Idaho National Engineering and Environmental Laboratory

Cermet Filters for Diesel Engine Emissions Reduction

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THE PROBLEM AND SOLUTION

- Diesel engine vehicles emit significant amount of fine soot particles during start-up and transient operations, as well as NO_x under lean burn conditions
- U.S. EPA will begin tightening the regulatory requirements to control these emissions from diesel powered vehicles
- The INEEL is developing a self-cleaning cermet filter technology to control soot and NO_x emissions from diesel engines

THE TECHNOLOGY

- The cermet filter is formed by a single-step combustion synthesis process
- Metal and ceramic powders are well mixed with or without sacrificial filler materials to form a near net shape compact
- The compact is fired at temperatures above 700ºC to initiate the combustion synthesis process
- The combustion temperature is much higher than the firing temperature
- The combustion synthesis is completed when all the metal components are reacted to form a net shape structure

CERMET FILTER PROPERTIES

- Net shape forming by combustion synthesis
- High melting temperatures (>1500°C)
- Thermal shock resistant & high heat capacity
- Inexpensive starting materials
- Many material compositions possible
- Light weight and mechanically strong
- Porosity sizes, shapes, structure manageable
- Capability for self-cleaning
- High particulate filtration efficiency
- NO_x reduction under reducing conditions
- Generate NH_3 and/or C_2H_2 when activated
- Catalytic to steam reforming of hydrocarbon

COMBUSTION SYNTHESIS OF $NiAl \cdot Al_2O_3$ CERMET FILTERS

(1) $Ni + Al + Al_2O_3 \rightarrow NiAl + Al_2O_3$

(2) $Ni + Al + Al_2O_3 \xrightarrow{a} NiAl + Al_2O_3 + W$

(3) $Ni + Al + Al_2O_3 + b \xrightarrow{a} NiAl + Al_2O_3 + W + F$

α = condition, $\Omega = NH_3$ producing phase

β = additives, $\Phi = C_2H_2$ producing phase

CARBON FILTRATION AND PRESSURE DROP TESTS

WITHOUT CARBON

Temp ^oC	Flow rate (l/m)	Line P (psi)	Upstream P (psi)	Downstream P (psig)
24	10	56	7	0
24	20	56	18	0
24	30	56	25	0
24	40	56	32	0
24	60	56	47	0

WITH CARBON

Temp ^oC	Flow rate (l/m)	Line P (psi)	Upstream P (psi)	Downstream P (psi)
24	10	56	8.5	0
24	20	56	15	0
24	30	56	23	0
24	40	56	30	0
24	50	56	37	0
24	60	56	51.5	0

Initial wt of cermet filter = 3.3073g
Final wt of cermet filter = 3.3070g
No clogging of the filter observed
Effective cermet filter area = 0.48 in^2.

Initial wt of carbon = 1.3846g
Final wt of carbon = 1.3826g
Filtration efficiency = 99.86%
Filter porosity » 25%

CERMET DESTRUCTION OF NITRIC OXIDE TEST

Test condition: 5% NO+ 1.67% C_2H_4 + 93.33% He

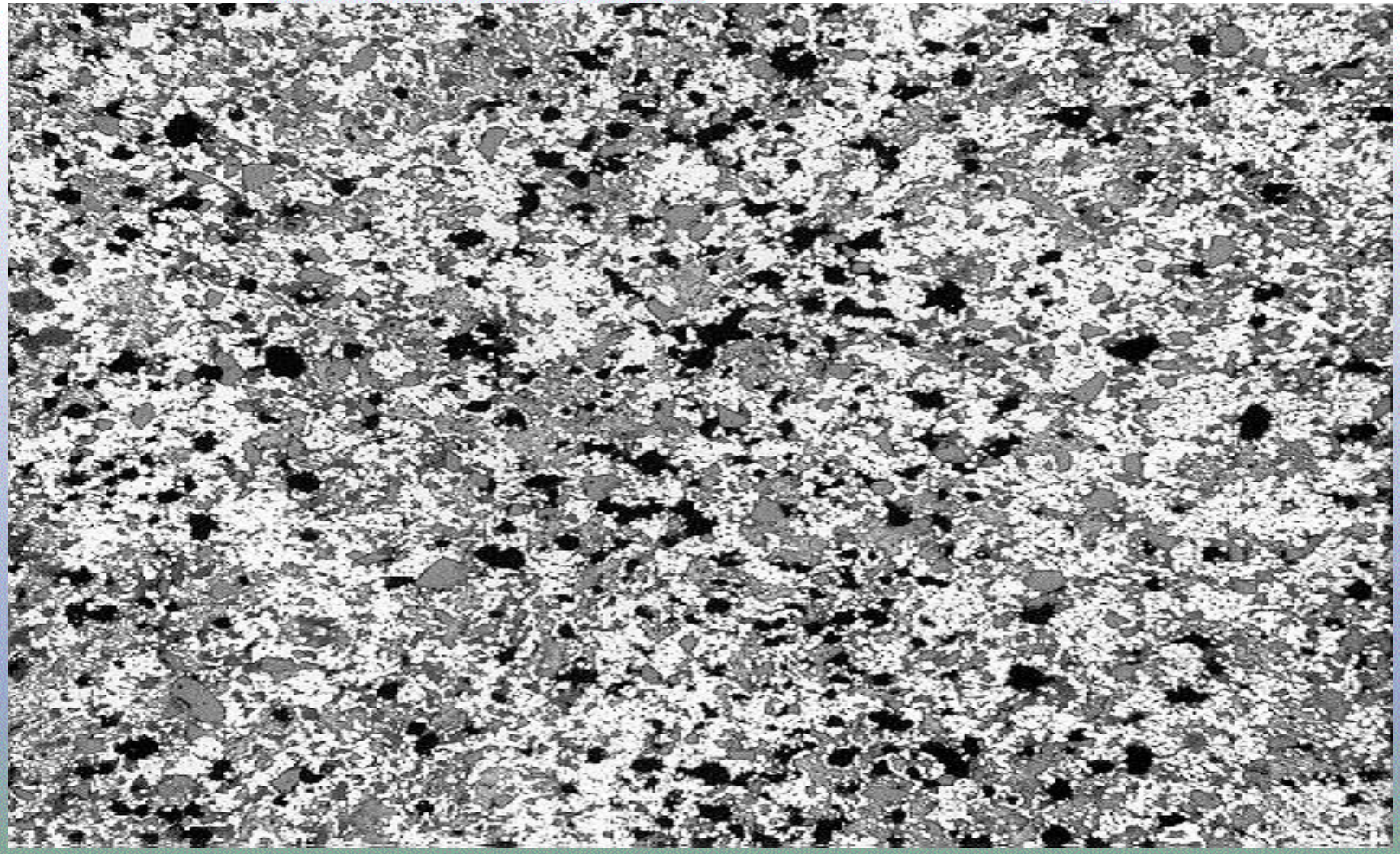
% NO conversion to N_2 under reducing atmosphere

Temperature °C	Sample 1	Sample 2	Sample 3
300	0	0	0
400	0	2.5	0
475	0	2.6	2
550	0	4.7	2
623	3.8	13.3	2
696	11.3	43.1	3
797	38.7	98.3	7
904		100	

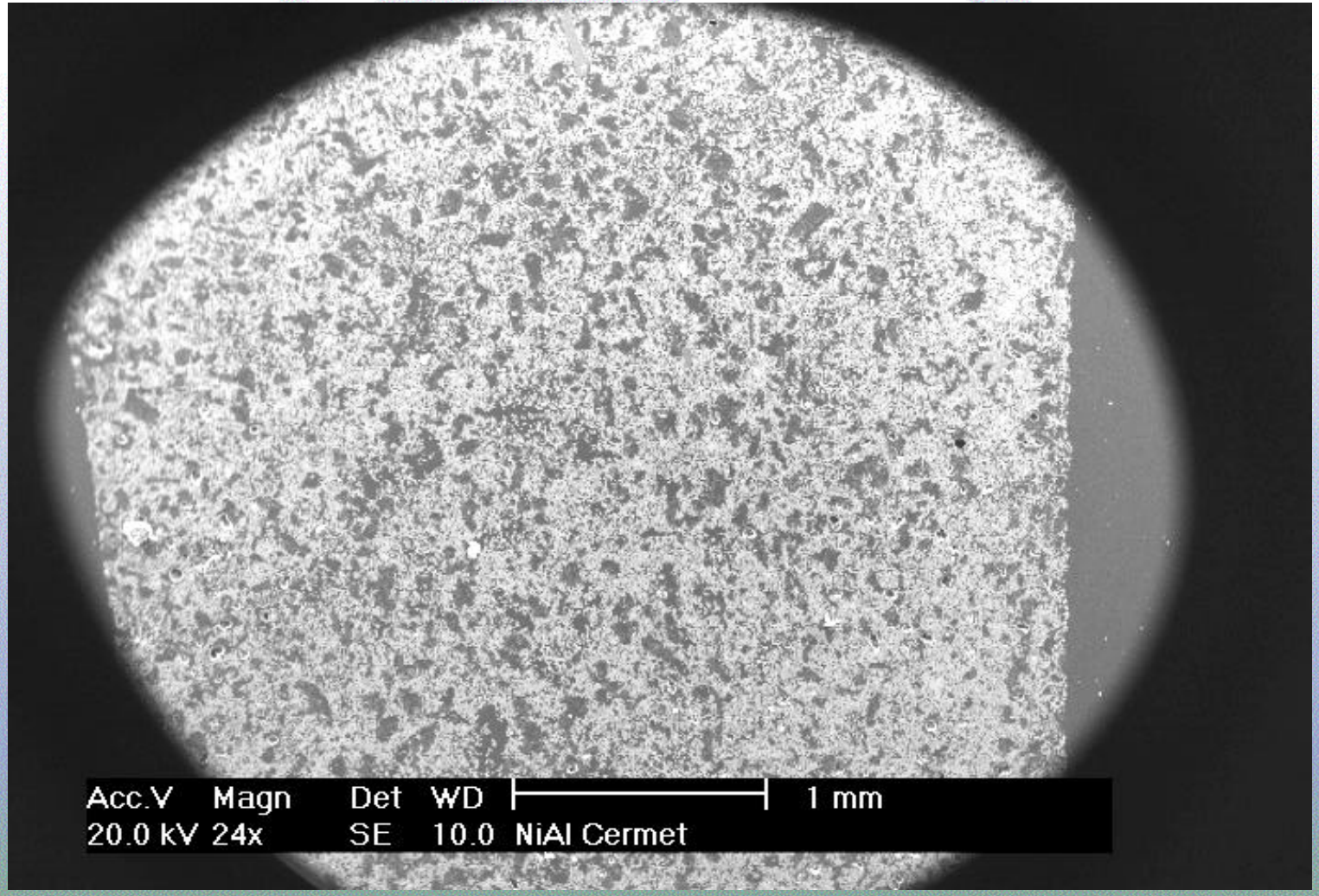
CERMET FILTER HYDROCARBON and CO DESTRUCTION TEST

°C	C_3H_6	CH_4	CO
25	0	0	0
101	0	0	0
203	2.1	0	5.3
302	1.4	0	6.1
403	0	0	8.9
478	11.3	15.9	24
553	47.8	23.3	81.2
627	93.8	25.2	97.0
702	100	36.0	100
797	100	52	100

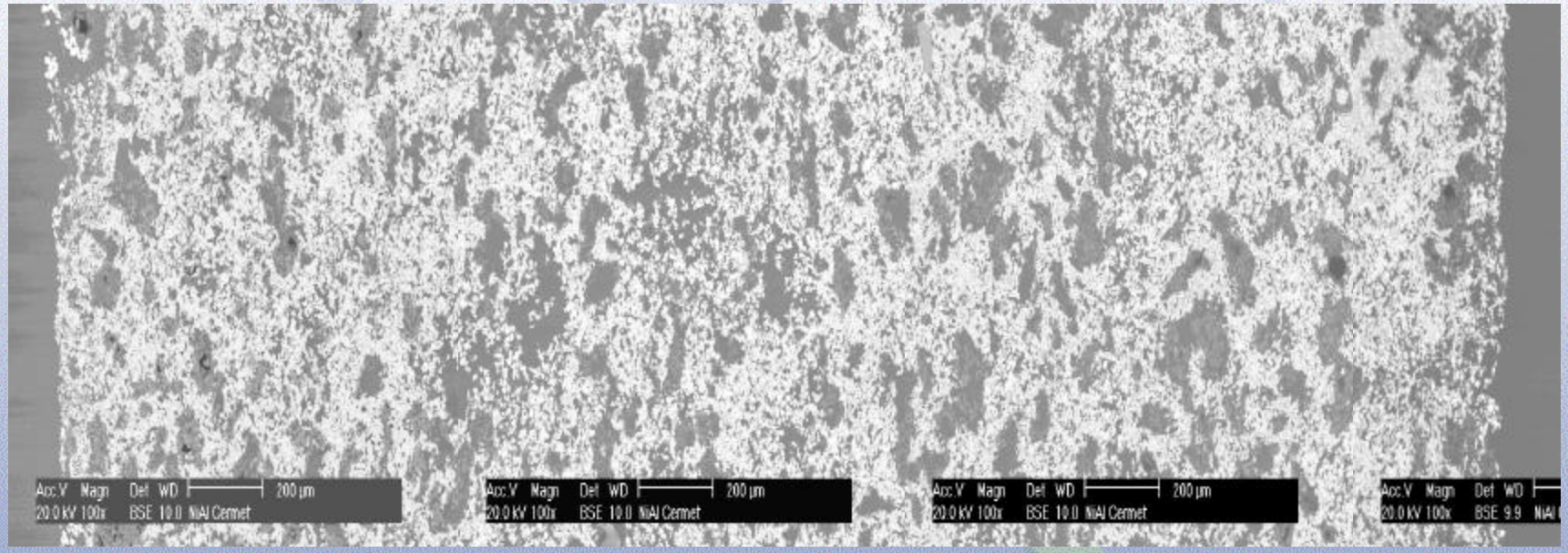
CERMET FILTER SURFACE MICROSTRUCTURE



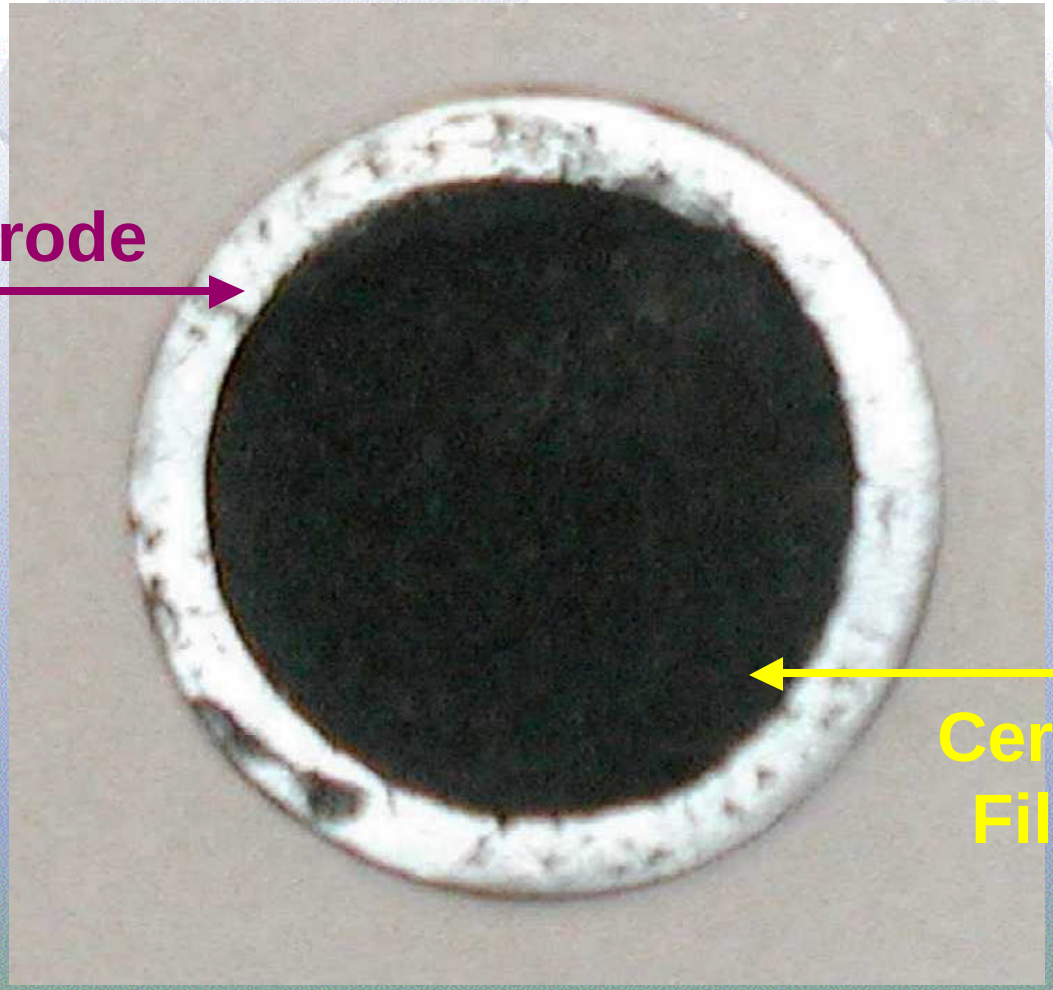
CERMET FILTER CROSS-SECTION



CERMET FILTER CROSS-SECTION MICROSTRUCTURE

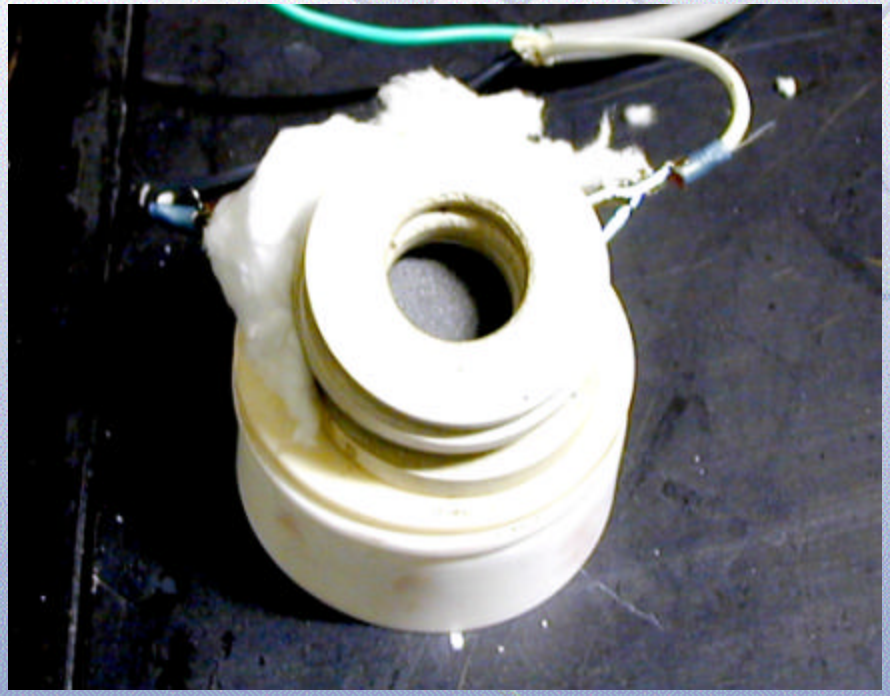


CERMET FILTER WITH BURN-IN ELECTRODES

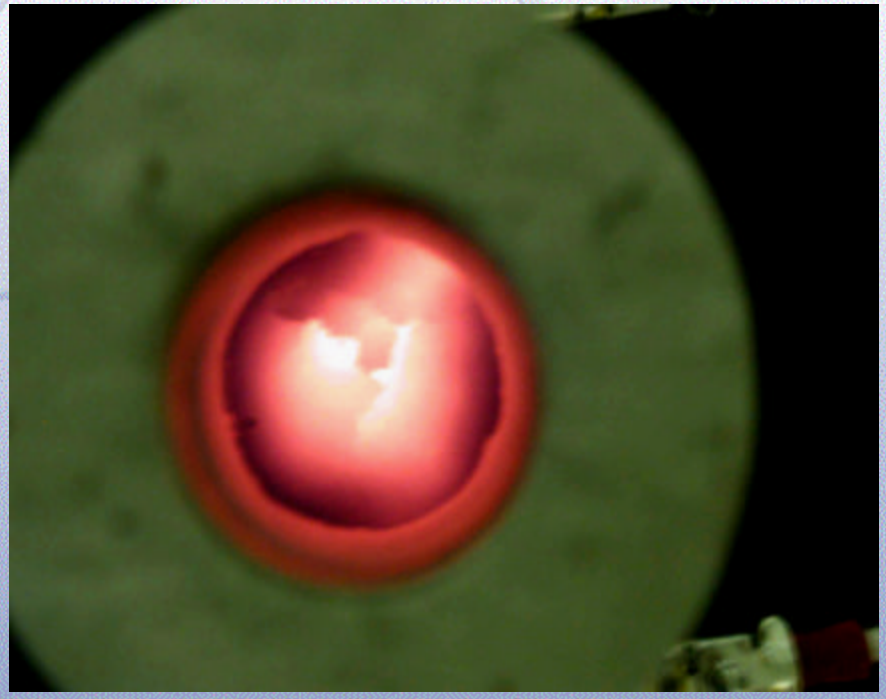


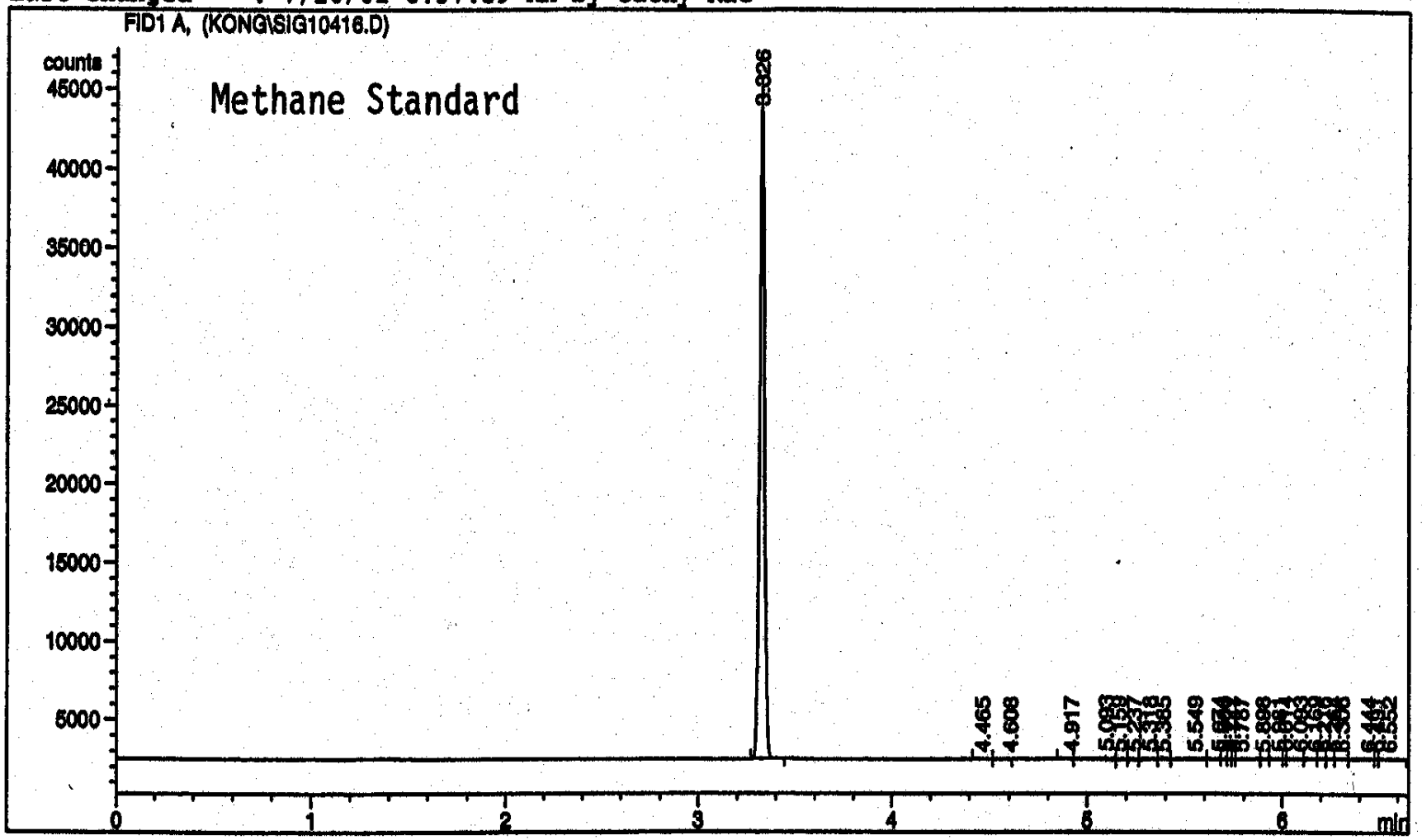
CERMET FILTER HEATING TEST

Before Heating



During Heating



GC ANALYSIS OF METHANE STANDARD

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