TANTALUM

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Tantalum was discovered by Anders Gustaf Ekeberg, a professor at Uppsala University in Uppsala, Sweden. He found this new element by analysis of a tantalite sample from Kimoto, Finland and an yttrotantalite from Ytterby, Sweden. The name tantalum for this element was derived from Tantalus, the son of Zeus in Greek mythology, due to the 'tantalising' difficulty of defining the chemical nature and other properties of the element. Numerous researchers attempted to isolate the element, but without success until the fractional crystallisation process of complex fluorides of tantalum and niobium provided the necessary separation clarity. The metal was produced in sufficient purity in the early 1900s which allowed the first commercial use as the filament in incandescent light bulbs.

Today the major use for tantalum is as the anode in a solid-state capacitor. The early 1940s saw the development of a wet capacitor using a rolled tantalum foil anode and cathode separated by a paper barrier in a metal container of gelled sulphuric acid. Later developments produced the manganese dioxide counter electrode that eliminated the leakage hazard associated with previous designs. The capacitor was designated as a 'solid' capacitor instead of a 'wet'. These capacitors were 'through hole' designs which generally required manual insertion for soldering to the circuit board. The chip capacitor design of the early 1980s and its many variations today permitted mass production of these devices via automated manufacturing technology.

The widespread use of tantalum capacitors in modern circuitry is accomplished by 'pick and place' equipment for positioning each capacitor on the circuit board. Tantalum capacitors are found in cellular phones and their support structure such as substations, also computers, especially laptops where space is at a premium, automotive control systems such as the ignition, motor control, airbag, and automatic braking (ABS) systems, medical appliances such as hearing aids and pacemakers, digital video and still cameras, and military electronics.

The capacitor applications involve the use of capacitor-grade tantalum powder which averaged about 50% of the total annual tantalum shipments during the five years prior to 2000. An additional quantity of tantalum is consumed as tantalum wire which serves as the lead wire for the tantalum anode in the capacitor. For each 1,000 lb of powder, approximately 140 lb of wire is needed. A smaller quantity of tantalum is required as components of anode sintering furnaces in the form of trays, heat shields, thermocouple wells and fasteners.

In 2000 and 2001, the tantalum powder shipments alone reached 61% of the total amount of tantalum shipped by processors. The ratio of powder shipments to total shipments by processors in 2002 fell back to about 44%, indicating that a significant correction was in progress in the capacitor industry.

Tantalum finds use in high-temperature alloys for both air and sea-based propulsion systems, as well as land-based turbines for power conversion. The metal and oxide are used as sputtering targets for the 'laying down' of a very thin film of tantalum metal, oxide, or nitride. Tantalum is used for the fabrication of corrosion-resistant equipment for chemical processing. Tantalum oxide is used in high refractive index optics, ceramic capacitor formulations, and in surface-acoustic-wave filters (lithium tantalate) in electronic circuitry. Tantalum carbide is used in cemented carbide formulations for cutting tools.

Medical applications are based on the total inertness of the metal to body fluids, a property which permits its use in hip and knee replacement fixtures as a 'sponge-like' material that supports bone growth, as well as in plates, screws and surgical clips.

Total tantalum shipments in 2002 (estimated) show an 11% decrease from the total tantalum shipments in 2001, although there is an uptrend with the second half of 2001 being the low point in the data. The total demand in 2002 was approximately 3.1 million pounds of tantalum, down from 3.4 Mlb the previous year. The 2001 shipments were influenced by a relatively strong demand during the first six months.

The perceived shortage for the metal created runaway demand for tantalum in 2000, which caused excessive buying (double and triple ordering) particularly in the capacitor segment, which in turn transferred into the other segments as purchasing managers noted the increase in delivery times and prices for normal product requests. This apparent demand cascaded down through the manufacturing chain to raw materials. Most raw materials are obtained through long term contracts, but the panic buying caused a surge in prices in the spot market, on which the remainder of the ore requirements are sold. It did not take very long for the buyers and sellers to realise that **there was no shortage**. Raw material prices plummeted, and today, have recovered to more historical levels.

Since the tantalum capacitor market consumes about 60% of the total demand, it is this segment in particular and the electronics industry in general that needs to rebound to cause the demand for tantalum to reach historical growth rates of 8 to 10% per year. The recovery seems to be in progress.

Production

Tantalum ores are found primarily in Australia, Brazil, central Africa, Canada and China.

The largest tantalum-mining operations in the world are the Greenbushes and Wodgina mines in Western Australia, owned and operated by Sons of Gwalia. Published reports show that the output of tantalite from the combined operation of these two mines was 2.6 Mlb of tantalum oxide in 2002 compared to 1.8 Mlb in 2001. This is an increase in production of 44%! Expansions at both mine sites were completed during 2002. A recent announcement by Sons of Gwalia states that production will be reduced in 2003 by 200,000 lb of tantalum oxide due to the industry downturn. The reduction will occur at the Greenbushes mine while operations at Wodgina will increase from 1.2 to 1.4 Mlb on an annualised basis.

Haddington International Resources is producing concentrates from its Bald Hill facility in Western Australia, with a reported annual production of about 150,000 lb of tantalum oxide. The Haddington production is included in the Gwalia production numbers.

The Tanco mine in Manitoba Province, Canada, has an annual capacity of about 150,000 lb of tantalum oxide. It has been in operation since 1970 and is owned by Cabot Corporation. Output is expected to continue for about 10 years based on current reserves. It is a hard-rock underground mine.

The Kenticha mine in Ethiopia continues to be owned and operated by the Ethiopian Government with production of about 120,000 lb/y of tantalum oxide. The output is sold by open tender to the highest bidder. Concentrate production is accomplished by simple gravity-based washing techniques on weathered pegmatite and alluvial ore.

The MIBRA mine, located near São João del Rei in Rondonia State in Brazil, is owned by Metallurg International Resources. Production is about 100,000 lb/y. This company has facilities at Fluminense in the same area for processing the ore and extracting tantalum oxide, not only from the MIBRA mine, but also from other small local mining operations, as well as from tin slag generated by the smelting of tin ores.

Mamoré Mineração e Metalurgia of the Paranapanema Group operates the Pitinga tin mine in the Amazonas region of Brazil. This mine produces a cassiterite-columbite middling product, which is converted into a ferro-niobium-tantalum alloy. The alloy is further processed as a raw material source for tantalum and niobium. The 5% tantalum content contributes about 220,000 lb/y to tantalum raw material supplies. Large stockpiles of tin slag at the Mamoré smelter are estimated to contain some 5 Mlb of tantalum oxide at a concentration of 1.6%. Processing difficulties have prevented utilisation of this low-grade source in the past.

The Yichun mine in central China continues to produce, with a capacity of at least 120,000 lb/y of tantalum oxide. Additional production in China is available from the Limu tin mine in Quangxi Province, the Ma Ar Kan lithium mine in Sichuan Province, and Keketouhai in the Altai Region.

Central Africa contains significant tantalum resources, with the most notable being located in the Democratic Republic of the Congo (DRC), Rwanda, Burundi, Uganda, Nigeria, Namibia and Mozambique. The civil and political unrest in central Africa, particularly in the area of the DRC, Rwanda, and Burundi over the past few years, has created a very unattractive situation for financial investment. Investigations by the United Nations into illegal mining activities by renegade militia, and difficulties in governing the region, have led to a drastic reduction in mining activity, not only for tantalite, but other mineral concentrates as well. Numerous organisations, including the membership of the Tantalum-Niobium International Study Center (TIC), continue to support the efforts of the United Nations and others to bring a stop to these illegal activities.

Concentrates became available from Mozambique during the year as the Marropino mine began production with an initial target of about 120,000 lb/y of contained tantalum oxide. Fleming Family & Partners is the major shareholder.

Numerous tantalum mineralisation projects have been examined for their economic potential and production of tantalum concentrates. The most prominent, due to their potential size, are the Abu Dabbab tantalite project (Gippsland Ltd, 50:50 with the Egyptian Geological Survey & Mining Authority) on the western shore of the Red Sea in Egypt, and the Ghurayyah project (Tertiary Minerals plc) in Saudi Arabia.

The Abu Dabbab deposit has been reported to contain a measured resource of 12 Mt at 274 g/t of tantalum oxide (7.25 Mlb) and an inferred resource of 13.7 Mlb of tantalum oxide. The ratio of tantalum oxide to niobium oxide is about 2.2:1. A feasibility study is scheduled for completion in 2003.

The Ghurayyah deposit has an inferred resource of 385 Mt at 245 g/t of tantalum oxide and 2,840 g/t of niobium oxide. Development of this deposit will probably be dependent on securing a market for the niobium content.

Numerous smaller projects are under consideration in Canada, Greenland, Bolivia, Brazil, Australia, Finland, and elsewhere. However, none of these potential mineral concentrate production sites is expected to be fully developed and put into production until a positive direction is indicated concerning the return to normal growth patterns for tantalum products, especially those associated with electronic applications.

A summary of tantalum raw material production is shown in Table 1.

It should be stated that the data in Table 1 do not include tantalum raw materials that were purchased by processors from companies that are not members of the TIC. These sources are reported to the TIC through the category of ‘Processor Receipts’ which also include the purchase of any tantalum-containing material that is destined for processing through ‘re-purification’ systems. These data are shown in Table 2, with tin slag and all tantalum minerals consolidated in one category.

The Processor Receipts are virtually equivalent to the tantalum oxide units shown as Raw Material Production. These data normally include mineral concentrate purchased from sales by the Defense National Stockpile Center (DNSC) in the US, as well as mineral concentrates purchased from non-TIC members. There were no sales of mineral concentrate by the DNSC during 2002. The only tantalum sales were 19,500 lb (contained tantalum) of tantalum metal, vacuum grade.

Consumption

The major processors of tantalum raw materials are H.C. Starck, Cabot Supermetals, Ningxia Non-Ferrous Metals Smelter, Metallurg International Resources, Mitsui Mining and Smelting Co., Ltd, and NAC Kazatomprom. There are also companies in China that are processing ores and slags for conversion into chemicals. The processing companies generally manufacture a variety of chemicals, powder, ingot and alloys.

The worldwide demand for tantalum powder for capacitor applications dropped from 3 Mlb to 1.65 Mlb comparing 2000 and 2001 shipments. An additional drop in demand during 2002 resulted in shipments that are *estimated* at 1.36 Mlb, with an upturn reported during the second half of 2002. Tantalum ingot shipments are down due primarily to cancellation of orders for aircraft engines and cancellation or delay of orders for land-based turbines for the generation of electricity. Other segments of the processor shipment categories were similarly affected, the only exception being the mill products area where an increase is noted based on *estimated* data (Table 3)

There is evidence that excess inventories continue to exist in the manufacturing pipeline, but it is anticipated that any remaining inventories should be worked out of the system during 2003. The telecommunications industry has projected that global cell phone demand will increase by 9.7% during 2003 based on expectations of an improvement in the global economy. This translates into a demand for 434 million phones, up from 396 million in 2002.

Pricing

Tantalum-bearing materials are not traded on the London Metal Exchange. Also, there are no published prices for tantalum or tantalum chemicals. The only pricing information that is published is a reference to tantalite mineral concentrates in *Metal Bulletin*. The TIC has no knowledge or comment concerning the accuracy of these published figures.

Tantalum mineral concentrates are sold on a price per pound of contained tantalum oxide content, not on the total weight of concentrate itself. The price per pound of contained tantalum oxide is influenced by the tantalum oxide concentration, with lower grades sold at a lower price per pound of tantalum oxide than high-content grades, because of additional cost in refining these lower grade materials.

The larger processors of tantalum-bearing materials generally purchase a significant quantity of their requirements through negotiated long-term contracts with those companies that are producing such material on a continuing basis. Additional material is available from small to medium mining operations where production of the mineral concentrate is intermittent and offered via periodic tender, with the sale going to the highest bidder or obtained through negotiation. Generally, traders will collect and consolidate the output from artisanal and small mining operations and offer it for sale to processors.

The pricing of tantalum chemicals, metal powders, alloys, and fabricated articles is generally established by negotiation between buyer and seller. Specifications for a particular chemical, metal powder, or fabricated article of metal or tantalum alloy are dictated by the application. Specifications, their influence on processing requirements, and the volume of a specific product, all influence the prices negotiated between buyer and seller.

Table 1. Tantalum Raw Material Production,
1999 – 2002 (Mlb contained tantalum oxide – 2002 data estimated)

	1999	2000	2001	2002e
Tantalite, columbite, struverite, others,	2.390	2.594	2.920	2.978
Tin slag, >2% tantalum oxide	1.717	1.722	0.802	0.421
Totals	**4.107**	**3.317**	**3.722**	**3.399**

Source: Tantalum-Niobium International Study Center (TIC)

Table 2. Processor Receipts, 1999-2002
(Mlb contained tantalum oxide – 2002 data estimated)

	1999	2000	2001	2002e
Tantalite, columbite, struverite, tin slag	3.216	4.278	5.397	2.439
Secondary materials, scrap, Ta_2O_5, K-salt	1.202	1.498	2.068	1.024
Totals	**4.418**	**5.776**	**7.465**	**3.463**

Source: Tantalum-Niobium International Study Center (TIC)

Table 3. Tantalum Product Shipments, 1999-2002
(Mlb contained tantalum – 2002 data estimated)

	1999	2000	2001	2002e
Ta_2O_5, K_2TaF_7 Chemicals	0.248	0.324	0.378	0.320
Tantalum ingot	0.320	0.282	0.307	0.275
Carbides	0.281	0.387	0.436	0.315
Capacitor powder	2.234	2.997	1.654	1.360
Mill products	0.566	0.729	0.476	0.530
Metallurgical powder, unwrought metal, scrap	0.178	0.208	0.191	0.300
Total	**3.827**	**4.927**	**3.442**	**3.100**

Source: Tantalum-Niobium International Study Center (TIC)