TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

BULLETIN N° 68 DECEMBER 1991 FOURTH QUARTER

Philadelphia

GENERAL ASSEMBLY

The Thirty-second General Assembly was held in Philadelphia on October 24th 1991, as part of a meeting from October 23rd to 25th sponsored and hosted by Cabot Corporation and Showa Cabot Supermetals. Presentations in the technical session reached a high standard, and a plant tour completed the scientific programme. More than 140 took part in the conference.

Cabot Corporation and Showa Cabot Supermetals invited all delegates, guests and their ladies to a splendid banquet, given a special Philadelphia atmosphere by the presence of "Benjamin Franklin" who presented the Liberty Bell, on behalf of the city, to the T.I.C. President. Social events also included a reception given by the T.I.C. The ladies' own programme included tours of historic Philadelphia mansions and a visit to the amazing Barnes Foundation to see the French Impressionist paintings collected by Dr Albert Barnes.

The General Assembly was chaired by T.I.C. President Mr Peter Adams, Thaisarco, and elected six new members (see last page of this Bulletin), bringing total membership to 63 after the resignation of nine companies. The audited accounts for the year ended June 30th 1991 were approved and the President reported that the financial situation was sound. The Technical Adviser, Mr Rod Tolley, reported on his year's activities, including EMC '91's exhibition, resolving problems of statistics gathering and editing the quarterly Bulletin.

For statistics collection the Assembly of members approved a modification to one of the rules protecting confidentiality in certain sections : where one company's contribution was more than 75 % of the total for a category, that category would be combined with others (amended from 65 % of the total).

Some copies of the **Proceedings of the International Symposium on Tantalum and Niobium** (ISBN 92 9093 001 2) are still available : the President announced a reduction in price to $ US 50 per copy, including postage and packing.

An informal meeting would be held in Brussels on April 7th 1992.

Mr Yoichiro Takekuro, Vacuum Metallurgical Company, was elected President for the coming year.

PHUKET, NOVEMBER 1992

The next General Assembly will take place in Phuket, Thailand, on November 17th as part of a meeting from November 16th to 19th 1992, giving delegates the opportunity to visit the Thaisarco tin smelter.

TECHNICAL SESSION

The technical papers were given in the morning and afternoon of October 24th, after the General Assembly. The morning session was chaired by Dr George Korinek, and it started with a paper given by Dr W.A. Spitzig of the Ames Laboratory, Iowa State University, on the development of copper-niobium and copper-tantalum composites. The two refractory metals have the great merit of having very low mutual solid solubility with copper and there are no intermetallic phases formed. Provided that the techniques for forming and working the mixtures can be developed, it should be possible to increase the strength of the copper (particularly at higher temperatures) while maintaining its electrical conductivity. This has been achieved by consumable electrode arc casting : radial slots cut in a cylinder of copper are filled with niobium or tantalum to form a composite electrode which is then melted into a mould under argon. An annealed Cu-5 % Nb alloy has an ultimate tensile strength of 900 MPa, nearly double that of a commercially available copper-chromium alloy of the same conductivity (80 % IACS), while the 15 % Nb alloy has a UTS of 1400 MPa, for only a small fall in conductivity. The alloys are now in commercial production.

The second paper concerned the use of refractory metals (in particular tantalum) for high explosive ordnance, and it was given by Dr Joseph Carleone of Aerojet. Discs of tantalum are set above an explosive charge which when detonated expels the disc while at the same time deforming it into a projectile. These have been used to great effect (in particular in the Gulf War) as the warheads of air-to-surface or surface-to-surface missiles such as the Hughes Tow 2B. Tantalum has the great merit of very high density combined with workability, giving it an edge over, for instance, tungsten. An earlier use of depleted uranium for this role has now been abandoned because of the hazard from radioactivity.

This was followed by a paper on metal oxide physics, given by Dr Khanin of our new member company Positron from St Petersburg. He described the fundamental research being done by his company and associates on the characteristics of tantalum and niobium capacitors and on factors affecting the properties of the oxide layer vital to performance.

Dr P. Kumar of Cabot then talked of the role of niobium and tantalum in superalloys, tracing their history from the addition of niobium to S 816 alloy in the 1940s to the current use of tantalum in single crystal, and of niobium in special low-expansion alloys.

Mr Mette of the Ulba Metallurgical Plant was unable to reach Philadelphia in time for our meeting, but his notes on the tantalum and niobium produced at the Kamenogorsk plant was read by Mr Linden of Gwalia. The plant produces vacuum arc and electron-beam melted tantalum and niobium, rolled sheet and foil and capacitor-grade tantalum powder.

In the afternoon, all of the papers were concerned with applications of tantalum powder (principally in capacitors) and the chair for this session was taken by Mr David Maguire of Kemet Electronics. The first paper, presented by Dr Hickl on behalf of colleagues at Cabot Corporation, was concerned with tantalum powder metallurgy preforms. Extrusion and forging of Ta powder packed in metal cans provides a convenient short-cut in the processing flow sheet, provided that the oxygen contents can be controlled in the finished product.

Mr Mudrolyubov, a colleague of Dr Khanin from St Petersburg, then described Positron's product range of tantalum and niobium capacitors (the latter being used where volume considerations are not paramount, or at times of difficulty in acquiring tantalum). Where their tantalum capacitors had a range of 1-470 μF, the niobium capacitors of equivalent size ranged from 0.67-150 μF.

Dr Chang then spoke on new developments by Cabot in its capacitor products. Improvements in tantalum powder to permit its use at higher specific capacitance and higher working voltage had resulted from extensive analysis of the controlled variables in its production. In this way it has proved possible to optimise particle size and morphology, and to minimise impurities so that consistently high CV values can be obtained.

Mr H. Adachi of Hitachi then delivered the very informative paper which is printed later in this Bulletin.

He was followed by Mr Y. Mizusaki of Showa Cabot Supermetals who showed how dependent the performance of tantalum capacitors was on the pore size distribution of the sinter, and that in turn on the form of the original powder (so making an interesting sequel to Dr Chang's paper earlier).

The session finished with a paper by Mr W. Millman of AVX on new opportunities for growth in sales of tantalum capacitors. The versatility of the tantalum capacitor, particularly in surface mounted circuits, was ensuring its expanding use. Its amenability to miniaturisation (thanks both to powder quality and product design) has proved a vital competitive factor : some items now have footprints of 1 mm square or less.

On the following day the delegates visited the Boyertown plant of Cabot Corporation (the co-host, with Showa Cabot, of the General Assembly and the related social functions). Here we were able to see almost all of the products that we had been hearing about in the technical papers. The range of products and the equipment used in their manufacture were most impressive and we were given a very thorough tour of all the facilities.

R.J. Tolley
Technical Adviser

T.I.C. statistics

TANTALUM

PRIMARY PRODUCTION

(quoted in lb Ta_2O_5 contained)

	3rd quarter 1991
Tin slag (2 % Ta_2O_5 and over)	179 535
Tantalite (all grades)	203 970
Other	6 470
Total	389 975

Note : 15 companies were asked to report, 14 replied. The companies which reported included the following, whose reports are essential before the data may be released :

Datuk Keramat Smelting, Greenbushes, Malaysia Smelting, Mamoré Mineração e Metalurgia, Metallurg group, Pan West Tantalum (Wodgina Mine production), Tantalum Mining Corporation of Canada, Thailand Smelting and Refining

QUARTERLY PRODUCTION ESTIMATES

(quoted in lb Ta_2O_5 contained)

LMB quotation :	*US $ 30*	*US $ 40*	*US $ 50*
4th quarter 1991	241 900	330 100	355 500
1st quarter 1992	256 900	340 100	365 500
2nd quarter 1992	256 900	346 100	371 500
3rd quarter 1992	256 900	345 600	372 500
4th quarter 1992	261 900	348 100	372 500

Note :

The quarterly production estimates are based on information available, and do not necessarily reflect total world production.

PROCESSORS' RECEIPTS

(quoted in lb Ta contained)

	3rd quarter 1991
Primary raw materials (e.g. tantalite, columbite, struverite, tin slag, synthetic concentrates)	190 323
Secondary materials (e.g. Ta_2O_5, K_2TaF_7, scrap)	126 885
Total	317 208

Note : 14 companies were asked to report, 13 replied.

PROCESSORS' SHIPMENTS

(quoted in lb Ta contained)

Product category	*3rd quarter 1991*
Ta_2O_5, K_2TaF_7	24 437
Carbides	76 395
Powder/anodes	208 383
Mill products	91 788
Ingot, unworked metal, other, scrap, alloy additive	62 375
Total	463 378

equivalent to 625 560 lb Ta_2O_5.

Notes :

In accordance with the rules of confidentiality "alloy additive" was combined with "ingot, unworked metal and other" and "scrap".

14 companies were asked to report, and in July and August all 14 replied, in September 13 replied. For both receipts and shipments by processors, reports by the following companies are essential before the data may be released :

Cabot Corporation, Electronic Materials and Refractory Metals, W.C. Heraeus, Kennametal, Metallurg Group, Mitsui Mining and Smelting, NRC Inc., Showa Cabot Supermetals, Hermann C. Starck Berlin, Treibacher Chemische Werke, Vacuum Metallurgical Company, V Tech

NIOBIUM

PRIMARY PRODUCTION

(quoted in lb Nb_2O_5 contained)

	3rd quarter 1991
Concentrates : columbite, pyrochlore	10 058 389
Occurring with tantalum : tin slag (over 2 % Ta_2O_5), tantalite, other	433 723
Total	10 492 112

Note :

17 companies were asked to report, 15 replied. The companies which reported included the following, whose reports are essential before the data may be released : Cambior, Mineração Catalao de Goiás, Niobium Products Co. (CBMM)

PROCESSORS' SHIPMENTS

(quoted in lb Nb contained)

	3rd quarter 1991
Compounds and alloy additive : chemical and unwrought forms (e.g. $NbCl_5$, Nb_2O_5, NiNb, FeNb [excluding HSLA grades])	562 747
Wrought niobium and its alloys in the form of mill products, powder, ingot and scrap	
(i) Pure niobium	53 117
(ii) Niobium alloys (such as NbZr, NbTi and NbCu)	69 917
HSLA grade FeNb	7 085 815
Total	7 771 596

Note : 15 companies were asked to report, 14 replied. Reports by the following companies are essential before the data may be released : Cabot Corporation, Electronic Materials and Refractory Metals, Greenbushes, W.C. Heraeus, Kennametal, Metallurg Group, Mitsui Mining and Smelting, Niobium Products Co. (CBMM), NRC Inc., Hermann C. Starck Berlin, Teledyne Wah Chang Albany, Treibacher Chemische Werke, Vacuum Metallurgical Company

Capacitor statistics

U.S. TANTALUM CAPACITOR SALES

(thousands of units)

2nd quarter 1991

Metal-cased	16 870
Moulded	55 930
Dipped	104 559
Chips	140 433
Wet slug	1 077
Total	318 869

Foil : not included.

(Data from EIA)

EUROPEAN TANTALUM CAPACITOR SHIPMENTS

(thousands of units)

2nd quarter 1991 185.311

(Data from ECTSP)

JAPANESE TANTALUM CAPACITOR PRODUCTION AND EXPORTS

(thousands of units)

2nd quarter 1991

Production	1 214 845
of which exports	276 524

(Data from JEIDA)

President's letter

It is a great honour to me to be elected as T.I.C. President for this year. I am very grateful to Mr Peter Adams, my predecessor, for the work he has done in keeping the T.I.C. in good order, and in expanding the organisation to include our first Russian member. My thanks are also due to Dr Korinek, who has been particularly helpful to me, and to other committee members, with the benefit of his long experience.

The changes now going on in the world and the resulting relaxation of tension should present our members with new opportunities for applications of tantalum and niobium. The T.I.C. will continue to act as the gatherer of information and the dispenser of advice to all potential users. Please give it all your support.

Yoichiro Takekuro
President
December 5th 1991

Recent advances in chip type capacitors in Japan

by Hiroshi Adachi, Hitachi A.I.C., Inc., Japan

(The author, from a major consumer of tantalum capacitors in Japan, gave this paper at the Philadelphia meeting of the T.I.C. In it, he describes the rapid advances being made by the principal competitors for tantalum, and suggests action needed to be taken by tantalum capacitor makers if they are to maintain their lead : Ed).

INTRODUCTION

Tantalum capacitors were regarded as technologically mature products about a decade ago and the growth rate of their production then seemed to have been saturated. However, the production of molded chip tantalum capacitors has been developed in accordance with the demand for miniaturization of electronic equipment and has shown a remarkable growth during these last ten years.

Recently, the production of molded chip tantalum capacitors has surpassed the production of dip style capacitors which were the predominant style of tantalum capacitor up to 1988. At present, the production of chip tantalum capacitors occupies 65 % of the whole tantalum capacitor production. This trend is expected to continue along with the production growth of electronic equipment employing semiconductor devices. However, technological innovation of the other chip-type capacitors, multilayer ceramic and solid aluminum capacitors, has been successful and these chip capacitors are gaining headway against tantalum capacitors in this application.

This paper considers the competitive relationship among these chip-type capacitors in Japan, and studies the technological direction of future tantalum capacitors.

1. MARKET CONDITIONS OF CHIP-TYPE CAPACITORS IN JAPAN

First, let us look at the transition of market conditions of tantalum, aluminum and ceramic capacitors in Japan.

Table 1 shows the quantities and revenue of each capacitor as well as its growth rate in 1985 and in 1990. The growth rates of ceramic and tantalum capacitors are high, but that of aluminum capacitor relatively low. The high growth rate of both ceramic and tantalum capacitors is supported by the development of their chip types, and the low growth rate of aluminum capacitors is because of the delay in the development of their chip type.

		1985	1990	Growth Rate
Ta	Quantity	2,175	4,266	1.96
	Value	49,687	65,268	1.31
Al	Quantity	18,660	26,081	1.40
	Value	168,836	192,231	1.14
Ceramic	Quantity	39,331	80,155	2.04
	Value	141,602	180,245	1.27

Quantity : Million unit
Value : Million ¥

Table 1 : Capacitor markets and their growth rate

Figure 1 shows the change in the ratio of chip type to total capacitors. The development of ceramic chip capacitors began earlier than that of others, but recently the ratio of chip type in tantalum capacitors has caught up with that for ceramic.

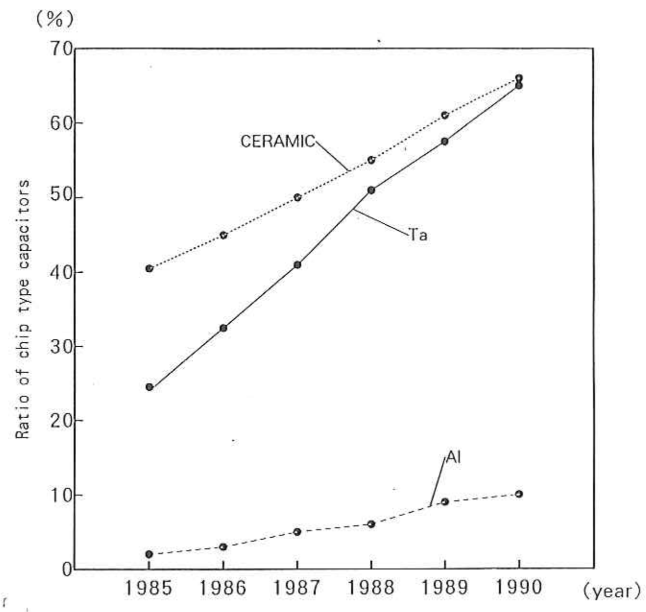

Fig. 1 : Changes in the ratio of chip type to all types of capacitors

Figure 2 shows the change in shipments and revenue of tantalum capacitors of chip, dip and metal case styles. Metal case capacitors have gradually decreased. Dip-type capacitors remain almost the same, but chip capacitors have increased 5.8 times during the last 6 years.

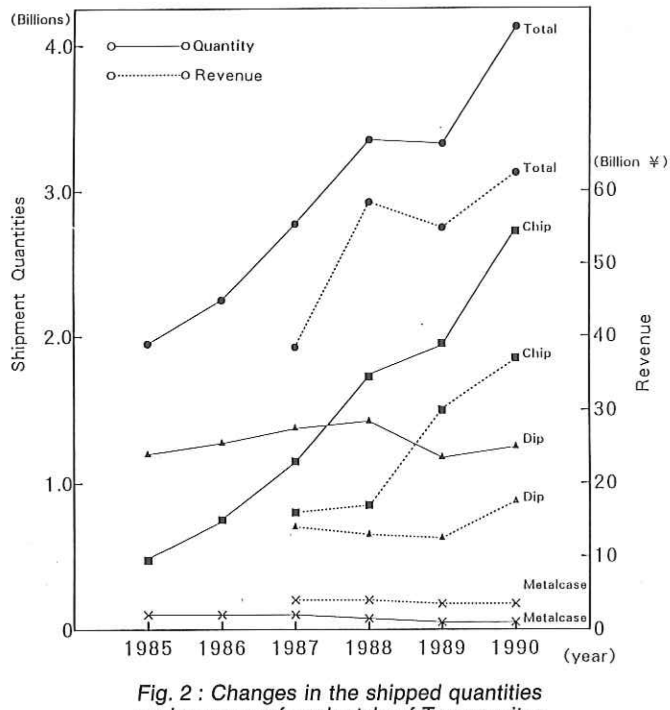

Fig. 2 : Changes in the shipped quantities and revenue of each style of Ta capacitor

Figure 3 shows the change in shipments classified according to the application fields of tantalum chip capacitors. Each shipment quantity is the total in each February from 1985 to 1991.

Great numbers of tantalum chip capacitors are used in small-sized and portable equipment such as VCRs, TV cameras combined with VCR, communications equipment and so on. The factors contributing to such a high growth rate of tantalum chip capacitors are the feasibility of obtaining large capacitance in small size compared to other types of capacitor, and their stable characteristics. As long as the miniaturization of electronic equipment and the demand for surface mount technology (SMT) continue, further growth of tantalum chip capacitor production can be expected.

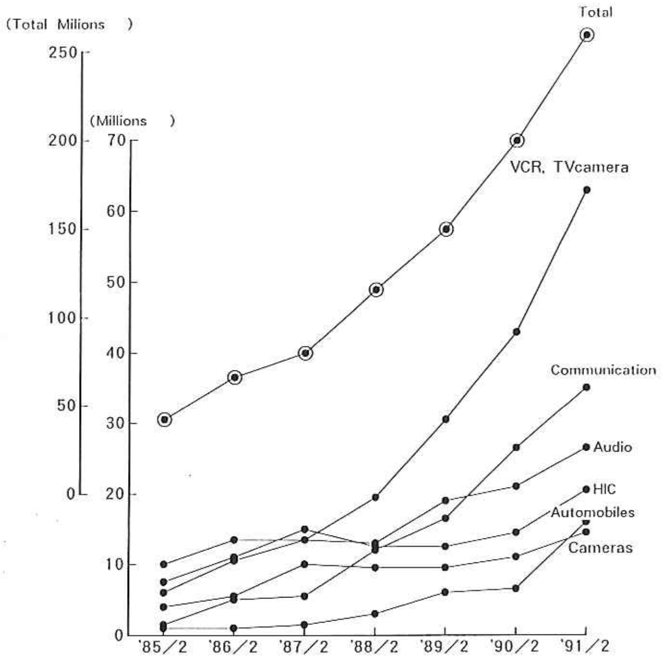

Fig. 3 : Changes in the shipped quantites of chip Ta capacitors according to the application (February of each year)

In the meantime, epoch-making technological innovations in other chip capacitors have emerged in recent years, as they have also with tantalum chip capacitors.

2. THE TREND OF CHIP-TYPE CAPACITORS

Various capacitors have inherent features which govern their selection for use in particular applications. Figure 4 shows the application ranges of each sort of capacitor according to its nominal capacitance : the capacitance range of ceramic is below 1.0 μF, that of tantalum is between 0.1 and 100 μF, and that of aluminum is above 1.0 μF. Recently, with the development of the lamination technology of ceramic capacitors, their capacitance range has been expanded.

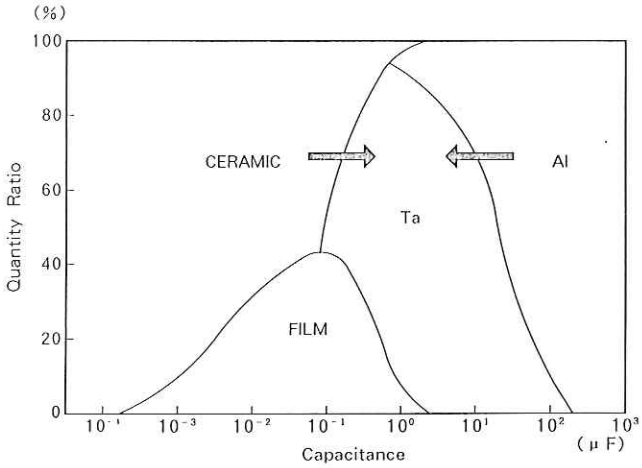

Fig. 4 : The competitive relationship between chip type capacitors

In the aluminum chip capacitor field, the solid electrolytic capacitor is being developed to replace the conventional liquid type. This technology has made the production of the chip-type aluminum capacitor easier and at the same time has made possible a great improvement in its inherent characteristics. These two sorts of capacitors are making headway in the application fields at present occupied by tantalum chip capacitors.

2.1 Chip-type multilayer ceramic capacitors

The development of chip-type ceramic capacitors has been advanced along with that of chip resistors and so has supported the introduction of SMT in electronic equipment. Ceramic chip capacitors have several features such as low cost, miniaturization and excellent frequency characteristics, but their capacitance range is lower than 1 μF, therefore the application fields of ceramic capacitors differ from those of tantalum chip capacitors.

Table 2 shows recent technological innovations in ceramic capacitors. Their miniaturization has continued to advance with the product size of their conventional leading capacitors changing from 3.2 × 1.6 mm (Code no. in EIA 3216) to 2.0 × 1.25 mm (2125), and this will be further reduced to 1.6 × 0.8 mm in the near future (Figure 5). In addition, the advance of lamination technology has made possible the production of dielectric layers 5 ~ 10 μm in thickness compared with the 15 ~ 20 μm of current capacitors.

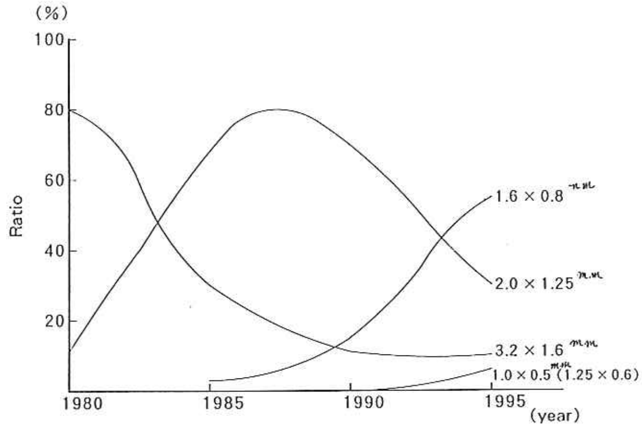

Fig. 5 : Trends in the size of chip ceramic capacitors

The thinner the dielectric layer, the larger capacitance we can put in the capacitors. This technology in ceramic capacitors has resulted in extension of the upper limit of the capacitance range from 1.0 to 10 μF for 3.2 × 1.6 mm size. This ceramic capacitance range makes it fully competitive with tantalum chip capacitors. However, this extended capacitance range causes a cost increase because more lamination layers are required and more consumption of inner electrode materials is needed. Recently, the use of base metals for the electrode materials has been studied, and by this technology the unit cost should come down to less than that of tantalum capacitors with the same capacitance.

2.2 Chip aluminum electrolytic capacitor

Aluminum chip capacitors trail behind the ceramic and tantalum chip capacitors because their electrolyte is liquid. The conventional aluminum chip capacitor is contained in a metal case together with the liquid electrolyte and is then encased in plastic. This makes it bulky and the capacitor life is limited because the liquid electrolyte dries up. In addition, its frequency response and other characteristics are inferior.

Item	Content	Comparison with Ta
Miniaturization of chip size	3.1 × 1.6^{mm} → 2.0 × 1.25 mm × 1.6 × 0.8^{mm} 1.0 × 0.5^{mm}	Competition range Cer 2.0 × 1.25^{mm} 0.1 ~ 1.0 μ F Ta 3.2 × 1.6^{mm}
Larger capacitance	(1) Thinner dielectric layer 15 ~ 20 μ m → 5 ~ 10 μ m (2) High dielectric const (3) More multiple lamination layers	Competition range 1.0 ~ 10 μ F at 3.2 × 1.6^{mm} size
Lower unit price	Adoption of base metals for inner electrode Pt-Pd → Ag-Pd → Ni	Same nominal capacitance 20 ~ 30 % lower

Table 2 : Trends of chip type multilayer ceramic capacitors

Technology	Means	Merits
Development of solidified electrolyte	1. Adoption of TCNQ complex salt Raising of MP from 210 °C to 240 °C Wound type ρ : 10^0 ~ 10^{-1} Ω m	Adaptability to SMT Improvement of frequency characteristics Elongation of capacitor's life Capacitance range 1.0 ~ 15 μ F
	2. Adoption of Polypyrrole (MnO_2 + Ppy) Single or multilayer type ρ; 10^{-1} Ω m	Adaptability to SMT Fairly good frequency characteristics Improvement in temperature characteristics Capacitance range 1.0 ~ 10 μ F

Table 3 : Trends of chip type aluminum electrolytic capacitors

However, replacement of this liquid electrolyte by an organic semiconductor or a functional polymer has been realized and the disadvantages are rapidly disappearing. Moreover, the frequency characteristics of solid aluminum chip capacitors have become much better than those of tantalum chip capacitors. This improvement of frequency characteristics has attracted the attention of circuit designers to the point where aluminum and tantalum chip capacitors are considered competitive from a frequency standpoint.

Table 3 shows the relative merits of the solid electrolytes proposed for aluminum chip capacitors. Newly developed aluminum chip capacitors have been realized by using two kinds of conductive polymers for electrolyte. One is a method using TCNQ complex salt : this form of capacitor was first put on the market in 1983, not as a chip but as a radial lead type. The melting point of conventional TCNQ salt is 210 °C and this temperature is lower than the soldering temperature of chip components, and so is not applicable to SMT. However, by mixing two kinds of TCNQ, it has been found that the melting point can be raised as high as 240 °C and at the same time the resultant complex salt has comparatively high conductivity.

Another electrolyte is polypyrrole (Ppy). Ppy has fairly good conductivity when prepared by electrolytic polymerization with addition of the appropriate dopant to the monomer. However, since the surface of the aluminum foil on which the dielectric film is formed is covered with insulating layers, the Ppy film cannot be formed by means of electrolytic polymerization on the foil. This problem has been overcome by applying MnO_2 to the formed foil surface by means of thermal decomposition of manganese salt and by using this MnO_2 as electrode. The Ppy film can then be prepared uniformly by electrolytic polymerization.

The TCNQ complex salt is currently being used for wound foil type capacitors, while Ppy is used for single-layer or laminated-layers type capacitors. The smallest size of these capacitors is close to the "D" case (7.3 x 4.3 mm) of molded tantalum chip capacitors, and it is difficult to miniaturize to the "A" (3.2 x 1.6 mm) or "B" (3.5 x 2.8 mm) size of present day tantalum capacitors.

3. COMPARISON OF THE THREE TYPES OF CHIP CAPACITOR

Figure 6 shows a comparison of the volumetric efficiency of various types of chip capacitors. The capacitance being contained in the same size capacitor is largest with tantalum, followed by ceramic and then aluminum, but the volume difference between tantalum and ceramic tends to diminish in the lower capacitance range.

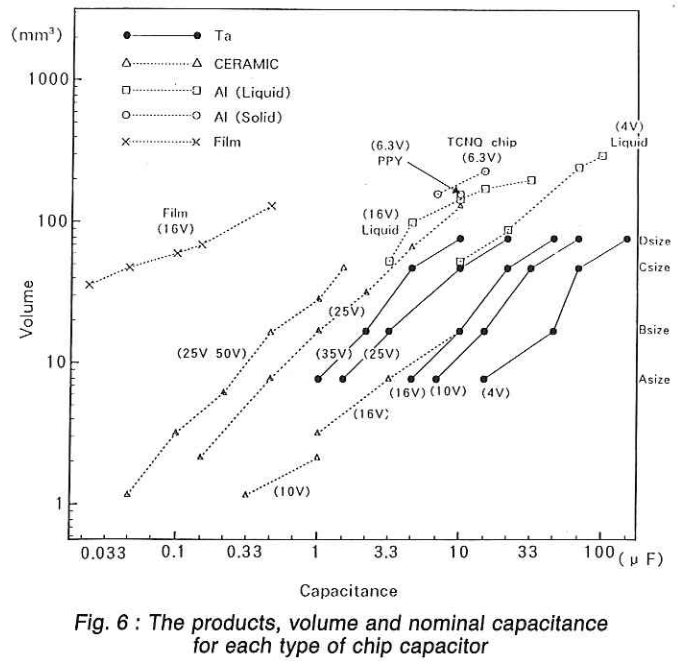

Fig. 6 : The products, volume and nominal capacitance for each type of chip capacitor

Figure 7 shows the frequency characteristics of impedance of various capacitors. It will be noted that the impedance of aluminum solid capacitors using conductive polymer are greatly improved compared with those using liquid electrolyte, and are closely approaching the characteristics of ceramic capacitors.

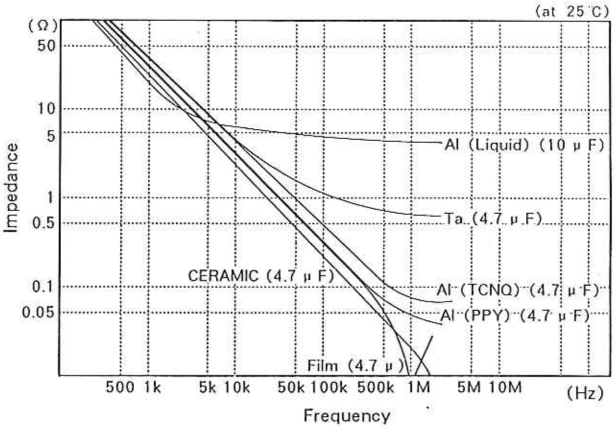

Fig. 7 : Impedance vs frequency

Figure 8 shows the comparison of capacitance change with temperature among various capacitors. The biggest drawback of ceramic capacitors is a large capacitance change with temperature and DC voltage. The temperature characteristics of aluminum solid capacitors are much better than those of liquid type and are often equal to or better than those of the equivalent tantalum capacitor.

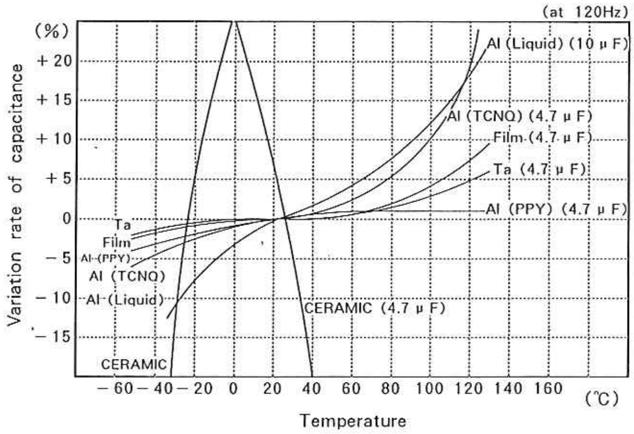

Fig. 8 : Variation of capacitance vs temperature

Table 4 summarizes the merits and demerits of the three types of chip capacitors. When tantalum capacitors are compared with ceramic, they are superior only in the capacitance change with temperature and voltage. Other characteristics of ceramic capacitors are better than those of tantalum. If the capacitance range of ceramic capacitors can be expanded to that of tantalum, some ceramic capacitors will replace tantalum (and such replacement has already started).

Aluminum solid capacitors will remain larger in size than equivalent tantalum capacitors, but have excellent frequency characteristics which may make them overall more competitive. In addition, it can be expected that ceramic and aluminum capacitors will be substituted for tantalum capacitors in certain applications on the ground of price.

Type \ Item		Max Voltage (V)	Max Cap. (μf)	Dielectric Strength	Leakage Current L.C	E.S.R IMP At High Frequency	Stability for Voltage And Temp.	Life	Cap/Volume	Unit Price
Ta		50	150	○	○	△	○	○	◎	×
Al	Liquid	50	300	◎	×	×	△	×	×	○
	TCNQ	20	15	△	△	○	○	○	△	△
	PPY	16	10	×	△	○	○	○	△	△
Ceramic		100	10	◎	◎	◎	×	○	○	○

◎ Strongest ○ Good △ Average × Weakest

Table 4 : Comparison of chip capacitors

4. FURTHER TRENDS IN CHIP-TYPE TANTALUM CAPACITORS

The fields of application of tantalum chip capacitors have been growing along with the development of electronic equipment manufactured using SMT. Furthermore, during the last few years, the drive to increase the capacitance range of tantalum chip capacitors has accelerated miniaturization and as a result, tantalum chip capacitors have been able to keep their superior position ahead of other chip capacitors.

Figure 9 shows the increase in the capacitance of tantalum chip capacitors in the past ten years. When tantalum chip capacitors started in 1981, the smallest case size "A" (3216) covered up to 3.3 μF at 4V. Since then the capacitance has extended one step almost every two years; at present "A" case size can cover 15 μF at 4V which used to be in the "C" (5832) case range. The miniaturization from "C" size to "A" means an actual volume reduction of more than 75 %. This capacitance extension or size miniaturization was realized mainly by the development of high CV (μFV/g) tantalum powder. In 1981, the highest value of tantalum powder was about 9000 to 10000 μFV/g; it is now 30000 μFV/g. Other innovations were in tantalum pellet production, the formation of dielectric film, electrolyte formation and so on.

Tantalum chip capacitors have maintained their superiority over other chip capacitors by the increased capacitance, but the competition with them is accelerating as the characteristics of ceramic and aluminum capacitors catch up with those of tantalum capacitors.

In Table 5, I have summed up what the makers of tantalum chip capacitors need to do to maintain their superior position. The drive for increased capacitance in tantalum chip capacitors resulting from the production of ever higher CV tantalum powder seems to be reaching its limit. One improvement as an alternative to increased capacitance lies perhaps in better packaging. For example, with the current resin mold packaging method, the capacitor element for "A" case size occupies only 15 % of the total capacitor volume.

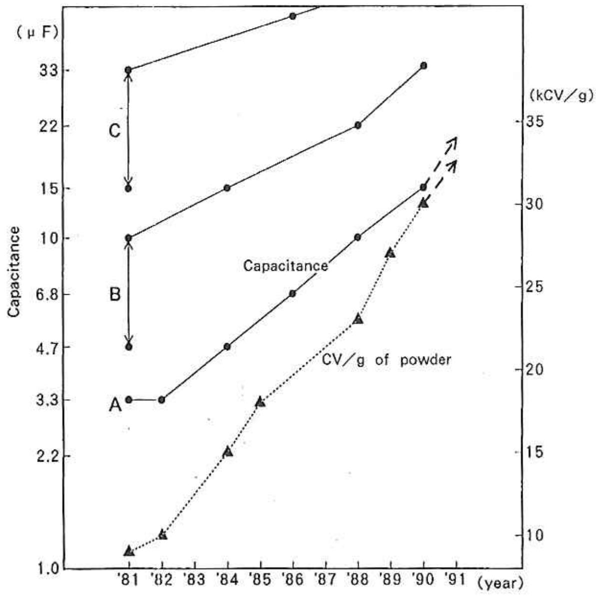

Fig. 9 : Increase in the capacitance of Ta chip capacitors (4 rated voltage)

An improvement in frequency characteristics is necessary for tantalum chip capacitors to compete with ceramic and improved solid aluminum capacitors. In addition, there has to be an improvement in noise limited characteristics at high frequency. To reduce impedance at high frequency, it is necessary either to lower the resistance value of the electrolyte or to improve the terminal structure.

Next comes the problem of size miniaturization. At present, most ceramic capacitors or resistor chips are of 2.0 × 1.25 mm (2125) size, and they are expected to be reduced to 1.6 × 0.8 mm (1608) in the near future. The higher density assembly of printed wiring boards will continue in the future for portable electronic equipment, and to meet this requirement, we shall have to strive for further miniaturization of tantalum chip capacitors.

5. SUMMARY

Recent trends in chip-type ceramic and aluminum capacitors in Japan have been reviewed, and their competitive relationship with the tantalum chip capacitor shown. Ceramic and aluminum chip capacitors are moving into the application fields of tantalum chip capacitors with the help of ceramic's increased capacitance capability and the development of the aluminum solidified electrolyte technique. This will require significant improvement in the characteristics of tantalum chip capacitors if they are to keep and to extend their fields of application. I will revert to certain other aspects of the competing materials for capacitors in a later paper.

Subjects	Methods	Changes expected
1. Extension of capacitance	Improvement of packaging Higher CV/g powder Lower formation voltage Lower sintering temp. for pellet	Establishment of new packaging method Degradation of tan δ and leakage current Degradation of withstanding voltage leakage current
2. Improvement of frequency characteristics	Improvement of solid electrolyte	Investigation of new materials Organic semi conductor PbO_2
3. Miniaturization of chip size	Smaller than 3.2 × 1.6 (A case) Less than 1.0 mm thick	Establishment of mass production technology New packaging method Capacitance range

Table 5 : Future subjects for technology change in tantalum chip capacitors

Publicity for the T.I.C.

In September we took the opportunity of the holding of the first European Metals Conference (EMC '91) in our home city of Brussels to have a small display at the exhibition run in conjunction with it. The Conference was a joint effort by the mining and metallurgical institutes of Belgium, Germany and Britain, and it attracted more than 250 delegates from all over the world, including sizeable contingents from Eastern Europe, Russia and Japan.

We had prepared a data sheet for our two metals, and this, together with a copy of our latest Bulletin, was handed out to all those visiting our stand. As result, our mailing list for the Bulletin has grown, we have generated some interest in potential new applications for our metals, and we even have a good chance of some new members from Eastern Europe.

This was the TIC's first venture into such publicity, and the experience gained was encouraging enough for us to consider taking a booth at the World Powder Metallurgy Congress in San Francisco to be held June 21st-26th, 1992. Perhaps we will see you there ?

I should be grateful to any member/reader with appropriate photographs, raw materials or products if he would lend them to me for the display. All donors will be acknowledged at the show.

R.J. Tolley
Technical Adviser

MEMBERSHIP

The six companies elected to membership by the Thirty-second General Assembly are :

Cerex,
P.B. 454,
F-74108 Annemasse Cedex, France.

Concord,
The Exchange,
71 Victoria Street,
London SW1H OHW, England.

Intermet Resources, Inc.,
108-18 Queens Boulevard,
Forest Hills,
New York 11375, U.S.A.

Vicond of Positron,
Kurchatova 10,
St Petersburg 194021, U.S.S.R.

Thai Tantalum Co., Ltd.,
6th Fl, Monririn Bldg.,
60 Soi Sailom, Phaholyothin 8,
Samsen-nai, Phayathai,
Bangkok 10400, Thailand.

Trinitech International, Inc.,
2225 Enterprise East,
Twinsburg,
Ohio 44087, U.S.A.

The following companies have resigned from membership :

Derby, Minera del Duero, Du Pont De Nemours, Elders Resources, Estanho Minas Brasil, IRCHA, Iscor, Metamin, Zimbabwe Mining Development Corporation