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Effect of Firing Time on YSZ Microstructure for No_x Sensing

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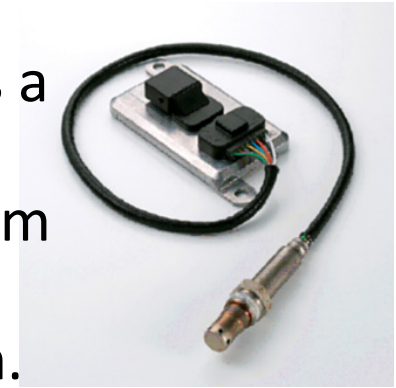
Outline

- Introduction
- Research Purpose and Objective
- Experimental Section
- Results
- Conclusions

Introduction

- NO_x Exhaust Gas Sensors for Diesel Vehicles
  - Used to check the vehicle exhaust to make sure it is clean.
  - If the exhaust is dirty (meaning has a high concentration of NO or NO_2) then an electronic signal is sent from the sensor to the engine computer system to correct engine operation.
  - NO_x sensors need to be highly sensitive, selective, accurate, and have a fast response time.



NGK commercial NO_x Sensor

What is YSZ?

- YSZ stands for Yttria Stabilized Zirconia
  - Y_2O_3 – Stabilized ZrO_2
  - An oxygen ion conducting electrolyte material
- It is used in high temperature applications, such as in gas sensors and solid oxide fuel cells.
- Usually, YSZ is used in a dense form. However, better NOx sensor performance has been reported for porous YSZ microstructures.

Porous YSZ based NO_x Sensors

- Research Purpose:
  - Generate knowledge needed to improve NO_x sensor microstructure to increase sensor selectivity, sensitivity, accuracy and response time.
- Research Objective:
  - To determine the affect of firing time and temperature on YSZ porosity.
    - Porosity : the property of being porous; being able to absorb gases or fluids

FLOW CHARTS FOR EXPERIMENT

Firing Process

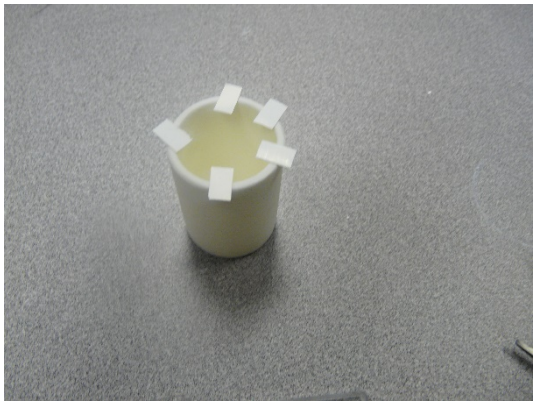
Materials for Firing

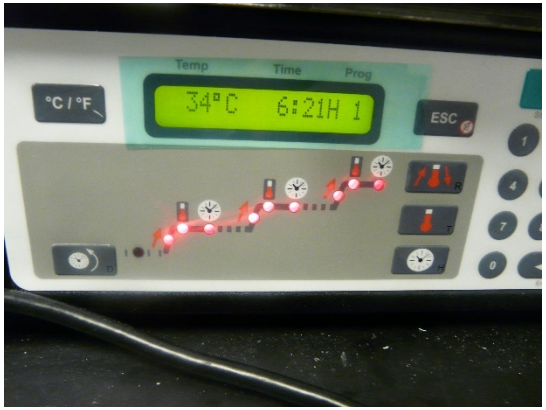
YSZ sheets

Box Furnace

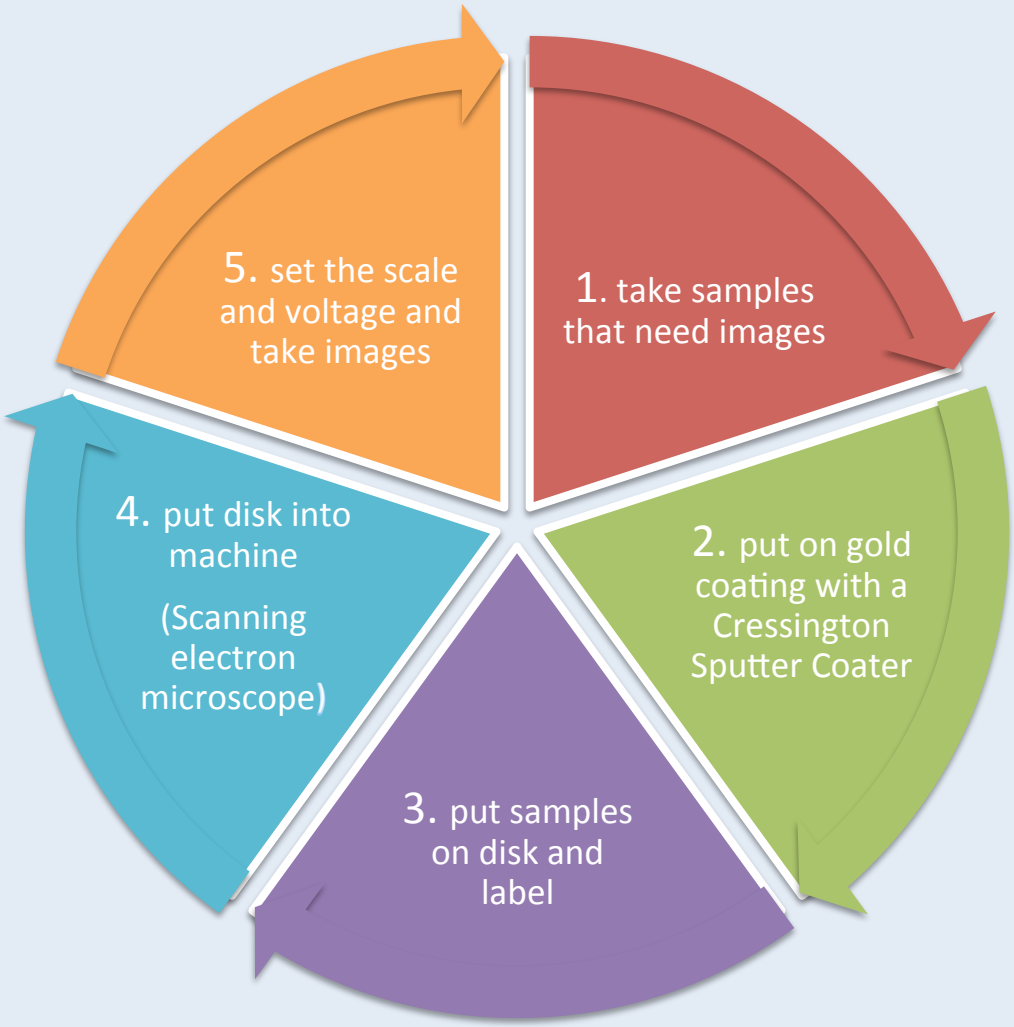
plier

crucible

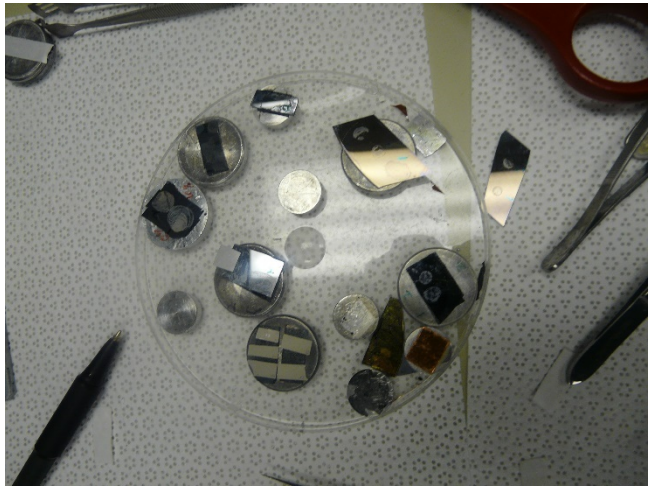


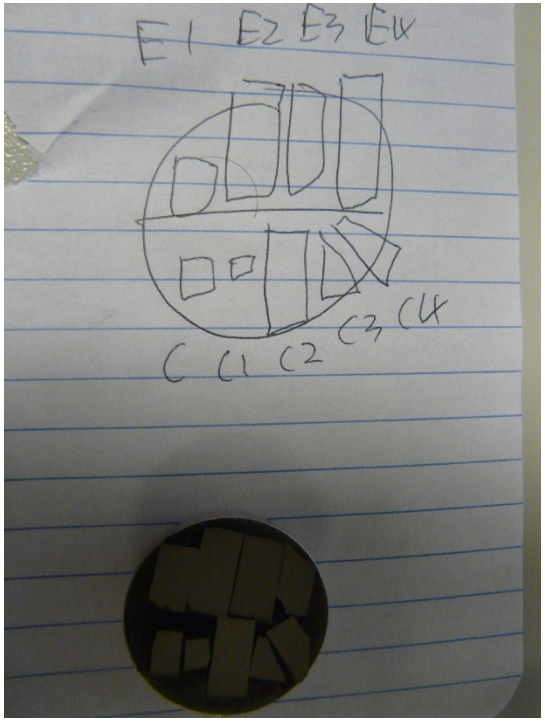


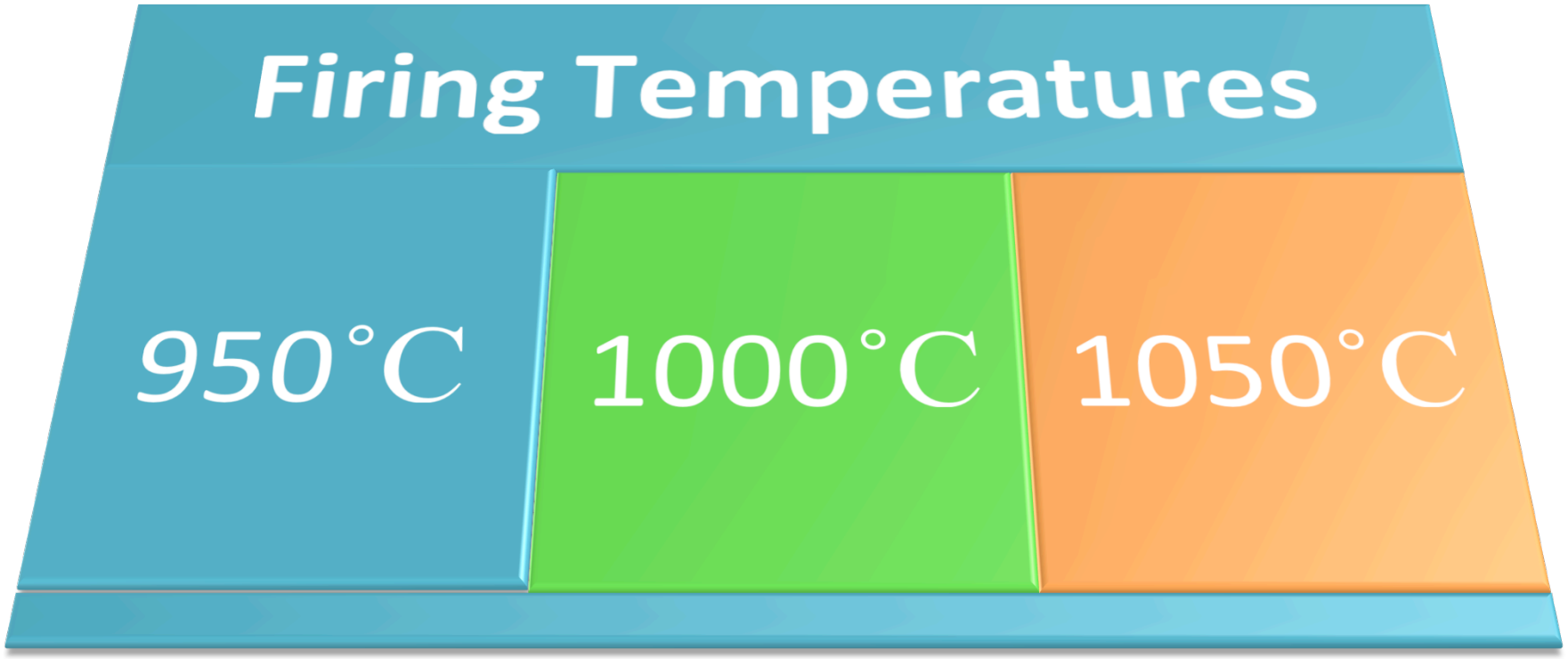
Imaging Process



Imaging Photos






Firing Temperatures
950°C
1000°C
1050°C

Firing Times

1 Hour	2 Hour	4 Hour	6 Hour	12 Hour

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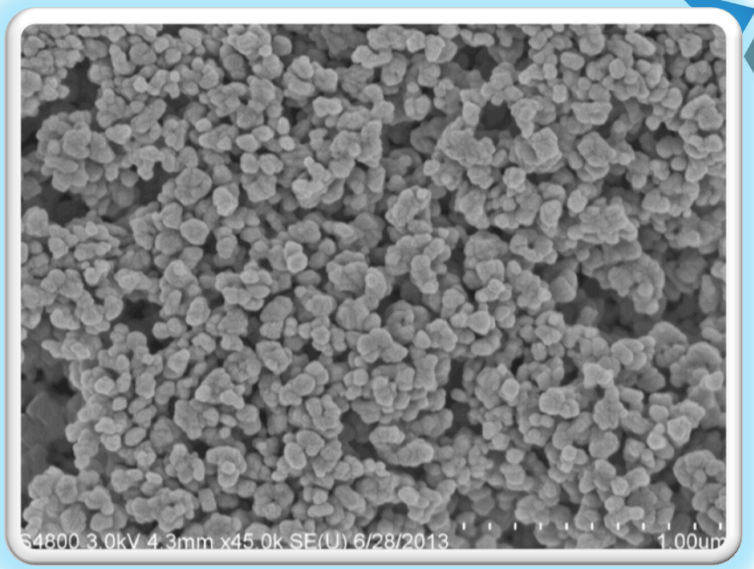
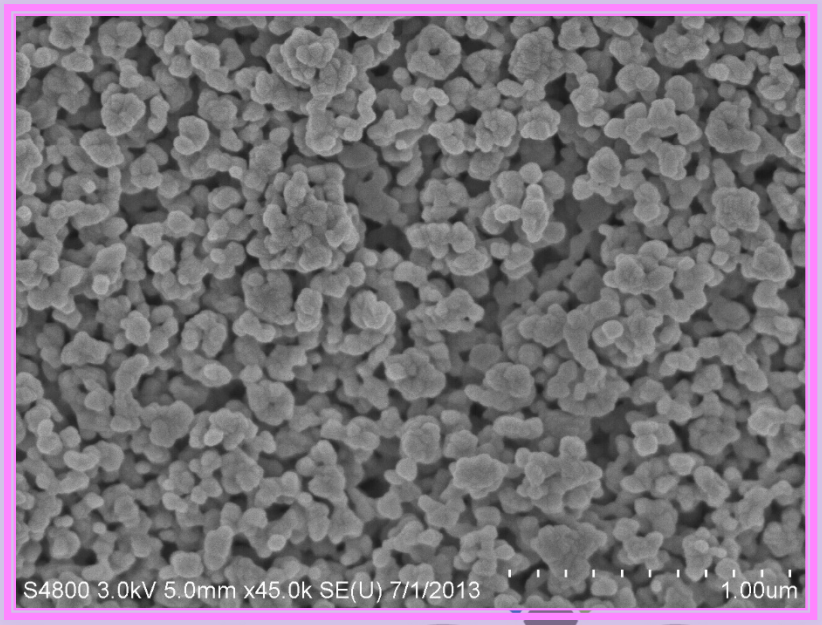
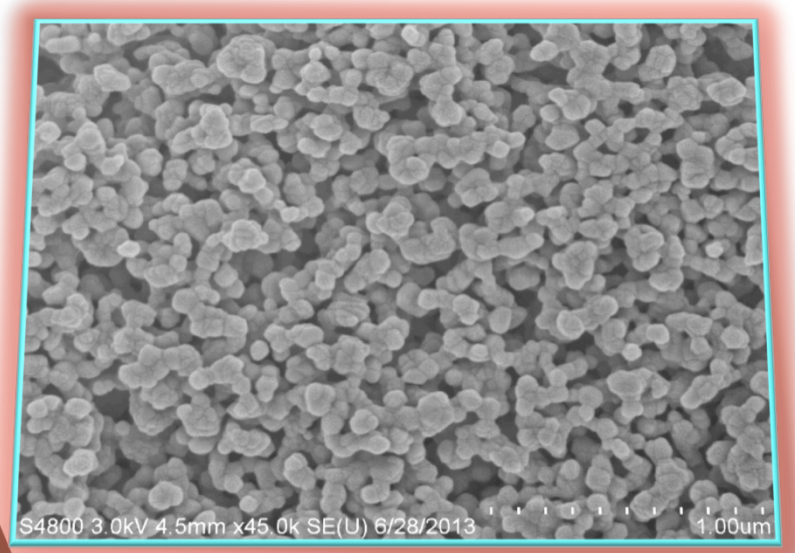
		950°C 1 Hour				
0.4794	0.5065	0.5591	0.4985	0.5180	0.4981	51%
		1000˚C 1 Hour				
0.4901	0.478	0.5091	0.4747	0.4765	0.4951	49%
		1050˚C 1 Hour				
0.4670	0.4712	0.5111	0.5035	0.4810	0.4992	49%

950˚C Image 1 1 Hour



1000˚C Image 2 1 Hour





1050˚C Image 3 1 Hour

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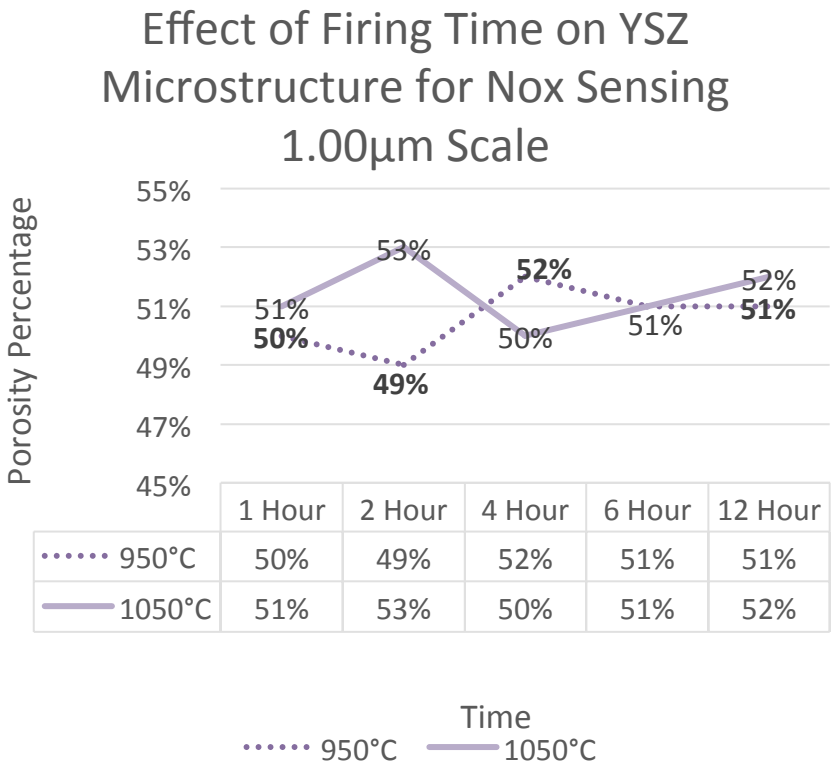
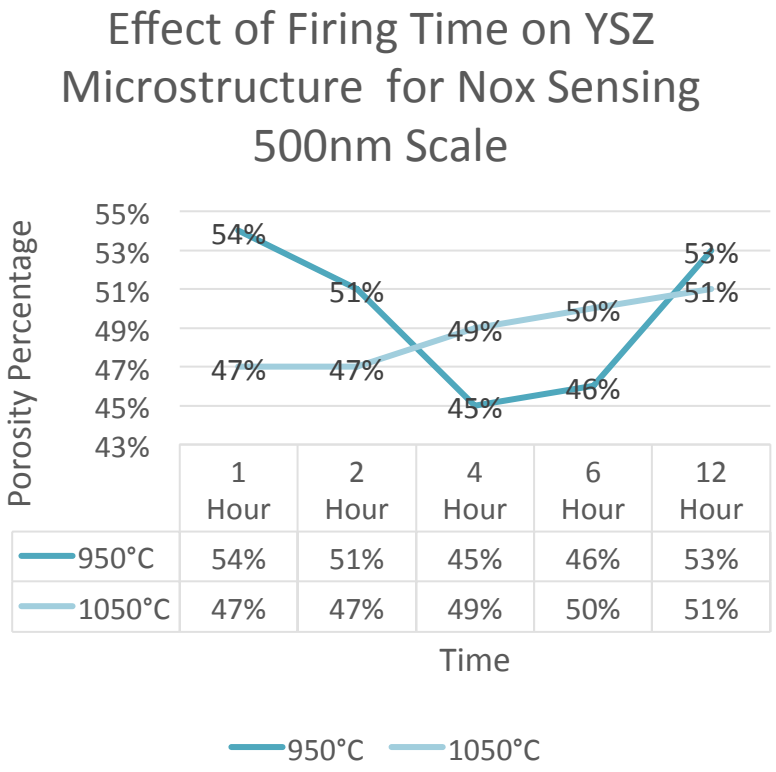
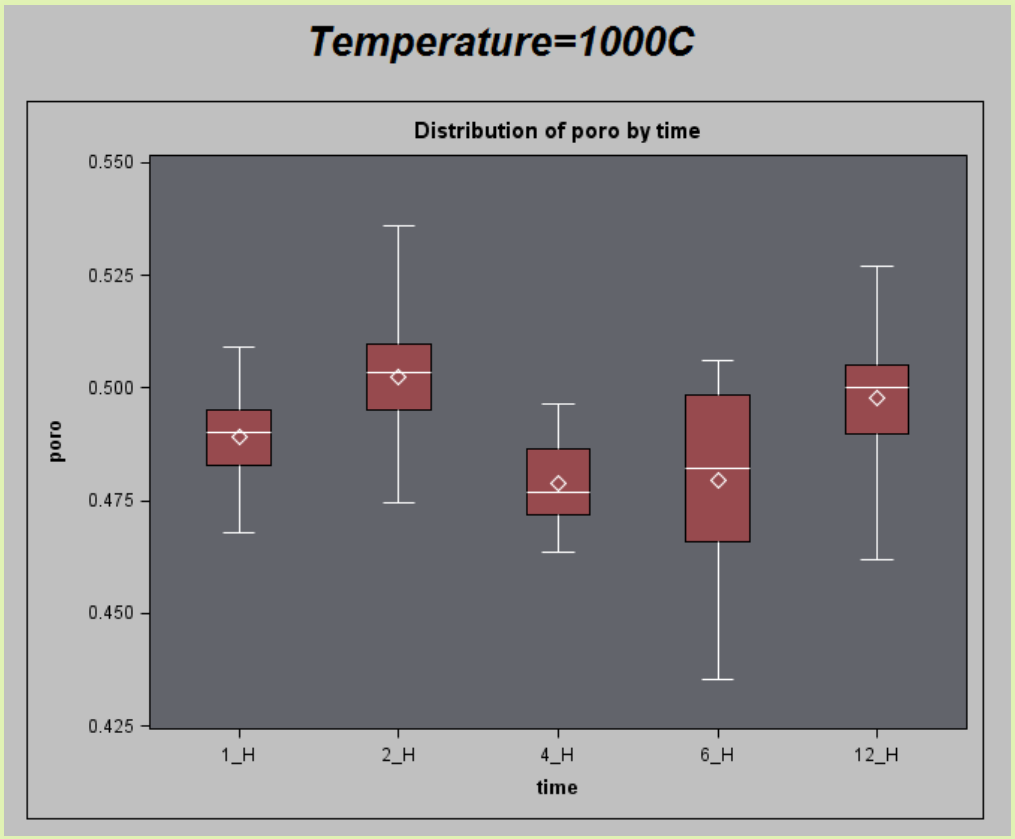
RESULTS


Effect of Firing Time on YSZ Microstructure for Nox Sensing 1.00µm Scale
Porosity Percentage
55%
53%
51%
49%
47%
45%
51%
53%
50%
49%
52%
50%
51%
52%
51%
51%
1 Hour
2 Hour
4 Hour
6 Hour
12 Hour
950°C
50%
49%
52%
51%
51%
1050°C
51%
53%
50%
51%
52%
Time
950°C
1050°C


Effect of Firing Time on YSZ Microstructure for Nox Sensing 500nm Scale
Porosity Percentage
55%
53%
51%
49%
47%
45%
43%
54%
51%
45%
46%
53%
47%
47%
49%
50%
51%
1 Hour
2 Hour
4 Hour
6 Hour
12 Hour
950°C
54%
51%
45%
46%
53%
1050°C
47%
47%
49%
50%
51%
Time
950°C
1050°C

1000°C



- After firing samples and doing SEM images ,the average porosity percentage was calculated using the Analysis of Variance(ANOVA)

1 Hour	49%
2 Hour	50%
4 Hour	48%
6 Hour	48%
12 Hour	50 %

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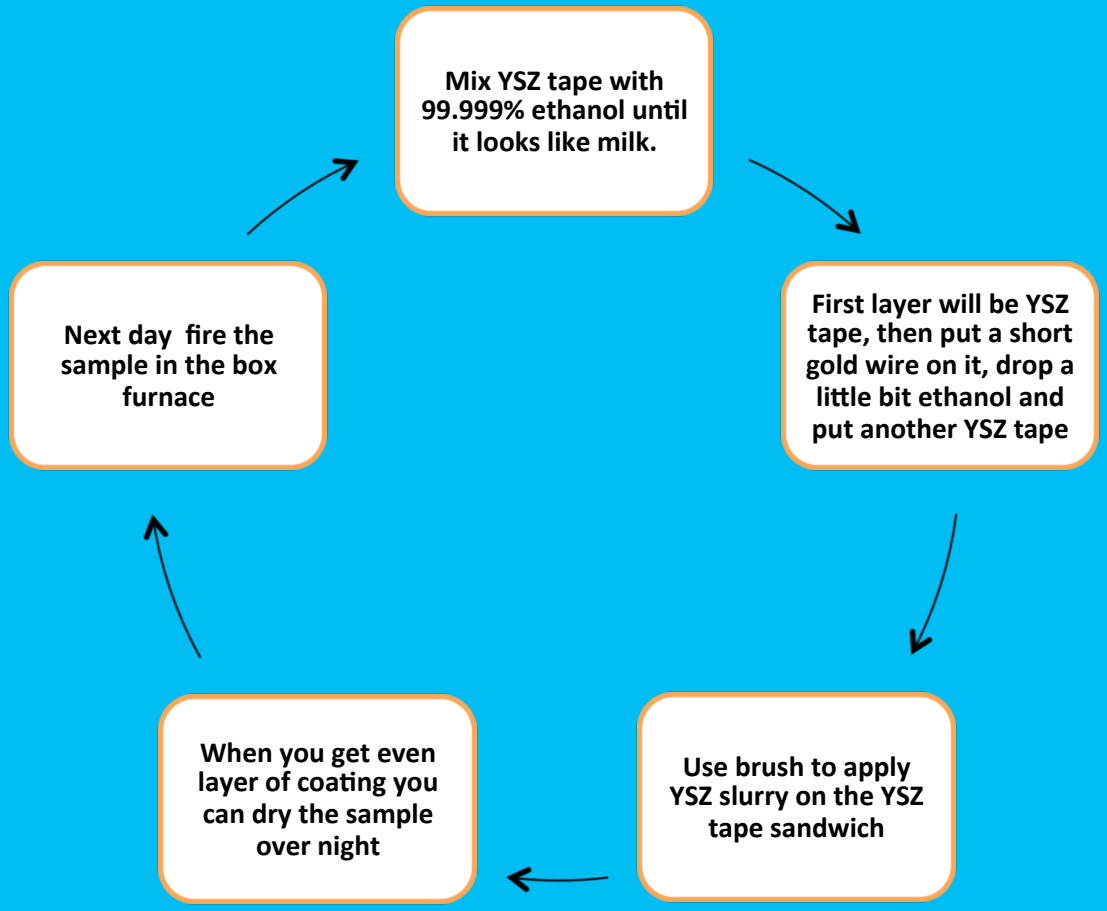
Slurry


Mix YSZ tape with 99.999% ethanol until it looks like milk.
First layer will be YSZ tape, then put a short gold wire on it, drop a little bit ethanol and put another YSZ tape
Use brush to apply YSZ slurry on the YSZ tape sandwich
When you get even layer of coating you can dry the sample over night
Next day fire the sample in the box furnace

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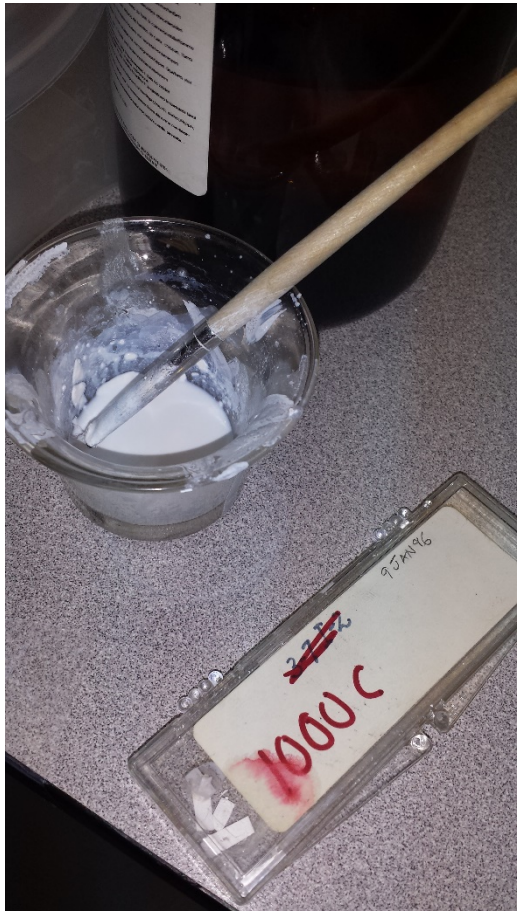
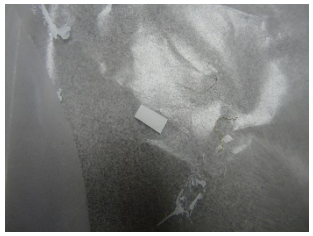
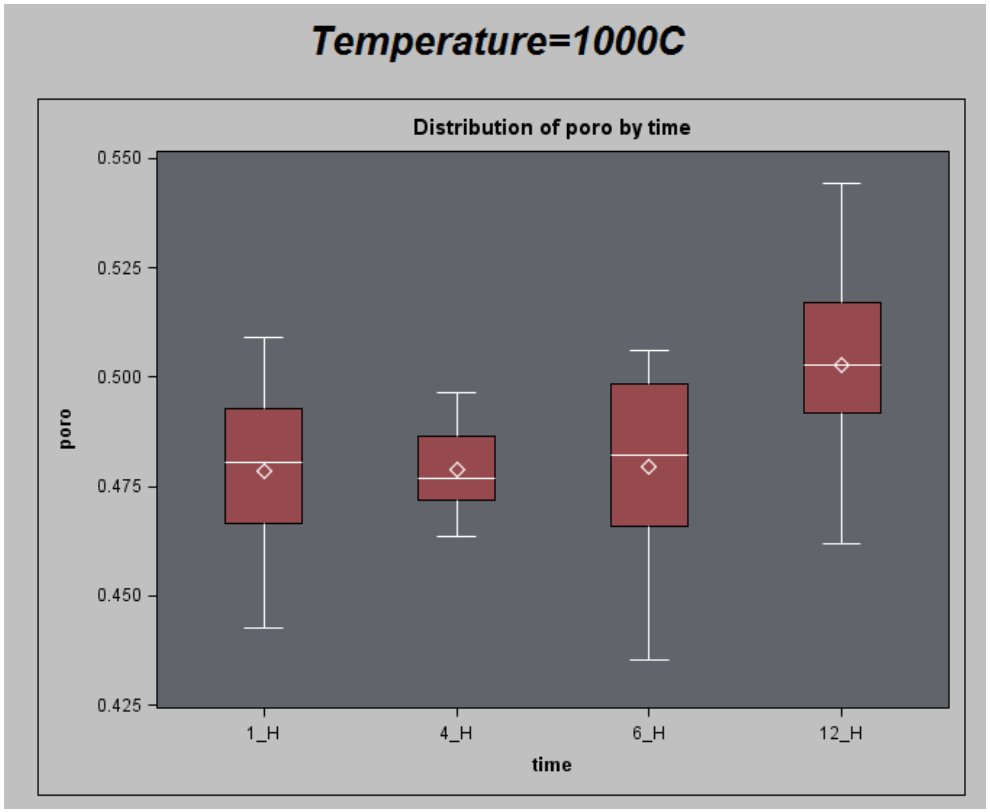
Photos for Slurry





1000˚C Coating



- → Used coating for 1000˚C at 1 hour and 12 Hour
- → The porosity percentage for 1 Hour with coating and wire is 47% overall
- → The porosity percentage for 12 hour with coating was 51% overall

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CONCLUSION

- The resolution of the 1.00µm appeared more accurate.
- The YSZ tape is about 50 % porous when fired at temperatures ranged from 950˚C - 1050˚C.
- Neither time nor temperature greatly impact porosity for the tape.
- Indicated by the Analysis of Variance (ANOVA), there is no interaction between temperature and time
  - the P-Values for temperature and time were 0.025907, temperature and 2.27^{-5}, time,
  - the time and temperature both affect porosity since their p-values were less than, (<) the alpha (α) level of 0.05.

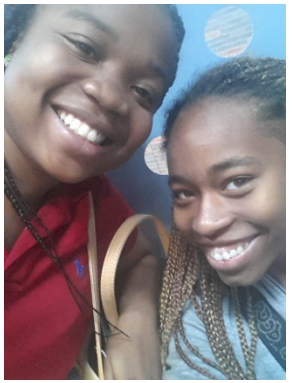
My Overall Experience

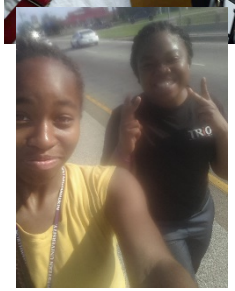
- Being a part of the LA-SIGMA REU for Summer 2013 allowed me great experience. It has encouraged and motivated me to look forward to graduate school by giving me a slight insight on what to expect. I enjoyed my summer here at Louisiana Tech and met many new people, I wish you all a great incoming school year.











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Acknowledgements

- This material is based upon work supported by the National Science Foundation under the NSF EPSCoR Cooperative Agreement No. EPS-1003897 with additional support from the Louisiana Board of Regents
- I want to thank all that allowed me this wonderful opportunity it has opened my eyes more on what to expect in the future
- Special thanks to Dr. Murray for mentoring me through this project allowing me to get a more clear understanding of what I was actually doing

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