
- Mechanical alloying of $LaSrCrO_3$ with starting elements: produced to fine a powder.
- Presently attempting to pre-alloy elements then mix in $LaSrCrO_3$, short time and lower energy.

Future Plans

- Have nano-phase LSF prepared and supply samples
- Explore alloys with low chromium volatization
- Compare “time to failure” of SOFC for various bipolar plate materials
- Explore perovskites as diesel reforming catalysts