NIOBIUM

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In 2003, niobium raw material (mostly pyrochlore) production was 96.7 Mlb of contained niobium oxide. This is down 6.4% from 2002. The actual niobium content was 67.6 Mlb and 13.6% above actual shipments by processors. With production higher than processor shipments it appears that the supply chain is making an effort to stabilise supplies in anticipation of the continued recovery in the world economies. Processor shipments of niobium products were approximately 59 Mlb or an 11% increase over 2002. Shipments of ferro-niobium HSLA steels accounted for 88% of the total.

Niobium was first identified by Charles Hatchett, an English chemist, in 1801. It was originally named columbium, after Christopher Columbus, in honour of it being discovered in a mineral from America.

Niobium and tantalum are Group Vb elements. They exhibit similar properties and are related mineralogically, physically, and chemically. They always occur together in nature. Economic quantities of niobium are contained in pyrochlore and columbite, with small quantities obtained as a by-product from the processing of tantalite, tin slag and struverite. Pyrochlore is a niobium-rich mineral, low in tantalum content. Columbite can be processed directly into a ferro-niobium-tantalum alloy with a 10:1 to 12:1 ratio of niobium to tantalum. Columbite is also processed via solvent extraction chemistry to separate the niobium from the tantalum prior to conversion into finished products ranging from vacuum-grade ferro- and nickel-niobium to niobium chemicals (primarily niobium oxide and carbide), pure metal and alloys.

Niobium is used in a wide variety of applications. The largest amount of niobium is use for the strengthening of HSLA (high strength, low alloy) steels. The largest end market is for large diameter steel pipelines for the transmission of natural gas and oil. HSLA steel is also used in the manufacture of automobiles and trucks. These include frames, wheels and structural members. Price increases in oil and natural gas, during the year, created new interest in exploration and transmission of these energy sources. Thus, there are increases in demand for energy transmission pipelines. HSLA grade steel is also used in the production of micro-alloyed steels for structural applications. The US and Europe consume about 73% of the total HSLA ferro-niobium production.

The world's largest deposit of pyrochlore is located at Araxá, in the state of Minas Gerais (MG) in Brazil. This open-pit mine is operated by Companhia Brasileira de Metalurgia e Mineração (CBMM), which supplies about 70% of the world demand for niobium products. This mine contains 460 Mt of ore averaging 2.5% niobium oxide.

In December 2003, CBMM commissioned two new manufacturing plants in its industrial complex in Araxá. The first project involved the installation of a new electron-beam furnace that will increase CBMM's niobium metal manufacturing capacity to 210 t/y. CBMM has also started to operate a new facility to manufacture vacuum grade niobium masteralloys: nickel-niobium, ferro-niobium, and niobium-aluminum. The new plant is outfitted with manufacturing equipment that has increased the annual production capacity of vacuum grade niobium masteralloys by 2,000 t.

The world's second-largest producer of pyrochlore is Anglo American Brazil's subsidiary, Mineração Catalão de Goiás (MCG), which operates the Catalão mine in Brazil. This deposit is similar in geology to the Araxá deposit, and has a niobium oxide content of 1.34% in run-of-mine ore. Physical processing, coupled with flotation, is used to upgrade the pyrochlore mineral to a nominal 57% niobium oxide concentrate. Conversion results in a production of about 3,600 t/y of HSLA-grade ferro-niobium.

The third significant pyrochlore operation is located at the Niobec mine in northeastern Quebec, Canada. The mine is operated as a joint venture between Cambior, a gold producer, which is responsible for the marketing activities of the joint venture, and Sequoia Minerals Inc, which is responsible for operation of the mine and production of ferro-niobium. The mine is the only producer of niobium in North America. The mining capacity is 3,000 t/d of ore, and the mine has at least 18 years of operation at the current mining rate.

Metallurg has been processing niobium and tantalum minerals and slags from its MIBRA mine near São João del Rei in Rondonia State in Brazil and from mineral concentrates acquired from local producers as well as sources external to Brazil.

The Pitinga tin mine in the Amazonas region of Brazil is operated by Mamoré Mineração e Metalurgia of the Paranapanema Group. The ore is processed into a cassiterite concentrate (tin recovery) and a cassiterite-columbite concentrate is processed into ferro-niobium-tantalum alloy. The alloy has an assay of 50% niobium and 5% tantalum.

As noted, it is estimated that 2003 production of raw materials was 96.7 Mlb of contained niobium oxide or the equivalent of 67.6 Mlb of niobium. (Table 1)

Processors

The facilities for producing ferro-niobium also produce high-purity niobium oxide (150 t/y) which is the feedstock for the production of vacuum grade ferro- and nickel-niobium and high purity niobium metal, the latter being produced via the direct aluminothermic reduction of the oxide followed by electron beam melting of the resultant ingots.

The major processors of tantalite, columbite and other niobium source materials are HC Starck, Cabot Supermetals, Mitsui Mining and Smelting, Ningxia Non-ferrous Metals Co and other smaller companies. Separation of

the two metals is achieved by solvent extraction and the metals have impurity levels in the parts per million range. These companies generally manufacture niobium and niobium chemical products of the highest purity for applications as optical grade oxides. Other niobium metal or vacuum-grade ferro- or nickel-niobium purity requirements demand exceedingly small percentages of low-temperature melting point elements, such as lead, tin, and zinc when used as an additive for the manufacture of certain alloys in aircraft applications. This segment of the industry generally focuses on niche applications requiring high-value products.

Other companies involved with the processing of niobium raw materials and production of chemicals, niobium metal and various alloys are A S Silmet, Wah Chang, Osram Sylvania, Zhuzhou Cemented Carbide Works, and Reading Alloys.

The shipments for all niobium-containing products totalled 59.5 Mlb (niobium contained) in 2003 (Table 2).

Uses

Niobium is a key element in the superconducting wire market. Niobium/titanium alloy is used as the primary material in the construction of the magnetic coils for Magnetic Resonance Imagery (MRI) equipment utilised in medicine for the detection of anomalies in soft tissue.

Niobium chemicals, primarily niobium oxide, are used in a wide variety of applications including high refractive index lenses, high dielectric, multilayer ceramic capacitor formulations; and in the manufacture of lithium niobate for Surface Accoustic Wave (SAW) filters, commonly used in electronic circuitry. Niobium carbide is used in the manufacture of cutting tools and in wear-resistant applications. With the advent of digital photography, oxides for lenses and electronic applications are growing by nearly 20% annually. The major market for SAW filters is in cell phones, and production of cell phones in 2003 totalled 470 million.

The vacuum-grade ferro- and nickel-niobium are used in the production of nickel-based superalloys where compositions range from 1% to 5% niobium. These alloys are used in aerospace and aircraft turbines, with land-based turbines also consuming significant quantities of niobium. The total amount of niobium consumed by this segment in 2003 was 6.0 Mlb.

End-market products made from pure metal and wrought forms of the pure metal, such as sheet, rod, and tubing, are utilised in applications such as corrosion-resistant equipment, sputtering targets, and cathodic protection systems. This segment consumed about 600,000 lb in 2003.

In the past two years, pure niobium powder has been developed for use in capacitors as a replacement for tantalum in specific circuitry requirements. The market is still deciding whether niobium or niobium oxide will be the anode material for the capacitors. In 2003, there are capacitor makers who have received positive feedback about the properties of niobium capacitors.

Although they may be initially limited to lower (10-volts and less) voltage applications, the technology is still new and will expand as more development work is funded. It is still unclear how much of the tantalum capacitor market will be substituted by niobium capacitors. The major breakthrough could come when niobium capacitors become a substitute for some aluminum or ceramic capacitors.

Pricing

There are no published prices for pyrochlore concentrates. These concentrates are consumed by those companies that mine and upgrade pyrochlore. Niobium-bearing minerals and products are not traded on the London Metal Exchange. The Tantalum-Niobium International Study Center has no knowledge or comment concerning any published prices of these mineral concentrates or the accuracy of that information should it become available.

Table 1: Niobium raw material production 2000 to 2003 (Mlb of contained niobium oxide)

	2000	2001	2002e	2003e
Pyrochlore and columbite concentrates	72.5	98.9	102.4	96.0
Tantalite, Struverite, tin slag	1.2	1.5	0.9	0.7
Total	**73.7**	**100.4**	**103.3**	**96.7**

Due to unusual circumstances with the TIC data, the 2002 and 2003 data are estimates.
Source: Tantalum-Niobium International Study Center.

Table 2: Niobium processor shipments (Mlb of contained niobium)

	2000	2001	2002e	2003e
Chemicals, VG FeNb, NiNb	6.3	6.7	4.9	6.0
Wrought Nb, Nb alloys as mill products, powder, ingot, and scrap				
Pure niobium	0.5	0.6	0.5	0.6
Alloys as NbTi, NbZr, NbCu	1.2	0.7	0.8	0.9
HSLA-grade FeNb	44.9	49.3	46.9	52.0
Total	**52.9**	**57.3**	**53.1**	**59.5**

Due to unusual circumstances with the TIC data, the 2002 and 2003 data are estimates.
Source: Tantalum-Niobium International Study Center.