

T I C

TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

The Thirty-ninth General Assembly in Prague was a great success, with more than 150 delegates and guests attending.

Our sincere thanks are extended to Ernie Chilton, Bill Millman and their crew who made sure the meeting ran without a hitch.

Prague itself is a beautiful city but unfortunately some of us did not get enough time outside the hotel to fully appreciate all of its architectural splendour.

The technical papers presented were an excellent balance and the high calibre of the speakers ensured an attentive audience for the whole day.

The committee is now busy considering the role of the T.I.C. and its staffing structure. There is a leaning among committee members towards a more electronically-based promotional activity for the T.I.C. rather than the technical advisory role filled by George Korinek.

We will advise you of the outcome of these deliberations in the next issue of the Bulletin.

Since our meeting in Prague, Sons of Gwalia has announced a significant increase in its in-the-ground reserves and resources of tantalum ore at both Greenbushes and Wodgina. The size, grade and accessibility to open cut mining should allay any remaining doubts some sections of the industry may have had about the future availability of tantalum.

We are now calling for papers for the Fortieth General Assembly in Perth and would welcome all suggestions for interesting topics on niobium and tantalum.

I extend to you best wishes for an enjoyable festive season and a successful and rewarding 1999.

JOHN LINDEN

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MEETING IN PRAGUE

The Tantalum-Niobium International Study Center held a conference in Prague, Czech Republic from October 11th to 13th 1998. The General Assembly of the association took place on Monday October 12th, followed by a technical programme covering aspects of the tantalum and niobium industry, especially in Europe.

AVX was the host for a splendid gala dinner that evening, in the Lord Mayor's Parlour on the island of Zofin. Guest speaker Mr Stanura gave an excellent presentation which was both entertaining and informative on the economics of the Czech Republic.

On Tuesday October 13th a large group travelled to Lanskrone, to the tantalum capacitor factory of AVX Czech Republic, where they were most cordially received and enjoyed an instructive plant tour.

A welcome reception on the first evening and sightseeing tours for the ladies and those not taking part in the field trip completed the programme.

GENERAL ASSEMBLY

Mr William Millman, President of the T.I.C. for 1997-98, chaired the Thirty-ninth General Assembly which carried out the business of the association. The audited accounts for the year ended June 30th 1998 were approved and the financial situation was pronounced to be sound.

Two companies, Silmet and Special Metals Fabrication, were elected to membership, and one associate member, Mr Michael Forrest was also elected. With the loss of two company members, the total number of members was therefore unchanged.

Dr George Korinek resigned as Technical Adviser and Editor of the quarterly Bulletin.

Mr John Linden, Sons of Gwalia, was elected President for 1998-99, succeeding Mr Millman. All the members of the Executive Committee were re-elected for a further term of office of one year.

The **Fortieth General Assembly** will be held on Monday October 25th 1999 in Perth, Western Australia, as part of a meeting from **October 24th to 26th 1999** hosted by Sons of Gwalia. A choice of plant tours, either to the Greenbushes mine or to the Wodgina mine, on October 26th, will be included in the programme.

TECHNICAL PROGRAMME

The following papers were presented in Prague (we shall be reprinting some of them in this and succeeding issues of the Bulletin):

- Tantalum Capacitor Market Trends 1998-2002
Mr Glenn Louch, AVX Corporation
- IBM Tantalum Capacitor Usage
Mrs Sylviane Bordas, Electronic Components Procurement Manager, IBM
- Reliability Indicators of Tantalum Capacitors
Mr T. Zednick, AVX Czech Republic, Professor J. Sikula and Mr J. Pavelka, Department of Physics, Technical University of Brno
- Tantalum and Niobium in Chemical Applications
Mr David Rowe, Special Metals Fabrication
- Tantalum and Niobium Developments in the former Soviet Union
Mr David Henderson, Metallurg International Resources
- Manufacturing of Lithium Niobate and Lithium Tantalate Crystal Wafers
Mr Peter Bordui, Crystal Technology
- SAW Filters using Lithium Tantalate for Mobile Communication Systems
Mr Masahiro Sugimoto, LSI Manufacturing Group, Fujitsu
- Technical and Commercial Development of the European Niobium Market
Dr Friedrich Heisterkamp, Niobium Products GmbH, and Mr Tadeu Carneiro, CBMM
- Tantalum in the Past Year, Tantalum Supply and Demand
Dr George Korinek, Technical Adviser, Tantalum-Niobium International Study Center

Dr George Korinek

Dr Korinek, who retired as Technical Adviser to the T.I.C. during the meeting in Prague, had served the association in this capacity for over five years. He had presented an overview of the tantalum and niobium industry to each General Assembly in that time, and had also presented papers at a number of international conferences to bring the two metals to the forefront of the attention of those present. He edited the quarterly Bulletin, and answered many inquiries from both inside and outside the organisation.

George Korinek was elected to the Executive Committee by the Eleventh General Assembly, when he was the nominated delegate of H.C. Starck Inc. He served twice as President of the association, in 1980-81 and again in 1989-90. After his retirement from Starck, he took up the post of Technical Adviser, succeeding Mr Rod Tolley in this role.

This retirement, we are sure, will not mean inactivity for George Korinek, and we wish him well.

TANTALUM SUPPLY AND DEMAND

**Tantalum-Niobium International Study Center
Brussels, Belgium**

Prepared by TIC in October, 1998

INTRODUCTION

Demand for tantalum (Ta) has been growing steadily since 1992 and reached a record of 3.14 million lbs of Ta metal (corresponding to 4.4 mil lbs of Ta_2O_5 in raw material) in 1997. This growth is due mainly to the increase in applications of Ta capacitors in the electronic industry, chiefly in PC's and telecommunications. Questions have been raised as to whether the tantalum raw material supply base is sufficient to sustain this growth in the future. This paper addresses this question.

TANTALUM DEMAND

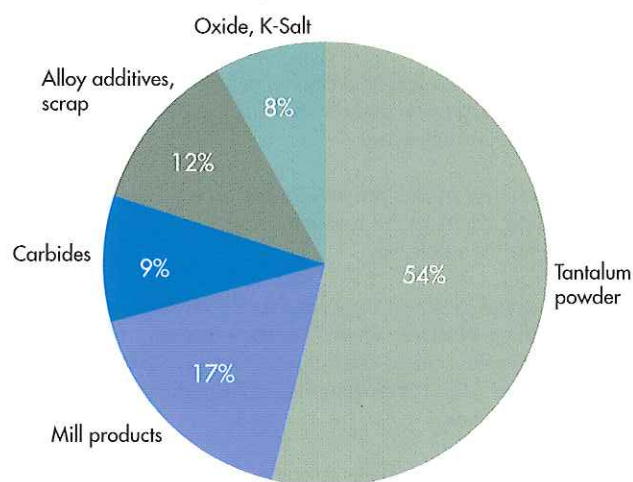


Figure 1: Shipments of Ta products (Millions of pounds)

Uses of tantalum are shown in Figure 1. The electronics industry is by far the largest consumer of tantalum with about 60% of the total in the form of powder, wire and furnace hardware. We will therefore discuss this application in some detail.

In the past, the production of tantalum capacitors experienced healthy growth. Between 1988 and 1997 the number of units produced annually increased from 5 to over 15 billion units. This growth is expected to continue, with 25 billion units forecast for the year 2000. Based on the number of units consumed in the capacitor industry, tantalum capacitors constitute the smallest segment, in comparison to multi-layer ceramics, aluminum, film and single layer ceramics.

Of the 450 billion capacitors produced per annum, less than 5% are tantalum units. However the latter showed a high growth rate of over 20% p.a. from 1988 to 1997. Consumption of Ta capacitors is forecast to increase by 14% per annum for the next 5 to 10 years. See Figure 2.

Capacitor Type	1995 (Units in Billions)	2000 (Units in Billions)	Growth Rate (Annualized)
Ceramic (Multilayer)	180	350	14%
Tantalum	13	25	14%
Aluminum	80	120	8%
Ceramic (Single Layer)	65	80	4%
Film	28	34	4%
Other	1	1	n/a
Total	367	610	11%

Figure 2: Worldwide capacitor consumption - Future growth

The main competitors of tantalum capacitors are multi-layer ceramics, mainly in small sizes less than 1 μ F, and electrolytic aluminum capacitors in the large sizes of 300 μ F and greater. Based on price alone, tantalum capacitors would not be considered as a first choice, but tantalum's outstanding characteristics have secured them an important position in modern electronics. These characteristics include high volumetric efficiency, very good frequency performance, and general reliability and excellent stability against temperature and applied voltage change. High growth areas, such as personal computers, portable telephones, beepers, and automotive electronic systems, are main users of Ta capacitors.

The compatibility of Ta capacitors with surface mounting technology for assembling integrated circuits contributed to the growth.

It is interesting to note that whereas the number of Ta capacitors increased by more than 200% between 1988 and 1996, the consumption of Ta powder increased by only about 40%.

There are three main reasons for this:

- There is a steady increase in the capacitance value of the powder used
- The chip capacitors which are very small in size have the highest growth rate of all capacitors
- Capacitor producers are progressing on their learning curve and are steadily improving yield and using powders close to their full potential.

Modern capacitor powders have a capacitance (CV/g) of 50-70K compared to 15-20K only four years ago. Developmental quantities of powders with CV/g of 100K have already been produced.

This development required the use of finer powders, sophisticated agglomeration techniques, and de-oxidation. Figure 3 shows the percentage of unit consumption of chips (surface mounted) and leaded capacitors with some projection for the future. The important role chip capacitors are playing is quite apparent.

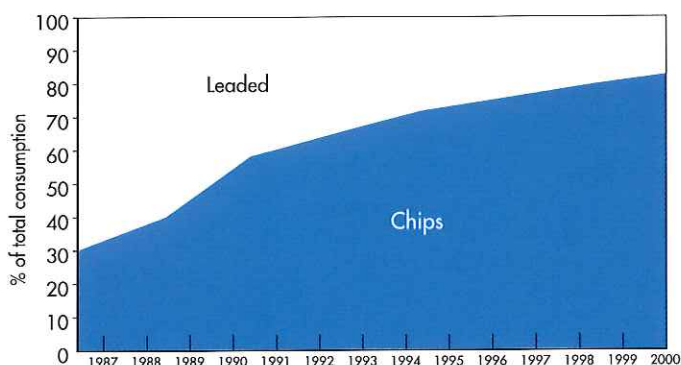


Figure 3: Unit tantalum consumption - World including Japan

All of the three above-mentioned factors are reflected in Figure 4.

	Capacitors (Billions of Units)	Powder Usage (Pounds per Million Units)	Powder Usage Total Pounds (000's)
1988	5.4	170	*917
1994	10.2	106	1,085
1995	13.0	100	1,300
2000	25.0	70	1,750

*An additional 220,000 lbs. were shipped in 1988 to hedge against price changes.
Tantalum wire demand in lbs. is forecast to add 18% to powder demand.

Figure 4: Worldwide tantalum powder consumption

The converging trends of increased numbers of tantalum capacitors required, and the reduced number of pounds of Ta powder needed to make them, resulted in a real growth rate of tantalum usage in the Ta capacitor industry of 5-8% p. a. (Figure 5). The development described above is expected to continue through 2010.

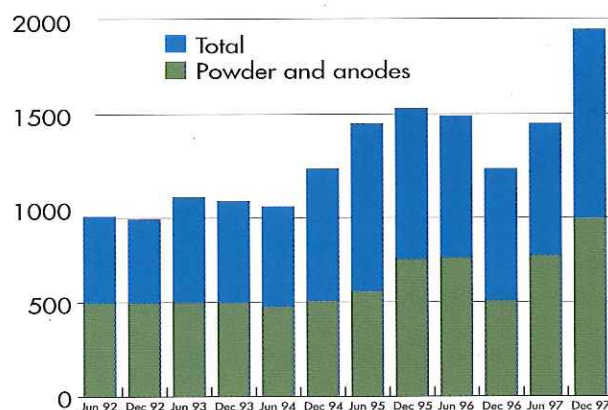


Figure 5: Tantalum demand (000's lbs of Ta)

The consumption of tantalum for super-alloys will be dependent on the health of the aircraft industry and is expected to grow by about 3% per annum.

The application of Ta carbide in the metal cutting industry is well established and will grow with the general economy and is estimated at 2% per annum.

The same applies for usage of tantalum as a corrosion resistant material for equipment in the chemical processing industry.

These factors would indicate that the total growth of tantalum will be around 5% on the average from the 1996-97 level and be supported mainly by the growth in electronics.

The recent developments in South East Asia and relative stagnation in Japan will certainly have negative influence on the growth short term.

TANTALUM SUPPLY

In nature, tantalum generally occurs in close association with niobium, tin, and titanium.

The most important sources of Ta raw materials are:

- Tantalite concentrates
- Tantalum-containing tin slags
- Columbite and struverite concentrates

Tantalum-containing slags were an important raw material in the past. Because of structural changes in the tin industry, their importance has decreased, with the exception of the substantial accumulated inventory of this material.

Towards the end of the 1980s, production from alluvial mines was also being reduced as the more easily accessible ore resources became depleted.

The combined effect of growth in demand for the electronics industry and the decreased supply from tin slags and alluvials meant that by 1990 the time had come to develop primary hard rock tantalum resources.

Sons of Gwalia's Greenbushes Mine in Western Australia had an established hard rock resource, which was developed based on a long-term supply contract with the two largest users, Cabot and H. C. Starck. This arrangement contributed very substantially to the price stabilization of the tantalum industry. Sons of Gwalia also took over the Wodgina Mine also in Western Australia in 1995 and became by far the largest primary producer of tantalum concentrate.

FUTURE SUPPLY

With the projected growth on the demand side of the tantalum industry, industry focus has shifted to future supply sources.

Primary Supply	000's Pounds Ta ₂ O ₅ Current 1998	Capacity 2002
AFRICA		
Kenticha Mine, Ethiopia The deposit is very large and low grade, with both an alluvial and hard rock component. Current production is from a primitive alluvial plant but plans are in progress to privatize the mine and increase production.	100	300
Morrúa, Mozambique This project is ready for a production decision. The resource is approximately 5 million tons and 500gm/ton, which is capable of sustaining an open cut mine for at least 7 years.	...	400
Zaire-Rwanda-Burundi Production from the Central African countries is mainly from a large number of small producers with material collected by traders. The political situation has meant that no investment has occurred in these to organize production. Actual production fluctuates from year to year but resources in easily accessible deposits are quite large.	200	300
Subtotal	300	1000
AUSTRALIA		
Greenbushes Mine The Greenbushes Mine will maintain this level of production and could be increased by a further 200-300 000lbs per annum subject to significant capital investment.	650	950

Wodgina Mine Plans are in place to increase production to 300 000lbs/annum and studies are ongoing to see what is required to increase production to the 500 000lbs/annum level.	170	300
Other Australian Production is also coming from the Bynoe project and potential exists in at least three other areas that could be developed at the right price.	50	200
Subtotal	870	1450
BRAZIL		
Metallurg The main mine at St. Joao Del Rei has closed but Metallurg continues to run its tin smelter and tantalum oxide plant on concentrates delivered by small miners and traders.	200	300
PARANAPANEMA		
Mamore The tin smelter in Sao Paulo has large stockpiles of low-grade tantalum-bearing tin slags which have the potential to be reprocessed for their tantalum content.	...	300
Pitinga This mine produces cassiterite and intermediate concentrates consisting predominantly of niobium with tin and tantalum values. The quantities produced are large and, as technology in handling and processing improves, the amount of tantalum made available to the market will increase.	50	200
Subtotal	250	800
CANADA		
Tanco The Tanco Mine produces tantalum as a co-product with spodumene and caesium. Reserves are sufficient to increase production for the medium term and drilling is proceeding to increase reserves.	100	300
CHINA		
Yichun Mine This large tonnage low-grade mine is the subject of a study to increase production significantly, with Vishay providing the expertise and arranging the financing.	120	300
Other Mines There are at least six producing mines of some significance but production is low and generally as a by-product of lithium minerals.	100	100
Subtotal	220	400

MALAYSIA

Struverite

This tantalum-containing ilmenite is produced from retreating tin tailings or 'amang'. The quantities have been declining and are likely to continue to do so.

Tin Slags

Low-grade tin slags are being reclaimed from dumps accumulated during the past 50 years of tin smelting. While the major accumulations have been reclaimed, a smaller supply continues to be available.

Subtotal

THAILAND

S. A. Minerals

Struverite production from retreating tin tailings and some primary tantalite.

Thaisarco

This tin smelter traditionally produced large quantities of tin slags containing high levels of tantalum. Current production is likely to increase as availability of better grades of cassiterite become available from the surrounding countries of Myanmar and Vietnam.

Tin Slags

Recovery of tin slags similar to Malaysia.

Subtotal (Figure 6)

Total Primary Supply Equivalent Ta

100 50

100 100

200 150

100 100

100 200

200 200

400 500

2340 4600
1800 3540

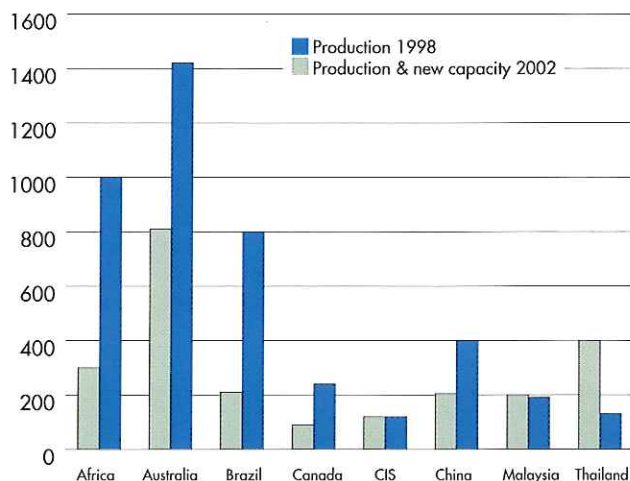


Figure 6: Primary tantalum supply (000's lbs)

SECONDARY SUPPLY

Scrap

The tantalum industry is becoming more sophisticated in collecting scrap from products of recycling. Industry estimates are that 25% of demand is collected for recycling and this could increase to 30%.

Recycle-Residue treatment

In the USA, past accumulations of residues are now being reprocessed and will generate tantalum for the medium term.

Inventories

US Government, Defense Logistics Agency

The policy is to reduce strategic stockpiles and tantalum has been allocated under the annual material disposal plan. The total stockpile contains sufficient material to support releases for a long time.

Processors

The industry traditionally carries large inventories in all forms of tantalum. The largest inventories are in the lowest value products, being the low-grade slags and ores.

Total industry inventories are estimated at some 10 million pounds Ta₂O₅ or sufficient for almost 3 years' consumption.

These inventories will be used to balance any demand-supply imbalance that might occur.

000's lbs Ta Metal
Current Capacity
1998 2002

600 800

200 200

120 250

650 ...

TOTAL SECONDARY SUPPLY

1570 1250

TOTAL SUPPLY (POUNDS TA)

3370 4790

To increase the primary production from about 2.3 million pounds Ta₂O₅ in 1998 to over 4.0 million pounds in 2002 will require major capital investment at Greenbushes and Wodgina (in Western Australia), Tanco (in Canada), Kenticha (in Ethiopia), Morrua (in Mozambique), and Yichun (in China). It is estimated that this investment would exceed \$100 million over the next 4-5 years.

SUMMARY

- The total growth of tantalum is and will be based primarily on the growth of the application of Ta capacitors.
- The present technological developments will continue and the very healthy growth of tantalum capacitors can be supported by much more modest growth of Ta powder consumption.
- The present level of tantalum raw material supply and the 'above ground' reserves are sufficient for the foreseeable future, subject to the successful development of the projects mentioned above.
- Subject to these developments taking place, the currently identifiable increase in primary production over the next 4-5 years can guarantee sufficient material for forecast demand until well into the next decade.
- Stability and fair pricing will be conducive to more active tantalum mineral development in the future than in the past and be of benefit to the tantalum industry at large.

To summarize – The overall demand for tantalum remains positive and sufficient resources have been identified and can be developed in order to supply this level of forecast demand.

Every reasonable attempt has been made to ensure the accuracy of the information set forth in this report. However, the TIC makes no warranties or representations regarding the accuracy and completeness of this report, and the TIC on its own behalf as well as on behalf of its members, expressly disclaims all liability for any damages (direct, indirect, incident or consequential damages of any kind whatsoever) that may result from any errors or omissions in this report or that may otherwise result from the use of this report.

TANTALUM CAPACITOR MARKET TRENDS 1998-2002

by Mr Glenn Louch, AVX Corporation

This paper will give an overview of some of the trends that are impacting and will impact the tantalum capacitor industry. After looking at some of the key factors driving the electronic industry today, I will move on to review how the industry has performed against the forecasts shown at the T.I.C. Symposium in Goslar in September 1995, then consider the important applications affecting the tantalum capacitor business today. Some of the specific applications which will impact the tantalum business over the next few years will be examined, and the risks and challenges facing the business now and in the immediate future will be identified. Finally I will show what I believe to be the unit demand over the next five years.

MARKET DRIVERS

The electronics industry is still very young, growing at more than 10% per year, and its influence on our lives will continue to grow at a dramatic rate. Any business that continually gives better performance at a lower cost year after year must be attractive to the end user. Electronics is pervasive: virtually every home now has more computing power within its four walls than the average medium size business had at its disposal a decade ago. In ten years' time we almost certainly will be able to stand up and say the same thing again. It is not only the PC which is concerned. Everyday domestic appliances and consumer products, such as vacuum cleaners, washing machines, toasters, irons, phones, cameras, all contain electronics too. The average family car now contains significantly more computing power than the Apollo moon mission had available.

The life-cycle for these products is becoming shorter. This is not because they are less reliable than earlier products but because they are outdated by changes in technology much faster. The life of a mobile phone averages around two years, in Japan it is one year. Portable computers, video cameras and mobile phones continue to get smaller and lighter. Each generation has more features and functions than the previous generation, and as it reaches maturity it is generally cheaper. Computers have add-on features to turn them into phones, phones have limited computer facilities. Shortly GPS capability will be available in phones and notebooks. This overlap and merging of capabilities will gather pace and spread into more everyday domestic appliances.

The use of tantalum has historically been the way to cram more capacitance into the smallest possible space. By continuing to develop new products and pre-empting and addressing future market needs, tantalum can add value to end products and enjoy real long term revenue growth, as well as unit growth.

'worldwide economic chaos' – March '94
'business has clearly improved' – December '94
'indicators point to reasonable growth rates' – March '95
'business conditions look very promising' – December '95
'signs that business will continue to improve' – March '96
'recent softness in the tantalum capacitor business' – June '96
'recent signs of recovery in the PC market' – December '96
'customers demand higher and higher performance' – March '97

Figure 1: Quotations from T.I.C. Bulletins

Figure 1 shows some selected statements from T.I.C. Bulletins over the past few years. A point to note is how fast the sentiments and actual market conditions change from very pessimistic to optimistic.

The electronics industry can re-invent itself and create new markets in a very short period of time. This is becoming even shorter as product life-cycles continue to be reduced. Headline products such as Dram, Microprocessors and PCs tend to shape much of the sentiment that is reported. In the background, analogue products, passive components and electromechanical items tend to perform at a more stable growth rate.

Clearly, today we are faced with a very turbulent set of economic conditions worldwide.

Historically the industry that we are serving has enjoyed continued double digit growth rates almost irrespective of global economic conditions. I firmly believe that electronics manufacturers will ride the storm far better than many other industries and double digit growth will continue to be the norm. End market unit growth is assured. Collectively how we translate this into similar levels of dollar growth is a major challenge that we all need to address today.

Tantalum capacitors represent only a tiny portion of the sales of all electronic components. We can choose either to try and ride on the coat tails of what happens to the end market or to recognise that the very rapid pace of change in the electronics business represents a major opportunity for tantalum. To achieve revenue growth we need new products and to demonstrate to system designers that we add real value.

Of course we are not operating in isolation and the past year has seen continued encroachment by other technologies, with ceramic capacitors now being developed up to 100pF and aluminium capacitors operating at lower ESR levels and over wider temperature ranges.

Capacitor type	1994	1995	2000	Growth rate
	Bu	Bu	Bu	Annualised, %
Multilayer ceramic	142	180	350	14
Aluminium	76	80	120	14
Tantalum	10	13	25	8

Figure 2: Tantalum market forecast, T.I.C. Symposium, September 1995

The forecast made by Kemet at the T.I.C. Symposium in Goslar in September 1995 is shown in Figure 2. These numbers were supported in the papers from Motorola and Intel. Motorola had a very aggressive demand forecast moving from a

requirement of 1.3 billion units in 1995 up to 7.2 billion units in the year 2000. It highlighted the relative price position between ceramic and tantalum and challenged the tantalum industry to address supply concerns and relative cost, otherwise it would be faced with looking at alternative solutions. Since 1995 Motorola has in fact designed out tantalum in favour of ceramic at every opportunity.

Intel also forecast a strong growth opportunity for tantalum but highlighted the availability concerns current at that time and the high costs relative to other technologies. It pointed out that designers were looking at alternative solutions.

Figure 3 shows how we have actually performed against the 1995 forecast. Through the four years shown here, ceramic has averaged a growth rate of 31% per year. Indications are that in 1998 this growth will be closer to 20%.

Consumption of aluminium has decreased over this timeframe and indications are that it will end 1998 at the same level or slightly lower.

Tantalum enjoyed an even higher growth rate in 1995 than had been previously forecast due to the shortage situation at that time. As is often the case, much of this demand was created through a build-up of safety stocks through the period of shortage. Over the time shown here tantalum growth averaged 12.5%.

In 1996 a large amount of new tantalum capacity came on stream and this caused the safety stock that had built up to be dramatically reduced; in fact, demand in 1996 was lower than in 1995. This situation was corrected in 1997 and realistic growth rates continued.

The shortage caused an increase in people moving to ceramic and aluminium, and delays in switching from leaded to surface mount.

CURRENT MARKET DRIVERS

CELLULAR PHONES

In 1995 the tantalum capacitor industry was enjoying a unit growth rate of 40%. This was heavily driven by demand in the cellular phone market segment. Since then, cellular phones have continued to be the dominant user of tantalum, even though the average chip count has fallen by half – the average has dropped from 30 per phone in 1994 to 15 today, and will fall further.

Capacitor type		1994 Bu	1995 Bu	1996 Bu	1997 Bu	1998 Bu	1999 Bu	2000 Bu
Multilayer ceramic	1995 forecast	142	180					350
	Actual	142	184	220	320			
Aluminium	1995 forecast	76	80					120
	Actual	76	83	60	66			
Tantalum	1995 forecast	10	13					25
	Actual	10	14	13	15			

Figure 3: Capacitor market consumption 1994-1997

This is not all bad news for tantalum as the mix of sizes has moved dramatically from A and B case to the larger case sizes. In 1995 it was almost unheard of to have a D or E case tantalum in a phone: today most digital phones will have between 2 and 6 D and E case parts per phone. From an anode weight standpoint the ratio between A and D case is close to 13 to 1. Therefore although the number of chips has dropped the actual tantalum powder usage per phone has in fact increased.

Thus the weight of tantalum has increased although the size and weight of the end product have decreased. The reason is that digital phones use a pulse based transmission system which requires large capacitance parts to provide the energy needed for the transmission pulses.

In January 1998 there were 207 million subscribers with cellular phones, 52% more than a year earlier. This means that 4.3% of the people in the world have a cellular phone. In Europe 19% of the population have such phones, and in Finland this proportion is more than 50%. The replacement market increases production of phones by an additional 20%. Although traffic is dominated by voice, multimode phones are starting to emerge.

PERSONAL COMPUTERS

I believe that the market has grown by at least 10% in dollar terms and by significantly more in terms of units.

The Internet has only just started to be used, but it is already a major driver in this segment, and will continue to be so.

In desktop systems, size is not an issue, and we have seen a number of manufacturers switch from tantalum to aluminium for reasons of cost. However, the market for notebook PC's is growing by more than 20% per year, much faster than desktop PC's, and here size is an issue: tantalum tends to dominate the higher capacitance requirements. The number of chip capacitors used in a PC motherboard can vary from zero to more than 100.

PC's tend to use larger case sizes and tighter ESR specifications than cellular phones, so although the volume is much lower the value of this segment is close to that for the cellular phones. For low ESR and high capacitance, high value tantalum capacitors dominate usage.

MASS STORAGE

1997 was a year that saw slower growth for the hard disk market as inventories were adjusted in the supply chain. Nevertheless some 127 million units were manufactured in 1997, 19% more than in the previous year.

The chip count here is an average of 7 per hard disk drive and the count for tantalum is decreasing, but the segment uses high capacitance and high voltage parts so this represents a major consumer of powder. The case size mix is dominated by larger case sizes and high voltage.

The density of the hard drive is increasing at a dramatic rate: in early 1994 the basic hard disk drive was 340 megabytes, now it is 6 gigabytes – but the cost to the end user is the same. The industry estimates that 1.3 hard disk drives are used in each personal computer. As manufacturers put more platters into their drives, the trend towards lower profile, high capacitance parts will continue. CD ROM uses no tantalum.

AUTOMOTIVE

Although automotive electronics is growing at a slower rate than the previous three segments, at 8% per year, I believe this will accelerate as legislation relating to pollution and fuel consumption is brought in. Environmental pressure will increase electronic content in cars.

Up to 20% of the cost of a luxury car is for electronics, and tantalum is used in ABS, airbag, engine management and instrumentation systems. The equipment which is standard in a luxury car today will become standard in less expensive models within two to three years, and this will increase the growth rate of this market.

Specifications for this segment are challenging to meet, and tantalum manufacturers will continue to develop enhanced specification products that sell at premium prices to support this market.

DIGITAL CAMERAS

Digital video and still cameras are an emerging market that consumes relatively few tantalum capacitors today, but they are still in their infancy and this situation will change. Sales of video cameras were 1.7 million units in 1997, an increase of more than 70% on 1996. Requirements for still cameras in 1997 were 2.1 million units, 61% more than in 1996. There are approximately 70 tantalum chips in each digital video camera and 30 tantalum chips in a still camera, the mix is dominated by A and R case products. Virtually all camera production and design is carried out in Japan.

Years ago, the first generation video camera was the largest consumer of tantalum, but for cost reasons this switched almost entirely to aluminium. The current generation of digital cameras is very much smaller and aluminium capacitors cannot easily be used, so with huge growth rates this will become a major user of tantalum.

FUTURE MARKET DRIVERS

CELLULAR PHONES

The number of new subscribers will continue to show a very significant increase over the next five years. The present new subscriber growth rate of 52% will fall to some 30% over that period, which is still substantial. The penetration of cellular phone use by 4.3% of the population will rise to about 10%. Current economic conditions will slow growth in the short term for both new subscribers and the replacement market.

Although the tantalum count will reduce from 15 to less than 10, the development of multimode and multiband phones will slow the opportunities for reduction in the number of chips.

The average life of a phone is two to three years, in Japan it is closer to one year. This will continue to shorten. The replacement market which currently represents some 20% of all phone production will accelerate significantly, and start to dominate that production.

The USA market is almost exclusively analogue with over 70 million users. Over the next five years digital will become the dominant technology, and this switch will boost the replacement market. In Europe the changeover took less than 30 months.

Future phones will need very high capacitance, higher than 2500pF, with very low ESR and low profile. In addition there will be a move from A and B case to 0805, 0603 and smaller.

In the longer term the cellular phone will become the preferred means of voice and data communication.

PERSONAL COMPUTERS

Growth will continue to be strong in the PC segment, and will remain above 10%. As higher performance CPU's emerge, such as 1G Hz CPU, there will be an increasing need for parts with ever lower ESR and higher capacitance. There is a possibility that monitors will be replaced by LCD displays.

The Internet will continue to be a prime driver for both new subscribers and upgrades, increased access will drive the replacement market. As voice recognition technology improves, voice activation capability will become standard; this will become the preferred entry method for data and access and will remove some of the barriers posed by the keyboard.

MASS STORAGE

Driven by PC growth and upgrades as people use Internet more and more, this segment will demonstrate strong growth for the foreseeable future. Growth in hard disk drives is forecast at 14% per year. Higher density and higher specification drives will limit the opportunities to replace tantalum with ceramic and drive the need for lower profile parts. DVD will replace CD ROM for higher capacity and speed, this is forecast to grow at more than 100% per year. High voltage will remain standard.

AUTOMOTIVE

A good insight into automotive future requirements can be gained by looking at avionics systems and the electronics used in Grand Prix cars. The extension to standard cars of the kind of systems used in these fields, associated with safety and security measures, control of pollution, and compliance with fuel conservation legislation, promises strong growth in this market segment.

Over the next five years we will start to see black box type systems in cars, GPS as standard associated with anti-theft devices, also control and monitoring of speed and automated toll capability. Collision avoidance and driver monitoring systems will be built into cars as standard, and traffic flow systems will emerge to control congestion. I foresee the abolition of the wiring loom, too.

I believe we will see the automotive electronics market grow by more than 10% per year from its historic 8% growth rate.

DIGITAL CAMERAS

The chip count in digital cameras will decrease from current levels of 30 in a still camera and 120 in a video camera to closer to 12 and 75. This will be driven by ceramic capacitors replacing tantalums. Even allowing for this we will see demand for tantalum increase from less than 200 million units in 1997 to close to 1 billion units by 2002. The size of video cameras will decrease by 50% over the next two years, while more functions will be added: the resulting growth is forecast to be between 15% and 51% per year for the next five years.

Still cameras will become standard features added on to all Personal Computers, giving forecast growth of between 25% and 55% per year for the next five years.

Video conferencing and video phones will be standard via the Internet, and used with PC's in all homes: this will drive demand for video cameras at the lower end of the market.

NOTEBOOKS AND PDA

I have separated Notebooks and Personal Digital Assistants (PDA) from the general PC market here, as their growth rate is dramatically higher than for desktop PC's, at more than 20% per year.

The PDA today is not much more than an electronic diary or scheduler and address book at the upper end of the market, but new low power, high performance CPU's and full function software will change this, it will have real PC capability. Voice entry and reliable pen based systems will develop to allow this market to explode.

Both of these markets will consume very high volumes of tantalum capacitors, with much of this being high capacitance, low voltage, low profile and low ESR products. The size of the finished product limits the opportunities to use aluminium capacitors instead of tantalum.

CAPACITOR MARKET

FORECAST

1997	1998	1999	2000	2001	2002
Bu	Bu	Bu	Bu	Bu	Bu
15	18	21	24	27	31

Figure 4: Tantalum capacitor market forecast 1997-2002

Figure 4 shows the tantalum capacitor market forecast through to the end of 2002. I estimate that consumption in 1998 will be close to 18 billion units, and from here the unit demand will grow by 72% in this timeframe.

There will be some shift in mix towards the higher capacitance and case parts, this being driven primarily by the cellular phone market.

Converting this unit growth into a reasonable revenue growth will depend on the industry addressing a number of significant challenges.

RISKS AND CHALLENGES

The failure level of tantalum is no higher than that of other dielectrics and in some instances it is better. The failure mode where parts burn is the single biggest challenge we have to address. In Japan there is already legislation to exclude parts that emit smoke or burn. Several major customers have already decided on alternative solutions even at the expense of increased cost and chip count. Any part that burns, from any supplier, for any reason, adds to the momentum to remove tantalum. As an industry we have to address this.

Inventory levels are very low, and there are no buffers in the system, so changes in demand are reflected directly through the supply chain and could cause spot shortages. We need to minimise these in order to avoid any panic that might encourage more designers to use ceramic capacitors instead.

Selling prices have been falling at almost 20% for the past two years so absorbing increases in the cost of raw materials is more or less impossible. Capacitor makers continue to invest in lower cost manufacturing and improved efficiency but no one can keep up with this erosion plus increased costs.

Reducing the time-to-market for new powders, processes and products is essential in order to stave off some price pressure. With system lifetimes at 12 months or less it is vital that we get these new products to market faster.

Ceramic multilayer capacitors will continue to encroach on the tantalum market, and aluminium capacitors will surely improve their surface mount capability. Once again new products and adding value to designers and their end products are fundamental, the key to meeting the challenge.

CONCLUSION

- End market growth is forecast to be more than 10% per year throughout the next five years
- Address failure mode or risk being designed out
- Changes in the product mix will continue to shift to larger case sizes and lower profile
- Also there will be an increased push to lower voltage and lower ESR
- Time-to-market for powders and capacitors must be reduced
- Tantalum industry must continue to invest to stay ahead of the cost reduction curve
- Tantalum is the most volumetrically efficient solution. Continued development for powders, processes and products is needed to stay ahead of alternative solutions from the standpoint of cost and performance
- The opportunity for a healthy long term future is in our hands.

Figure 5: Summary

The tantalum industry from raw material through to finished capacitors has the opportunity to benefit from the growth rates in the market we serve. I firmly believe that we need to grasp this opportunity and re-establish tantalum as the most volumetrically efficient solution for all case sizes and applications. We must address failure mode and time-to-market, and improve the way we engage with our customers' design teams if we are to convert the unit growth into revenue growth of similar levels.

ASSOCIATE MEMBERSHIP

Associate membership of the Tantalum-Niobium International Study Center is available to individuals, academic and government institutions, researchers... For those interested in the two metals but not involved in commercial activity, this is a good way to keep in touch with developments, for a fee of only US\$500 per year. Associates receive the quarterly Bulletin, statistics reports and monthly abstracts listings, as well as invitations to the meetings and General Assemblies of the T.I.C.

Details and application forms may be obtained from the T.I.C. office in Brussels.

Full membership, for companies involved in the extraction, processing or use of tantalum or niobium, or with a continuing interest in these metals, can be taken up at any time of the year (and ratified by the next General Assembly): for this also application may be made to the T.I.C. office.



Tour group arriving at the plant of AVX Czech Republic at Lanskrout: on the far right is Mr Jiri Kohout who masterminded the plant tour arrangements



Visitors and the new extension to the factory, under construction: on the left is Mr Bill Millman, President of the T.I.C. 1997-98



Sightseeing group in Prague: Mrs Korinek (left), Mr Larry McHugh pushing Mrs Mary Jane Tyler, who took part in the entire event in spite of suffering from a broken leg (photo by Mrs Linda McHugh)

MEMBERSHIP

These two companies were elected to membership by the Thirty-ninth General Assembly on October 12th 1998:

Special Metals Fabrication Ltd.

Horndon Industrial Park,
West Horndon, Brentwood,
Essex CM13 3XD, England.
Tel.: +44 1277 811251
Fax: +44 1277 810255
Delegate: Mr Graham Russ, Managing Director

AS Silmet

Keskstr 2,
40231 Sillamäe, Estonia.
Tel.: +372 39 29 100
Fax: +372 39 29 111
Delegate: Mr Jaak Järv, Director of commerce

Trinitech International Inc. resigned from membership. The membership of Saha Electro Components was terminated.

Associate members

Mr Michael Forrest was elected to associate membership. The resignations of Mr Ira Friedman and Mr Christian Polak as associate members were accepted.

MEMBER COMPANY NEWS

Sons of Gwalia

Sons of Gwalia announced recently to the Australian Stock Exchange a substantial increase of tantalite resources at its Wodgina and Greenbushes Tantalite Mines in Western Australia.

Recently the company has been exploring at the Wodgina Mine near Port Hedland in Western Australia in an area to the east of the existing open cut operations below surface cover. A large drilling programme of approximately 15 000 metres of drilling is approximately 50% complete but has already delineated substantial widths of flat lying pegmatites containing tantalite at variable depths and to a maximum of approximately 250 metres.

This discovery has been called Mt Cassiterite East and is open at depth and in all directions.

A preliminary resource model has defined approximately 28 million tonnes at a grade of 415g/t Ta_2O_5 , equivalent to approximately 25 million lb. of in situ Ta_2O_5 . This compares to the in situ 1.95 million lb. of Ta_2O_5 in reserves and resources when the Mine was acquired in June 1996.

The company is currently upgrading its Wodgina plant facilities with the objective of increasing tantalite production at the Wodgina Mine from the current 180 000 lb. a year to 300 000 lb. a year.

Greenbushes Mine

At the company's Greenbushes Tantalite Mine, in the south-west of Western Australia, the company has been pursuing a conceptual target of a very large, low grade, low strip ratio tantalum resource to the south of the existing Cornwall open cut mine and operations. This programme has been successful and a large, low grade resource has been delineated in this area.

When combined with the existing Cornwall open cut tantalite resources at Greenbushes, a total measured and indicated resource of approximately 173 million tonnes at a grade of 200g/t has been delineated, equivalent to approximately 75 million lb. of in situ Ta_2O_5 .

The Greenbushes Mine is currently producing approximately 650 000lb. of tantalite concentrates per annum from ore with an average head grade of 360g/t and a metallurgical recovery of approximately 55%.

Combined tantalite resources

The combined resources at the Wodgina and Greenbushes Mines now total approximately 100 million lb. in situ Ta_2O_5 , as against the combined reserves of 44 million lb. referred to in the company's Annual Report dated 30th June 1998.

The new resources constitute by far the largest known tantalite resources in the world. This places the company in an extremely strong and strategic position in relation to supplying long term global demand for tantalite, particularly from the electronics industry which has indicated a requirement for secure and increased supplies of tantalite raw materials.

Siemens Matsushita

Siemens Matsushita has opened a new facility for tantalum chip capacitors in Evora, Portugal. The new plant will increase production in stages to one billion components a year, thus increasing Siemens Matsushita's total annual output of tantalum chip capacitors to 1.6 billion components by the year 2001. The new facility contains the most advanced machinery of its kind for automated production and testing and will employ nearly 400 people.

The Capacitors Division of Siemens Matsushita Components began mass production of tantalum chip capacitors at its plant in Heidenheim, Germany, in 1990. Today this is the only company to manufacture these components in the European Union, and it says it is the number one supplier to the European automotive electronics industry.

The company has also announced availability of new V case tantalum capacitors, low profile D case with 16 different capacitance/voltage ratings.

Cambior

In its financial report for the third quarter of 1998, Cambior states that its share of production from the Niobec mines was 283 tonnes of niobium.

Sogem USA

The T.I.C. membership of Sogem USA has been transferred to Sogem S.A. in Brussels, 31 rue du Marais, 1000 Brussels, Belgium, and the delegate is Mr Bruno Deliens.

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