

T I C

TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

The Fortieth General Assembly was a tremendous success. More than 120 delegates and guests attended the meeting in Perth, Western Australia.

The technical papers presented were excellent in both content and presentation. The panel discussion at the close of the meeting was also very informative and enlightening. We were very fortunate to have these leaders of our industry share their views on the future with the assembly.

John Linden and the entire Gwalia team worked very hard to make the meeting a success and to make us feel at home 'down under'. We thank you.

We are pleased to announce the appointment of C. Edward (Ed) Mosheim to the position of Technical Promotion Officer. Ed brings many years of industry experience to the position and will be an integral part of the T.I.C. leadership.

Plans for Symposium 2000 at the Grand Hyatt in San Francisco are progressing nicely. We had a tremendous response to the call for papers. This Symposium is shaping up to be a 'benchmark' meeting that delegates will remember as one of the best ever.

I hope you have a very enjoyable holiday season and a prosperous and rewarding 2000.

Charles Culbertson II
President

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ASSEMBLY IN PERTH

Sons of Gwalia hosted the Fortieth General Assembly of the T.I.C. in the beautiful city of Perth, Western Australia, from October 24th to 26th 1999, which was heralded as a great success. More than 150 member company delegates, their guests and spouses, enjoyed the technical and social programme, plant tours and sightseeing, and the delightful spring sunshine.

The General Assembly of the association elected three new members – Crystal Technology, Inc., Fujitsu Media Devices Limited, Malaysia Smelting Corporation Bhd. – bringing total membership to 54 companies. The annual accounts were approved and a stable financial position was noted. The T.I.C. announced the appointment of a Technical Promotion Officer, Mr C. Edward Mosheim, who would be making every effort to bring tantalum and niobium to the attention of a wider world.

Mr John Linden, Head of Marketing in the Minerals Division at Sons of Gwalia, brought to a close an active year as President of the T.I.C. by organising this meeting in Perth. Mr Charles Culbertson II, President and Chief Operating Officer of Kemet Corporation, was elected President for the coming year. Dr Harry Stuart retired from the Executive Committee after many years' service including holding the Presidency in 1988-89. Mr Tadeu Carneiro of Reference Metals was elected to the Committee.

As this meeting saw the twenty-fifth anniversary of the foundation of the T.I.C., a video recording of greetings from 'Old Friends' was shown, bringing great pleasure to the assembled group as they recognised players from earlier days in the industry.

A cocktail reception by the pool welcomed the visitors to Perth. Sons of Gwalia were the hosts for a splendid gala dinner in the exclusive setting of the Lake Karrinyup Country Club, where an accomplished player of the didgeridoo entertained fascinated guests while they sipped apéritifs. When the after-dinner speaker was introduced, the audience assumed suitably solemn expressions, but bemusement turned to hilarity as they realised that his speciality was jokes rather than any serious aspect of management consultancy, and they had been hoaxed but in the nicest way.

On Tuesday October 26th, one group set off to the south by bus to tour the ever expanding mine at Greenbushes, source of much of the world's tantalum raw materials. Meanwhile another, smaller, group left northwards by aircraft and bus to visit the Wodgina mine, also a supply of high grade tantalite: a comprehensive visit to the extraction site and concentrating plant, recently commissioned, was most informative. Both these trips to the installations of Sons of Gwalia were highly appreciated by the participants, who learned a great deal about reserves, resources and mining methods.

Technical programme

Current production and options for the future of both the Greenbushes Mine and the Wodgina Mine were discussed by Mr David Bale, General Manager of the Minerals Division of Sons of Gwalia.

Although the production of concentrates from mining is the main source of tantalum raw materials, tantalum is also a by-product of tin smelting. Mr Yeap Soon Sit reviewed the role of tin slag from South East Asia over the past few years and attempted a projection for the future.

Mr Jorge Salles also presented the operations of tin mining and smelting, but in a very different part of the world, Brazil, where his company Paranapanema is active.

The majority of tantalum is processed to make tantalum capacitor powder: Mr Tomoo Izumi of Showa Cabot Supermetals explained what is meant by the capacitance of the powder and how it is constantly improved to meet the needs of the capacitor manufacturers.

Niobium is used to good effect in superalloys for components in extreme conditions at high temperatures where reliability is paramount, such as aircraft engines. Dr Graham Durber described how his company Western Australian Specialty Alloys had reached the forefront of its field in a very short time with its developments in melting technology.

Very recently, commercial exploitation of the optical and electronic properties of niobium has found two new uses. Improvement of the anti-glare properties of glass in architecture, and ensuring that carbon films adhere to razor blades may appear to be very different, but both are thin film applications for niobium, as Mr Tadeu Carneiro of Reference Metals revealed in the paper he had prepared with his co-author Dr Harry Stuart.

Nokia is a company taking advantage of the reliability of tantalum capacitors in the confined spaces of mobile phones. Mr Søren Kjaer gave a wide ranging account of this burgeoning industry in the presentation he had created with his colleague Ms Merja Kangas.

Other superalloys using niobium in jets and rockets also featured in the talk given by Mr Barry Valder of Oremet Wah Chang. Yet another application of niobium relies on its superconducting properties at very low temperatures and he told the assembly about the use of large quantities of niobium-titanium for high energy physics research.

An interesting panel discussion on the structure of the tantalum industry, and the panel members' views on its future, closed the technical programme for the day. Participants were Mr Peter Lalor, CEO of Sons of Gwalia; Mr Kennett Burnes, President of Cabot Corporation; Mr Charles Culbertson II, President and COO of Kemet Corporation; and Mr Avi Eden, Director of Vishay Intertechnology, thus representing sectors of the industry from raw materials through refining to application in capacitors. The chairman was the T.I.C.'s retiring President, Mr John Linden.

OVERVIEW OF THE TANTALUM AND NIOBIUM INDUSTRIES FOR 1998 AND 1999

This presentation was made by Mr John Linden, Sons of Gwalia, as the President's Address to the T.I.C. meeting in Perth, Western Australia, on October 25th 1999

The tantalum industry rebounded from a short period of inventory correction during 1998 to continue its steady growth path now in its fifth year.

The niobium industry is also showing strong demand and continued growth in all sectors.

TANTALUM RAW MATERIAL SUPPLY

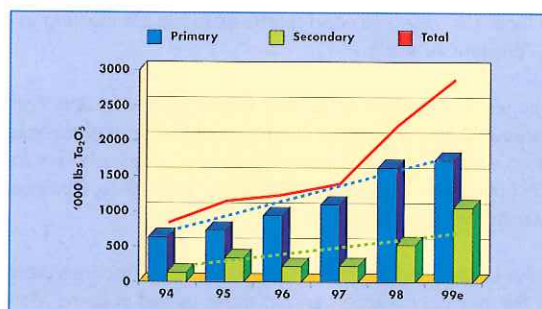


Figure 1: Tantalum production (raw materials)

Production as reported to the T.I.C., as everyone knows, only represents part of the story because a large number of small-scale producers in Africa, South-East Asia and Brazil do not report to the T.I.C.

Nevertheless, producers' shipments of both primary and secondary materials have been increasing steadily as a result of production increases from the major producers and tin smelters.

Producer shipments are expected to exceed 2.5 million lb Ta₂O₅ during 1999, with primary concentrates increasing to 1.8 million lb and tin slags to 0.7 million lb.

The increased demand has firmed prices for raw materials, which in turn has encouraged new production from small operations in Africa, Brazil and Thailand.

Apart from Sons of Gwalia's Wodgina mine, there has not been any development of a significant new mine project and one project in Mozambique has been put on hold.

There has been adequate supply to meet the increased demand and indications are that this situation will continue.

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Receipts

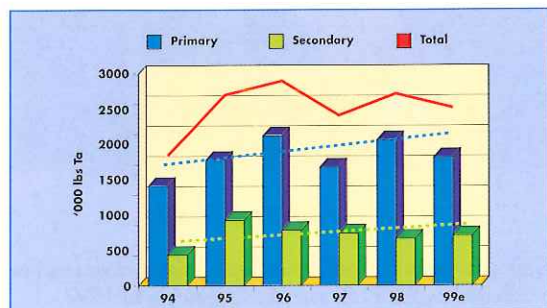


Figure 2: Tantalum processors' receipts

The T.I.C. statistics for processor receipts of tantalum containing materials and shipments of finished products give the best picture of industry supply and demand.

Receipts of both primary and secondary materials have been increasing steadily over the past five years. A significant proportion of these receipts consists of synthetic concentrates produced from low grade tin slags recovered from Malaysia and Thailand which are not reported in producer statistics.

Releases by the Defense Logistics Agency constitute another important component of the receipts not reported elsewhere, these amount to some 200 000 lb of Ta_2O_5 per annum.

Receipts of primary materials are increasing faster than secondary materials, which also include a greater proportion of scrap and recycled materials.

Total receipts are now close to 4 million lb Ta_2O_5 per annum containing some 3 million lb of recoverable tantalum.

The 1996 T.I.C. primary processor receipts appear to have an anomalously high number but the average over the years 1995-97 is probably fairly correct.

Shipments

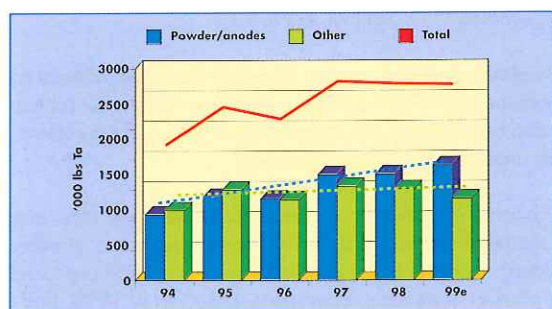


Figure 3: Tantalum processors' shipments

The powder/anodes shipments show a steadily increasing trend, while the shipments of all other products have remained relatively steady.

Usage of tantalum in the electronics industry is growing at some 10% per annum which translates to a 5% growth for tantalum overall.

Total demand is steady at some 4.1 million lb of Ta_2O_5 in raw material and some 3.2 million lb tantalum in products. Industry experts expect this growth trend to continue.

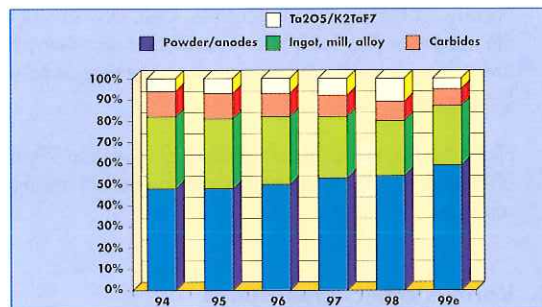


Figure 4: Tantalum product shipments

Over the past six years, shipments of powder and anodes have increased from just under 50% to almost 60% of total tantalum shipments.

Metallurgical grade tantalum mill products, consisting of wire, rod, foil, sheet plate and tubing for non-electronic applications, make up about 10% of total demand and this rises to some 25% when ingot and alloy categories are added.

Metallurgical applications are mainly in the chemical and pharmaceutical process industries where resistance to most forms of acid attack is the property exploited.

1. Chemical process industry and pharmaceutical process industry

About 35-45% of the total metallurgical grade products go into applications in the chemical and pharmaceutical process industry. Tantalum has extremely good corrosion resistance in most inorganic and organic acid environments (except hydrofluoric acid) and is traditionally used in combination with glass and glass lined vessels where properties of glass and metals have to be combined. A typical application is the construction of heat exchangers for heating, cooling and recovering hot sulphuric acid.

Recently, tantalum is not only considered in environments where corrosion resistance is the driving force. Totally bio-inert properties of tantalum find increasing interest in the pharmaceutical industry. The pharmaceutical process industry is changing more and more to multi-purpose units where tantalum helps to avoid any contamination. Contamination by nickel and chromium from stainless steel can be avoided by using tantalum.

This market is closely related to investments in this industry. Some big projects may count for a significant percentage of the yearly consumption of this market segment. For a ten year period, an average growth rate of about 5% can be estimated.

2. Sputtering targets

Another 30-40% of the metallurgical grade tantalum mill products find their application in sputtering targets for electronic devices. Applications for liquid crystal displays have been known for about 10 years and are used in laptop computers etc. Significant new business is seen by sputtering diffusion barriers on very large scale integrated circuits. In the integrated circuits, aluminium has to be replaced by higher conductivity copper in order to allow further miniaturisation. Copper can only be used in connection with silicon with a diffusion barrier in between. Tantalum nitride is a very promising solution and is achieved by sputtering tantalum plate material.

Because of higher current densities, logic devices will be the first to see Cu/TaN/Si and memory devices may follow a few years later when giga-byte memory chips will be produced.

Highest purity materials of tantalum of minimum 99.95% are specified to be produced applying vacuum melting routes.

3. Various other applications

In other applications, tantalum properties such as diffusion barriers, oxygen gettering, high melting point, high density and high ductility are of interest in the processing industry, fundamental research and development, instrumentation, medical and military.

Inventory - change

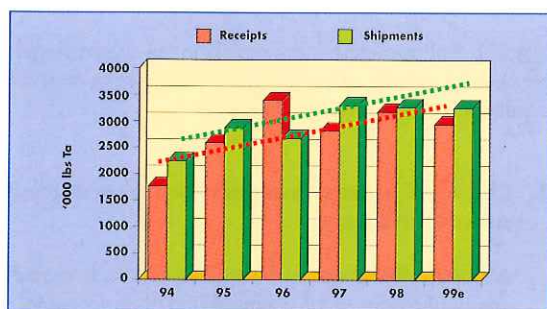


Figure 5: Processors' receipts and shipments

The processor receipts and shipments statistics show a remarkably close and parallel trend, with increased shipments matched by increasing receipts.

The lines of best fit are almost parallel but displaced by a constant 300 000 lb of Ta_2O_5

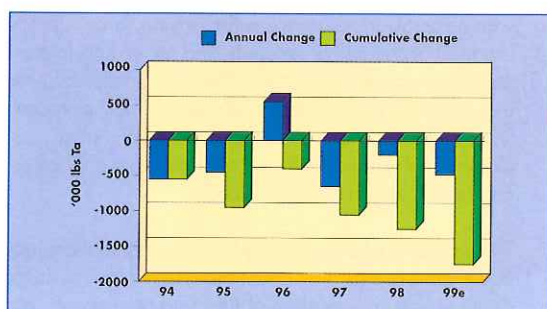


Figure 6: Processors' inventory change

The cumulative effect of this shift over the past six years means that processor inventories are shown to have been drawn down by some 1.5 million lb of tantalum. The anomaly mentioned previously, in 1996, is even more pronounced in these figures.

The tantalum industry has traditionally operated with large inventories so it is not unusual to see periods of inventory reduction and periods of inventory building.

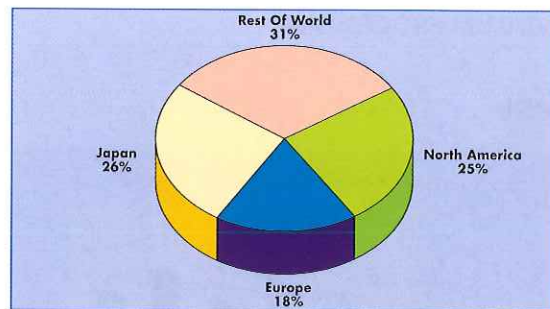


Figure 7: Capacitor consumption

Capacitor consumption by number of pieces data has now been collected by the T.I.C. since the beginning of 1997.

The pie chart shows the consumption by region in number of units consumed.

Niobium raw material supply

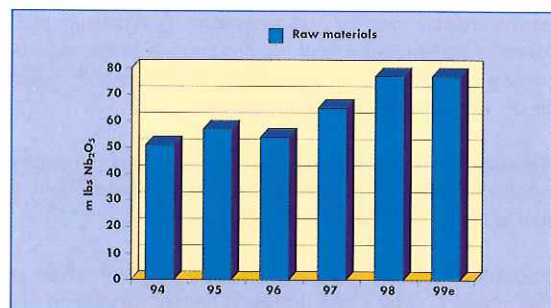


Figure 8: Niobium processors' receipts

Niobium from pyrochlore has been increasing in line with rising demand for end products. Supply as a by-product from tantalite concentrates and columbites is approximately 500 000 lb Nb_2O_5 per annum.

Production capacity of niobium raw materials is significantly larger than demand.

There is no issue with supply. Total supply is now running at approximately 75-80 million lb Nb_2O_5 .

Niobium products are manufactured from two different types of niobium ores. The most important is pyrochlore but niobium can also be obtained as a by-product of tantalum operations which process columbite-tantalite ores.

Pyrochlore production continues to be the single most important source of niobium units for all final applications. However, a substantial increase in the amount of niobium oxide produced as a by-product of tantalum operations, observed in 1998, had a significant impact on the higher value added markets such as niobium masteralloys used in superalloy manufacturing, special grade niobium oxides for lenses and ceramic capacitors and niobium metal.

Niobium products obtained from pyrochlore continue to be supplied by three major producers. CBMM - Companhia Brasileira de Metalurgia e Mineração - is the largest single source of niobium in the world. Its mine and production facilities are located in Araxá, Minas Gerais, Brazil. Mineração Catalão de Goiás is the second Brazilian producer and a member of the Anglo-American Group. The Niobec mine in Quebec, Canada, jointly owned by Teck and Cambior, completes the picture: this mine is operated by Teck and its products are marketed by Cambior, Inc.

CBMM started a major expansion programme involving a total investment of more than \$80 million in 1998. The programme includes an increase in ore concentration capacity from 50 000 tpy to 80 000 tpy. It also involves the replacement of the existing leaching and calcination plant with a new pyrometallurgical process to purify the pyrochlore concentrate. This plant will also have an 80 000 tpy capacity. In addition, the introduction of new facilities for crushing, sizing and automated packaging of ferroniobium, as well as the introduction of a second electric-arc furnace for ferroniobium production, will increase CBMM's ferroniobium production capacity to 45 000 tpy. CBMM is a totally integrated niobium company and offers ferroniobium, niobium oxide, nickelniobium, vacuum grade ferroniobium, niobium metal, special grades of niobium oxide and niobium compounds for application in catalysts.

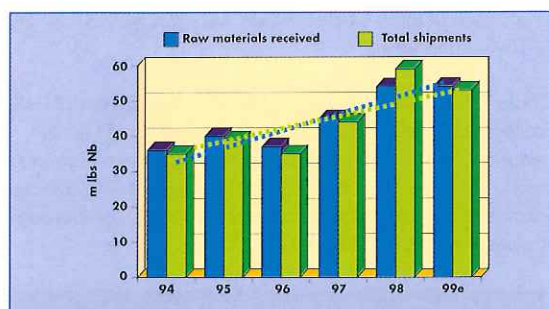


Figure 9: Niobium processors' receipts and shipments

Processor receipts and shipments vary from year to year but match over time, reflecting that supply is turned on and off according to demand.

The industry structure is significantly different from tantalum as full integration exists between production, processor and end-product supplier.

CBMM, the largest producer of pyrochlore, is currently investing \$80 m to increase production and processing capacity.

Processor shipments



Figure 10: Niobium processors' shipments

The main use of niobium is in HSLA steel, with minor quantities used as pure metal, metal alloy and oxide.

Growth in the use of HSLA steels drives the requirements for the niobium market, with major applications in pipeline and automotive steels.

The CERN project in Switzerland and specialty application in the aircraft industry add to total demand but requirements are more variable.

Niobium consumption in the steel industry increased in 1998 driven by the strong demand for pipelines and automobiles which in turn contained more niobium than was previously the case. Modern pipeline steels provide designers with higher strength and better toughness allowing companies in this industry to comply with increasingly stringent regulations related to safety of pipelines, especially with regard to their fracture arrest characteristics. In the automotive industry, despite the trend towards reduction in the total amount of steel used in cars, the amount of high strength niobium containing steels is continuously increasing. As a consequence, in 1998, total shipments of standard grade ferroniobium were close to 30 000 tonnes, representing a distinct increase compared to 1997 shipments.

The second half of 1998 did not show the same consumption rate for niobium oxide and niobium masteralloys used in superalloys as the previous year. Lack of orders from the manufacturers of aircraft engines slowed down the consumption pattern for these niobium products by the end of the year. Business associated with land-based turbines for power generation continued strong which helped to contain the downward trend of consumption. The total amount of niobium oxide equivalent consumed in superalloys and special applications such as lenses and ceramic capacitors was approximately 15% less than that consumed in 1997. It is estimated that approximately 2200 tonnes of niobium oxide equivalent were consumed in these applications in 1998.

Consumption of niobium metal and its alloys jumped from the usual 0.5 million lb per year to more than 1.2 million lb in 1998. The main reason for this increase was the demand from the construction of the Large Hadron Collider, a particle accelerator being built in Switzerland by CERN and which will consume some 400 tonnes of niobium over a three year period. The market for MRI units is also increasing and new niches are being developed for niobium metal applications such as coatings applied by sputtering to architectural glasses, special lenses, flat panel displays and razor blades.

The sale of niobium products in general is unique to the extent that it is characterised by price stability. The principal niobium product, standard grade ferroniobium, has sold for between \$6.50 and 7.50 per pound of niobium contained (expressed in historical dollars) for more than 20 years. The average price of this product was \$6.90 per pound of niobium contained in 1998. The pyrochlore raw material used to produce this product is not sold on the open market and is consumed internally by the producers of standard grade ferroniobium. The average price of technical grade niobium oxide used to produce masteralloys for use by the superalloy melters was in the region of \$8.80 per pound of material in 1998. Sales of vacuum grade ferroniobium were commonly reported at \$17.00 per pound of niobium contained and nickelniobium at \$18.50 per pound of niobium contained. Niobium metal products are a low volume commodity with a variety of specific technical requirements and specifications and therefore prices depend on the final product and application. Prices were reported to be as low as \$24 per pound of niobium in ingot form to as high as \$100 per pound of niobium in special shapes.

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COMMERCIAL APPLICATIONS OF NIOBIUM IN THIN FILMS

Presentation by Mr Tadeu Carneiro and Dr Harry Stuart,
Reference Metals Company, Inc., Bridgeville, PA, U.S.A., to the
meeting in Perth on October 25th 1999

INTRODUCTION

Niobium metal and niobium-based alloys have been commercially established as materials of choice for several applications involving advanced technologies. Niobium-47wt%titanium continues to be the niobium-based alloy with the largest demand and is present in the superconducting magnets used in MRI and NMR units. Also in superconducting applications, niobium metal is used in RF cavities (linear accelerators) and niobium-tin is the material of choice when higher magnetic fields are needed (e.g. ITER project). Niobium-based alloys have been established as high-temperature materials since the late 50's. The most important alloy in this case is C103 (Nb-10wt%Hf-1wt%Ti). This alloy is currently used in rocket thrust cones, high-temperature valves and thrust augmentor flaps of turbine engines. Niobium corrosion properties resemble those of tantalum and therefore make the element and its alloys an excellent choice for applications requiring resistance to aggressive environments. Pure niobium, niobium-1wt%zirconium, niobium-40wt%tantalum and niobium-55wt%titanium are examples of materials currently used to resist different corrosion environments.

More recently, niobium has developed into an important material for thin film applications. Although niobium metal is used as the starting material, the great majority of the commercial niobium thin films are actually one of several niobium oxides.

Niobium oxide films can be formed with different stoichiometries to attain different final properties. Niobium pentoxide (Nb_2O_5) is a semiconductor with a band gap of about 3.5eV, whereas NbO has metallic conductivity and appearance^(1,2). NbO_2 is used in microelectronics for switching devices⁽²⁾. Nb_2O_5 can be used as a dielectric because of its high dielectric constant (11 to 100) or as an antireflection coating, because of its high refractive index (2.2 to 2.6)⁽¹⁾. In addition, it can also be used as a barrier layer in Josephson junctions and for decorations since the whole spectrum of colors can be achieved by varying the thickness of the oxide layer.

In addition to its optical and dielectric properties, niobium was also found to be an important material for improving the adhesion of diamond-like-carbon (DLC) coatings in stainless steel substrates, such as that used in razor blades.

The purpose of this paper is to present data related to some specific applications of these niobium thin films such as those involving glass products, lenses and razor blades.

Data related to the high purity niobium metal manufactured by CBMM for these applications are also presented in this paper.

OPTICAL COATINGS

Niobium oxide thin films can be present in "stacks" of optical coatings to accomplish different tasks. However, the application where niobium is mostly used is related to the anti-reflection coatings.

Anti-reflection coatings

Anti-reflection is achieved as a direct result of light reflections from interfaces between very thin films that destructively interfere with light resulting in a low total reflectance from the coated transparent object.

A coating with a thickness a quarter the wavelength of light, with a refractive index equal to the square root of the refractive index of the substrate, will yield an anti-reflection coating⁽³⁾.

In practice it is difficult to achieve anti-reflection with a single layer as dictated by theory because it is almost impossible to find the materials with matching refractive indexes to obtain the necessary destructive interference. Instead, a multiple stack of optically transparent inorganic materials accomplishes the task. Typical materials used in these stacks include TiO_2 , ZrO_2 , Nb_2O_5 , SiO_2 , Ta_2O_5 and MgF_2 ⁽⁴⁾.

Table 1⁽⁶⁾ shows the configuration of a four-layer anti-reflection coating on glass. These stacks are usually built with a sequence of pairs of low-refraction-index/high-refraction-index materials. The specific coating of Table 1 reduces the average reflectance of the system by a factor of 10, when compared with plain glass, i.e., from 4.3% to 0.4%.

Layer Nr.	Thickness (nm)	Refractive index (n)
Air		1
1	0.0866	1.47
2	0.1176	2.3
3	0.0348	1.47
4	0.0125	2.3
Glass		1.52

Table 1: Example of anti-reflection coating for glass for visible light. ⁽⁶⁾

The use of anti-reflection thin films is finding increasing acceptance in several applications. The main importance of these anti-reflecting coatings is to enhance visual acuity by increasing the amount of light transmitted through the transparent object in question.

In lenses made of glass or plastic, anti-reflection coatings can promote such increase in visual acuity. A standard plastic lens can reflect as much as 8 percent of the incident light. Adding an anti-reflection stack to the lens can increase transmittance to greater than 98 percent⁽⁴⁾.

It is also accepted that the normal reflectance on the front surface of glass is approximately 4.5 percent. Thus, anti-reflection coating can improve the performance of computer screens by reducing photopic reflectance to a minimum. BOC Coating Technology⁽⁵⁾ has developed a thin film system for this purpose, which is also conductive and therefore eliminates static electricity buildup on the display. Another example is OCLI's recently patented absorbing anti-reflection coating for computer displays that relies on niobium pentoxide as the high-refractive index material⁽⁷⁾.

Examples of additional markets where anti-reflective coatings can be useful are those involving glass in museum displays and shop-windows⁽⁵⁾.

Other optical uses

The high refractive index of niobium pentoxide makes this material an option in every solution involving a stack of different oxide coatings applied to glass to improve its performance.

Several markets have been impacted by the use of these high-performance glasses. A good example involves architectural glasses and the use of solar control and low-emissivity coatings to improve the energy balance of buildings. Another area involves the automotive industry and the application of reflecting glass for sunroofs and side window glass, solar control for windshields and side windows and electrically conductive glass for heated windshields.

NIOBIUM AS AN INTERLAYER MATERIAL

In the process of improving the performance of razor blades with regard to precision edge degradation, Gillette developed and patented a system that relies on diamond-like-carbon (DLC) for this purpose⁽⁸⁻¹⁰⁾.

The literature suggests⁽¹¹⁾ that, in the initial years, the application of diamond-like-carbon was restricted to areas involving optical coatings and magnetic storage media because of the difficulty of DLC in gaining good adhesion to metallic substrates, among other reasons.

The application of niobium as an interlayer material helps to improve the adhesion of DLC coating to stainless steel substrates.

In the cross section of a multilayer structure in a Gillette razor blade, the diamond-like-carbon layer is approximately 20 nm thick and the niobium interlayer is approximately 10 nm thick. There is also a 30 to 100 nm thick layer in the substrate that forms a layer of nano-polycrystalline grains, probably as a result of the deposition process.

The analysis of the microstructure evidenced very good and continuous adherence at the interfaces between DLC and Nb layers.

The use of niobium as a coating material in cutting blades is also mentioned in more recent patents assigned to Warner-Lambert Company⁽¹²⁾ and to Advanced Refractory Technologies, Inc.⁽¹³⁾.

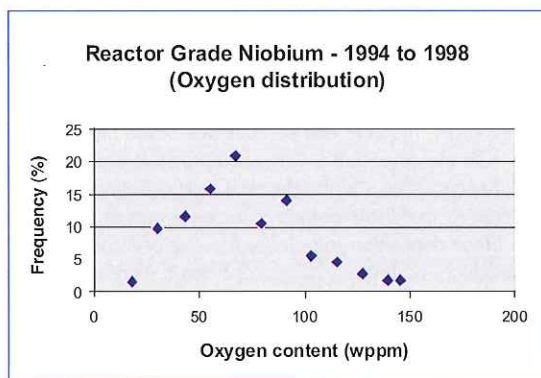
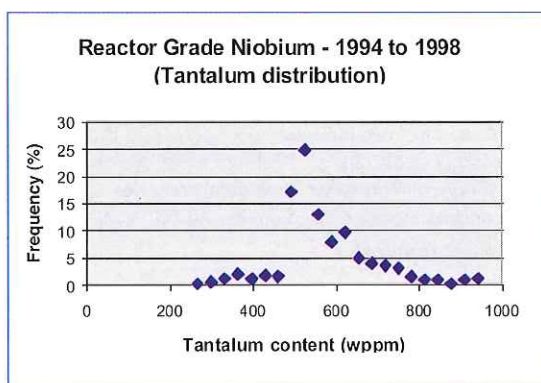


Figure 1a: Distribution of tantalum and oxygen contents of reactor grade niobium ingots manufactured by CBMM from 1994 to 1998

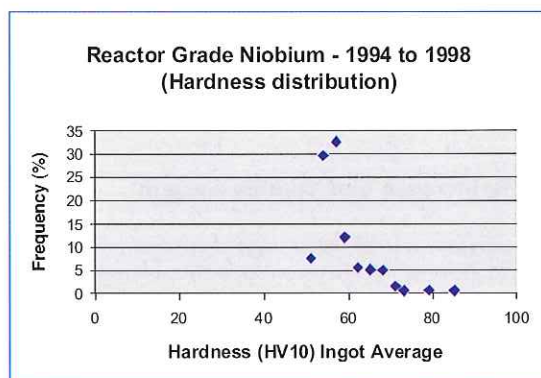
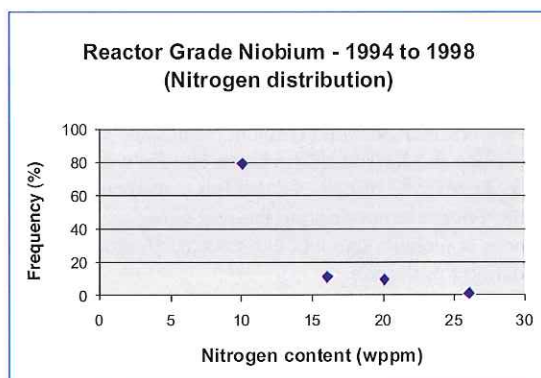


Figure 1b: Distribution of nitrogen content and hardness of reactor grade niobium ingots manufactured by CBMM from 1994 to 1998

MARKET CONSIDERATIONS

Flat niobium plates (usually rectangular) with thickness in the range 1/4" to 1/2" are the most commonly used products for sputtering target applications. Niobium tubes are also used for rotating cylindrical magnetron (rotatable) cathodes. Some of these tubes are approximately 6" in diameter by 50" long with wall thickness in the vicinity of 1".

This market is highly fragmented with several small-to-medium size companies involved in the supply chain. Lack of standardization and small volumes help in perpetuating this fragmentation.

The current total demand is estimated to be in the range of 35 to 40 tonnes of niobium finished plates and tubes per year. However, it is also expected that niobium will increase its participation in these applications, for both new and established applications.

For example, niobium can be sputtered seven times faster than titanium. On the other hand, when compared to titanium as a material that provides a high refractive index coating, niobium always showed the disadvantage associated with its price and density. Since deposition rate drives the cost of most thin film coated products, niobium is being considered increasingly as an option for high-performance optical coatings. This includes areas where titanium was traditionally the best option available.

Application of niobium is still small compared to other materials in these markets (such as titanium). Thus, it is possible that the benefit of higher volumes is still not realized for niobium end-users. Higher volumes coupled with standard sizes should help in improving the overall cost-structure of niobium targets for this market.

CBMM'S NIOBIUM METAL PRODUCTS

CBMM has manufactured niobium metal since the beginning of 1989 when a 500KW electron-beam furnace was commissioned in Araxá, MG, Brazil. CBMM has continuously operated the electron-beam furnace during the past ten years. More than 400 tonnes of niobium and niobium-zirconium ingots were produced during this decade.

Niobium metal manufactured by CBMM has been used for all known end-uses, including the most sophisticated involving the manufacturing of wrought products for sputtering targets, superconducting RF cavities and low-temperature superconducting wire.

Figure 1 presents the distribution of tantalum, oxygen and nitrogen, as well as the average hardness distribution for all reactor grade niobium ingots produced between 1994 and 1998.

Capacity increase and Quality System

The company is in the latest stage of a major investment programme to increase its production capacity and upgrade manufacturing processes. Approximately \$80 million have been invested in this new expansion plan. Among other process improvements, this programme will increase CBMM's ferroniobium production capacity by 50% by the end of 1999 (from 30 000 tpy to 45 000 tpy).

CBMM has operated a quality management system according to the ISO 9002 Standard since 1994 and an Environmental Management System since 1997, when it became the first mining company in the world to be certified according to the ISO 14001 Specification. CBMM's Environmental Management System is applicable to all steps of manufacturing from mining to the final products.

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DEFENSE LOGISTICS AGENCY

The Agency has again been active in offering materials from the Stockpile. It is considering making offers through the Internet rather than by its present method of bids, but has not yet reached a decision on this change.

Tantalum oxide: Tantalum oxide containing approximately 20 000lb Ta was made available for fiscal year 2000, with an initial offering date of October 21st 1999.

Tantalum carbide: Approximately 4000lb contained Ta in tantalum carbide were made available for fiscal year 2000, with the initial offering due on October 28th 1999. 2000lb Ta contained in tantalum carbide was awarded to H.C. Starck at an approximate market price of \$124 000, but the next offer, due on November 18th, was postponed to the quarter January-March 2000.

Tantalum metal, capacitor grade: The Agency announced that it was soliciting offers for the sale of approximately 50 000lb tantalum in fiscal year 2000, with an initial offering date of November 9th 1999. The circular dated October 21st was superseded on October 29th by a corrected chemical analysis.

On November 25th Metal Bulletin reported that all the available material had been awarded, for an estimated market value of \$3.7m, thereby exhausting the total allotment for the year to the end of September 2000. The companies buying the capacitor grade tantalum metal were H.C. Starck, Hi-Temp Specialty Metals and Recovery Dynamics, although the amounts taken by each firm were not announced.

Tantalum metal, vacuum grade: In Bulletin 99 of September 1999 we reported that approximately 9000lb vacuum grade tantalum was to be offered on September 20th. Metal Bulletin reported on October 7th that approximately 9800lb of vacuum grade tantalum metal were awarded to H.C. Starck and Hi-Temp Specialty Metals, the amount taken by each company was not indicated.

The initial offer date for fiscal year 2000 was November 22nd 1999, and the amount available was approximately 40 000lb of metal ingot.

Ferroniobium: Bids were invited for ferroniobium steel grade and ferroniobium superalloy grade on October 26th 1999. The DLA offered for sale approximately 400 000lb contained niobium in the form of ferroniobium for the fiscal year 2000.

More than half the offered material was sold to ABS and Triad Alloys, reported Metal Bulletin (November 25th 1999), for approximately \$1.5m. The journal went on to say that the DLA hoped to sell the rest of the year's allotment on the next offer date, November 23rd.

It was reported by Metal Bulletin that nearly all the ferroniobium allotted for sale in 1999 was sold: authorised to sell 400 000lb of niobium in ferroniobium in the year, the DLA had sold 394 368lb. 900 632lb was left in the National Defense Stockpile, of which about 250 000lb was of vacuum grade material.

Niobium metal: All the niobium metal authorised for sale in 1999 had been sold, according to Metal Bulletin, 'reducing Stockpile holdings to 141 123lb of contained metal'.

An offer dated November 12th was cancelled and rescheduled for December 10th, for lack of interest in bidding.

MEMBER COMPANY NEWS

The three new members elected by the Fortieth General Assembly are:

Crystal Technology, Inc.

1040 E. Meadow Circle,
Palo Alto,
CA 94303,
U.S.A.
Tel.: +1 650 856 7911
Fax: +1 650 354 0134
Activity: Manufacture of lithium niobate and tantalate

Fujitsu Media Devices Limited

Sun Hamada Bldg.,
1-19-20, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033,
Japan.
Tel.: +81 45 471 0061
Fax: +81 45 471 0076
Activity: Manufacture of lithium niobate

Malaysia Smelting Corporation Bhd

27 Jalan Pantai,
12000 Butterworth,
Malaysia.
Tel.: +60 4 333 3500
Fax: +60 4 332 6499
Activity: Tin smelting, which may produce tantalum as a by-product in the slag

Cambior

Cambior Inc. and Teck Corporation have announced the completion of a feasibility study for the expansion of the concentrator at the Niobec Mine, which they jointly own. The expansion will be completed in two phases. The first phase will require an investment estimated at Cdn\$7 million and is expected to increase production by 20% in the second half of the year 2000. The second phase will require further investments, estimated at Cdn\$3 million, and will gradually increase production by up to an additional 20%, which Cambior believes is warranted by demand in the world niobium market. Construction could begin straight away, and its objective is to allow the Niobec Mine to maintain its historical market share of the worldwide niobium market.

Cambior was due to put its 'Block 3' into production in the third quarter of 1999, containing proven and probable reserves of approximately 7 million tonnes grading 0.73% Nb₂O₅. Its share of production from the Niobec Mine in the third quarter of 1999 was 286 tonnes of niobium contained in ferro-niobium, almost an identical amount to the 283 tonnes produced in the third quarter of 1998. This brought production for the first nine months of 1999 to 868 tonnes Nb in FeNb (826 tonnes in 1998).

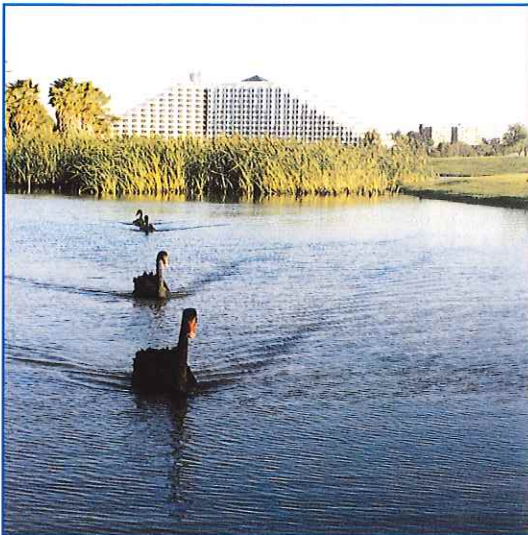
Cambior is proud of its achievement in obtaining ISO 14001 environmental certification, proving that its operating processes are consistent and effective, and it will continue to strive for further improvement. It takes safety considerations very seriously, and investigates accidents thoroughly, it stresses.

(continued on page 12)

Pictures of Perth Meeting



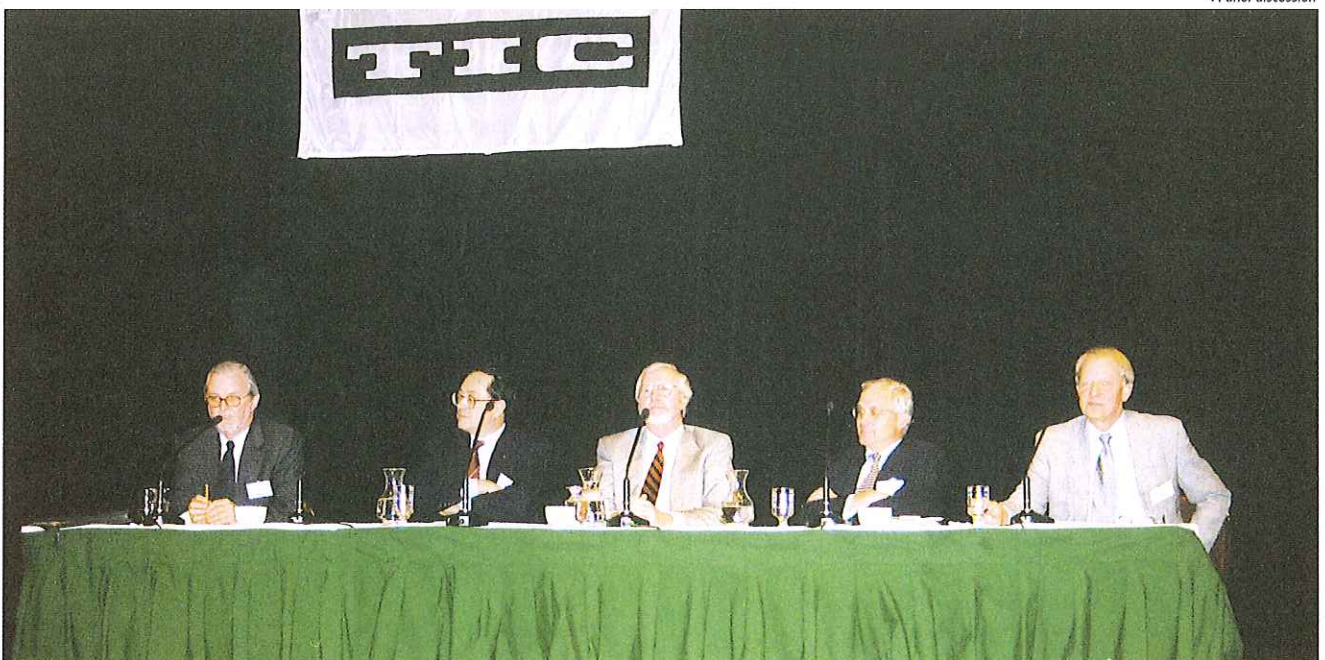
Gala Dinner at Lake Karrinyup
Country Club
Guest speaker
▼



Burswood Hotel
(with black swans)
▼



▼ Didgeridoo player



▼ Panel discussion

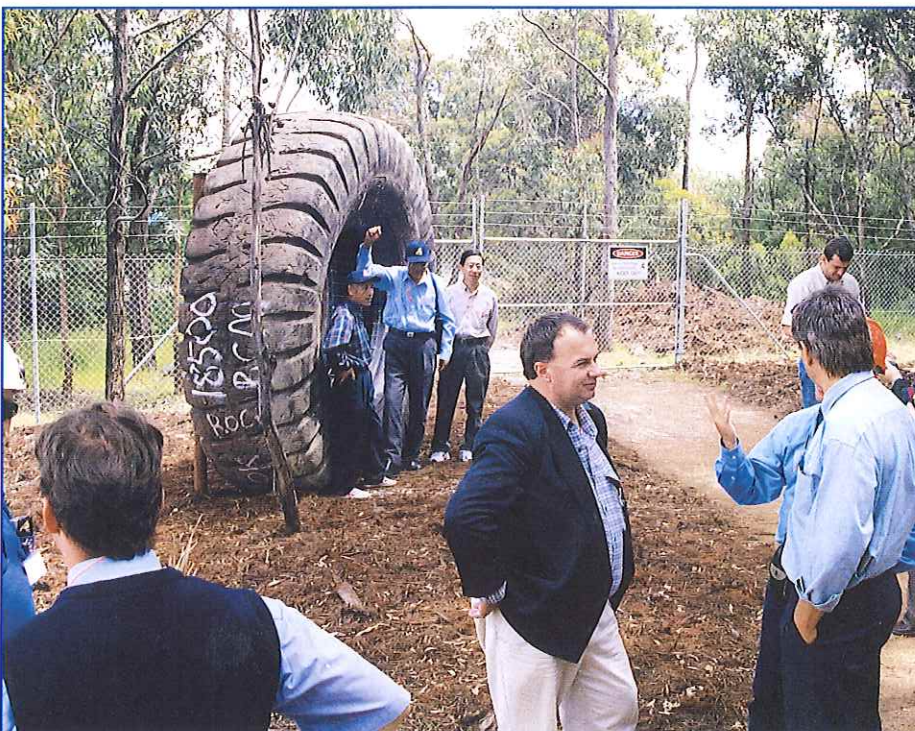
Pictures of Perth Meeting



Plant Tour to Greenbushes



Photos by
Ed Mosheim



(continued from page 9)

The company contributes to the community by developing training programmes and scholarships, assisting local hospitals to buy state-of-the-art equipment, and underwriting sports and other activities to improve the quality of life for residents in its area.

One environmental venture is particularly appealing: a tailings pond has been converted into a lake of 120 hectares, the water has reached a quality sufficient for human consumption and as a result wildlife is abundant in the area. Cambior is working with Ducks Unlimited to install breeding facilities and build up the bio-diversity of the lake, showing that co-operation of industry, government and volunteers can benefit a region and its population, both human and wildlife.

Catalão de Goiás

The contact numbers for Mineração Catalão de Goiás have been modified:

Tel.: +55 11 3226 8333

Fax: +55 11 3226 8300

Cluff Mining

The e-mail address for the delegate of Cluff Mining is: bruno.deliens@sogemnet.com

EPCOS

To increase familiarity with the new Epcos logo of the companies including the T.I.C. member formerly called Siemens Matsushita, lively advertising campaigns based on a football player and an ingenious map of the Americas composed from electronic components are being pursued.

Epcos is on the Internet at <http://www.epcos.com> with information about the company and its products.

Heraeus

W.C. Heraeus GmbH & Co KG includes in its product range Co-Cr-(Pt,Ta,B,Ni,Nb,X) magnetic targets for sputtering applications. The targets produced by Heraeus have 'consistently set the standard in terms of target material yield, sputter process stability, sputtered media property uniformity and performance', says the firm.

Kemet

Kemet Corporation reported record sales for the quarter ended September 30th 1999, with net sales 35% above the figure for the equivalent period in 1998. 'Kemet's record shipments and bookings for the second quarter reflect the exciting growth momentum that is under way in our segment of the electronics industry', stated Mr David E. Maguire, Chairman and CEO. 'All indications are for this high demand for our products to continue well into the future. We are making every effort to accommodate our customers' needs by increasing our operating efficiencies and adding the appropriate production capacity for both our tantalum and multilayer ceramic capacitor operations.'

Sales of surface-mounted capacitors increased 43% for the quarter over the same quarter in 1998, while sales of leaded capacitors were at a very similar level to the previous year. Export sales were led by a 69% increase in sales to Asia.

On November 29th 1999 Kemet announced that it had applied for listing of its common stock on the New York Stock Exchange, and expected to begin trading on or about December 9th. It has been a publicly traded company since 1992, trading on the Nasdaq Stock Market under 'KMET'.

Mr Maguire said that Kemet Corporation was experiencing unprecedented growth and expected that recognition of this growth would be enhanced by the move to the New York Stock Exchange.

Company information is available on <http://www.kemet.com>.

Kennametal

In its annual report for the fiscal year 1999 Kennametal frankly described its financial performance as 'disappointing'. A downturn in the markets served by the company was seen as the reason why sales were down 7% from 1998: although the automotive industry maintained strength, 'the oil and gas field service industries, agricultural and off-road equipment industry and other markets' did not fare well. Measures to control costs were undertaken, including reduction in the work force, salary reduction and cancellation or reduction of a variety of activities, thus limiting operating expenses and helping to mitigate the shortfall in sales.

Nevertheless the company says that it generated strong cash flow and reduced its debt. It rationalised its inventory and introduced more new products than ever before. It continued to develop its Internet marketing and sales capabilities, seen as channel which will continue to grow in popularity with customers. For North America a single distribution centre replaced eight warehouse locations, and in Europe a single source for distribution was created by integrating recently acquired Greenfield operations with existing Kennametal activities to form Kennametal Hertel EDG. The Mining and Construction Division continues to hold the leading market share in its sector: although sales of mining tools and of metallurgical powders used in oil and gas exploration and drilling did not go well, construction activity was vigorous, boosting sales of tools.

The firm maintains that 'it is the only company in the world that can provide consumable tools and industrial supplies to customers of all sizes through whatever sales channel they choose'. It intends to continue its cost control and to offer the broadest choice of products, with a view to improved performance in the coming year.

Oremet-Wah Chang

Mr Barry P. Valder is now the nominated delegate for Oremet-Wah Chang, as Mr Tom Cordier has retired.

Matsushita Electronic Components

Our delegate has sent the following information regarding the company's web site and e-mail addresses:

Web site at <http://www.maco.panasonic.co.jp>

e-mail to PAN36116@pas.mei.co.jp

Sogem

The e-mail address for the delegate of Sogem is: bruno.deliens@sogemnet.com

Ulba Metallurgical Plant

Following a re-organisation, the membership of Ulba Metallurgical Plant has been transferred to Kazatomprom:

NAC Kazatomprom,

168 Bogenbay Batyr Street,

480012 Almaty,

Republic of Kazakhstan.

Tel.: +7 3272 627859, +7 3272 691690

Fax: +7 3272 503541

e-mail: larisa@uran.almaty.kz