Powder Metals

OVERVIEW

ATI Wah Chang is a producer of hafnium (Hf), niobium (Nb), and zirconium (Zr) metal products. These elements and their alloys are available in a variety of forms including (but not limited to): mill products, hydride and/or dehydride powders, ultra high purity products, and chemicals. ATI Wah Chang also produces tungsten-silver, tungsten-copper, molybdenum silver/copper infiltrated composites, which are produced either as machinable blanks or finished part configurations. ATI Wah Chang's products are utilized in aerospace, space, chemical processing, medical, recreational, electronic, military and nuclear applications worldwide.

Powder Characteristics

ATI Wah Chang produces powders from niobium, zirconium, and hafnium through the hydride-dehydride process. The metals, in various purities or alloys, are reacted to form brittle hydrides. The hydrides are crushed and classified to specific particle size ranges. For dehydride powders, the hydride is out gassed under vacuum yielding the original metal or alloy as a powder. Wah Chang has the capability for processing powder under inert gas through all operations to maintain material purity. Hydride and/or dehydride powder from the metals is angular and irregular in shape. The particular aspect ratio averages 2.5:1 with the distribution trailing off at approximately 5:1. The surface is of an angular and fractured nature but not porous. The powder is readily compacted to sufficient green strength and density for vacuum sintering and subsequent processing. The crushing process produces a full distribution or spectrum of particle sizes. This particle size distribution can be controlled to some degree via classification methods by removing upper and/or lower limits. However, as the fine and coarse limits come closer together the yield diminishes and the process cost increases. Powders are currently offered down to a -325 (44 µm) distribution. For any given particle size range a tolerance must be agreed upon in terms of the percentage of over/undersize acceptable. Sharp cut offs of the particular size distribution are not practical, however the distribution mean may be shifted in one direction or another. Differences between sieves of the same size will yield slightly different results as well. All of the powder products provided can sustain combustion but special care should be exercised with -200 and down mesh zirconium and hafnium powders (and hydrides) to avoid spontaneous pyrophoric reaction.

ATI Wah Chang | PO Box 460 | Old Salem Road NE | Albany, Oregon 97321
TOLL FREE: 888-926-4211 x6977 | PHONE: 541-967-6977 | FAX: 541-967-6994 | EMAIL: custserv@ATImetals.com | WEB: www.wahchang.com

TESTING METHODS

ATI Wah Chang performs sieve analysis for all powders. Oxygen, nitrogen, carbon and hydrogen are analyzed for all dehydride powders. Carbon analysis is not performed on hydrides. Wah Chang can provide a typical chemical analysis; however for all elements other than oxygen, nitrogen, carbon and hydrogen. Each individual element must be specified and a laboratory charge may apply. All desired tests other than standard sieve for particular size distribution must be specified and may incur an extra cost.

Table 1. Test Specifications

Screen Analysis	ASTM B-214
Flow Rate	ASTM B-213
Apparent Density	ASTM B-212
Tap Density	ASTM B-527

Hot Roll Consolidation

- ATI Wah Chang has extensive experience with hot roll, 100% density, consolidation of reactive metal powders.
- Maximum widths of 18" (45.72 cm)

Sintering

- Hydrogen atmosphere
- Up to 2200°C (3992°F)
- Sizes up to a one cubic foot envelope can be accommodated, however weight restrictions may limit part size.

Infiltration

- Hydrogen atmosphere
- Routinely used for copper and silver with tungsten/molybdenum matrix

Pressing

Cold Isostatic

- ATI Wah Chang has flexible containers up to 12" (30.48 cm) diameter accommodating 56" (142.24 cm) of fill depth.
- Pressures up to 25,000 psig

Mechanical

- Single and multiple station pill presses
- Up to 8" (20.32 cm) diameter, 100 ton

Hydraulic

- Up to 14" (35.56 cm) diameter, 2500 ton

PARTICLE SIZE/MESH SIZE COMPARISON

Table 2. Mesh Size vs. Opening Size

Mesh size US STD Sieve	Opening size (inches)	Opening Size (millimeters)	Opening Size (microns)
10	0.0787	2	2000
12	0.0661	1.679	1680
14	0.0555	1.41	1410
16	0.0469	1.191	1190
18	0.0394	1.001	1000
20	0.0331	0.841	841
25	0.0278	0.706	707
30	0.0234	0.594	595
35	0.0197	0.5	500
40	0.0165	0.419	420
45	0.0139	0.353	354
50	0.0117	0.297	297
60	0.0098	0.249	250
70	0.0083	0.211	210
80	0.007	0.178	177
100	0.0059	0.15	149
120	0.0049	0.125	125
140	0.0041	0.104	105
170	0.0035	0.089	88
230	0.0025	0.064	63
270	0.0021	0.053	53
325	0.0017	0.043	44
400	0.0015	0.038	37

(for reference only)

At any given time, not all products are available in all mesh fractions.

Tensile bolting cloth and market grade screens with various wire sizes will result in different opening sizes.

COPPER INFILTRATED TUNGSTEN

ATI Wah Chang manufactures tungsten-copper composition material in a nominal 90/10% composition. It is manufactured by pressing tungsten powder, sintering to form a strong matrix, and filling the pores by infiltrating with liquid copper. The resultant composite retains the toughness of the tungsten matrix while the copper affords machinability and excellent thermal and electrical properties.

ATI Wah Chang material has been used for rocket nozzle and thrust vectoring components since the 1960's due to its toughness and ability to withstand extreme shock and erosion at very high temperatures. Other uses for these materials include thermal heat sinks for electronics, demanding electronic contact applications, resistance welding and EDM electrodes. This product is distinguished from other manufacturers' tungsten-copper by a superior tungsten matrix and a very low porosity.

Table 3. Typical Properties

% Tungsten, by weight	89.1
% Copper, by weight	10.9
Density g/cm^3	17
Hardness, DPH, (10 Kg)	275
Elastic modulus in tension (dynamic) GPa	310
Tensile strength, MPa	550
Thermal conductivity, W/m°K (20°C)	194
Specific heat, J/g°K	0.16
Thermal expansion, 20-400°C, 10^{-6} /°C	6.6

Other compositions including W-Ag and Mo-Cu are also available on special order. Components and/or blanks are made to order, availability of material in stock is limited.

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HAFNIUM POWDER

ATI Wah Chang produces hafnium powder as per the general capabilities mentioned previously. The purities available are suited for either commercial or nuclear applications. Nuclear grade can be used to produce rate-control parts and various apparatus in nuclear electrical power generators as well as applications in nuclear fuel processing. Commercial grade forms a basis for various chemicals, sputtering targets, pyrotechnical applications, plasma spray coatings, and alloy additions. The table below gives a TYPICAL chemical analysis based upon nominal mesh sizes stated. Please refer to general powder capabilities and testing.

Table 4. Typical Chemical Analysis (Commercial)

Element	Nominal -100 x down	Nominal -325 x down
Carbon	< 150	< 150
Nitrogen	< 250	< 250
Hydrogen	< 250	< 250
Oxygen	< 2500	< 3500
Aluminum	< 100	< 100
Niobium	< 100	< 100
Copper	< 100	< 100
Iron	< 250	< 250
Tantalum	< 200	< 200
Tungsten	< 150	< 150
Zirconium	< 4.5%	< 4.5%

All elements are shown in ppm except zirconium. Other screen sizes are available on request.

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NOMINAL HAFNIUM POWDER TECHNICAL DATA

All elements are shown in ppm except zirconium. Other screen sizes are available on request.

Table 5. Typical Sieve Analysis

Nominal Mesh	20 Mesh Sieve	40 Mesh Sieve	60 Mesh Sieve	80 Mesh Sieve	100 Mesh Sieve	140 Mesh Sieve	200 Mesh Sieve	270 Mesh Sieve	325 Mesh Sieve	Pan
-lOOXdown					< 9	28	29	18	9	10
-325Xdown									< 9	> 91

Table 6. Density (g/cc)

Nominal Manufactured Mesh	Tap Density (for info only)
-lOOXdown	6.9
-325Xdown	5.3

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HAFNIUM HYDRIDE - TECHNICAL GRADE

Formula

$HfH_{1.6-2.0}$

Formula Weight

180.1-180.5

Description

A dull, grey-black powder.

Typical Analysis

ppm on hafnium metal basis except where noted

Table 7. Typical Chemical Analysis

Zr	Al	Fe	H	N	O	Si	Ti
< 4 %	50	100-250	1.0%	100	1500-3500	50	50

Normal Purity

99.8% $(Hf+Zr)H_x$

Particle Size

This powder is available in sizes from +20 mesh to -325 mesh, depending on customer requirements. Specific mesh size cuts may be available at an extra charge. Check for availability.

Bulk Density

250-340 lbs./ft^3

Packaging

Packaged under argon in sealed metal cans placed inside an outer steel container.

Handling

Hafnium hydride should be handled as a flammable solid whose ignitability increases with diminishing particle size. See MSDS for further information.

NIOBIUM POWDER

ATI Wah Chang produces niobium powder in two compositions: Grade 1 and Grade 2, with Grade 1 being low tantalum.

Applications for niobium powders include:

- High-temperature components, especially for the aerospace industry
- Alloy additions, including some for superconducting materials
- Plasma spray coatings
- Filters
- Certain corrosion-resistant applications

Call for technical assistance for your specific application.

Table 8. Typical Chemical Analysis (Commercial)

Element	Grade 1 -60 mesh	Grade 1 -325 mesh	Grade 2 -60 mesh	Grade 2 -325 mesh
Carbon	< 100	< 100	< 100	< 100
Nitrogen	60	150	60	150
Hydrogen	250	250	250	250
Oxygen	< 1500	< 3000	< 1500	< 3000
Aluminum	150	150	150	150
Iron	< 200	< 300	< 200	< 300
Silicon	< 100	< 100	< 100	< 100
Tantalum	< 1000	< 1000	< 3000	< 3000

Please refer to general powder capabilities and inquire about mesh sizes and alloys available.

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NOMINAL NIOBIUM POWDER TECHNICAL DATA

The following values are expressed as percent of sample retained upon test sieve of given mesh size.

Table 9. Typical Sieve Analysis

Nominal Mesh	20 Mesh Sieve	40 Mesh Sieve	60 Mesh Sieve	80 Mesh Sieve	100 Mesh Sieve	200 Mesh Sieve	325 Mesh Sieve	Pan
-20Xdown	< 9	25	28		16	13	5	7
-60Xdown			< 9	27	14	11	13	14
-200Xdown						< 9	51	45
-325Xdown							< 9	> 91

Table 10. Density (g/cc)

Nominal Manufactured Mesh	Tap Density (for info only)
-20Xdown	5.2
-60Xdown	4.9
-200Xdown	4.6
-325Xdown	3.9

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ZIRCONIUM POWDER

ATI Wah Chang produces zirconium powder in a variety of compositions: pure zirconium with < 2000 ppm hafnium; commercially pure zirconium with < 4.5% hafnium; and nuclear quality material. All powder is produced via the hydride/dehydride process from vacuum melt refined stock removing halogens, light metals, and other low boiling contaminants. All powders are available either as dehydride or hydride. Please refer to the general description of powder properties. All of these products are amenable to traditional powder metallurgy processes.

Aside from powder metallurgy manufacture of near net shape components, applications include but are not limited to:

- pyrotechnics
- gettering
- thermal spraying
- alloy additions
- proprietary compounds

Certain alloys are available upon inquiry. Some materials are involved in classified programs and require formal treatment of inquiries.

Table 11. Nominal Chemical Analysis (ppm Except Hafnium)

	Typical 99% plus	
	Pure Zirconium - 8Oxdown	Pure Zirconium - 325Xdown
Element		
Carbon	< 250	< 250
Nitrogen	< 150	< 275
Hydrogen	< 100	< 150
Oxygen	< 2500	< 3750
Chlorine	< 10	< 10
Magnesium	< 10	< 10
Hafnium	< 2000	< 2000
Iron+Chromium	< 1000	< 1000

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NOMINAL ZIRCONIUM POWDER TECHNICAL DATA

The following values are expressed as percents of sample retained upon test sieve of a given mesh size.

Table 12. Typical Sieve Analysis

Nominal Mesh	20 Mesh Sieve	40 Mesh Sieve	60 Mesh Sieve	80 Mesh Sieve	100 Mesh Sieve	140 Mesh Sieve	200 Mesh Sieve	275 Mesh Sieve	325 Mesh Sieve	Pan
-20Xdown	< 5	23	19		15		16		9	13
-80Xdown				< 5	12	29	18		17	19
-80/+325				< 5	19	38	26		11	2
-140/+325						< 5	38	37	18	3
-325Xdown									< 9	> 91

Table 13. Typical Hall Flow Rate

Nominal Mesh	Time (seconds)
-20Xdown	Does not flow
-80/+325	32
-140/+325	33
-325	Does not flow

Table 14. Nominal Density (G/CC)

Nominal Mesh	Apparent Density	Tap Density
-20Xdown	-	3.8
-80Xdown	-	3.1
80/+325n	2.7	3.4
140/+325	2.5	3.2
325Xdown	-	2.8

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ZR-MG GRAIN REFINER

Use:

ATI Wah Chang Zr-Mg is used as a grain refiner for magnesium, being an excellent source for zirconium. Zr-Mg will also reduce iron and aluminum levels in magnesium.

What it is:

Finely divided zirconium particles in magnesium with a small amount of magnesium chloride. The zirconium content is guaranteed to be a minimum of 60% by weight but is typically closer to 70%.

Table 15. Physical Data	
Boiling Point @ 760 mm Hg	Above 1000°C (1832°F)
Specific Gravity	Approx. 4
pH of Solutions	> 7 because of Mg being present
Freezing/Melting Point	Above 5OO°C (932°F)
Bulk Density	Approx. 100 lb/cu.ft.
Heat of Solution	Low
Odor	Odorless

Supplied as:

Loose chips at -1 inch +10 mesh in 55 gallon steel drums double poly bag lined and back-filled with argon with desiccant; weighing approximately 700 lbs. (317.5 kg) Can also be supplied as 1/4 lb. compacts. Special packaging is available upon request.

Table 16. Chemical Components In %	
Zirconium	50-60
Magnesium	40-50
Magnesium Chloride	1-5

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VACUUM GRADE FERRO-NIOBIUM

Table 17: Typical Chemical Analysis		
Element	Specification	Typical
Al %	< 1.0	< 0.75
C ppm	< 500	< 200
Cr ppm	< 500	< 200
Cu ppm	< 100	< 50
Mn ppm	< 500	< 300
N ppm	< 500	< 200
Nb %	> 60.0	> 63.0
Ni ppm	< 1000	< 250
O ppm	< 800	< 500
P ppm	< 200	< 150
Pb ppm	< 25	< 20
S ppm	< 200	< 150
Si ppm	< 2000	< 1500
Sn ppm	< 100	< 50
Ta ppm	< 3000	< 2000
Ti ppm	< 1000	< 500
As ppm	< 75	< 50
B ppm	< 50	< 10
Bi ppm	< 50	< 10
Sb ppm	< 75	< 50
W ppm	< 100	< 30
Zn ppm	< 100	< 50

Typical purity 63.5% contained Nb supplied chunks. Typical size 2" x down.

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