TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN ISSUE No 27 SEPTEMBER 1981 THIRD QUARTER

T.I.C. Activities

The Sixteenth General Assembly of the Tantalum Producers International Study Center will be held in Brussels on Thursday, October 29th 1981, to carry out the formal business of the association. The agenda will include the election of the Executive Committee and Officers for the coming year.

Following the Assembly, there will be a complementary programme of presentations and discussions on subjects of interest to members and their guests.

SEVENTEENTH GENERAL ASSEMBLY

The Seventeenth General Assembly will be held in early June 1982 at Tulsa, Oklahoma, U.S.A. Fansteel, Inc. will be the host company and expects to include a visit by delegates and guests to their basic-processing plant in nearby Muscogee, Oklahoma. The exact dates and programme will be established during the Sixteenth General Assembly. Members should be planning their schedules for attendance of this interesting meeting.

PUBLICATIONS OF THE T.I.C.

There are still a number of copies of the "Proceedings of the First International Symposium on Tantalum" available. They may be ordered at US $ 25 each from the Secretary, rue aux Laines 1, 1000 Brussels, Belgium.

The study sponsored by the T.I.C. in October 1980, "Worldwide Tantalum Study : Assessment of Availability and Price, 1980-1985" is available to non-members of the T.I.C. by subscription of US $ 4,000. Those interested in acquiring a copy should address the Secretary of the T.I.C. or Ayers, Whitmore & Company, Inc. (formerly Emory Ayers Associates Inc.), 950 Third Avenue, New York, NY 10022, U.S.A.

Japanese tantalum consumption

Due to the lack of published data, the T.I.C. "Bulletin" has not included tantalum data from Japan since issue no. 19 in September 1979. During a recent visit to Japan, the Editor collected enough information from various sources for the following article.

Consumption of tantalum products in Japan during 1979 and 1980 have been compared on the same basis as previously published data for 1977 and 1978 :

Product (unit : m.t.)	*1977*	*1978*	*1979*	*1980*
Powder (Cap. & Metall. Gr.)	76.3	73.5	105.0	92.8
Chemical Compounds (Carbide & Oxide)	38.0	44.0	52.0	42.4
Mill Products (Electr. & Chemical)	25.2	28.4	37.4	36.9
Total	139.5	145.9	194.4	172.1
% Growth Rate	+ 1 %	+ 4.6 %	+ 33.2 %	—11.5 %

An approximate division among market segments shows the predominance of use by the electronics industry :

Market Segment	*1978*	*1979*	*1980*
Electronics	61	67	68
Industrial	9	6	8
Cutting Tools	20	19	17
Lens	10	8	7
	100	100	100

T.I.C. SIXTEENTH GENERAL ASSEMBLY

The Sixteenth General Assembly of the Tantalum Producers International Study Center will be convened at 9.30 a.m. on Thursday, October 29th 1981 at the Cercle Royal Gaulois, rue de la Loi 5, 1000 Brussels.

The agenda for the meeting will be :

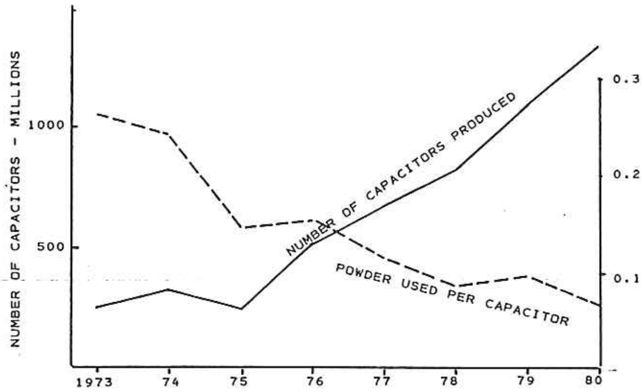
1. Presidential greetings and address to the members.
2. Minutes of the Fifteenth General Assembly.
3. New member election.
4. Report of the Executive Committee.
5. Production statistics : first and second quarters of 1981.
6. Statutory elections.
7. Seventeenth General Assembly.
8. Other business.

After the formal meeting, there will be a presentation on a subject of general interest to the delegates. The name of the speaker and the topic for discussion will be announced shortly.

The General Assembly is open to delegates of member companies and their associates. Prospective new members and invited guests of member companies may join the meeting for the programme following the formal business of the association.

For further details of the meeting arrangements or information on the T.I.C., please contact Mrs J.A. Wickens, Secretary, Tantalum Producers International Study Center, rue aux Laines 1, 1000 Brussels, Belgium; cable address Tictan Brussels.

The proportion of the total consumption by the electronics industry has been steadily increasing during the past ten years from 54 % in the early part of the decade to the 68 % currently. This has continued regularly but in a lesser proportion than the growth in the number of capacitor units produced each year. Examination of trends shows that the consumption of powder per unit of capacitors produced is now only one-quarter of what it was in 1973.



The decline in market share for uses other than electronics is only the result of the electronics market growing at a greater rate. Consumption in these areas has been reasonably stable. The consumption of carbide and oxide reached a peak in 1979 but much of that material was considered to be used to build-up inventories in view of a threatened shortage. With signs of economic slump developing by mid-1980, the consumers of carbide and oxide began to reduce inventories and a drop-off in sales of new product resulted. There are no serious indications of either accelerated scrap recycle or extensive substitution in the carbide market.

The source of the materials consumed, imports versus domestic production, indicates a continuing stable market for exporters to Japan in about the same proportion of the market as always.

Source (unit : m.t.)	*1978*	*1979*	*1980*
Imports	50.2	72.7	57.7
Domestic production	95.7	121.7	114.4
Total	145.9	194.4	172.1
% Produced in Japan	65.6	62.6	66.5

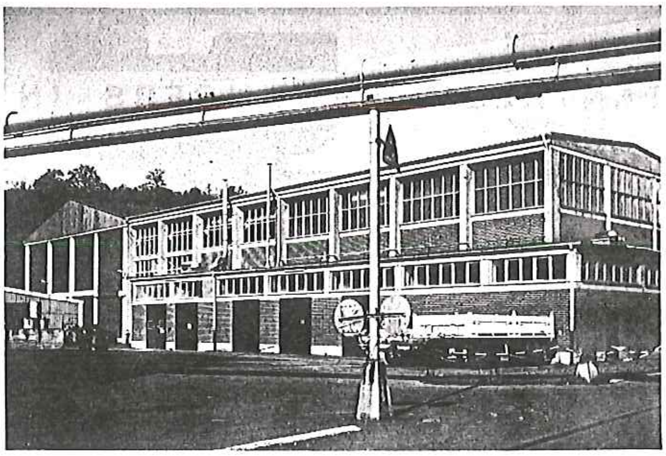
The proportion of consumption which is domestically produced has been relatively constant, ranging from 61.5 % in 1974 to a high of 68.4 % in 1976.

The metal producers continue to rely on sources in Europe and the United States for their supply of potassium fluotantalate as there is no production of the salt in Japan. But the domestic production, from imported ores and slags, of tantalum carbide and oxide continues to be about 72-73 % of the total consumption of these materials.

A rough forecast indicates that the tantalum industry expects a drop in total consumption in 1981 of about 15 %, 25 m.t. on a metal basis. Almost all of this drop will be in the electronics industry, partly as a result of the general world economic condition and partly due to the continuing trend of using less material per unit produced by the capacitor makers.

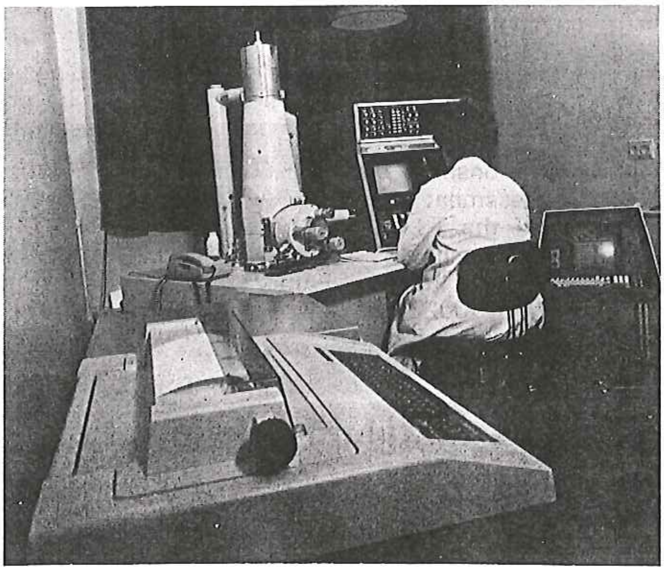
T.I.C. Plant Tour at Hermann C. Starck Berlin

As a part of the programme of the Fifteenth General Assembly of the T.I.C. in May 1981, delegates and guests were treated to a detailed plant tour of the integrated tantalum facility which constitutes a large part of the Goslar, West Germany, plant of Hermann C. Starck Berlin.



As a preliminary to the actual tour, visitors gathered in a plant conference room where a presentation, "The Extractive Metallurgy of Tantalum" was presented by Peter Borchers, Technical Director of HCS. As a result of this presentation, the visitors were briefed in advance so that they would have a better understanding of the processing in the plant and their observations during the tour were more meaningful. (This presentation, in most part, is included in this issue of the "Bulletin".)

The final portion of the tour included a detailed demonstration of the various analytical and quality-control procedures in the extensive testing laboratory of the plant. In addition to a complete wet-chemistry laboratory, both diffraction and x-ray spectroscopy are used to effect chemical control.



The tour was concluded by those visitors whose schedules permitted having an excellent lunch at the "Ratskeller", the restaurant in the cellars of the Town Hall in the Medieval Market Place of Goslar.

The extractive metallurgy of tantalum

The following article has been taken from a presentation written by Peter Borchers and George J. Korinek of Hermann C. Starck and used as an introduction to the tour of the Goslar, West Germany, *plant of Starck during the programme of the Fifteenth General Assembly of the T.I.C. in May 1981.*

Separating from the accompanying elements and purification are the main targets of the extractive metallurgy of tantalum. In order to optimize the unique properties of tantalum, the metal or the compound must have a high degree of purity. Direct application in the form of a ferro-alloy, which is common in other refractory metals, e.g. the sister metal niobium, is not possible. The type and number of operations needed depend on the grade and nature of the raw materials.

Tantalum occurs generally in close association with niobium, titanium and tin, sometimes with rare earths, uranium and thorium. Most of the placer or pegmatite type of ore can be enriched by wet gravity, magnetic or electrostatic methods or flotation to concentrates containing up to 70 % combined Ta_2O_5 and Nb_2O_5. Compositions of the main types of concentrates, the traditional raw materials of the processing industry, are

Tantalite	40-80 % Ta_2O_5,	2-30 % Nb_2O_5
Columbite	1-40 % Ta_2O_5,	40-57 % Nb_2O_5
Wodginite	45-56 % Ta_2O_5,	3-15 % Nb_2O_5
Microlite	50-70 % Ta_2O_5,	5-10 % Nb_2O_5

Only a small portion of the tantalites closely associated with the tin mineral cassiterite can be recovered by beneficiation methods. The bulk of the tantalum is collected in tin slags from the tin smelters in different grades depending on the original concentration in the tin concentrates and the efficiency of the smelting operation.

Source	*% Ta_2O_5*	*% Nb_2O_5*	*% TiO_2*	*% FeO*
High Grade				
Australia	10	5.5	9	10
Zaire	11	10	2	9
Thailand	12	9	13	10
Medium Grade				
South Africa	5	7	2	14
Nigeria	4	12	7	13
Malaysia	4	4	11	15
Thailand	5	4	18	11
Low grade				
Malaysia	0.8-2	0.8-2	5-9	18
Thailand	0.3-1	0.2-1	1-5	20
Brazil	1-2	2-4	20	8
Singapore	1-2	1-2	15	19

Slags with Ta_2O_5 content of more than 10 % have been or are treated directly by chemical means to recover Ta/Nb. Whereas the development of new sources of tantalite looks promising at present, it is unlikely that the availability of high grade slags will increase substantially in the near future. Therefore, the utilization of low-grade tin slags is an absolute necessity to close the gap between supply and demand. The tonnage-wise more abundant slags below 2 % Ta_2O_5 were long considered worthless and were used for road construction and sand-blasting. But now, after an explosion of the tantalum raw material price, they are mined for sale.

Since slag is an artificial, homogeneous and glass-like product, ore treatment methods fail to upgrade. Selective chemical methods like acid- and alkali-leaching or chlorination also fail or are only partially successful. Nor are the results better in an attempt to recrystallize the slag in a plasma arc to get new boundaries amenable to selective chemical treatment.

Finally, melting processes are successful : melting the slag in an electric arc furnace, sometimes with the addition of an iron source, and reducing with carbon, collecting the Ta/Nb carbides in the form of a ferro-alloy.

For further enrichment of the alloy, three main production routes are used :

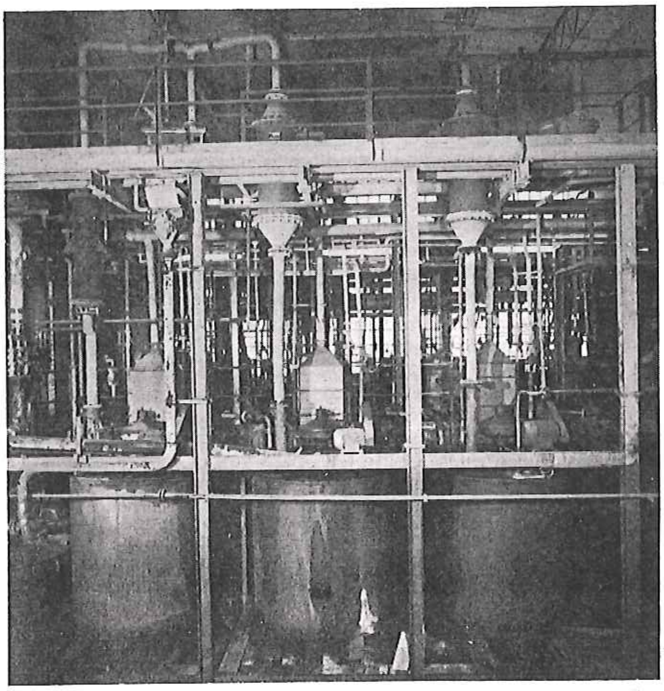
1) Leaching the iron with mineral acids, sometimes followed by an alkali leach, and converting the carbides to acid-soluble oxide by an oxidizing roast.
2) Chlorinating the alloy in a sodium-iron-chloride melt, yielding a raw chloride mixture which is subsequently hydrolized or separated by fractional distillation.
3) Remelting with addition of oxidizing agents.

After a long period of research and development, H.C. Starck succeeded in developing a special high-recovery process combination which is now used in their 18,000 ton/year slag treatment plant in Germany. Several typical results of enrichment to an artificial Ta/Nb concentrate resembling natural ore concentrates are as follows :

	Slag (Malaysia)	*Alloy*	*Synthetic Concentrate*
Ta_2O_5	4 %	~15 % } as	26.9 %
Nb_2O_5	4.3 %	~17 % } metal	30.9 %
TiO_2	10.5 %		18.6 %
SnO_2	1.5 %		0.1 %
WO_3	2 %		0.1 %
P_2O_5	1.2 %		0.1 %
FeO	15 %		8 %
Ta_2O_5	2 %	~ 8 % } as	20.8 %
Nb_2O_5	2.2 %	~10 % } metal	25.6 %
TiO_2	10.5 %		25.0 %
SnO_2	1.2 %		0.1 %
WO_3	2.6 %		0.1 %
P_2O_5	1.2 %		0.1 %
FeO	15 %		8 %

DECOMPOSITION AND EXTRACTION

Various processes for decomposition and extraction are known by the tantalum industry. Few of them are introduced into industrial practice. Decomposition of the ore by alkali fluxes is no longer used. Most of the plants employ the acid digestion route with HF or HF + H_2SO_4 which can be applied to a broad spectrum of natural or artificial concentrates and high grade slags.

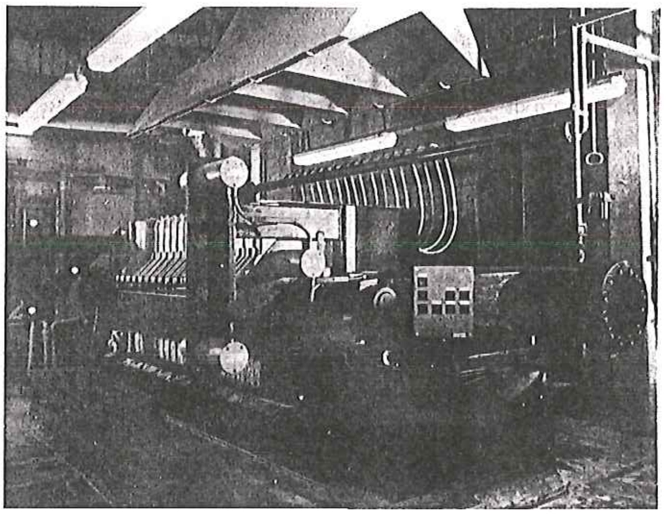


Ta extraction plant.

The application of this method is limited, less so for technical than for economic reasons, considering the expensive HF consumption for non-valuable constituents like SiO_2, TiO_2 and Fe. The separation of the highly corrosive Ta/Nb/Ti solution from insoluble material is a special problem which is partly overcome by decantation processes or solved by filtration in closed automatic filter devices. The insoluble residues which can contain valuable Ta/Nb contents can be recycled or melted in the tin slag process.

Modern solvent extraction techniques have totally replaced the previous Marignac process in which Ta and Nb were separated by multi-stage fractional crystallization of the potassium double salts. In the early fifties, the US Bureau of Mines systematically tested a great number of acid and solvent systems which make it possible to extract tantalum, preferentially to niobium and other elements, into an organic solvent.

The HF/H_2SO_4 system which allows high extraction recoveries in the digestion step, is well suited for subsequent liquid-liquid extraction. In a typical modern industrial-sized unit, first Ta and Nb



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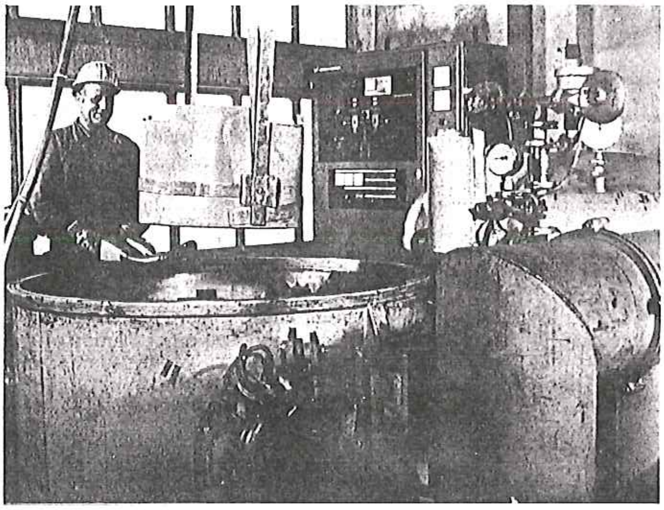


Carbide furnace.

are co-extracted in the methyl-isobutyl ketone, from highly acid HF/H_2SO_4 solutions and separated from Ti and most of the other constituents of the aqueous solution. Then niobium is stripped with diluted acid, and finally tantalum is extracted by ammonium fluoride.

This ideal combination of separation and purification by solvent extraction, which is preferably performed in simple multi-stage mixer and settler units, can be considered as one of the most important developments in the history of tantalum and columbium chemistry.

Tantalum and niobium hydroxides are precipitated with ammonia from the corresponding strip solutions and converted to the oxides by calcining. Potassium tantalum fluoride, the "K-Salt", is crystallized by adding potassium ions to the organic tantalum phase or the tantalum strip solution. Because of the good crystallization characteristics and low solubility of this tantalum compound, it is possible to achieve additional purification. The recycled ketone must be regularly cleaned by distillation.

THE CHLORIDE PROCESS

Most of the constituents of tantalum ore form stable anhydrous chlorides, their boiling points differing over a wide range. So the chlorination technology offers good possibilities for extraction and purification. The use of low-cost chemicals is another advantage, while working in a closed system favours good environmental conditions.

In the sixties, the Swiss company CIBA developed this chemistry successfully into an industrial technique to produce pure Ta and Nb compounds in tonnage size. The decomposition and extraction step was first done in the traditional manner, introducing dry chlorine in a heated mixture of ore and reducing agent. But this technique was replaced soon by a less difficult and more economic process in which a Ta/Nb ferro-alloy was chlorinated in a melt of sodium-iron chloride. The volatilized chlorides were roughly separated in a solid fraction containing Ta, Nb and other high-boiling point chlorides, and a liquid fraction containing the low-boiling chlorides of Ti, Si and Sn. Iron chlorides were retained in the salt melt which is a great improvement over the oxide chlorination.

The solid chloride mixture is separated by fractional distillation in heated packed glass columns using the very small difference in boiling points of the $TaCl_5$ (232 °C) and $NbCl_5$ (245 °C). The pure chlorides are converted to oxides by means of a special steam hydrolysis or taken as feed material for the metal reduction.

Because only glass, quartz or teflon material is in contact with the chlorides and no additional chemicals are used, it is possible to produce extremely pure compounds. Since sophisticated equipment and maintenance are expensive, production costs are remarkably high and the use of this technology is only justified where a higher degree of purity is required, e.g. in optical glasses where the content of colouring systems must be far below 5 ppm. Other important applications of the chlorides are in C.V.D. or as feed material for plasma and submicron powders.

TANTALUM CARBIDE AND METAL POWDERS

Tantalum oxide is the feed material for the production of tantalum carbide which is produced by heating an intimate mixture of the oxide with lamp-black in an oxygen-free system at 1600 °C-1800 °C. The adjustment of the combined and free carbon is normally performed in induction-heated vacuum furnaces by the addition of either oxide or carbon. Solid solutions of TaC and NbC or TaC, TiC and WC, which are increasingly required by the cemented carbide industry, need high-temperature vacuum treatment, i.e. 2000 °C, to achieve the 100 % formation of mixed crystals.

Generally very fine and porous powders are obtained from carbon- and sodium-reduction, more dense and dendritic powder from the fused-salt electrolysis. The simpler and less expensive fluoride method favours the use of K-salt as a feed material for metal reduction. Geographically, the fused salt electrolysis was first, and in comparatively large size, introduced in the USA (Fansteel), while the sodium reduction was first used in Europe - Germany and U.K.

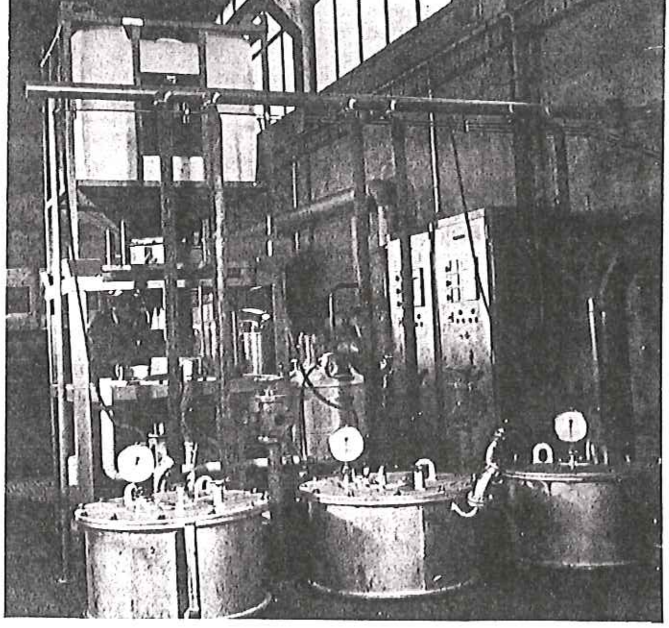
The final decision for most processing companies to employ primarily only sodium reduction was stimulated by the required powder quality for the growing demand of the electronics industry. This industry processes generally two types of capacitor grade powders :

1) The sodium-reduced high capacitance powder for lower working voltage applications (consumer and automotive industry)
2) the "melted" (or EB melted) powder with medium capacitance for high working voltages (military and aerospace industries).

It is evident that the melted powders can be produced from any kind of pure tantalum metal by EB or arc melting and subsequent embrittlement with hydrogen, comminuting, degassing, etc.

On the basis of present knowledge, however, the growing demand for high-capacitor powders — more capacity per weight of tantalum and per volume of capacitor — can only be met by improving the sodium reduction process.

Ta metal production.



Three processing technology models are now in operation :

1) Pot reduction where the exothermic reaction is externally induced by applying heat.
2) Stirred smelt reduction where the process is controlled by the rate of addition of liquid sodium.
3) Continuous reduction where a combined paste of K-salt, sodium and inert salt are continuously fed and ignited.

High cap powders must have a fine particle size and an optimum particle shape and grain size distribution to form the highest possible surface in the sintered anode body. The stability of the dielectric oxide film in the electrolytic capacitor is strongly influenced by the purity. The desired properties can be positively influenced by controlling the conditions of sodium reduction, such as temperature, temperature profile, concentration or dilution of the reactants. In the processes which do not work with a salt melt, the physical conditions and activity of the K-salt play an important role for the performance of the process and the electric properties of the product.

All of the industrially used processes can achieve recovery rates of 90 to 95 % metal, with oxygen contents of the magnitude of 1500-2500 ppm. But the percentage of high cap powder, which can be selected out of this feed, differs from a low of 20 % in an uncontrolled exothermic reaction to a high of 90 % in the best controlled process.

In the continuous PL process as well as in other processes with fully controlled reaction, it is possible to achieve both highest capacitance and high recovery rates. This was needed to reduce the cost of capacitance per gram and to compensate for the increase of raw material prices, keeping tantalum in a competitive position against aluminium and ceramic capacitors.

As we have seen from the production of capacitor powders, it is necessary to find a compromise between particle size and surface on the one hand, and oxygen content on the other. The requirements for the preparation of metallic ductile tantalum, which is necessary for the fabrication of wire, rods and sheet, are quite different and are adversely affected by even the smallest content of oxygen, nitrogen or carbon. These requirements can be achieved only partially in the reduction process, but to a greater extent in additional refinement processes like arc- and EB-melting. Both processes need the feed material in the form of electrodes which are capable of supporting their own weight. These electrodes are prepared by pressing, sintering and welding heavier pieces together. In the arc melting process, these consumable electrodes are vacuum melted into a water-cooled crucible at several thousand amps and 20-35 volts.

In the more expensive electron-beam melting furnace, electrons from one or several guns are accelerated at high velocity in a vacuum, and when they impinge on the metal being melted, they release their kinetic energy in the form of heat. The metal melts into a water-cooled copper mould.

In arc melting it is easier to obtain a good ingot sidewall, smaller grains, and the finished product is higher in yield strength and in ultimate tensile strength.

On the other hand, EB-melting can produce high purity metal from a feed stock that is high in oxygen and volatile metallic impurities such as iron, nickel, etc. This process is increasingly used for the reclaiming of scrap.

An important and very typical advantage of solid tantalum is the fact that it can be converted to powder by embrittlement with hydrogen, whereby the powdered brittle hydride is easily decomposed in a vacuum furnace to yield purified metal powder. This embrittlement can be done even with pieces of ingot weighing some hundreds of pounds.

In connection with the EB-melting of scrap, another important development in recent years should be mentioned, the recovery of tantalum from the complicated capacitor scrap. This scrap, containing 20 % tantalum with silver and manganese, encapsulated in plastic or metal cases with nickel or copper lead wires attached, can be converted to the coloured Ta-anodes by a combination of mechanical and chemical means. The recovered anodes can be melted in an EB furnace or consumed in carbide production. The recycling of tantalum from electronic scrap, requiring good organization for collecting and sorting, has become an important additional source of tantalum.

Tantalum scrap resulting from the manufacture of mill products is usually recycled by remelting. The last significant source of secondary tantalum is the TaC content of used cemented carbide tips. The carbide industry is employing its own system to use the valuable carbides as long as possible by in-plant recycling and mixing in reclaimed powders from carefully sorted and treated scrap. But this multiple use results in the devaluation of some TaC through mixing and dilution. The worn-out parts, mixtures and grindings have to be treated in a step-by-step chemical operation consisting of oxidation and comminution, tungsten extraction, and cobalt extraction and the final recovery of a Ta/Nb/Ti oxide mixture with smaller amounts of the other constituents. These sludges are used as feed for solvent extraction plants. The overall recovery rate of this tantalum is estimated to be still fairly low.

Tantalum capacitors in Japan

The following paper was presented at the Fifteenth General Assembly of the T.I.C. by Mr. Hidehiro Okuda, Vice President, Nippon Electric Company Limited.

The reputation of N.E.C. in expanding the Japanese tantalum capacitor market should be shared with tantalum material suppliers who have always tried to give us their best cooperation in improving tantalum powders, wire and foil. I would like to express my respect and appreciation to all of those material suppliers.

Skyrocketing prices of tantalum materials during the past three years, however, caused critical damage to all of the tantalum capacitor manufacturers. The price hikes were too drastic and too frequent for capacitor manufacturers to absorb them by our own cost reduction efforts. We were forced to pass those increased costs on to our customers and, as a result, lost a considerable part of the tantalum capacitor market created and maintained by our continuous efforts in the past.

Until 1978, price increase of tantalum materials had taken place rather gently so that the capacitor manufacturers could absorb increased costs and could expand the market. Development of higher CV value powders by tantalum material suppliers and improvement of process technology by capacitor manufacturers went hand in hand gradually to decrease consumption of tantalum powder per capacitance value ever since 1979. Miniaturization in tantalum capacitor sizes, made possible by the improvement in CV value per gram, also contributed to the healthy growth of the tantalum capacitor market.

HISTORY OF TANTALUM CAPACITORS IN JAPAN

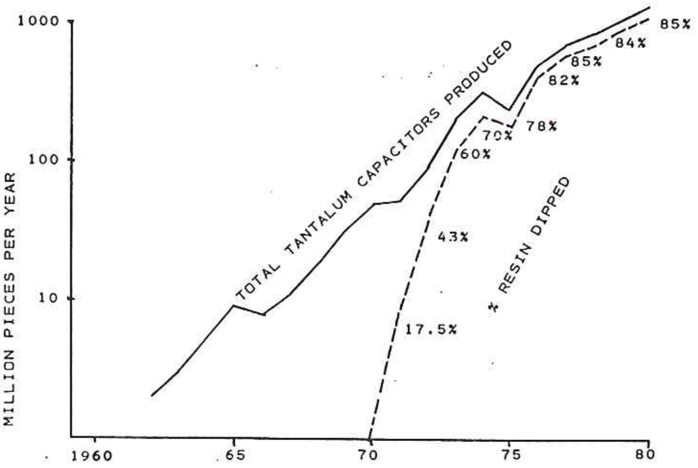
The first transistor application to electronic products started with radios in 1955 and it was just a matter of course to apply them to telecommunication equipment too. Since the impedance in transistor circuits is approximately one-tenth of that in electron tube circuits, electrolytic capacitors are most suitable in view of their features, large capacitance in small physical size. Their low rated voltage characteristics are not disadvantageous since transistor circuits do not require high voltage operation as electron tube circuits do.

Aluminium electrolytic capacitors available at that time were not sufficient in impedance characteristics and were considered rather unreliable because of the dry-up problem. They were reasonably good for consumer electronics like radios but were not good enough for telecommunication equipment which required rather high reliability over a long period of time.

In 1956, for the first time in Japan, tantalum capacitors were put into practical application in transistorized carrier transmission equipment. They were wet type tantalum foil capacitors, not solid type capacitors which were still in the development stage. Tantalum foil capacitors, however, using liquid electrolyte, like aluminium electrolytic capacitors, still had insufficient reliability since they also had a possibility of the dry-up problem. In order to solve this, NEC developed solid electrolytic tantalum foil capacitors, different from currently used solid tantalum capacitors in that germanium was used as the solid electrolyte and aluminium was used as the cathode electrode. Winding the composite foil, however, made it very difficult to produce in quantity as the tantalum oxide film formed on the foil surface was too sensitive to accept mechanical stress. Therefore, they did not find wide application.

About three years later, in 1959, sintered slug type solid tantalum capacitors, originally developed by Bell Laboratories in the U.S., were adopted for telecommunication equipment in Japan. Since then, the main stream of tantalum capacitors has been the solid type and they have experienced healthy growth for about ten years in the industrial market for telecommunications and computers.

Technological progress in the late 60's in improving humidity characteristics made it possible to produce solid tantalum capacitors encapsulated in epoxy resin. This provided enormous possibilities to the tantalum capacitor industry to penetrate the broad range of the consumer electronics market. Resin-dipped tantalum capacitors have reached about 85 % of the total tantalum capacitors sold in Japan. Through cost reduction efforts and the performance characteristics and small physical size, resin-dipped capacitors have attained superiority over aluminium electrolytic capacitors and have attained the remarkable market penetration.



TANTALUM CAPACITORS IN JAPAN

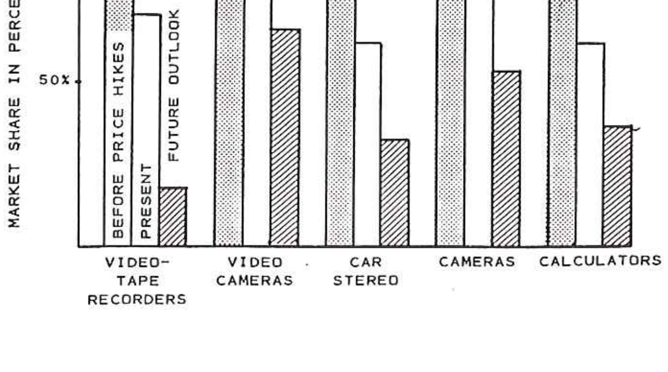
Demand for tantalum capacitors in Japan is overwhelming in consumer electronics where resin-dippeds are dominant. The Japanese market differs to a great extent from that in the U.S. or Europe. In the U.S., the demand for resin-dipped devices is increasing but they are still estimated to be below 50 % of the market. This difference in market situation can be explained by the fact that the Japanese electronics industry is still dominated by consumer electronics, although telecommunication, computer and other industrial applications have reached 45 % of the total. In the U.S., industrial electronics, together with military electronics, are estimated to be 88 % of the total.

Resin-dipped tantalum capacitors are used as follows in the Japanese market :

Television	7.5 %
Video tape recorders	12.8 %
Stereo systems	3.1 %
Stereo tape decks	1.6 %
Radio Cassette recorders	4.8 %
Tape recorders	18.0 %
Car stereo	18.6 %
Toys	10.7 %
Elec. Music Instr.	2.3 %
Cameras	14.3 %
Elec. Mechanical Equip.	0.8 %
Electronic calculators	5.6 %

The reasons why tantalum capacitors are so widely used in these areas are the need for small physical size, the excellent performance characteristics compared to other types and the superiority of tantalums in price, physical size and electrical performance in synthetic consideration. Since 1979, however, the latter category has completely faded out due to the price hikes, the emergence of subminiature aluminium electrolytic capacitors (30 % physical size reduction) and aggressive pricing in monolithic ceramic capacitors resulting from cost reductions, thinner ceramic films for higher capacitance sizes and smaller physical size.

Besides price hikes, the uncertain prospects for tantalum materials gave customers both anxiety and distrust against tantalum capacitors. Since tantalum capacitor manufacturers could not have any clear picture for the future, there was no way for us to give a definite answer to our customers about future prices and material shortages. The situation was so desperate that we were forced just to let our market go to other capacitors while we asked only minimum price increases from our customers. The bad influence of tantalum capacitor price hikes in those major applications where resin-dipped tantalums are used is shown by comparison :



TANTALUM CAPACITORS IN THE FUTURE

Electronics is one of the most promising industries for the next generation. But the more the electronics industry develops, the severer the market competition will be. Only the people who can meet the competition will be able to enjoy prosperous dollar volume business from the enormous increase in production quantities.

Since I have been with the tantalum capacitor business for almost 30 years, it is my earnest desire that we can minimize the bad influence of material price hikes to the capacitor market and lend our experience to future business expansion. From this standpoint, let's look at the future tantalum market in Japan.

1) Industrial markets (Telecommunications, computers, etc.)
   Stable, but not rapid, growth is projected because high reliability is the first priority.
2) Consumer markets (75 % of the total and very competitive).
   Moderate growth based on product development focused on miniaturization of current devices and greater use of chip style devices.
3) Automotive market.
   Rapid expansion.

Since the Japanese tantalum capacitor industry relies heavily on the consumer market, the detail about what we should do in the future is

1) Miniaturization — The electronics industry has an insatiable demand for miniaturization. In a portable stereo, now booming throughout the world, tantalum capacitors, due to price increase, were replaced by other types to reduce cost. But, because of miniaturization, the most advanced models have come back to tantalums as only the small physical size can meet the subminiaturized design. Portable consumer electronic products will have steady growth in the future and the pursuit of smaller tantalum capacitors will maintain the market.
2) Automatic Assembly — Along with miniaturization, automation for the assembly of consumer electronics is rapidly advancing. The new technology requires as many as possible of the chip-style components for direct surface mounting on printed circuits. Chip components save surface area on P.C. boards and, in some cases, can be mounted onto the soldering side of the P.C. boards to minimize the P.C. board size.
3) Automotive electronics — High reliability is the greatest concern especially in systems which are directly related to human life such as emission control, anti-skid devices, etc. For these critical applications, tantalum capacitors are advantageous in their superior temperature range, high reliability, and small physical size.

I believe that the advantages of tantalum capacitors in electrical performance and small physical size over all other capacitors still preserves the possibility of more effective utilization than aluminium electrolytic capacitors and monolithic ceramics. This outlook is based on our estimation that the CV value of tantalum powder will go up to around 30,000 within four to five years. Since greater progress is projected in monolithic ceramic capacitors, however, I feel that they will be more competitive than aluminium electrolytics.

CONCLUSION

In the Japanese market, dominated by consumer electronics, miniaturization of tantalum capacitors and tantalum chip capacitors, suitable for automatic assembly, are eagerly required. The development of higher CV rated powders is urgently needed to meet the market requirements. This is not only a must to recover the lost market, but also it is the only way to bring long term and healthy growth in the tantalum capacitor business. And it will also save precious tantalum mineral resources.

Now is the time, I have to emphasize, for closer mutual cooperation among tantalum miners, tantalum material producers and tantalum capacitor manufacturers than ever before. It is our responsibility to fulfil our customers' needs with well balanced services attainable only through combined efforts by reasonable ore prices, development of higher CV powders, and improvement of capacitor design and manufacturing. I am sure that mutual cooperation promises a fruitful and beneficial business in each industry in the future.

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