

# NOx Sensors in the Exhaust Systems of Automobiles

presented by

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# What are NO and NO<sub>2</sub>?

- NO (nitrogen monoxide) and NO<sub>2</sub> (nitrogen dioxide) are pollutants that our vehicles release.
- Because these can cause harm to the environment, the release of them by vehicles is regulated by the EPA (Environmental Protection Agency.)



# Why do we have to change the NOx sensors that we have now?

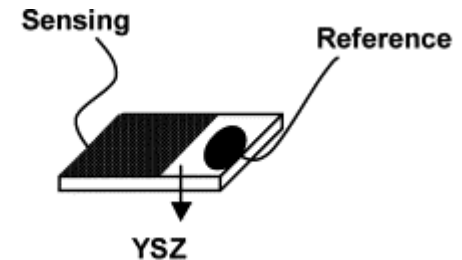
- At different time intervals, the EPA will announce that the levels of NOx that is released must be reduced.
- We must lower the NOx emission requirements as the EPA regulations become more stringent.
- This includes being able to detect smaller amounts of NOx.
- As we work to make new sensors that will accommodate the new regulations, we are looking at the cost efficiency of materials as well as the effectiveness to meet these new regulations.



# Yttria Stabilized Zirconia based NOx Sensor

- NOx sensors are used in diesel exhaust systems.
- YSZ is the most common sensor used.

1. The sensor must withstand high temperatures (600-800°C) for long time periods.
2. The sensor output signal should be insensitive to the moisture content.
3. The sensor should provide stable signals even in the absence of oxygen.
4. The sensor needs to be inexpensive.



# The Electrolyte and Electrode Switch

- Typically Ysz electrolytes are dense and are accompanied by porous electrodes.
- Recent studies have found that porous Ysz can improve NOx sensing.
- This switch is accompanied by dense electrodes.

This is the method we are using in our research. We are using Gold wire as the electrode. The Ysz is the now the electrolyte.





# The Reasons for Using Scandia Substituted Zirconia

Scandia has a higher ionic conductivity than yttria which may increase sensor sensitivity.

This is good because:

- Scandia is in the same group on the periodic table as yttria, so it should have the same properties.
- Scandia's atomic weight is significantly less than that of yttria.

Periodic Table of the Elements

1 H 1.01																	18 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (97.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (208.98)	85 At (209.99)	86 Rn (222.02)
87 Fr (223.02)	88 Ra (226.03)	89 Ac (227.03)	104 Rf (261.11)	105 Ha (262.11)	106 Sg (263.12)												
		58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (144.91)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97		
		90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237.05)	94 Pu (244.06)	95 Am (243.06)	96 Cm (247.07)	97 Bk (247.07)	98 Cf (251.08)	99 Es (252.08)	100 Fm (257.10)	101 Md (258.10)	102 No (259.10)	103 Lr (262.11)		



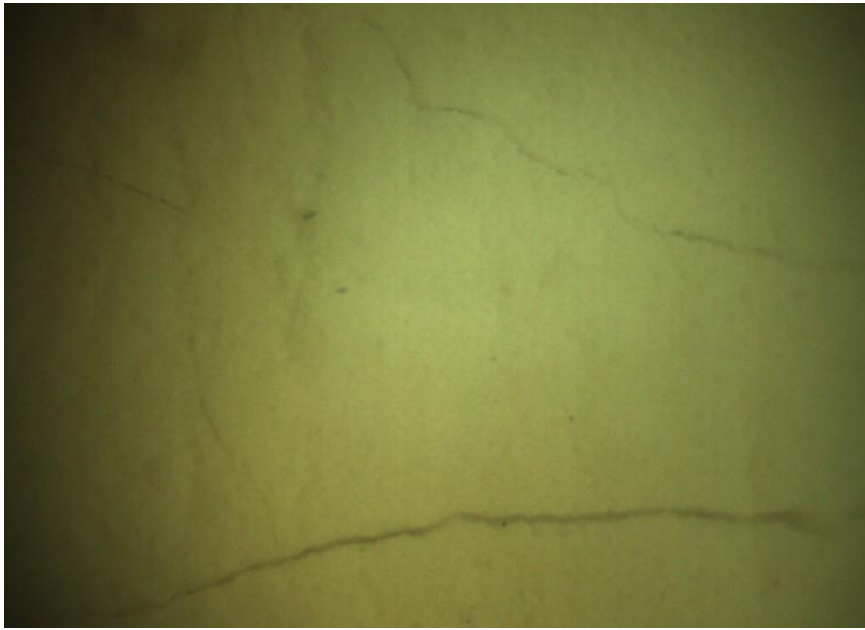
# The Methods Used in the Characterization of Our Samples

- Impedance Spectroscopy is used to determine the rate of the reaction
- The NOVA 2200e-Surface Area and Pore size Analyzer to determine the porosity of our material
- The SEM (scanning electron microscope) was used to look at our samples by essentially reading the feedback from the electrons hitting atoms of the sample.
- The optical microscope was also used to look at the micro-scale surface and details of our samples. (This is the methods that I was most involved with.)





# The Differences of Our Samples with the Optical Microscope



Yttria substituted zirconia sample



Scandia substituted zirconia sample



# Continued Research

At this time the research is not complete. The texture of the scandia sample is not consistent with the texture of the yttrium sample. This could be due to a slight difference in the technique that was used with the scandia sample. Binders are being obtained in order to recreate a more uniform sample and then the scandia sample will be remade and tested.

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