S14-27
N89-13656
181382
11P.

CHARACTERIZATION OF ZrO_2-Y_2O_3 THERMAL SPRAY POWDER SYSTEMS

Thomas E. Mantkowski and David V. Rigney
Aircraft Engine Business Group
General Electric Company, Evendale, Ohio 45215-6301

and

Marc J. Froning and N. Jayaraman
Department of Materials Science and Metallurgical Engineering
University of Cincinnati, Cincinnati, Ohio 45221-0012

The overall objective of this program is to establish the interrelation between the raw material in the coating process and the performance of the coating deposit. It is anticipated that these interrelations will help establish more precise specifications for the procurement of raw materials. This paper presents some of the preliminary results of this program.

Powder samples of ZrO_2-8% Y_2O_3 manufactured by different processes such as (i) spray drying, (ii) spray drying and sintering, (iii) sintering and crushing, (iv) casting and crushing, and (v) casting, crushing and fusing were initially characterized for particle size and shape, microstructure and morphology, surface area, density, flow characteristics, and qualitative and quantitative phase distribution. The powder manufacturing process did appear to have significant effects on all the above characteristics. For example, the two extreme cases were: (i) the spray dried powders were spherical and inhomogeneous with a large surface area, low density and low mass flow rate, and contained primarily the monoclinic ZrO_2 phase with additional small amounts of free Y_2O_3; (ii) the fused, cast and crushed powders were dense irregular particles with a low surface area and high mass flow rate and contained primarily cubic phase with small amounts of monoclinic and additional unidentified phase. Both narrow and wide size distributions of particle sizes were found in the as received powder samples.

The powders were air-plasma-sprayed using identical spray parameters on Hastalloy-x substrate with a VPS NiCrAlY bond coating. The coated samples were characterized for microstructure, erosion resistance and qualitative and quantitative phase distribution. The coatings ranged from highly dense to highly porous and this appeared to primarily depend upon the initial particle size. The coated samples were subjected to thermal cycling, and similar characterization was carried out on the exposed samples. In general, as observed by other investigators, the highly porous coatings appeared to withstand a greater number of thermal cycles. Further work is in progress to confirm the preliminary thermal cycling test results, and in characterizing the coated and thermal cycled samples.

TABLE 1

CHEMICAL COMPOSITION OF EXPERIMENTAL POWDERS

Vendor Codes	Powder Types	Composition [by KEVEX]	Composition [wet chemistry]
W	Spray Dried	2.60% Hf [0.0-3.0] 3.40% Y [2.1-4.6]	0.6% Si 0.9% Hf 6.8% Y
J	Spray Dried	0.24% Ca [0.0-0.6] 0.00% Ti [0.0-0.5] 2.60% Hf [0.0-1.2] 8.60% Y [8.4-35.6]	0.3% Ti 0.4% Si 1.3% Hf 7.3% Y
A	Spray Dried	0.00% Ti [0.0-0.3] 0.00% Ca [0.0-0.3] 0.31% Fe [0.0-0.3] 2.19% Hf [0.0-2.3] 12.20% Y [5.1-15.3]	0.2% Ti 0.7% Si 8.4% Y
C	Spray Dried & Sintered	2.41% Hf [1.5-3.1] 9.10% Y [8.7-11.8]	0.2% Ti 0.7% Si 7.6% Y
B	Sintered & Crushed	0.00% K [0.0-0.2] 0.25% Ni [0.0-0.0] 1.49% Hf [0.9-3.3] 11.10% Y [7.0-13.0]	0.2% Ti 0.3% Si 8.2% Y
Y	Sintered & Crushed	0.00% Ca [0.0-0.3] 0.00% Ti [0.0-0.3] 0.00% Fe [0.0-1.1] 1.35% Hf [0.0-2.5] 7.81% Y [4.7-7.0]	0.1% Ti 0.2% Si 1.5% Hf 7.4% Y
J	Cast, Crushed, & Fused	0.00% Ti [0.0-0.3] 2.11% Hf [0.6-1.4] 8.16% Y [4.3-12.4]	0.1% Si 0.2% Ti 7.0% Y
H	Fused, Cast, & Crushed	0.00% Ti [0.0-0.1] 0.00% Mg [0.0-0.2] 1.21% Hf [0.0-1.5] 10.20% Y [6.4-8.0]	0.2% Mg 0.1% Ti 0.3% Si 8.6% Y
J	Fused, Cast, & Crushed	0.00% Mn [0.0-0.2] 0.14% Ti [0.0-0.0] 1.95% Hf [0.0-1.3] 9.24% Y [4.9-8.5]	0.1% Si 0.2% T 6.4% Y

TABLE 2

PLASMA SPRAY PARAMETERS

	Air	Vacuum
Plasma Gun	Metco 7M	Metco 7MB
Primary/Secondary Gas	N_2/H_2	Ar/H_2
Gun Power	36 KW	50 KW
Traverse Rate	100 sfpm	100 sfpm
Powder Feed Rate	6 Lbs./Hr.	10 Lbs./Hr.
Preheat	None	1800°F
Spray Distance	5 In.	12 In.
Other	90° air impingement cooling	40 torr Abs. Pressure, RTA cleaned

TABLE 3

PHYSICAL PROPERTIES OF THE AS-RECEIVED EXPERIMENTAL POWDERS

Vendor Codes	Powder Types	Shape [by SEM]	Color	Density [g/mil]	Flowability [hall, g/s]	Size [Microtrac]	Surface Area [sq. m/g]
W	Spray Dried	Porous Spheres	White	5.54	5.2	*	3.60
J	Spray Dried	Spheres	White	5.55	6.4	MD=46.7 SD=23.0	1.60
A	Spray Dried	Spheres	Pale Yellow	5.60	7.2	*	1.39
C	Sintered	Rough Spheres	Pale Yellow	5.82	7.6	MV=67.7 SD=30.0	0.187
B	Sintered & Crushed	Rough Spheres	Light Yellow	5.96	7.0	MV=74.4 SD=25.4	0.256
Y	Sintered & Crushed	Irregular	Light Yellow	5.96	7.0	MV=53.2 SD=31.5	0.39
J	Cast, Crushed and Fused	Spheres/ Angular/ Acicular	Dark Yellow	5.67	9.6	MV=50.0 SD=23.4	0.073
H	Fused, Cast, and Crushed	Irregular	Dark Yellow	6.03	8.7	MV=65.4 SD=35.6	0.00656
J	Fused, Cast, and Crushed	Angular	Dark Yellow	6.05	8.3	MV=51.1 SD=22.0	0.081

* Powders Dissolve in Water

TABLE 4

TBC LIFE AND EROSION RESISTANCE

Vendor Codes	Powder Types	Erosion Resistance [sec/mil]	Thermal Cycles to Failure
W	Spray Dried	9.5	40
J	Spray Dried	7.4	285
A	Spray Dried	4.1	700
C	Sintered & Crushed	6.1	660
B	Sintered & Crushed	7.1	1000
Y	Sintered & Crushed	6.6	410
J	Cast, Crushed & Fused	10.5	380
H	Fused, Cast & Crushed	9.6	310
J	Fused, Cast & Crushed	11.6	390

Vendor J-Spray Dried

Vendor B-Sintered

Vendor H-Cast & Crushed

Figure 1. - Metallographic evaluation of ZrO_2 - $8Y_2O_3$ powders.

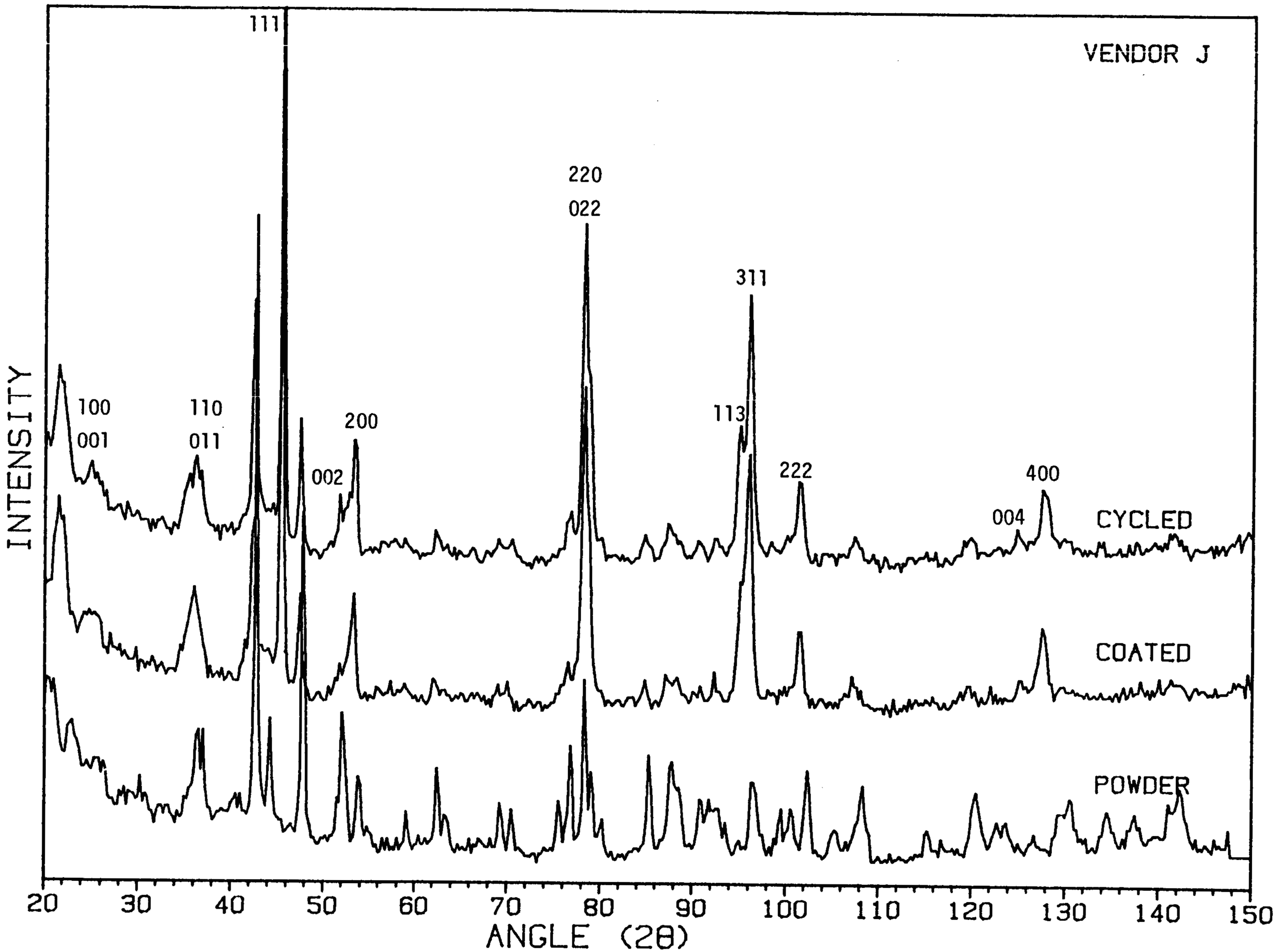


Figure 2. - XRD analysis of vendor J's TBC system.

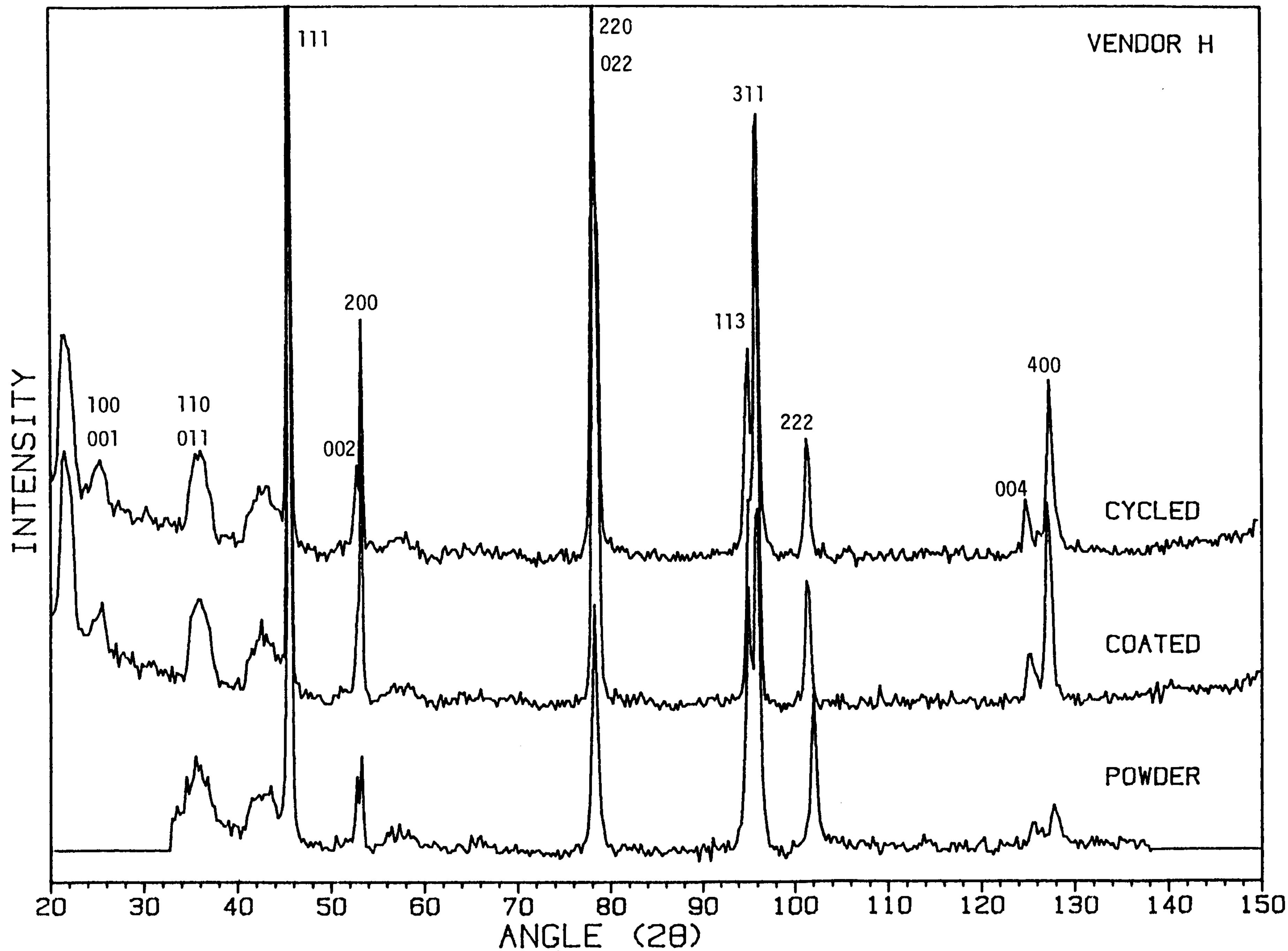


Figure 3. - XRD analysis of vendor H's TBC system.

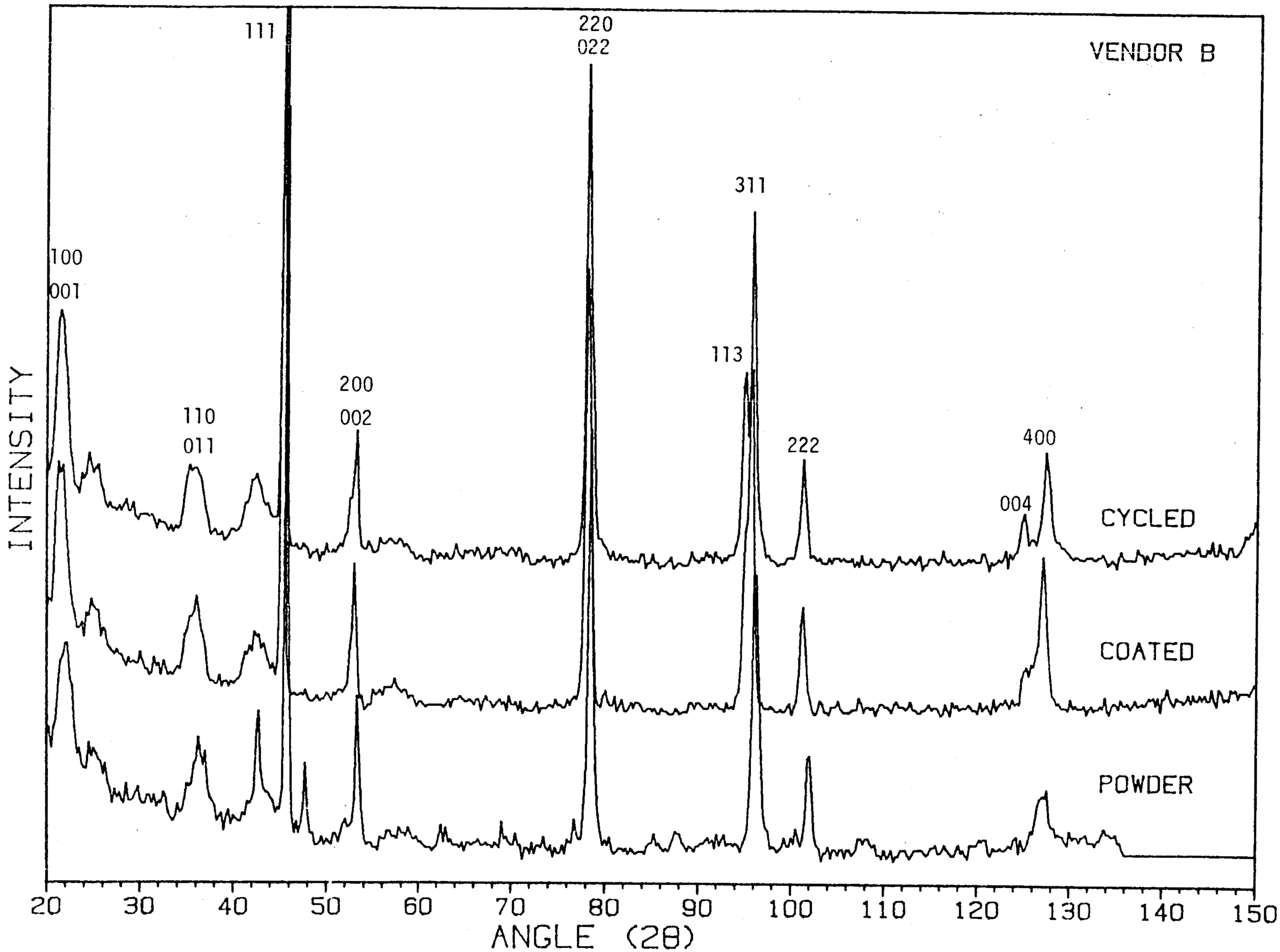
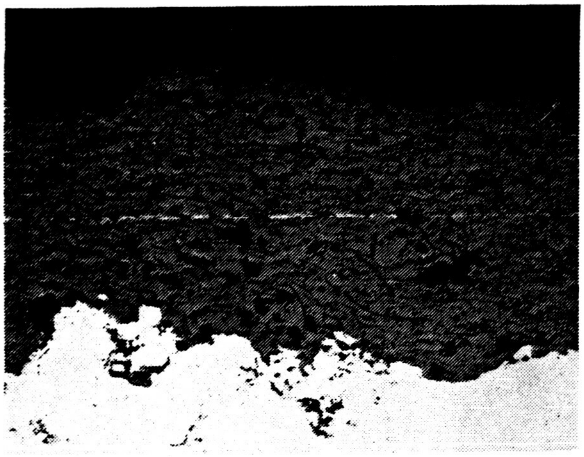
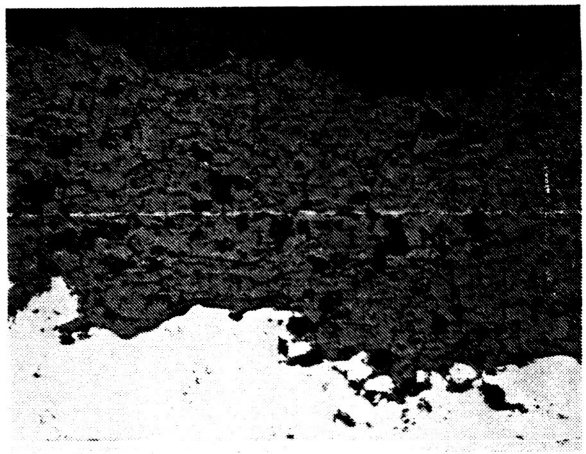


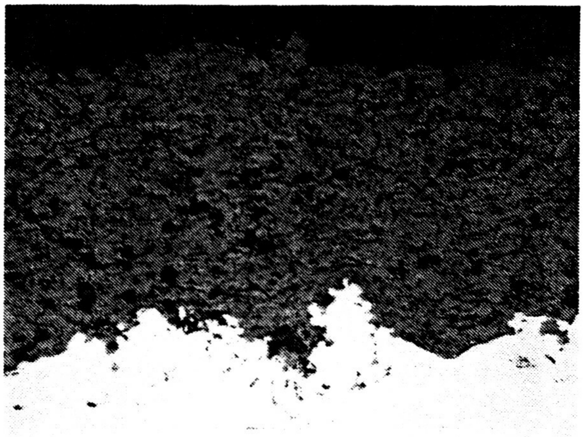
Figure 4. - XRD analysis of vendor B's TBC system.



Vendor J



Vendor B

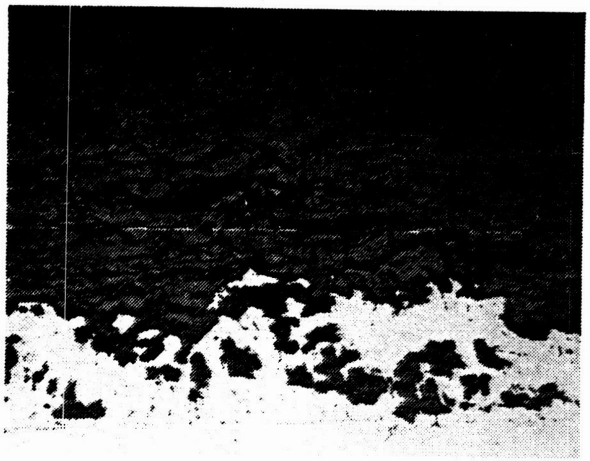


Vendor H

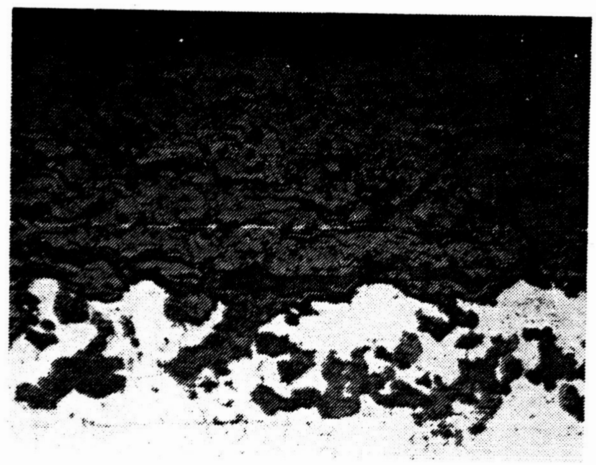
Figure 5. - Metallographic evaluation of as-sprayed TBC's.

ORIGINAL PAGE IS
OF POOR QUALITY

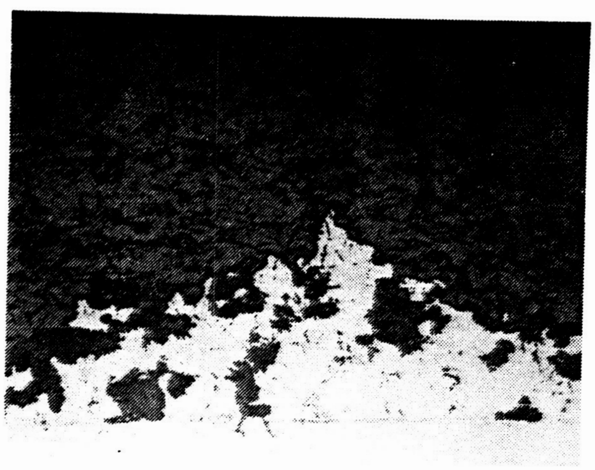
ORIGINAL PAGE IS
OF POOR QUALITY



Vendor J-285 Cycles



Vendor B-1000 Cycles



Vendor H-310 Cycles

Figure 6. - Metallographic evaluation of exposed TBC's.