TANTALUM INTERNATIONAL STUDY CENTER

BULLETIN No 44 OCTOBER 1985 FOURTH QUARTER

Twenty-fourth General Assembly

The Twenty-fourth General Assembly of the Tantalum International Study Center will be held at 9 a.m. on Tuesday October 22nd 1985 at 40 rue Washington, 1050 Brussels, with a complementary programme on the evening of October 21st and on the morning and afternoon of October 22nd, as well as a tour for accompanying spouses.

The meeting will open with a Cocktail Party at the Hilton Hotel from 6 to 8 p.m. on Monday October 21st : all delegates and their ladies are cordially invited as guests of the T.I.C.

On the morning of Tuesday October 22nd a continental breakfast will be served from 8 to 9 a.m. at 40 rue Washington. The General Assembly will be convened at 9 a.m., and a short coffee break will follow. The programme of presentations and discussions will run from 10.30 a.m. to about 4 p.m., with an interval from 1 to 2.15 p.m., when delegates will be the guests of the T.I.C. at luncheon.

Presentations will include :

— Presidential Address by Mr Carroll G. Killen, President of the T.I.C.

— "The role of the Technical Officer of the T.I.C., and what can be achieved", by Mr Andrew Jones, T.I.C.

— "Plansee and powder metallurgy — special activities in tantalum and niobium", by Dr Hugo M. Ortner, Head of Analytical Services, Metallwerk Plansee GmbH, Reutte, Austria.

— "Projected niobium demands in applied superconductivity : 1986-2000 A.D.", by Dr Harry Stuart and Mr Charles Laverick, Niobium Products Co. Ltd., Pittsburgh, U.S.A.

— "The changing role of the metal trader in the tantalum business", by Mr Hubert E. Hutton, Norore Corporation, New York City, U.S.A.

A panel discussion on current interests will also be arranged, and it is hoped that delegates will suggest subjects which they would like to introduce into the debate.

It is planned that a tour for accompanying spouses should take place during this day, probably visiting Bruges, a historic town with fine gothic buildings, about one hour's drive from Brussels.

TWENTY-FOURTH GENERAL ASSEMBLY TO BE HELD AT 9 A.M. ON TUESDAY OCTOBER 22ND 1985 AT THE INTERNATIONAL ASSOCIATION CENTRE, 40 RUE WASHINGTON, 1050 BRUSSELS

AGENDA

1. **Voting proxies.**
2. **Opening address by the President, Mr Carroll Killen.**
3. **Minutes of the Twenty-third General Assembly (held in Boston on June 13th 1985).**
4. **Membership : applications, resignations.**
5. **Financial matters.**
6. **Report of the Executive Committee.**
7. **Statistics : production, processing, capacitors, forecasts of production.**
8. **Niobium interests.**
9. **Statutory elections.**
10. **Forthcoming General Assemblies.**
11. **Other business.**

President's letter

Twelve months ago, the tantalum industry looked forward, after three difficult years, to a period of renewed growth. Unfortunately, after a short "boom period", the book to bill ratio in the industry once again became negative. It now appears that this condition will continue well into the first half of next year.

To a large extent, the health of the tantalum industry is dependent upon the health of the electronics industry. This fact is adequately demonstrated at the present time — both the electronics and the tantalum industries are experiencing a recession while, at the same time, many other industries are experiencing a period of growth.

In order to improve the ratio between non-electronic and electronic uses of tantalum, several of our members have suggested that the research and development programs of our member companies should includes projects whose objective is to develop new uses for tantalum. That we have not been successful in this endeavor suggests that we may have been complacent as a result of our earlier successes. Whatever the reason, we, as an industry, must address this problem if the tantalum industry is to become, once again, a growth industry.

The Twenty-fourth General Assembly will soon take place. Its location will be in Brussels. An excellent program has been planned and will include an update of our efforts to make the statistical program more useful. You will also hear from our Technical Officer, Mr Andrew Jones. In addition, interesting papers will be presented by Dr Harry Stuart of Niobium Products Company, Dr Hugo Ortner of Metallwerk Plansee and Mr Hubert Hutton of Norore Corporation.

This will be a General Assembly that you cannot afford to miss. On your way to Brussels, why not consider possible ways that the scope of our industry can be enlarged ? Once in Brussels, why not discuss your ideas with others, perhaps a new jewel will be born ? And, last but not least, why not bring your spouse ? There will be a special program for spouses.

I look forward to seeing each of you in Brussels.

Carroll G. Killen
President

Abstracts of papers to be given at the Brussels meeting

PLANSEE AND POWDER METALLURGY - SPECIAL ACTIVITIES IN TANTALUM AND NIOBIUM

Dr Hugo M. Ortner, Head of Analytical Services, Metallwerk Plansee GmbH, 6600 Reutte, Austria.

An overview is first given on the development of Metallwerk Plansee, founded in 1921 by Prof. Paul Schwarzkopf, from a laboratory-sized production, employing some 20 people, to an international company. At the parent firm in Reutte 2,000 persons are presently employed, and the worldwide figure is approaching 2,800.

Some special activities by Plansee on tantalum and niobium will then be discussed :

— Tantalum and niobium as materials for the manufacture of heavy load-bearing prosthetic devices.

These two metals combine excellent corrosion resistance and bio-inertness with good ductility and workability. For bigger implants, niobium is preferred for its low density. The next stage in new materials for bone surgery implants will be niobium, dispersion-strengthened with niobium oxides.

— Another still rather exotic application of niobium and tantalum is their use as mint metals.

Both metals are well coinable and corrosion resistant, and their production is limited and therefore the number of producers is easily controllable, which is very important for this application. In addition, Plansee coins can be made absolutely safe against counterfeiting. Medallions for special occasions can also be coloured by anodic oxidation.

— Nb_3Sn-superconductors exhibit several advantages over "conventional" NbTi-superconductors. Their critical temperature is considerably higher (18°K against 9°K for NbTi) and their critical field is 28 Tesla as compared to 14.1 Tesla for NbTi. A new production process for Nb_3Sn-superconductors was presented by Plansee on the occasion of the 11th Plansee Seminar last May.

— Another interesting and expanding application for niobium and tantalum is their use as ultrapure materials for sputter targets, especially for the electronic industry. Targets of pure tantalum and niobium, and of some of their alloys and compounds are manufactured with closely-controlled trace levels. Values, e.g. for alkali metals as low as less than 1 ppb of sodium and less than 15 ppb of potassium, have been recently established by neutron activation analysis at Plansee. From the outset of the industrial application of thin film technology, Plansee has pioneered the development of modern coating technologies. It is a leading producer and supplier of evaporation sources made of refractory metals, Plansee tantalum evaporation boats or coils being used all over the world.

— Grain-stabilised tantalum wires have been produced for quite some time as leads for the production of tantalum capacitors with sintered anodes or for foil-type capacitors. Only recently was it possible to establish yttrium trace levels at 0.3 to 1 ppm, which lead to good grain stabilisation by secondary ion mass spectrometry (SIMS). The lowest level of yttrium which still shows detectable grain-stabilising effects was found to be 0.01 ppm. It was also shown by SIMS that for many elements the sintering of tantalum is an excellent purifying step with depletion factors for various trace contaminants of between 10 and 200.

PROJECTED NIOBIUM DEMANDS IN APPLIED SUPERCONDUCTIVITY : 1986-2000 A.D.

Dr Harry Stuart and Mr Charles Laverick, Niobium Products Co. Ltd.

Probable niobium demand for technologies involving applied superconductivity is projected to the end of the century. Each major application, present and potential, is considered. Feasible commercialization dates and growth rates of demand for each use are derived from a study of current development plans and their implications for future technology. Anticipated demands for niobium in magnetic resonance imaging equipment for medical diagnostics overshadow demands for all other present and projected superconducting applications. In the past, government-supported development programs in particle physics and energy were the mainstay of the industry. Energy development programs have since been curtailed. However, in the U.S., a very high energy superconducting particle accelerator has been proposed and could require a million pounds of alloy (~ 460 tonnes), i.e. about 230 tonnes of contained niobium.

The cumulative demand for high purity feedstock niobium metal for superconductors from 1985 through 2000 could be as high as 6,000 tonnes or as low as 2,000 tonnes in the absence of new applications as yet unforeseen. Total world consumption for all purposes in 1984 was estimated at 15,000 tonnes, increasing at 6 per cent per year. Available niobium resources at the CBMM mine in Araxa exceed anticipated future world demand for all uses for over 500 years.

THE CHANGING ROLE OF THE METAL TRADER IN THE TANTALUM BUSINESS

Mr Hubert E. Hutton, Norore Corporation.

In the past, traders have acted as middlemen between miners and consumers who needed this kind of contact. This is contrasted to the current situation, not only for tantalum but other raw materials, in which the trading houses have as their main function the rendering of a variety of services to both miners and consumers.

Improvement in the quality control of high capacitance tantalum powders

(The following article has been taken from a paper by Dr W-W. Albrecht and Dr A. Hoppe, both of Hermann C. Starck Berlin, which was presented at the T.I.C. General Asembly held in Boston, U.S.A., on June 13th 1985.)

INTRODUCTION

The costs and prices associated with raw material supply have frequently been discussed at the T.I.C. In particular, the high price of tantalum has made it desirable for its use to be reduced to a minimum, and to be limited to those applications for which it is required for purposes of quality. In the field of tantalum capacitors, this trend has led to the development of high capacitance powders, which have a large surface area due to their fineness, and also a high purity. This has resulted in less tantalum being used per capacitor.

In 1975, for example, a 10 μF/35 V capacitor contained 0.23 g tantalum; the same capacitor in 1985 contained only 0.11 g.

So it may be seen that the development of high capacitance powders has contributed much to maintain the price competitiveness of tantalum capacitors, and thereby to increase the use of tantalum powder over the long term.

At the same time that high capacitance powders were being introduced, considerable efforts were made to improve the quality of capacitors. Substantial progress was made and the failure rates of components improved significantly as a result. Because of established specifications, it was common practice to tolerate failure rates in the percentage range. Today a different understanding of quality has led to the failure rates of tantalum capacitors having to be in the range of ppm.

The resulting demands on the quality of tantalum powders used for capacitors are the subject of the following article. In particular, improvements in sodium reduction process and in process and product control will be discussed.

CONTROL OF TANTALUM POWDER

Pressed and sintered tantalum powder is used as one of the electrodes in a tantalum capacitor. Only the surface area of powder is used to store electrical energy, so that is why finer and finer tantalum powders are being used, i.e. powders which have an increasingly large surface area per gram of tantalum.

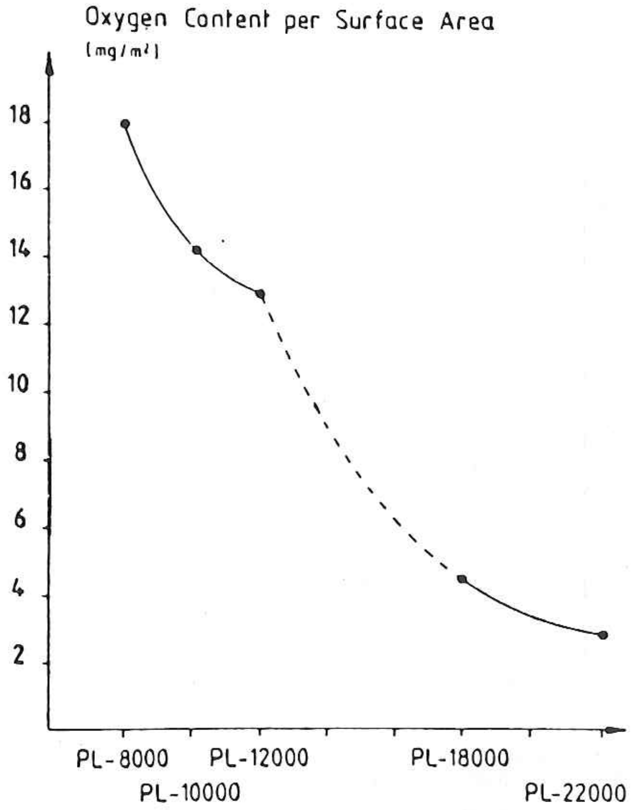
This development has led to Hermann C. Starck increasing the capacitance value of their powders from 8,000 μC/g in 1975 to 22,000 μC/g in 1983, almost a three-fold increase in eight years. This has resulted in tantalum powder being used more economically.

Quality requirements on tantalum powders are described by mechanical, chemical, physical and electrical data.

Mechanical	- Formability - Flowability	Permits Working on High Speed-Presses
Chemical	- Purity	Important for Preparation of a Stable Oxide-Film/ Leakage Current
Physical	- Grain Size - Specific Surface Area	Precondition for a High Specific Capacitance
Electrical	- Specific Capacitance - Leakage Current - Break-Down Voltage	Important for Universal Use of the Powder in a Capacitor

The improvement in the quality is intended to attain two fundamental goals :

— to improve the parameters of the powder, for example, in the reduction of impurities. This is presented below using the example of the oxygen content in individual PL-powders, as produced at Hermann C. Starck. This kind of quality improvement will not be discussed.



— to produce a constant product, i.e. to maintain the individual parameters of tantalum powders of the same grade. This aspect will be discussed in greater detail later.

To approach this goal of uniformity, a manufacturer can use either a batch or a continuous process. The method being largely used at present is to produce a number of powder lots and then select as appropriate, according to customer requirements.

However, this method is uneconomical; furthermore it indicates that the production process is not under control. A more economical method, and one which yields a uniformly high quality, is to produce each and every lot within the desired specification. This is achieved by continuous production process and precise production control, and also by a linear presentation of all process and product parameters.

IMPROVEMENTS IN SODIUM REDUCTION PROCESS

The majority of manufacturers produce tantalum powder in a batch process, in which several hundred kilograms of K_2TaF_7 are melted with inert salts and then reduced to metal by being stirred with liquid sodium. After completion of the reduction, the material is cooled to room temperature, crushed and the soluble salts are removed by washing.

The production of high capacitance powders in a batch process requires an exact dosage of sodium as well as external cooling during the highly exothermic reduction phase.

It is evident that the conditions of this batch process, such as temperature or concentration of the reactive elements, change permanently so that an exact control of the production process is difficult. This is reflected in the relatively broad grain size distribution of the tantalum powders produced by this process.

To avoid the danger of parameters varying from batch to batch, a continuous sodium reduction process is used at Hermann C. Starck.

K_2TaF_7, liquid sodium and inert salts are mixed and charged in quantities of a few kilograms into tantalum lined trays which then pass through a continuous furnace. This continuous sodium reduction process is followed by crushing, washing and heat treatment of the tantalum powder.

The advantages of such a method are that :

— The reactive elements, K_2TaF_7 and sodium, are well mixed at the time of reduction. The ratios of concentration are identical in all trays.

— The individual trays pass through an atmosphere with a specific and easily controllable temperature.

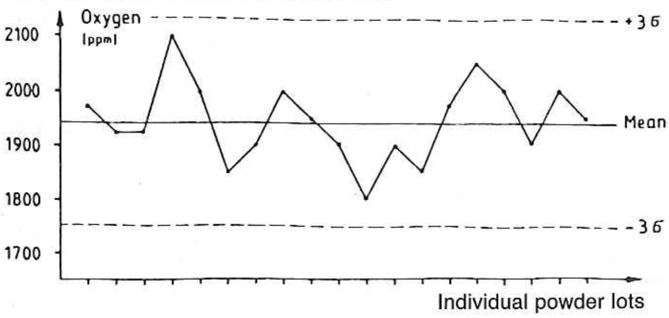
— Due to the low mass of the reactive components in each tray, the influence of the exothermic reaction is drastically reduced. This yields a very uniform grain size distribution.

— With this method homogeneous lots can be produced in almost any quantity. However, the quality of the composition of each lot can be controlled as frequently as required.

IMPROVEMENT IN PROCESS CONTROL

The state of technology today demands that the parameters applied to tantalum powders are not only described by specifying maximum values but that their variations can be controlled in a linear manner with the aid of control charts so that both maximum and minimum values can be established.

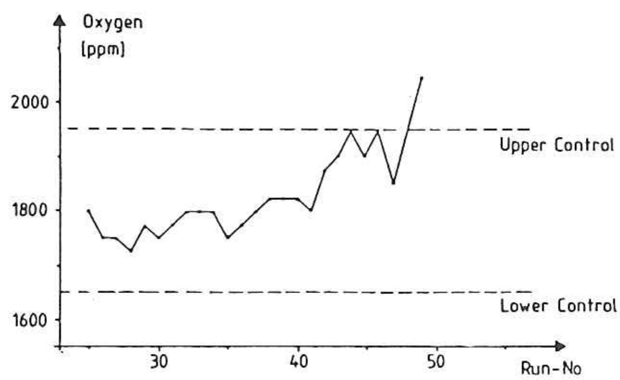
For example, one critical factor for describing tantalum powders is the oxygen content. A uniformly low oxygen content from lot to lot is, especially in the case of high capacitance powders, not always easy to maintain due to the small size and large surface area of the individual particles. Shown below is a typical graph of the variations in oxygen content, each point representing a particular tantalum powder lot. Maximum and minimum values are calculated as the average of three deviations from the standard value.



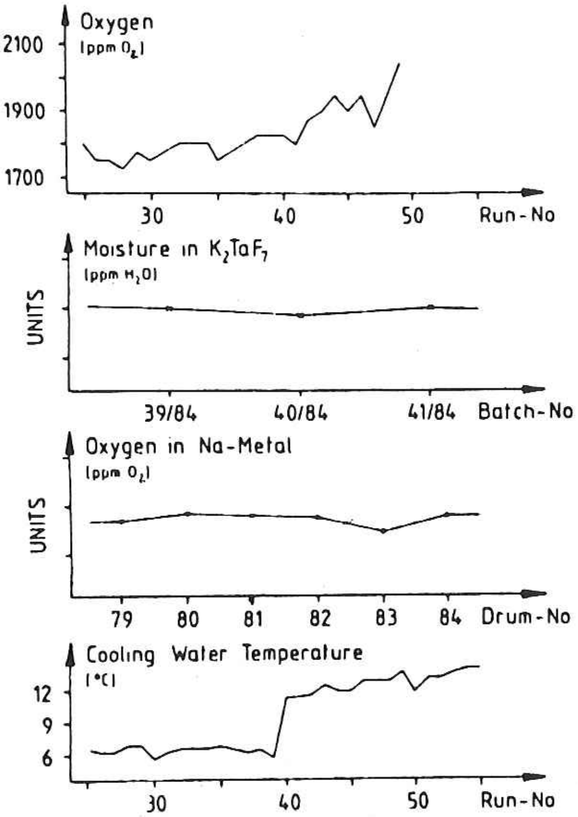
This type of presentation in the form of a control chart can be used for any other parameter, such as capacitance or grain size.

It is the task of the tantalum powder manufacturer to keep the parameters of each shipment within the established plus and minus limits, and also to recognise trends which lead to an increase or decrease in order to avoid exceeding the allowed limits.

A specific case is presented below — a deviation in the oxygen content. Routine quality controls revealed that the oxygen content was increasing continuously from lot to lot.



There were some production and raw material parameters which were most likely to be contributing to this oxygen content increase, namely the humidity in K_2TaF_7, the oxygen content in the sodium and the temperature of the cooling water.



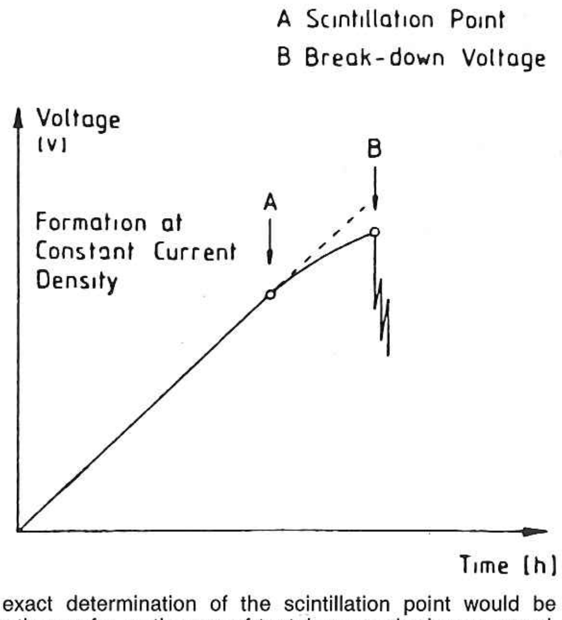
In this case only the temperature of the coolant changed synchronically with the oxygen content, and so the increase in oxygen was eliminated by adding an improved cooling system.

To increase the effectiveness of quality circles at Hermann C. Starck, a computer system has been installed so that every person concerned is supplied with the necessary information as quickly as possible. This system not only produces control charts of the electrical, physical and chemical parameters, but also correlates them against the process parameters and quality of the raw materials used.

IMPROVEMENT IN PRODUCT CONTROL

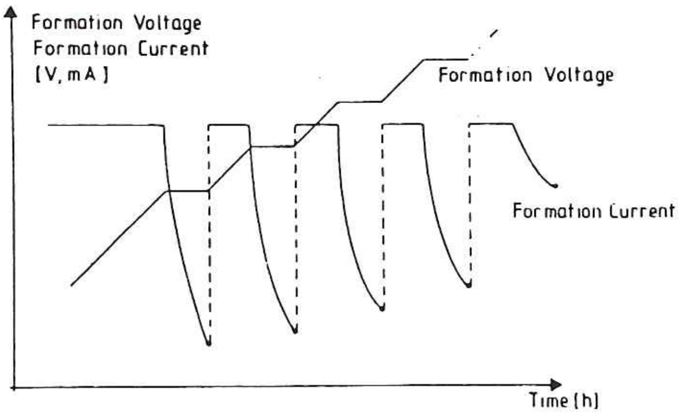
Up to now, improvements in the sodium reduction process and in process control have been discussed. Besides this, it is necessary to upgrade the product control parameters, which will be discussed using the example of break-down voltage.

Break-down voltage is usually measured by placing a sintered tantalum anode in an electrolyte and charging it with increasing voltage. The curve which results is usually composed of two parts : a linear increase with the uniform formation of a tantalum oxide film, and another line which deviates from the linearity and which exhibits defects in the oxide film due to scintillation.

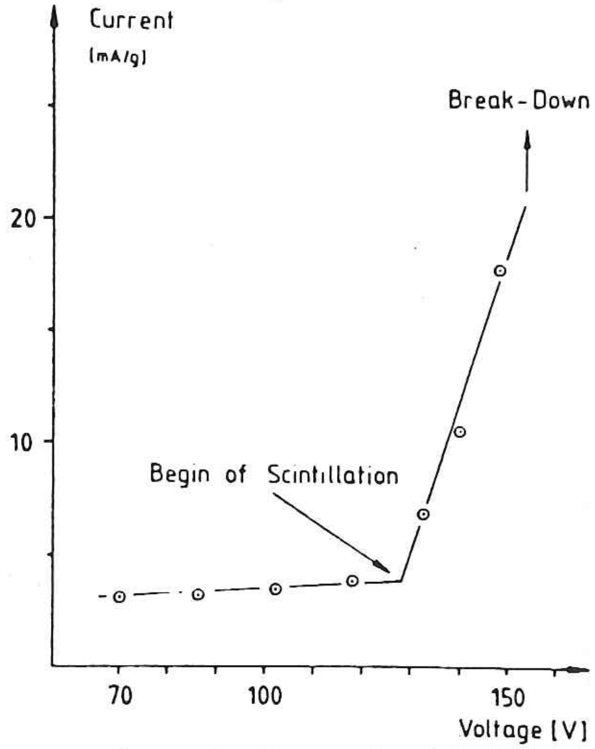


The exact determination of the scintillation point would be most interesting as far as the use of tantalum powder is concerned, since this determines the maximum formation voltage with which the sintered anode can be charged.

With the aid of a computer, the formation curve can be divided into a number of steps, i.e. the formation voltage, which in the BDV-test usually increases in a linear way, has been divided into discrete voltage steps with holding periods.



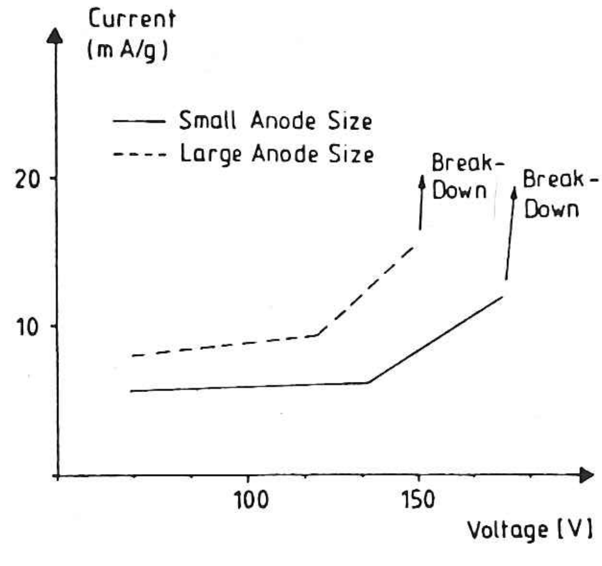
The formation currents of each step at the end of each holding period can be plotted against formation voltage :



One can easily recognise the two points of the BDV-curve, the beginning of scintillation (A) and the break-down voltage (B).

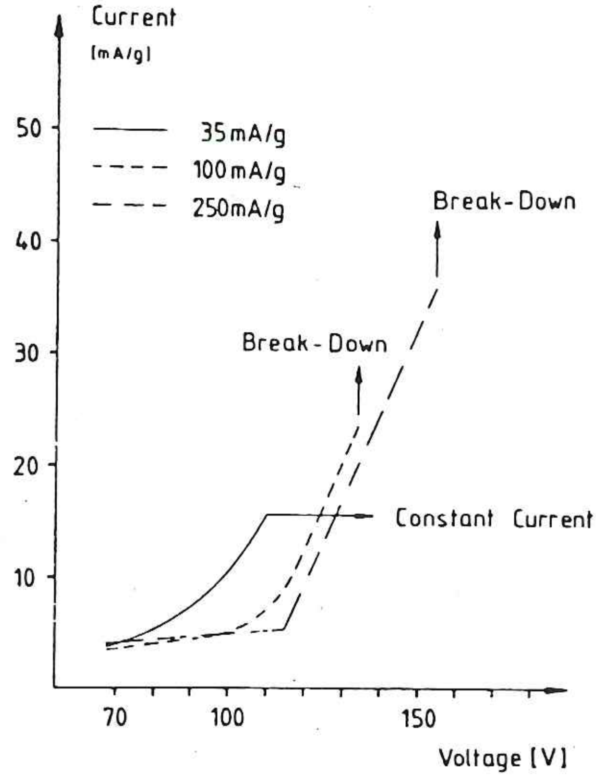
This modified testing method serves as the basis for studying a number of factors which influence the production of tantalum capacitors, such as the anode size, the formation current and the formation bath temperature :

Influence of anode size :

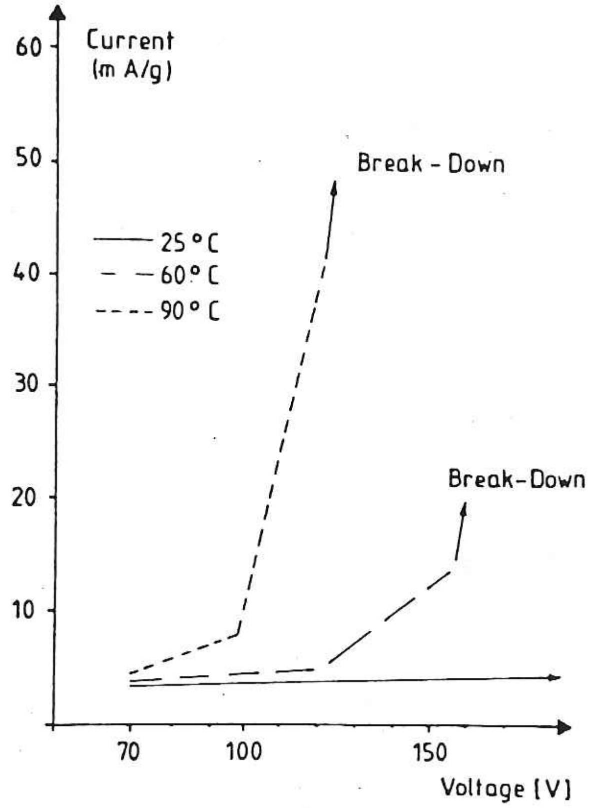


This testing method was applied in the previously mentioned examples to the formation of a sintered anode, but it can also be applied in a modified form to already formed anodes in order to test the quality of the oxide film.

Influence of current density :



Influence of formation bath temperature :



CONCLUSION

These examples of improvement in the quality control of high capacitance tantalum powders should assist in manufacturing powders of a more uniform quality, and more accurately describing these powders with the help of modified testing methods.

It should be emphasised that such improved quality control does not eliminate all difficulties in the manufacture of tantalum capacitors. However, tantalum powder of a consistent quality will contribute greatly to the quality of tantalum capacitors produced therefrom.

Tantalum supply and demand

This article is based on a supply and demand summary which was prepared by Mr John Linden, Managing Director of Greenbushes Tin Ltd. It is essentially an update on an earlier article entitled "Tantalum Markets and Marketing", also by Mr Linden, which appeared in the Bulletin of June 1984. This latest summary was made using assumptions based on the market situation in February 1985.

The summary (reproduced below) shows the Western World tantalum supply and demand position with the resultant inventory balance, both forecast (1985 onwards) and historical. The recycle from scrap column represents 20 % of the two years prior processor demand, re-entering the raw material stream.

DEMAND FOR TANTALUM

Total demand is equivalent to processor demand, together with Eastern Bloc requirements.

The Eastern Bloc countries are estimated to import 300 000 lb Ta_2O_5 annually (from 1983). GSA requirements for the U.S. stockpile are excluded from this summary.

From 1984 to 1989, annual processor demand is predicted to increase by a net 200 000 lb, which is equivalent to a 6 % growth in five years (1.2 % per annum). Some of this demand will be fulfilled from processor and trade inventories, which are forecast to be reduced from a 1983 high of 6.6 m lb to 2.1 m lb in 1987.

So in the five years following 1984 a total of 1.6 m lb is predicted to come from inventory, accounting for almost 9 % of total demand over that period.

The balance will come from raw material supply.

SUPPLY OF TANTALUM

Increased production from 1985 is based on :

1. increased prices
2. restarting of closed capacity
3. Greenbushes and other new capacity
4. relaxation of tin quotas.

Total supply is forecast to increase by 110 % from 1984 to 1989. It can be summarised as follows :
(figures are percentages of total supply for the period of time in question)

	1975-79	*1980-84*	*1985-89*
Tin slags	45	36	25
Tantalites	30	20	28
Columbites	12	8	4
Scrap	nil	20	19
Low grade slags (from inventory)	13	16	24

Due to relaxation of ITC quotas on tin production, supply of slag should start to increase from 1987. Its relative importance as a raw material, however, will be decreased to about one quarter of world requirements.

As a source of tantalum, columbites will experience a real decrease. This will be due to cheaper, alternative columbium raw material being used.

Low grade slag inventories will continue to be run down at a progressively increasing rate. It is probable that slags greater than 2.5 % Ta_2O_5 will last until 1988/89.

Tantalites are forecast to become the major tantalum raw material by 1987, thereafter accounting for approximately 30 % of total supply.

FORECAST FOR THE NEXT FIVE YEARS

The following can be concluded :

1. Raw material supply will be sufficient to satisfy demand after 1987.
2. Total demand will be sustained until at least 1989.
3. Inventories of normal materials in the possession of processors and traders, and of low grade slags, will continue to be run down in the next five years.

TANTALUM SUPPLY AND DEMAND SUMMARY

000's lb Ta_2O_5

Year	Price US$/lb	Supply: Tin Slags	Supply: Tantalites	Supply: Columbites	Scrap Recycle 20 %	LG Slags	Total Supply	Processor Demand	Exports to Eastern Bloc	Total Demand	Inventory: Trade Processor	Inventory: Old Slags
1975	10.00	1 140	820	190		—	2 150	2 000			4 300	
1976	12.00	1 171	780	115		200	2 266	2 300			4 266	
1977	17.00	1 281	802	338		350	2 771	2 550			4 487	
1978	50.00	1 147	787	408		550	2 892	2 825			4 554	
1979	95.00	1 432	855	513		600	3 400	3 475			4 479	
		6 171	4 044	1 564		1 700	13 479	13 150				
1980	100.00	1 263	995	422	565	600	3 845	3 205	200	3 405	4 919	6 560
1981	60.00	1 100	440	300	695	1 060	3 595	2 099	200	2 299	6 215	5 500
1982	25.00	1 000	480	150	640	250	2 520	1 900	200	2 100	6 635	5 250
1983	30.00	700	400	100	420	—	1 620	2 400	300	2 700	5 555	5 250
1984	30.00	700	400	100	380	250	1 830	3 200	300	3 500	3 885	5 000
		4 763	2 715	1 072		2 160	13 410	12 804				
1985	35.00	700	500	200	480	600	2 480	3 200	300	3 500	2 865	4 400
1986	45.00	700	700	150	640	700	2 890	3 000	300	3 300	2 455	3 700
1987	55.00	800	1 000	130	640	700	3 270	3 300	300	3 600	2 125	3 000
1988	65.00	900	1 150	60	600	1 000	3 710	3 400	300	3 700	2 135	2 000
1989	65.00	1 000	1 150	60	660	1 000	3 870	3 400	300	3 700	2 305	1 000
		4 100	4 500	600		4 000	16 220	16 300				

The U.S. National Stockpile

This article is based on a speech made by Mr Kent N. Knowles, Assistant Commissioner of the Office of Stockpile Transactions, at the Boston meeting of the T.I.C. on June 13th 1985.

The National Defense Stockpile is comprised of about 95 commodities, valued at approximately $ 10,000 million. The storage facilities represent an enormous warehousing operation in which millions of tons of materials are maintained for long periods of time. Storage locations — more than 100 exist — range from a commercial bank vault in New York, where industrial diamonds are displayed for periodic sales, to expansive warehouses and outdoor storage areas on the West Coast, where many of the metals are stored. While metals may constitute the major part of the Stockpile, the commodities also include such diverse materials as bauxite, fluorspar, graphite, iodine, jewel bearings, rubber and opium gum.

The business of the Office of Stockpile Transactions is operated under a large number of rules and regulations which originate largely from external sources. Overall Stockpile policy also originates from outside the office, principal guidance coming from the President of the United States through the National Security Council and the Director of the Federal Emergency Management Agency. The Office of Management and Budget sets budget levels, and the Administrator of GSA sets program and procurement guidelines. The office is responsible for the buying, selling, marketing and technical analysis, and related policy, for the Stockpile.

HISTORY OF THE STOCKPILE

During World War One, U.S. requirements for war materials were coordinated with its allies, but the vulnerability of defense efforts to critical materials shortages became dramatically clear. This experience taught the lesson that the dependence upon foreign sources for strategic and critical materials was a weakness in defense capability.

The first Stockpile legislation for the United States was passed in 1939, and provided for the acquisition of strategic and critical materials which were either non-existent in the United States or were insufficiently developed to satisfy military and industrial needs. The law also encouraged the development of U.S. deposits of such materials. The United States began to stockpile materials in 1940.

Following World War Two, a government commission reviewed the effectiveness of U.S. critical materials policies during the war and recommended policy and planning changes which took into account technological progress being made at that time. Subsequently, large quantities of materials were acquired for the Stockpile through direct purchase, the use of foreign counterpart funds accruing from U.S. foreign aid programs, barter transactions using surplus agricultural products, and by the transfer of surplus war commodities. At the start of the Korean War in 1950, the Stockpile had a value of about $ 1,600 million. In 1964, the value had grown to $ 7,800 million, this point marking the end of major acquisitions for the Stockpile until 1982.

THE STOCKPILE TODAY

In the late 1970's, the United States Congress decided to update the 1939 legislation. The result was the Strategic and Critical Materials Stock Piling Act of 1979, sometimes referred to as the Stockpile Act. This law provides the present basic set of directives and guidelines to restructure the Stockpile. Some key points of the law are :

- The Stockpile is to have a **strategic** value, being a dynamic component of the defense policy of the United States.
- The Stockpile is to meet the projected needs of the United States for a three-year conventional war. Planning must include not only military requirements but those of the civilian economy as well.
- The Stockpile Act provides clear directives on responsibilities in buying and selling commodities. The Office of Stockpile Transactions is required to be a responsible participant in domestic and world markets, making efforts to avoid undue disruption of these markets and also to protect the financial interests of the government. The principal objective is to restructure the Stockpile for national security through the purchase of priority materials and the sale of excess commodities.

Another important provision of the 1979 legislation was the establishment of the Stockpile Transaction Fund, an account in which the proceeds from sales of surplus Stockpile commodities accumulate. This fund is used for the purchase of priority strategic and critical materials, and stood at approximately $ 215 million on April 30, 1985. No general or tax revenues are used for Stockpile acquisitions; therefore, in order to buy, excess materials must be sold. The law provides that the funds for purchases will come from the sale of excess materials.

The selection of which commodities to buy or sell depends, in part, on current market conditions. In the case of sales, selection also depends, in part, on the amount of the material in excess of Stockpile goals. Acquisitions depend on how short of goal the commodity is, current budget levels and defense priority. The Office of Stockpile Transactions constantly reviews the market situation, works closely with other interested agencies, and also hears from industry. Decisions to further the objectives of the Stockpile are made with full regard to the market. Open and competitive bids for acquisitions are used as much as possible, in order to obtain the best price for the government.

Under current legislation, the office is authorized to sell tin, tungsten, industrial diamond stones, and several other materials. GSA made sales of about $ 53 million in excess materials in 1984 and additional disposals (exchanges) of about $ 19 million were made to finance the ferroalloys program. So far in 1985, cash sales are $ 14 million and disposals total $ 33 million in support of the ferroalloys program.

GSA began the recent restructuring of the Stockpile in 1981 and in May of this year 12 materials had been acquired for a total of $ 367 million. The purchases included 282,883 pounds of tantalum minerals (contained tantalum metal), which were made from four companies — Amalgamet, Bomar Resources, Greenbushes and the Norore Corporation, at prices ranging from $ 29.85 to $ 36.85 per pound of tantalum pentoxide (Ta_2O_5). The first of these acquisitions took place in December 1981, the last in January 1984, care being taken in the timing and quantities of purchases to avoid undue market disruption. No purchases of columbium were made during this period.

The existing Stockpile goal for tantalum minerals is 8.4 million pounds in terms of tantalum metal content, approximately 35 per cent of this having been met. The existing Stockpile goal for columbium concentrates is 5.6 million pounds, in terms of columbium metal content and about 50 per cent of this goal has been met.

THE FUTURE

The acquisition program has been halted pending completion of a Stockpile goals study by the National Security Council (NSC). In the latter part of 1983, President Reagan directed the NSC to conduct a major review of the strategic and critical materials stockpiling program to ensure that it reflected the requirements of national defense.

The Stockpile is clearly out of balance. Of the 95 commodities, 45 are currently listed as being short of goal, while 37 others are in excess.

When the NSC review is completed, a plan for attaining the revised goals will be submitted to the Congress. An announcement by the White House is expected soon.

On Monday, July 5th, the President of the United States announced new policy guidelines for the National Stockpile. The key elements of this policy together with the new stockpile goals for tantalum and columbium are given below.

On the basis of the new stockpile study of materials requirements and supplies during a protracted military conflict, the President has decided that the stockpile for the 42 materials studied (which include tantalum and columbium) will now contain $ 6,646 million in materials and include two tiers.

Goals of $ 691 million (Tier I) are proposed for materials that would be required during a military conflict that would not be available in sufficient quantities from domestic or reliable foreign sources. The stockpile will also contain a Supplemental Reserve of strategic and critical materials currently valued at $ 5,955 million (Tier II). The Supplemental Reserve will contain materials that the government already possesses. This reserve will offer additional assurance against materials shortages during a period of military conflict. These new stockpile goals will eliminate the $ 9,700 million unmet goal.

The new stockpile will result in surplus materials of $ 3,200 million, as opposed to the $ 3,500 million surplus calculated by the previous Administration. The mix of materials considered to be surplus, however, is different.

The Stockpile goals for columbium and tantalum have been changed as follows :

	Columbium	*Tantalum*
	(000's lb metal contained)	
Old objective :	5,600	8,400
In Stockpile :	2,800	1,960

(Stockpile quantities obtained using 50 per cent of goal for columbium and 35 per cent of goal for tantalum)

New objective :		
Tier I	nil	1,900 ($ 72 m)
Tier II	2,532 ($ 19 m)	1,023 ($ 84 m)
Total	2,532 ($ 19 m)	2,923 ($ 156 m)

(Values based on May 31st market prices)

This would appear to leave the stockpile short of goal by about 963,000 lb of tantalum metal and in excess by about 268,000 lb columbium metal.

Solid tantalum capacitors

(The following article has been abstracted from a presentation made by Mr David Maguire, Union Carbide Corporation, at the Twenty-third General Assembly of the Tantalum International Study Center held in Boston, Massachusetts, U.S.A., on June 13th 1985.)

INTRODUCTION

This presentation focuses on solid tantalum capacitors, where they fit into the worldwide total capacitor market, the opportunity for more rapid growth emerging from advancing circuit technology and the threat to growth emerging from advancing materials technology. The historical and estimated future growth for solid tantalum capacitors and the tantalum materials used is examined in relation to the necessary cost economics which influence the growth.

WORLDWIDE CAPACITOR MARKET

The estimated worldwide consumption of capacitors in 1984 is about 100 billion units.

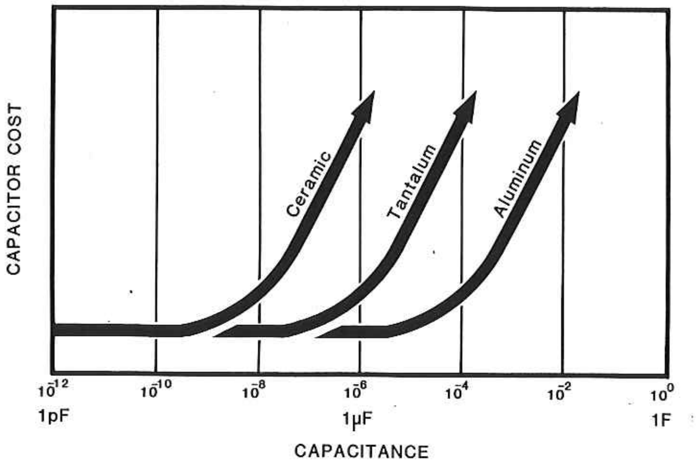
DIELECTRIC	QUANTITY Millions Of Units
CERAMIC DISK	29,000
CERAMIC MONOLITHIC	26,000
TANTALUM	4,000
ALUMINUM	24,000
FILM	12,000
OTHERS	1,000
TOTAL	96,000

A growth of 6 % per year is tied to the growth of the Electronics Industry, in general, and of active circuit devices, in particular. Thirty years ago active circuit devices were vacuum tubes, displaced by transistors and then by integrated circuits. Doom-sayers had predicted a loss in capacitor growth due to integrated circuits but their increasing complexity broadened their application and the growth demand for capacitors has continued unabated.

There is a difference in growth rates within the various dielectrics, ceramic monolithic capacitors growing at 20 % per year, tantalum capacitors growing at 12 % per year but ceramic disk capacitors shrinking. Even so, tantalum capacitors are only about 4 % of the total.

WHERE TANTALUM CAPACITORS FIT

A chart best shows the relative range of practical capacitors and the relative cost of ceramic, tantalum and aluminium dielectrics over the practical range from one picofarad (10^{-12} farads) up to about 10 000 microfarads.



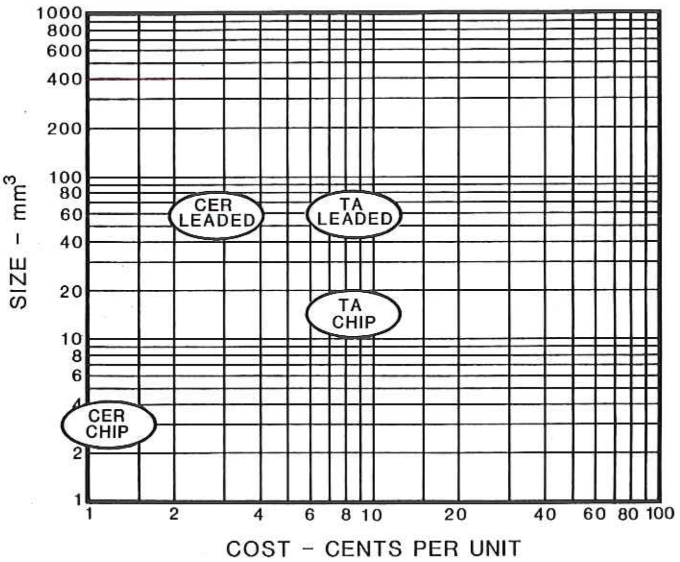
With each dielectric system, the materials cost for added capacitance begins strongly to influence the total capacitor cost above a threshold level. Improvement in materials technology is tending to shift the whole chart spectrum to the right but increasing application temperatures tend to force usage to the left because aluminums use a liquid or paste dielectric which boils off like water. Tantalum capacitors see about 300 °C in processing and ceramics see about 900 °C. Thus, both tantalums and ceramics can withstand assembly temperatures up to about 300 °C.

APPLICATION CONSIDERATIONS

Although there are many technical considerations which may influence the design choice to meet special considerations, the two important application considerations of size and cost are best highlighted by charts.

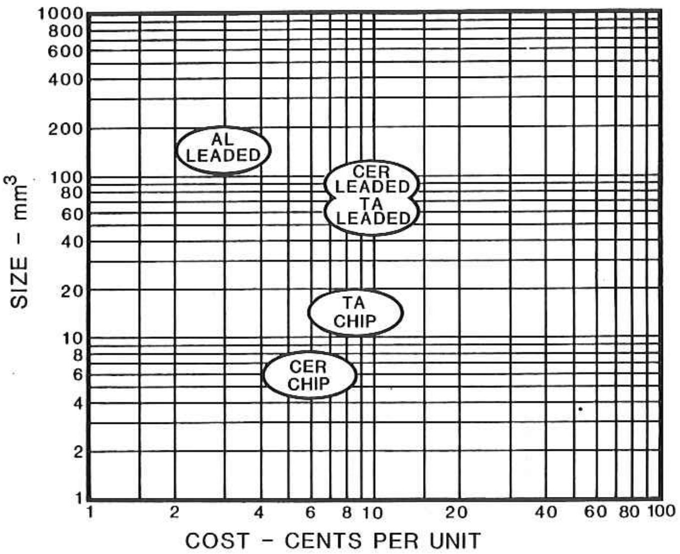
If the designer needs a capacitor at 0.1 µf with lead wires for conventional assembly, the choice would be a leaded ceramic capacitor. About ten years ago, the choice would have been a leaded tantalum capacitor. If the designer wanted a chip capacitor, the choice is clearly a ceramic chip which is the lowest cost and lowest volume part.

0.1μF



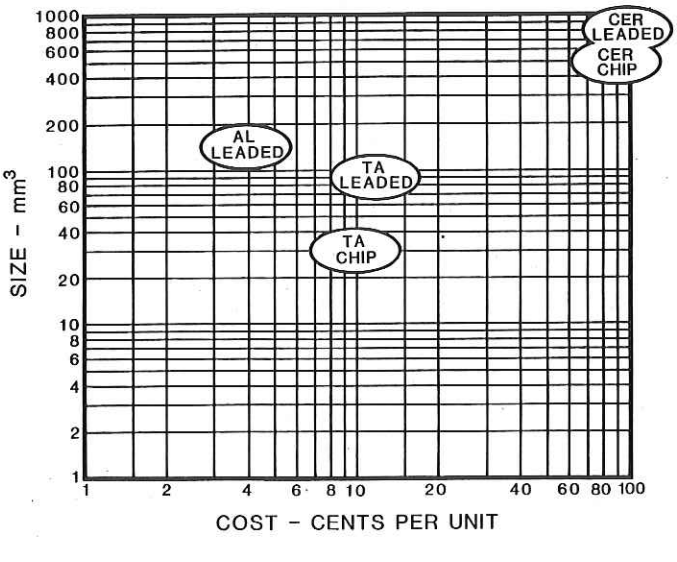
If cost is the over-riding consideration in a leaded application at 1 μf, the aluminium capacitor is best. If size is important, the leaded tantalum is best. If the application is for a surface mounted capacitor with the implied high temperature requirements, the ceramic chip has some advantage over the tantalum chip.

1μF



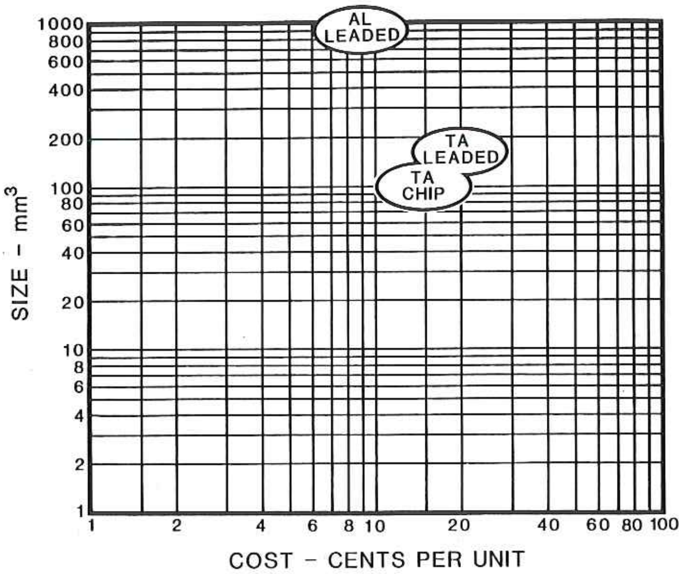
At 10 μf, ceramic dielectrics are in the $1 range and would not be used. The leaded aluminum capacitor shows the lowest cost and the tantalum chip capacitor shows the smallest size.

10μF



At 100 μf, the aluminum capacitor has the edge based strictly on cost. The tantalum leaded capacitor has the best size and the only choice for a surface mounted chip is the tantalum capacitor.

100μF



THE OPPORTUNITY

In automobile radios of recent vintage, the components all have lead wires and are assembled by inserting the lead wires through holes in the circuit board, soldering the wires to terminals laminated to the board. These circuits used a multitude of ceramic disk capacitors, no monolithic ceramics, a number of tantalum capacitors, a number of aluminum capacitors and, perhaps, a film capacitor.

In the new assembly technology, Surface Mounted Devices (SMD), the capacitor element without leads is glued to a circuit board and is subsequently soldered to the board. Since, in this application, the capacitor elements are exposed to temperatures of 260 °C to 320 °C, ceramics and tantalums can be used but aluminums cannot.

As the world shifts from conventional electronic circuit assembly with leaded components to surface mounted chips, there is a shift in the type of capacitors used as is shown in a capacitor count for an automotive radio circuit.

Capacitor Count
AUTOMOBILE RADIO CIRCUIT

DIELECTRIC	CONVENTIONAL	S M D
CERAMIC DISK	23	—
CERAMIC MONOLITHIC	—	24
TANTALUM	6	16
ALUMINUM	7	—
FILM	1	1
OTHER	3	3
TOTAL	40	44

All of the conventional disk ceramics are displaced with monolithic ceramic chips and the conventional aluminum capacitors are displaced with tantalum chips. A similar capacitor count in a circuit for a floppy disk drive used in personal computers shows exactly the same displacement. In the automobile radio circuit, the total capacitor count went up slightly while in the floppy disk count, the total capacitors went down slightly. In summary, the current shifts will not affect the total capacitor usage, but this does offer an opportunity for tantalum capacitors to increase their share of the total.

THE THREAT

The threat to the tantalum capacitor is the encroachment at the low end by monolithic ceramics. During the past ten years, monolithics have decreased in size by a factor of five to seven times and in cost by a factor of 4. The improvement has resulted from the use of better materials with a higher dielectric constant, a fundamental property called "K". We can improve the surface area of tantalum powder but we are constrained with the tantalum oxide constant of about 25. The ceramic dielectric, in comparison, can be that of a large number of different chemical compounds. A typical 1 μf part can have a K of about 12500 and K factors have been demonstrated at five times that level. Thus, improving ceramic materials technology has resulted in a displacement of some of the low value tantalum capacitors and threatens to displace a larger range of the tantalums from the low side.

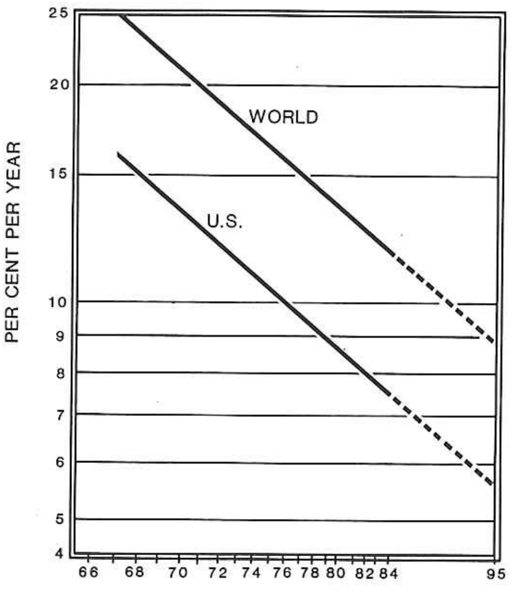
GROWTH PROJECTION

The historical growth pattern of solid tantalum capacitors shows a trend line from 150 million pieces in 1966 to 1150 million pieces in 1984. There have been some large cyclical swings such as the 30 % drop from 500 million to 340 million in the 1974-1975 period and the 22 % drop from 900 million to 700 million over the 1979-1982 period. It is expected that 1985 will be at about 900 million pieces, a drop of about 250 million from 1984.

While there are many exogenous factors which can influence the future growth of solid tantalum capacitors, the best "guess" at this time would suggest that the U.S. market would be just over 2 billion pieces in ten years. Applying the logic developed for the U.S. market to the world market for tantalum capacitors, the worldwide consumption of solid tantalum capacitors would rise from about four billion units in 1984 to about ten billion units in ten years.

A projection of growth rate versus time for the U.S. and worldwide market areas shows an intrinsic reduction in year-over-year growth rates with time, consistent with most product life-cycle growth behaviour. That is, the early period is characterized by very rapid growth, on a year-over-year percentage basis, and this growth rate gradually declines as the product matures.

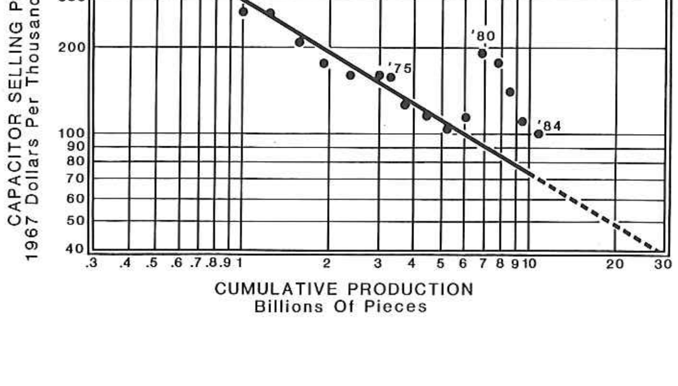
Growth Rates
SOLID TANTALUM CAPACITORS



The growth rate for the U.S. is projected lower than for the world as a whole because the U.S. was a few years ahead of the world consumption of tantalum capacitors, and the using community is abandoning the U.S. in favor of lower labor cost areas.

THE ECONOMICS

A plot of the U.S. price of solid tantalum capacitors, in terms of constant dollars versus the cumulative volume produced, shows a classic learning curve which applies to many products over their life cycles.



Tantalum capacitors have followed this learning curve for many years up to 1980. The central tendency is for the cost to reduce by 30 % every time the cumulative volume doubles. Prices were a little depressed in 1969 and the 1972-1973 period, and were a little high during the peak demand period of 1974-1975. But the excursion of 1980 is unprecedented, endangering the growth rate of the product and is still partially uncorrected. The 1984 average price level has been examined in great detail. One conclusion reached is that it is not related to product mix. The percentage of very large tantalum capacitors has been reduced as a consequence of the 1980 cost explosion when users reacted quickly to eliminate these $3 capacitors in their systems wherever possible. The true cause of the deviation of current price from the learning curve is found to relate to the tantalum cost.

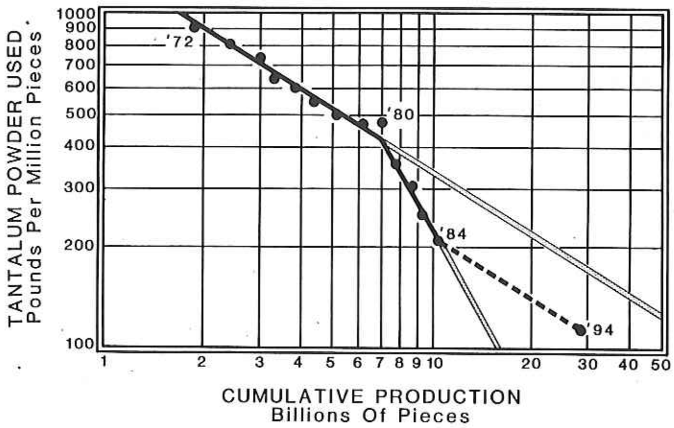
Historical cost relationships help to visualize and understand the tantalum materials cost problem. The underlying problem is that the cost of tantalum powder rose by a factor of 6 over the 1978-1980 period, has not come down since then and now remains at more than $2\frac{1}{2}$ times the 1977-1978 level. The increase in average powder charge, doubled over the same time period, has partially offset the cost increase. This still leaves, however, the cost of powder on a cost per coulomb basis about 30-40 % higher than would be expected. The expectation is that the powder cost should remain about constant in current-dollars while declining in constant-dollars to the extent that the value added to the basic raw material decreases with experience.

The bottom line of the above is that the capacitor cost must be brought back into the learning curve if the growth projections are to be achieved. As a corollary, the average materials cost, in terms of dollars per coulomb, must be brought back down to the historical expected levels. This level should be achievable. Some tantalum powder types are at the target level now but the average powder-mix cost is still high.

With a team effort where the powder producers make higher charge powders available and the capacitor producers learn how to use these powders, the mutual objectives for business growth at acceptable earnings quality can be achieved.

TANTALUM POWDER USAGE

A normal progression down the learning curve was evident for many years up until 1979.



In 1980, the tantalum usage per capacitor was about 15 % higher than expected due to the "shortage". Old electron-beam powders were used in place of the newer higher charge, but unavailable, sodium reduced powders. The cost shock also spurred industry to accelerate the learning curve through intense development efforts. Both the powder producers and capacitor producers made rapid advancements. Indeed, the powder consumption per tantalum capacitor dropped by more than 50 % over four years. The 1984 level fits fairly well with the estimated million pound powder consumption after adjustments for a smaller capacitance mix in Japan, the presence of wet tantalum capacitor demand and capacitor producer yields.

If the more rapid learning curve decline were maintained, it would imply that tantalum powder consumption would be only 40 pounds per million pieces by 1994 or a total of 400 000 lb for the ten billion pieces projected. This also implies, however, an average charge of about 35,000 μC/gram, not very realistic. We have assumed a resumption of the previous learning curve slope, but permanently displaced due to the price shock. On this basis, the consumption for 1994 to serve the U.S. capacitor demand would be about 300 000 lb. Therefore, a total of about one million pounds of tantalum powder would be required to produce the ten billion unit capacitor projection in 1994. Powder shipments by world area, of course, depend upon where capacitor powder manufacturing plants will be located ten years from now.

SUMMARY

There is a healthy and growing worldwide market for capacitors in which tantalum dielectrics represent only about 4 % of the total. Advancing circuit assembly technology opens the opportunity to displace a portion of the aluminum capacitors, now about 24 % of the total. Concurrently, advancing materials technology threatens to displace lower valued tantalum capacitors. A balance of the growth opportunity, the low-value displacement threat and the ability to return tantalum materials cost to a historical experience level could result in a ten billion unit tantalum capacitor demand in 1994. Tantalum materials requirements for capacitors over the next ten years should be relatively flat at about one million pounds per year.

Statistics

Price Waterhouse report the following collected statistics for T.I.C. member companies :

PRODUCTION AND SHIPMENTS

2nd quarter 1985
(quoted in lb Ta_2O_5 contained)

Category	*Material grade*	*Production*	*Shipments*	*Response*
A/B	Tin slags	294,713	136,942	21/24
C	Tantalite under 25 % Ta_2O_5	0	0	
D/F	Tantalite over 25 % Ta_2O_5 and other materials	91,461	101,688	
	Total	386,174	238,630	

Note : In accordance with the rules of confidentiality, categories A and B and D and F have been combined, as shown, because certain individual returns accounted for more than 65 % of the total of the category concerned.

PROCESSORS' SHIPMENTS

2nd quarter 1985
(quoted in lb tantalum contained)

Product category	*Shipments*	*Response*
Tantalum oxide	34,062	18/19
Alloy additive	46,695	
Carbides	125,268	
Powder/anodes	187,279	
Mill products	77,422	
Scrap, ingot, unworked metal and other	48,170	
Total	518,896	

Note : In accordance with the rules of confidentiality, the categories "Scrap" and "Ingot, unworked metal and other" have been combined, because in each category one individual return exceeded 65 % of the total of the category concerned.

QUARTERLY PRODUCTION ESTIMATES

(quoted in lb Ta_2O_5 contained)

LMB quotation	*US$ 30*	*US$ 40*	*US$ 50*
3rd quarter 1985	373,750	397,780	563,600
4th quarter 1985	401,950	475,980	601,600
1st quarter 1986	411,610	485,650	616,660
2nd quarter 1986	414,810	498,840	644,860
3rd quarter 1986	421,750	497,840	644,800

Note : These estimates are based on information received to date, and do not necessarily reflect total world production.

Capacitor statistics

U.S. TANTALUM CAPACITOR SALES
(thousands of units)

(Data from Electronic Industries Association)

2nd quarter 1985

Type	*U.S. Shipments*	*Exports*	*Total*
Foil	353	4	357
Metal cased	36,670	9,685	46,355
Non-metal cased	137,546	22,492	160,038
Chips	13,942	1,669	15,611
Wet slug	2,715	152	2,867
Total	191,226	34,002	225,228

(Note : On the advice of the EIA, the previously-reported categories of "Manufacturers" and "Distributors" have been combined into "U.S. Shipments", meaning shipments to U.S.-located consumers.)

On May 21st 1985, the EIA published revised sales data for the years 1981, 1982 and 1983. They are reproduced below.

Type	*U.S. Shipments*	*Exports*	*Total*
1981			
Foil	1,316	0	1,316
Metal cased	220,499	40,246	260,745
Non-metal cased	456,618	30,611	487,229
Chips	25,853	0	25,853
Wet slug	12,633	1,905	14,538
Total	716,919	72,762	789,681
1982			
Foil	1,200	0	1,200
Metal cased	199,594	41,082	240,676
Non-metal cased	423,244	36,202	459,446
Chips	29,525	0	29,525
Wet slug	11,598	1,730	13,328
Total	665,161	79,014	744,175
1983			
Foil	1,197	55	1,252
Metal cased	211,224	39,876	251,100
Non-metal cased	479,094	59,453	538,547
Chips	19,233	14,359	33,592
Wet slug	10,449	1,396	11,845
Total	721,197	115,139	836,336

EUROPEAN TANTALUM CAPACITOR SHIPMENTS
(thousands of units)

2nd quarter 1985	149,338
1st quarter 1985	155,251

(Data from ECTSP — shipments from European manufacturers to European-located consumers only.)

JAPANESE TANTALUM CAPACITOR PRODUCTION AND EXPORTS

JEIDA data for the 2nd quarter 1985 are not yet available.

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