# TANTALUM

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In 2003, it is estimated that the overall tantalum market, as represented by members of the Tantalum-Niobium International Study Center (TIC), grew at the rate of about 7%. The largest increase was in tantalum powder supplied to the tantalum capacitor manufacturers which grew by nearly 19% (Table 3). Tantalum supplied to capacitor makers is the largest end market for tantalum materials. Units of tantalum capacitors grew by 18%. Over the past three years, the average size of tantalum capacitors has dropped from about 50 mg/unit to about 30 mg/unit. This is a reflection of the smaller-size capacitors in demand in the electronic end markets. This size reduction is due to lower voltages, lower powder requirements and new circuit designs. Inventories of tantalum and tantalum-containing materials in the electronic supply chain decreased during the year. It is believed, except for some isolated instances, inventories are approaching desired levels. The market for tantalum mill products and ingot did not grow from 2002 to 2003, but there were increases in the sputtering target and chemical process segments.

Tantalum was discovered by the Swedish researcher, Anders Gustaf Ekeberg. He found this new element by analysis of a tantalite sample from Kimoto, Finland, and an yttro-tantalite from Ytterby, Sweden. The name tantalum was derived from Tantalus, the son of Zeus in Greek mythology, because of the 'tantalising' difficulty of defining the chemical nature and other properties of the element. Numerous researchers attempted to isolate the element without success until the fractional crystallisation process of complex fluorides of tantalum and niobium provided the necessary separation clarity. The first commercial use was the incandescent light-bulb filaments in the early 1900s.

## Uses

The major use for tantalum remains the anode in a solid-state capacitor. In the early 1940s, the wet capacitor was developed with a rolled tantalum foil anode and cathode separated by a paper barrier in a metal container of gelled sulphuric acid. Later, a manganese dioxide counter-electrode was developed that eliminated the leakage hazard associated with previous designs. The capacitor was designated as a 'solid' capacitor instead of a 'wet' capacitor. In the past four years, the development of a conductive polymer counter-electrode has resulted in tantalum capacitors with very low equivalent-series-resistance. This gives longer battery life in mobile applications and yields higher capacitance at higher frequencies.

Early capacitors were made with lead wires extending from the capacitor. This required manual soldering to the circuit board. In the early 1980s, chip capacitors were developed to take advantage of the many electronic designs that required smaller sizes (footprints) and high-speed insertion on the circuit board. The widespread use of tantalum capacitors in modern circuitry is due to the capacitors' high reliability, high capacitance in a small volume, and good temperature stability at the ranges currently required by modern electronic applications. Tantalum capacitors have become the standard in the new multifunction cell phones, wired and wireless infrastructure for mobile telephony, laptop and mobile computers, and other applications where space is limited and high performance is required. Tantalum capacitors are also used in 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 high reliability military electronics.

Capacitor applications use capacitor-grade tantalum powder and wire. The combined amount accounts for nearly 60% of the total tantalum shipped during 2003. For each 1 lb of powder used, approximately 0.2 lb of wire is used. Smaller amounts of tantalum are required in equipment for sintering anodes: furnace trays, heat shields, thermocouple wells and fasteners. The trend to lower sintering temperatures has allowed some capacitor manufacturers to substitute less expensive metals for tantalum in these applications.

In 2003, the TIC estimates that tantalum powder shipments, alone, reached 49% of the total amount of tantalum shipped by processors. This was an increase from 44% in 2002. Most of this change over the past three years has come from inventory changes and not so much from the end-market mix. New technology in semiconductor manufacturing has given sputtering targets made from tantalum a more significant role. The metal and oxide are used as sputtering targets for depositing a very thin film of tantalum metal, oxide, or nitride on the substrate. When considering applications for both oxides and metal, the electronic supply chain will consume as much as 65% of the tantalum products sold. The percentage could go higher as the electronic market resumes its more traditional growth rates.

Tantalum is used in high-temperature alloys for both air and sea-based propulsion systems as well as land-based turbines for power conversion. 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 cutting tools.

Medical applications are based on the total inertness of the metal to body fluids, 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. Tantalum anodes are finding their way into implantable electronic medical devices.

Total tantalum shipments (estimated) in 2003 are still below the peak shipments of 2000 when the industry shipped much more than the demand required by the end users. However, shipments in 2002 and 2003 have increased and show that the industry is following the recoveries in the electronic, chemical and alloys industries. Historic growth rates for tantalum have been 8-10%/y. There are competent forecasters who predict that worldwide electronics will grow by about 10% in 2004 and 2005.

**Production**

Economic tantalum raw material deposits 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 owned and operated by Sons of Gwalia (SOG) in Western Australia. Published reports show that the output of tantalite from the combined operation of these two mines was 2.1 Mlb of tantalum oxide in 2003 compared with 2.3 Mlb in 2002. This decrease was due to a weaker demand in the first half of 2003. In the second half, their production increased. It is expected that production will expand marginally until 2005.

SOG is reviewing the commissioning of an underground mine at Greenbushes. The underground mine is necessary in order to access higher grades of tantalum raw materials. Currently, the grades being mined at Greenbushes mine are lower in grade and incur higher processing costs. The Wodgina mine has indicated higher-grade mineralisation of an additional 5-6 Mt, and studies to develop the assets could be completed over the next six months.

Haddington International Resources is producing concentrates from its Bald Hill facility in Western Australia, with a reported production of 53,000 lb in the second quarter of 2003. (The Haddington production is included in the Gwalia production numbers.)

The Tanco mine in Manitoba Province, Canada, has a capacity of about 150,000 lb/y of tantalum oxide. It has been in operation since 1970 and is owned by Cabot Corp. Output is expected to continue for about ten years based on current output.

Tantalum Australia reports that it has an agreement with Boston University for the solid oxygen-ion conducting membrane processing technology (SOM) reactor that will take a continuous feed of tantalum oxide into the reactor and pure metal will be deposited on the cathode. The company also reached agreement to acquire two more tantalum and niobium projects in the Gascoyne mineral fields. It began shipping tantalum in October against contracts signed in June with a European metal refining group.

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. 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, Brazil, is owned by Metallurg International Resources. Production is about 100,000 lb/y. The company has facilities at Fluminense for processing the ore and extracting tantalum oxide.

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. The Jiujiang Tanbre Smelter reported producing 65 t of tantalum and niobium oxides.

Concentrates became available from Mozambique during the year as the Marropino mine began production, with a target of about 120,000 lb/y of contained tantalum oxide.

Other smaller projects are under consideration, including the Gippsland project in Abu Dabbab, Egypt, the Mamoré project in Brazil, Tertiary's Ghurayyah deposit in Saudi Arabia and others in China. None of these is expected to be fully developed and put into production until end markets show sustainable growth.

**Data**

In 2002 and 2003, unusual conditions existed that made the *official* TIC statistics incomplete. Hence the data provided are estimates. The tantalum raw material production data in Table 1 do not include materials that were purchased by non-TIC processors. These data are reported to the TIC through the category of ‘Processor Receipts’ in Table 2, and also include the purchase of any tantalum-containing material that is destined for processing through ‘re-purification’ systems. These data are shown in the following table, with tin slag and all tantalum minerals consolidated in one category.

Processor receipts are shown in Table 2. 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.

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 with conversion into chemicals. The processing companies generally manufacture a variety of chemicals, powder, ingot and alloys.

The data show that there have been excess inventories in the electronic supply chain caused by the bubble of 2000 and 2001. It is anticipated that any remaining inventories have been worked out of the system during 2003. The telecommunications industry, one of the largest consumers of tantalum capacitors, projected that global cell phone demand will increase by more than 10% during 2004, based on expectations of an improvement in the global economy. This translates into a demand for 520 million phones, up from 471 million in 2003.

**Pricing**

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

Pricing of raw materials is usually conducted through long-term contracts between miners and producers. Pricing of tantalum chemicals, metal powders, alloys, and fabricated articles is generally established by negotiation between buyer and seller. In addition, the US Defense National Stockpile Center (DNSC) from time to time will sell tantalum materials from its strategic stockpile. These offers and prices are available from the DNSC website and press releases.

**Table 1**
**Tantalum raw material production (Mlb contained tantalum oxide)**

| | 2000 | 2001 | 2002[e] | 2003[e] |
|---|---|---|---|---|
| Tantalite, columbite, Struverite, others | 2.6 | 2.9 | 3.0 | 2.6 |
| Tin Slag, >2% tantalum oxide | 0.7 | 0.8 | 0.4 | 0.5 |
| Totals | 3.3 | 3.7 | 3.4 | 3.1 |

[e] :Estimate: Source: Tantalum-Niobium International Study Center (T.I.C.)

Tables continued next page.

**Table 2**
**Processor receipts (Mlb contained tantalum oxide)**

| | 2000 | 2001 | 2002[e] | 2003[e] |
|---|---|---|---|---|
| Tantalite, columbite struverite, tin slag | 4.3 | 5.4 | 2.4 | 3.1 |
| Secondary materials, Scrap, $Ta_2O_5$, K-Salt | 1.5 | 2.1 | 1.1 | 0.9 |
| Totals | 5.8 | 7.5 | 3.5 | 4.0 |

[e] : Estimate. Source: Tantalum-Niobium International Study Center (TIC)

**Table 3**
**Tantalum processor shipments, (Mlb of contained tantalum)**

| | 2000 | 2001 | 2002[e] | 2003[e] |
|---|---|---|---|---|
| $Ta_2O_5$,$K_2TaF_7$,chemicals | 0.32 | 0.38 | 0.32 | 0.32 |
| Tantalum ingot | 0.28 | 0.31 | 0.28 | 0.30 |
| Carbides | 0.39 | 0.44 | 0.31 | 0.31 |
| Capacitor powder | 3.00 | 1.65 | 1.36 | 1.62 |
| Mill products | 0.73 | 0.48 | 0.53 | 0.50 |
| Metallurgical powder, Unwrought metal & scrap | 0.21 | 0.19 | 0.30 | 0.28 |
| Total | 4.93 | 3.45 | 3.10 | 3.33 |

[e] : Estimate. Source: Tantalum-Niobium International Study Center (TIC)