

NIOBIUM

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In 2004, worldwide production of niobium raw material (mostly pyrochlore) reached 101.7 Mlb of contained niobium oxide (Nb_2O_5). This is a 13.5% increase from 2003 and is about equal to the volume in 2001. The data reported in Tables 1 and 2, for 2002, 2003 and 2004 are reported data from the members of the Tantalum-Niobium International Study Center (TIC) and are revisions of the estimated data published in 2004. The actual niobium metal content of the raw materials was 71.1 Mlb, which is approximately equal to the 72.4 Mlb of niobium processor shipments, indicating that mine production and processor shipments are in equilibrium.

Niobium products are used in a wide variety of applications. The largest end market for HSLA steel is for large diameter steel pipelines for the transmission of natural gas and oil. Price increases in oil and natural gas during the year have created a new interest in exploration for, and transmission of, these energy sources, hence there is increased demand for energy transmission pipelines. HSLA steel is also used in the manufacture of frames, wheels and structural members for automobiles and trucks. HSLA-grade steel is 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.

History

Niobium was identified in 1801 by Charles Hatchett, an English chemist. 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 that 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, complex mineral of calcium and sodium. It also contains iron, titanium, rare earths and other elements, but is low in tantalum. Columbite, which is a niobate of iron and manganese, 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.

Primary producers

The world's largest deposit of pyrochlore is located at Araxá, in Minas Gerais State, Brazil. This open-pit mine is operated by Companhia Brasileira de Metalurgia e Mineração (CBMM), and supplies between 65% and 70% of the world demand for niobium products. The Araxá deposit contains 460 Mt of reserves averaging 2.5% niobium oxide.

In December 2003, CBMM commissioned two new manufacturing plants in its industrial complex at Araxá. The first project involved the installation of a new electron-beam furnace to increase CBMM's pure niobium metal manufacturing capacity to 210 t/y. The furnace can produce ingot up to 38-cm in diameter. CBMM has also started to operate a new facility to manufacture vacuum-grade niobium masteralloys: nickel-niobium, ferro-niobium, and niobium-aluminium. The new plant is fitted with manufacturing equipment that has increased the annual production capacity of vacuum-grade niobium masteralloys by 2,000 t. This accounts for about 8 to 9% of the output of niobium. CBMM also has medium-term plans to increase production capacity of all niobium products from 50,000 t to 70,000 t/y.

The world's second-largest producer of pyrochlore is Anglo American's Mineração Catalão de Goiás (MCG), which operates the Catalão open pit mine in Brazil. This deposit is similar in geology to the Araxá deposit, with a niobium oxide content of 1.34%. It is estimated that the mine has proved reserves of 15.4 Mt. 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 3,500 t/y of HSLA-grade ferro-niobium. Anglo American's market share is estimated to be between 14 and 18%.

The third significant mining operation is Niobec in northeastern Quebec, Canada. This mine contains both pyrochlore and columbite. In 2004, Cambior Inc acquired the remaining 50% of the Niobec mine from Mazarin Mining Corp Inc and now owns 100%. The mine is the only producer of niobium in North America and produces between 12% and 14% of the world's supply of niobium in the form of ferro-niobium. The mine has reserves of 24.3 Mt averaging 0.66% Nb₂O₅, sufficient for a mine life of 18 years at the current rate of production.

Two other operations, Metallurg and Mamoré, when taken together, produce less than 10% of total niobium supply. Metallurg/Cia Industrial Fluminense has been processing niobium and tantalum minerals and slags from its Mibra mine near São João del Rei in Rondonia State, Brazil, from mineral concentrates acquired from local producers and outside Brazil. Mamoré Mineração e Metalurgia, a member of the Paranapanema Group, operates the Pitinga tin mine in the Amazonas region of Brazil. The ore is processed into a cassiterite-columbite concentrate (for tin recovery) and the columbite-containing slag is processed to yield a ferro-niobium-tantalum alloy containing 50% niobium and 5% tantalum.

Mamoré has increased its production from tin slag as a result of the increase in demand for tin.

Table 1

Niobium raw material production 2002-04
 ('000 lb of contained Nb₂O₅)

	2002	2003	2004
Pyrochlore and columbite concentrates	102,355	88,810	100,863
Tantalite, struverite, tin slag	924	832	879
Total	103,279	89,642	101,742

Source: Tantalum-Niobium International Study Center

Processors

Most facilities that produce ferro-niobium also produce high-purity niobium oxide which is the feedstock for the production of vacuum-grade ferro- and nickel-niobium and high-purity niobium metal. High-purity metal is produced via the direct aluminothermic reduction of the oxide followed by electron beam melting of the resultant ingots. The major processors of niobium products made from ingot, oxide or as a by-product of their tantalum business include: CBMM, Wah Chang, H C Starck, Cabot Supermetals, Mitsui Mining and Smelting, Silmet AS, Osram Sylvania, Zhuzhou Cemented Carbide Works, Reading Alloys and Ningxia Non-ferrous Metals Co. CBMM is an integrated producer whose operations go from mining to finished materials.

Processor shipments

Processor shipments of niobium products increased to 72.4 Mlb in 2004, an increase of 13.3% from 2003. Shipments of ferro-niobium for high strength, low alloy (HSLA) and stainless steels, which are the largest application, accounted for 89% of the total processor shipments. HSLA consumes about 75% and stainless steel the remainder of the niobium produced.

Table 2**Niobium processor shipments
(’000 lb of contained niobium)**

	2002	2003	2004
Chemicals,	2,797	3,200	3,376
Vacuum Grade FeNb, NiNb	2,037	1,995	2,872
Pure niobium mill product, ingot, power and scrap	614	1,050	1,001
Alloys as NbTi, NbZr, NbCu	758	874	673
HSLA-grade FeNb	50,660	56,809	64,455
Total	56,866	63,928	72,377

Source: Tantalum-Niobium International Study Center

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. The development of open MRI equipment has made the equipment more comfortable for patients.

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 acoustic wave (SAW) filters, commonly used in electronic circuitry. The major market for SAW filters is in cell phones. With the advent of digital photography, oxides for lenses and electronic applications are growing at nearly 20% annually. A very new application for niobium chemicals is with catalytic conversion of palm oil into biodiesel fuels. This fuel is environmentally friendly as it reduces the emission of carbon dioxide from combustion engines. Niobium carbide is used in the manufacture of cutting tools and in wear-resistant applications.

Vacuum-grade ferro- and nickel-niobium are used in the production of nickel-based superalloys where compositions range from 1% to 5% Nb. 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 2004 was 2.9 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 1.0 Mlb in 2003 and 2004, an increase of more than 60% over 2002.

In the past four years, pure niobium and niobium oxide powders have been developed for use in capacitors as a replacement for tantalum in specific circuitry requirements. At this point, all of the capacitors being marketed are made with niobium oxide. Although they may be initially limited to lower voltage (10-volts and less) 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 aluminium or ceramic capacitors.

Pricing:

There are no published prices for pyrochlore concentrates. These concentrates are consumed in-house by those companies that mine and upgrade this mineral. Niobium-bearing minerals and products, such as ferro-niobium, are not traded on the London Metal Exchange. The TIC has no knowledge or comment concerning any published prices of these mineral concentrates, or the accuracy of that information should it become available.