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TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

Friends,

In April Members of the Executive Committee along with the Technical Promotions Officer and Secretary General met in Brussels to review and outline the technical and social programmes for the forthcoming Forty-seventh General Assembly to be held in Innsbruck, Austria. Plansee will be the host company. I am pleased to be able to report that the detailed planning, logistics, organisation and technical programme is taking form and promises to be as engaging and attractive as the location for this year's assembly. Major progress has been accomplished by the Transport Committee tackling the critical issue of material transportation and a progress report on this will be provided by our Technical Promotions Officer Mr Ulric Schwela at the General Assembly.

I would also like to take the opportunity to thank Mr Michael Tamlin for his contributions over the years to the T.I.C. through his efforts on the Executive, Technical Programme and Transport Committees. Mike is moving on to pastures new outside the tantalum industry and I can only say that it is their gain and our loss. On behalf of the T.I.C. I extend our best wishes to Mike and thanks for his years of contributions to the association.

Much work still remains in bringing the Technical Programme to fruition and so I would continue to solicit the help and assistance of the many talented members of our association. Your contributions are what make the association as strong as it is today.

The Secretary General and Technical Promotions Officer are fully engaged in making a success of the next General Assembly so please assist when asked.

It only leaves me to wish that you all continue to enjoy the summer season and I look forward to further updating you on our progress closer to the date of the General Assembly.

William Millman
T.I.C. President

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Goldenes Dachl J.W.

INNSBRUCK, OCTOBER 2006

The annual meeting of the Tantalum-Niobium International Study Center will be held in Innsbruck, Austria, from October 15th to 17th 2006, with the Forty-seventh General Assembly on the morning of Monday October 16th.

The meeting will be based at the Hilton Hotel, where the technical sessions will be held and accommodation has been reserved for participants.

On Sunday October 15th the registration desk will be open from 10a.m. to 5p.m. All participants are invited to a Welcome Reception from 6p.m. to 8p.m. On Monday October 16th the General Assembly of the T.I.C. member companies will be followed by the first technical session, and then lunch. The afternoon will be free, and optional sightseeing tours will be arranged. The second technical session will take place on the morning of Tuesday October 17th, followed by lunch and the closing of the meeting. There will not be a plant tour.

On Monday evening all participants, guests and accompanying persons are invited to a Gala Dinner in the Riesensaal of the Imperial Palace of Innsbruck, the Hofburg, as guests of Plansee AG and the T.I.C. The Palace first built by Archduke Siegmund in 1460 was rebuilt between 1754 and 1773 on the orders of the Empress Maria Theresa in late Gothic style with rococo detailing. The Riesensaal, described as the most lavish banqueting hall in the Alps, is decorated in white and gold and is lined with portraits of the Habsburgs.

Sightseeing tours will be arranged for accompanying persons.

Hofburg, Innsbruck *J.W.*

Technical programme

Technical presentations will include a review of T.I.C. statistics and industry news, developments in the project to survey the transport of raw materials, applications of niobium and tantalum and methods of processing of the metals.

Innsbruck is a delightful town situated at the foot of soaring mountains in the Tyrol. It has an old centre with museums and churches illustrating its long history as well as shops and restaurants to suit today's needs. It will be an attractive setting for those engaged in the world of tantalum and niobium to meet and exchange views once again.

Invitations will be sent to member company nominated delegates three months before the event. Others who would be interested in attending should contact the Secretary General at 40 rue Washington, 1050 Brussels, Belgium, or info@tanb.org.

BOOK REVIEW

The Chemistry of Tantalum and Niobium Fluoride Compounds

by Anatoly Agulyansky

The book's introduction opens with a very positive statement on the utility of tantalum and niobium and goes on to demonstrate a multitude of uses. It progresses to a look at the quantities used around the world, partly using a table and pie charts based on T.I.C. statistical data for the 1999-2001 period, referenced to Mosheim in T.I.C. Quarterly Bulletin 112, December 2002, an article printed from the presentation given at the meeting in Kyoto in October 2002.

Chapters 2 to 7 give in-depth coverage on a broad front to the specialised subject of fluoride compounds, looking first at the synthesis of tantalum and niobium fluorides using a multitude of synthetic routes, as well as the types of compounds that are obtained depending on the various starting materials. Several chapters are devoted to the characterisation of the compounds obtained, in solutions and in melts, and an examination of their properties, notably thermal and ferroelectric properties.

Chapter 8 provides a comprehensive look at niobium and tantalum processing. The 85 pages go into much more detail than many previous books and are a very welcome up-to-date examination of the various methods employed, from digestion of raw materials, through options for extraction and preparation of oxides and K-salt, to the production of metals by reduction. Many people will find it worth buying the book for this chapter alone.

The book is available from Elsevier, Customer Service Department. The address is Linacre House, Jordan Hill, Oxford OX2 8DP, UK, for Europe, the Middle East and Africa, and 11830 Westline Industrial Drive, St Louis, MO 63146, U.S.A. for Canada and U.S.A.

DLA/DNSC

The Defense National Stockpile Center Revised Annual Materials Plan (AMP) for the year to September 30th 2006 included:

Columbium carbide powder	0 lb Cb
Columbium concentrates	560 000 lb Cb
Columbium metal ingots	20 000 lb Cb
Tantalum carbide powder	4000 lb Ta
Tantalum metal ingots	40 000 lb Ta
Tantalum metal powder	40 000 lb Ta
Tantalum minerals	500 000 lb Ta
Tantalum oxide	20 000 lb Ta

In February 2006 tantalum minerals containing 160 000 lb Ta were sold to DM Chemi-Met for approximately $6.4 million. The tantalum minerals in the AMP were then exhausted, announced the DLA; sales had totalled 514 000 lb Ta. Sales in March under the BOA system were 2500 lb Ta in tantalum carbide and 9900 lb Cb in ingot, for approximately $220 000, to ABS Alloys and Metals. All the columbium ingot in the AMP had thus been sold.

No sales were made in April or May. In June bids were due by June 7th for two lots of tantalum carbide, each about 900 lb Ta. The DLA stated that this offering represented 'the remaining tantalum units for sale under the FY 2006 AMP authority'.

Although the BOA is available on a weekly basis, offerings seem to be made once each month. If the tantalum carbide offered in June is sold, and no further changes are made to the Plan authorising sales, there will be no further tantalum materials sold from the Stockpile before the AMP for fiscal year 2007 (from October 1st 2006) is applicable.

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TRENDS IN TANTALUM AND NIOBIUM CAPACITORS

This article is based on a paper by T. Zednicek, AVX Czech Republic, and two presentations at the T.I.C. Symposium Tantalum and Niobium World by William Millman, AVX

ABSTRACT

Tantalum has been a favored capacitor technology in space-limited designs for a long time. Recent years have seen the emergence of one or two equivalent technologies offering many of the advantages of tantalum, such as volumetric efficiency and reliability. Two notable rivals already well into their commercialisation phase are niobium oxide capacitors and tantalum capacitors with conductive polymer cathodes. A circuit designer trying to choose between these solid electrolyte capacitor systems has a number of trade-offs and subtleties of operation to consider. The paper will review the latest electronic application needs and discuss feasibility of the latest technology trends in tantalum, niobium oxide and polymer capacitors.

INTRODUCTION

The conventional tantalum capacitor with a MnO_2 second electrode system has proven for more than 50 years it is a solution with both high reliability and high volumetric efficiency. Continuous improvements led to the development of higher CV (capacitance times voltage constant) powders that allowed the creation of capacitors with even higher capacitance in small dimensions. Three main features of tantalum capacitors have directed development: reduction of equivalent series resistance (ESR), reduction in risk of ignition and supply chain flexibility. Evolution of DC/DC converters and power supplies has required ESR to be reduced significantly and safety to be increased. Supply chain flexibility issues grew during the electronics business upturn in 2000 when slow response time from the tantalum supply chain resulted in a serious shortage of tantalum capacitors. Despite the supply chain having now brought on much additional capacity to prevent recurrence of the tight situation in 2000, it has remained in people's minds as a restriction and a reason to replace tantalum capacitors in their boards.

Two new steps in technology have been successfully introduced to the market in order to meet the requirements of designers of the latest electronic devices: tantalum capacitors with polymer electrode and niobium oxide capacitors.

Major reductions in ESR can be achieved by replacing the MnO_2 electrode by conductive polymer. The conductivity of MnO_2 is 100 times less than that of metals and it represents a significant part of the total capacitor's ESR. Replacement of oxygen-rich MnO_2 also helped to reduce the potential for ignition of the capacitors with a polymer cathode.

Niobium is a sister metal to tantalum and it has many similar features. Development of niobium capacitors was pursued mainly to resolve issues with supply chain and availability as niobium is more abundant in nature. Niobium oxide has been found to be the niobium based material with the best features for production of capacitors. It exhibits a metal-like conductivity and can be produced with simpler and higher yielding powder manufacturing techniques. Niobium oxide also provides high resistance to ignition and improved safety through its efficient self-arresting failure mechanism. Additionally a capacitor made from NbO material improves steady state reliability.

The limitation at the early stage of implementation of these new technologies is a relatively lower CV in comparison to the conventional tantalum capacitors with MnO_2. However the process of high CV introduction of these new technologies is rapid, based on knowledge already gained from the 'base' tantalum technology. Figure 1 shows the evolution of downsizing on a very popular rating 100µF 6.3V.

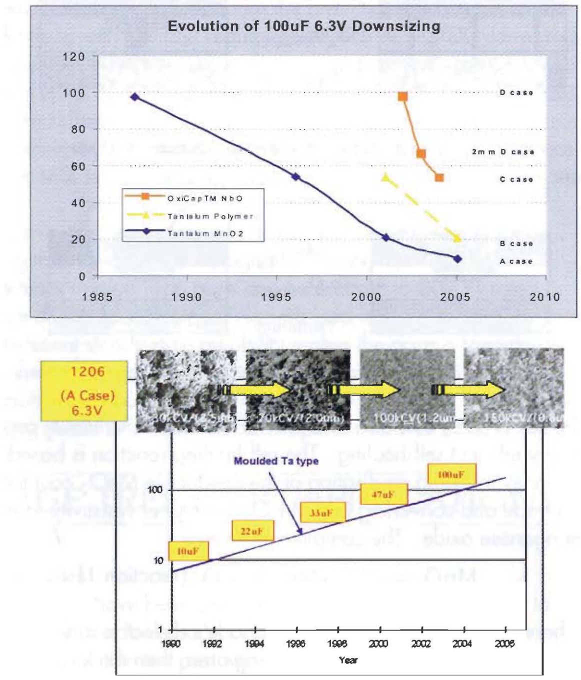


Figure 1: Time evolution of 100µF 6.3V downsizing

It is possible to see that even today the conventional technology offers the highest CV solution in an A case. However both polymer and NbO technologies are moving rapidly towards higher CV and will provide an equivalent solution in the near future. It should also be noted that higher derating (i.e. use of capacitor at a lower voltage than rated) is recommended for tantalum MnO_2 capacitors in low impedance circuits and from the application point of view the offering in polymer technology today is already equivalent. This suggests that the role of polymer and NbO technologies will grow in future as a way to increase CV of capacitors in applications.

KEY FEATURES

Key features of tantalum polymer and NbO capacitors that make the capacitors popular for circuit applications are described here. [More detail: references 1 to 5.]

MnO_2 Electrode

The conventional technology with MnO_2 was introduced to the market 30-40 years ago as a major improvement over the wet tantalum electrolyte electrode system. Since that time the tantalum MnO_2 capacitor has established its position as a highly reliable, stable and high CV capacitor. Voltage range is typically from 2.5 to 50V and case size offering has grown from basic four EIA cases (A,B,C,D) to more than fifteen to fit better with specific height or space constraints. The other case sizes include larger cases to offer capacitance up to 1500µF, small cases with high CV but minimum footprint and low profiles with height as low as 0.6mm. The unique flexibility of the powder technology to provide thin and flat capacitors is very important when height is critical, in applications such as cellular phones and MicroHardDrives. The conventional MnO_2 technology strength is in robustness to thermo-mechanical load, temperature and DC Bias stability, voltage range up to 50V and very good steady state reliability. That is why the most popular applications of tantalum MnO_2 capacitors today include automotive (up to 175°C operation temperature), military, aerospace, medical and high end applications such as servers.

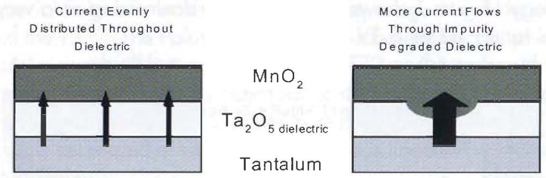


Figure 2: Current flow through dielectric fault site

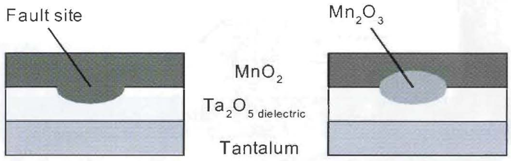


Figure 3: Fault site in dielectric after MnO_2 self-healing process

The key process that defines behavior of a tantalum MnO_2 capacitor is very efficient self-healing. The self-healing reaction is based on thermally inducing oxidisation of the conductive MnO_2 counter-electrode and converting into Mn_2O_3 – a higher resistivity form of manganese oxide. The complete reaction is:

$$MnO_2 \xrightarrow{+heat} Mn_2O_3 + O^* \text{ [reaction 1]}$$

If there is an area on the tantalum anode's dielectric surface that has thinner dielectric than the surrounding area, then the larger proportion of the capacitor's current (charging, leakage, etc.) will flow through that site (see Figure 2), causing localised heating. As the temperature at the fault site increases, reaction 1 takes place converting conductive manganese dioxide (MnO_2), which has a resistivity of between 1 and 10 Ohm/cm^2, to Mn_2O_3 which has a resistivity between 10^6 and 10^7 Ohm/cm^2. Thus the conduction site is effectively 'plugged' or 'capped', as shown in Figure 3, and the fault current clears.

The oxygen produced is absorbed by any tantalum oxides of a lower order than tantalum pentoxide (Ta_2O_5) present in the dielectric layer, such as TaO_2, or any MnO in the counter-electrode layer. [Self-healing system: reference 6.]

The self-healing reaction 1 applies to situations where current availability is limited. In the case of high surge currents in low impedance applications, the breakdown of the dielectric can progress faster than the healing mechanisms, which can result in a hard short circuit and complete thermal breakdown. Thus it is of importance to protect tantalum capacitors against any surges that can exceed their design capabilities. [Surge current and derating rules on tantalum MnO_2 capacitors: reference 7.]

Polymer Electrode

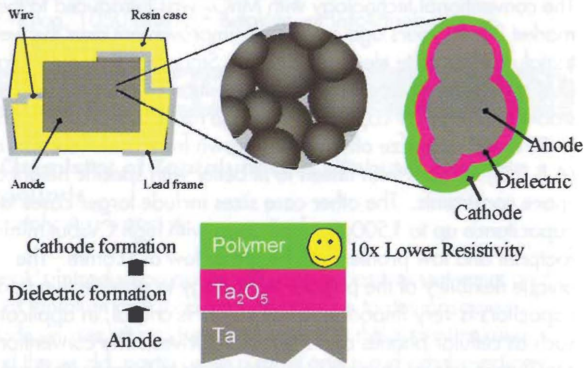


Figure 4: Construction of tantalum capacitor with conductive polymer

One of the major contributors to ESR of the capacitor is the second electrode. The conventional tantalum capacitor using MnO_2 as a second electrode with a relatively high resistivity is replaced in tantalum polymer capacitors by an organic material – conductive polymer. This replacement leads to significant reduction of ESR, especially at frequencies above 100kHz. Typically the ESR value is reduced in polymer technology by about a quarter compared to the MnO_2 electrode.

As oxygen is not in the structure, there is reduced risk of ignition. MnO_2 is not present, so the efficient self-healing reaction 1 can not take place. But conductive polymer shows a different kind of self healing process. The polymer layer evaporates, or 'peels off', at the failure site, which stops further current flow at the site – see Figure 5 and reference 5.

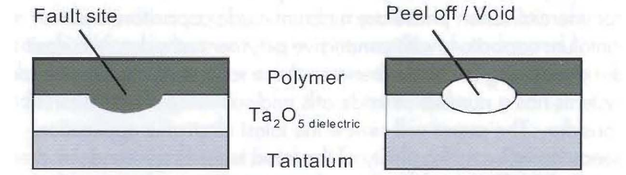


Figure 5: The self-healing process in polymer

The polymer self-healing process has been found in practice to be less effective than MnO_2 self-healing in conventional tantalum capacitors. There are some limitations of polymers in voltage range, sensitivity to thermo-electrical load and humidity. This is reflected in specification of some manufacturers to 105°C maximum temperature range, limited lead-free reflow capability (one time 255°C peak) and MSL level 3 (Moisture Sensitive Level 3 = storage in dry pack). The basic leakage current specification is also 10 times higher than for tantalum MnO_2 capacitors. Although these disadvantages may currently limit use of polymer capacitor for some high-end, military, medical and aerospace applications, tantalum polymer capacitors will fully meet requirements of the majority mass volume consumer applications. The recent improvement of tantalum polymer by some manufacturers has also significantly improved the features, and specification has been upgraded to 125°C maximum temperature range and full compatibility with lead-free reflow (3x260°C 10s reflow). [Reference 8] Polymer technology has found a good home in the latest consumer designs mainly due to its low ESR and reduced ignition features.

Niobium Oxide Capacitors

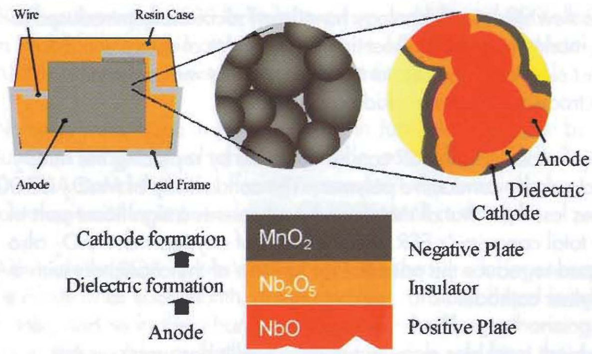


Figure 6: Construction of niobium oxide capacitor

The technology of niobium oxide capacitors is based on that of conventional tantalum capacitors with MnO_2 electrode. The first electrode, originally made from tantalum powder, is replaced by powder of niobium oxide (NbO). The MnO_2 self-healing process as in reaction 1 works efficiently also in the case of NbO capacitor. However, there are some differences.

NbO as a material has a very high ignition energy compared to tantalum due to the oxygen content in the base material (so the risk of combustion is much less with NbO). There is also one more very effective self-arresting mechanism that makes these capacitors safer than other technologies: if there is a dielectric breakdown, high resistance NbO sub-oxide NbO_2 is thermally formed on the junction between NbO (first electrode) and Nb_2O_5 (dielectric). The transformation temperature is lower than the MnO_2 self-healing process of reaction 1 and thus it is effective and complementary to this reaction. (Figure 7.)

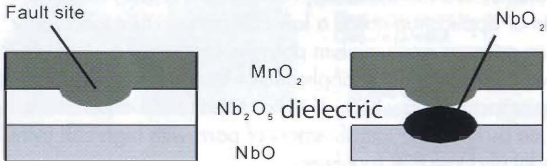


Figure 7: NbO_2 self-arresting process

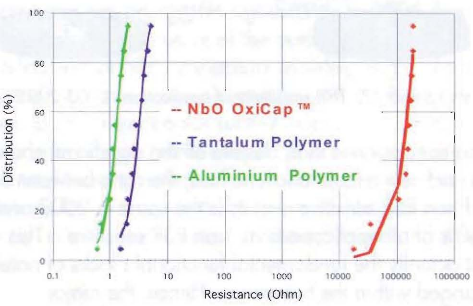


Figure 8: Resistance after breakdown in NbO, Ta polymer and aluminium polymer capacitors

As a result the capacitor is not likely to become a short circuit after the main Nb_2O_5 dielectric breakdown, but it typically maintains a high resistance of around 34 kOhms. Figure 8 shows a comparison of resistance after breakdown on tantalum polymer, aluminium polymer and NbO capacitors. It can be noted externally just as a slight increase of leakage current, otherwise the capacitor keeps working.

Thus the NbO capacitor is not likely to fail as a short circuit in applications within its rated voltage. The capacitor can be thermally damaged only if used in cases out of specification such as over-voltage breakdown (more than about four times rated voltage), reverse voltage, excessive ripple current and high acceleration of temperature with voltage. NbO capacitors, as well as tantalum MnO_2, are very robust against thermo-mechanical load and comply with 3x260ºC 10s lead-free reflow requirements. The limited oxygen flow at operating temperatures together with the self-healing and self-arresting processes are the main contributors to excellent steady state reliability, typically 10 times better than conventional tantalum capacitors. The superiority in safety ('non-burn') of NbO capacitors has been verified in mass production. Over 500 million NbO (OxiCap™) capacitors have been manufactured and sold by March 2006 without a single recorded incident of burning in the field. The manufacturing and test programmes for both tantalum and oxide capacitors involve very low impedance ageing and high current surges and while low level burning exists with tantalum none has ever been experienced with oxide capacitors. This is a strong, statistically reasoned proof of the safety of NbO capacitors in application and field.

There are currently some limitations of NbO technology, namely voltage range (10V maximum), lower CV compared to tantalum capacitors and higher temperature derating over 85°C. Leakage current specification is twice that of conventional Ta MnO_2 capacitors. [More details: references 1-2.]

Key Features: Summary

Conventional MnO_2 tantalum capacitors are the ideal choice for applications with requirements for high temperatures (currently up to 175ºC), high voltage (up to 50V) and established reliability. The technology offers highest CV in a small package. It is possible to use them up to 80% of rated voltage, but in low impedance circuits further derating needs to be applied [reference 7].

Tantalum polymer capacitors are the best choice for consumer applications with low ESR requirements such as DC/DC converters in notebooks, PDA, telecom and other applications. The parts can be used up to 80% of rated voltage. Manufacturer's specifications of lead-free reflow process capability, temperature range ratings, leakage current and appropriate storage/handling in accordance with the MSL level should be verified for the needs of the application.

Niobium oxide capacitors offer the safest available alternative among the capacitor technologies with good cost-versus-performance value. The parts can be used up to 80% of rated voltage and they are compatible with lead-free reflow requirements. The excellent steady state reliability makes the parts a favorite choice not only for consumer applications but also for high end, automotive, computer and professional. Appropriate temperature derating needs to be applied for temperatures over 85°C.

USAGE TRENDS IN APPLICATIONS

Notebooks

PC notebooks have been selected as the application example to demonstrate trends in usage of tantalum and the new capacitor technologies within the past two years. The following chapter compares usage of capacitors in notebooks designed and manufactured in 2003 and 2005. The notebook industry represents a good example of transition from high-end business to consumer type of applications in this period, and this move has significantly increased the importance of flexibility in design and manufacturing. One of the key capabilities that had to be achieved was selection of the right high-tech components with the best performance versus low cost.

The analysis presented in this paper is based on in-house AVX detail analysis (teardown) of four notebooks from different manufacturers made in 2003 and six notebooks made in 2005. The analysis includes statistics on the following capacitor technologies: tantalum MnO_2, tantalum polymer, niobium oxide and aluminium polymer. MLCC capacitors have not been included in this report as these are not body coded and it is difficult to recognise the capacitance and voltage on a board without a detailed destructive analysis. In two cases aluminium electrolytic can type capacitors were used (one each in two different notebooks), but as they were so few statistically these were excluded from the report.

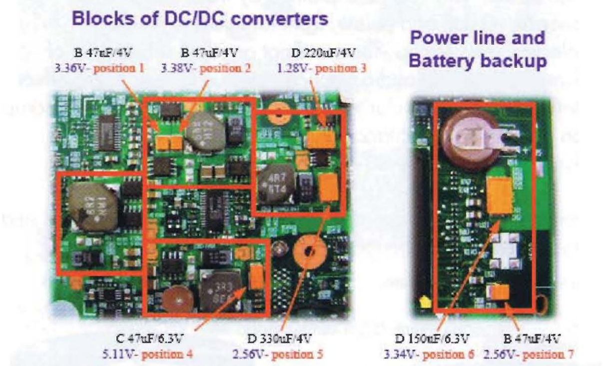
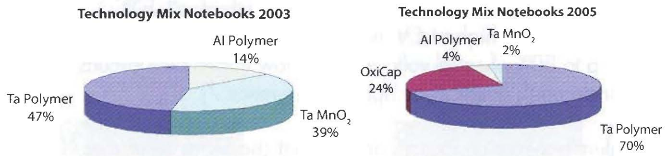


Figure 9: Example of NbO capacitor use in notebook computer

Figures 10 and 11 demonstrate how the capacitor technology usage changed in just two years. In the same time, the total typical count of tantalum MnO_2, tantalum polymer, aluminium polymer and NbO capacitors (further noted as 'capacitors' only) moved from 19 in 2003 to 28 in 2005.

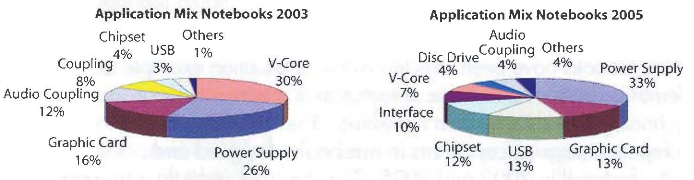


Figures 10 and 11: Technology mix in notebooks 2003-2005

The share of conventional tantalum MnO_2 capacitors has dropped significantly from 40% in 2003 to just 2% in 2005. The shortage of tantalum capacitors in year 2000 and surge issues in low impedance applications has led to a 'no-tantalum' policy by some manufacturers. The share of Ta MnO_2 capacitors moved by 50% to tantalum polymers and the other 50% to NbO (OxiCap^{TM}) as the new technology became available on the market from 2003.

Aluminium polymer capacitors remained in position in V-core applications as the main processor bulk capacitors. The total count of capacitors per notebook has fallen; the share of aluminium polymers has also dropped.

The next comparison in figures 12 and 13 shows the change of usage for various applications.



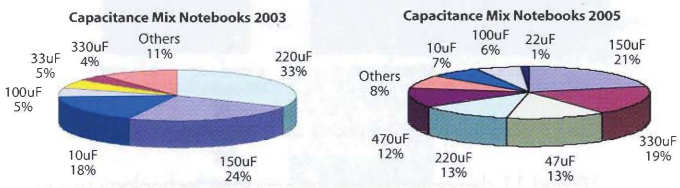
Figures 12 and 13: Application mix change 2003-2005

The main application of these capacitors in notebooks in 2003 was V-core processor filtering with tantalum and aluminium polymer capacitors. The V-core application has moved to a minor application in 2005 as a result of, firstly, improvement in parts capacitance and reduction of ESR resulting in lower unit count per processor, and, secondly, increased usage of capacitors in other applications.

A major increase is seen mainly in USB port application, where advanced USB 2.0 standard and USB port count per notebook has moved the USB capacitor usage among the top three in 2005.

The other trend is a reduction of the share in coupling applications. 2003 notebooks show 20% of capacitors in coupling or audio coupling applications. The coupling application in 2005 has dropped to 4%. This can be explained by transition of small capacitance, ~10µF and below, from tantalum to MLCC technologies. MLCC capacitors are not an ideal substitution of tantalum capacitors in audio applications due to their piezo effect that downgrades signal clarity and added noise. That is why some portion of the low capacitance parts is remaining with the tantalum/niobium oxide technology.

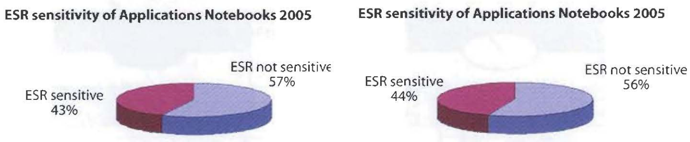
The trends seen in the applications are confirmed in Figures 14 and 15 which show share of capacitance value.



Figures 14 and 15: Capacitance mix change 2003-2005

220µF capacitors were popular choices for V-core applications in 2003 but were replaced by 470µF and 330µF in 2005 with reduced component counts. The majority of USB ports are using 150µF capacitors and together with some other applications 150µF became the most popular capacitance value in 2005. Low capacitance parts (10µF) have dropped from top three position with 18% share to just 7%: this can be explained by migration to MLCC technology.

An interesting finding can be observed in Figures 16 and 17 with analysis of share between 'ESR sensitive' and 'non ESR sensitive' applications. 'ESR sensitive' application means that the board position or application needs a low ESR part, so that today only tantalum polymer or aluminium polymer can be used. 'Non ESR sensitive' application is an application where it is not necessary to use capacitors with low ESR. This has been found experimentally, based on oscilloscope measurement of parts with high ESR (MnO_2 electrode) and low ESR (polymer).



Figures 16 and 17: ESR sensitivity of applications 2003-2005

An interesting conclusion is that, despite all the significant changes in applications and new circuit functionalities, the ratio between ESR sensitive and non ESR sensitive circuits is the same in 2003 and 2005 with 60% of all applications as 'non ESR sensitive'. This suggests that actually the fundamental functional blocks of notebooks have not changed within the two years. Hence, the major performance improvements and cost reductions have been achieved through implementation of the new technologies into the existing functional blocks.

Notes: The application analysis is approximate, based on experimental evaluation. The relatively small size of the sample of notebooks tested should be taken into consideration, and hence the conclusions presented can not necessarily be generalised.

Desktop PC

The analysis described above was performed on notebooks; however, there is an opportunity for adoption of NbO technology also in desktop PCs, that is to say, the product already in consumer product area for a long time. Recent reliability issues with aluminium capacitors in desktop PCs have again raised questions on the true cost of ownership of aluminium capacitors in processor filtering. Leaking electrolyte has resulted in CAP, ESR and leakage instability that has stopped operation of many desktop computers in the hands of end users. The warranty claims and cost to brand image can easily eliminate the very narrow margins that many desktop PC manufacturers struggle to achieve. The reliability level of aluminium electrolytic capacitors is typically between 1000 and 5000 hours at 85°C. This may be a considerable limitation for many applications such as LCD displays, LCD and plasma screens, televisions and PCs.

NbO capacitors have no wear-out mechanism and due to their self-healing and self-arresting mechanisms they provide the highest level of safety and reliability within the capacitor technologies. The MTBF (Mean Time Between Failures) is in the range of 200 000 to 500 000 hours, which is up to 100 times better than aluminium capacitors. NbO can operate at temperatures ranging from -55°C to 105°C (generic series), or even to 125°C (higher grade series), with little degradation of capacitance with time as very often seen in case of aluminium capacitors where the electrolyte dries out, especially at continuously operating temperatures of 40°C to 85°C which are typical of a PC environment. Often designers have to include a redundant level of capacitance, adding to both cost and bulk.

Automotive

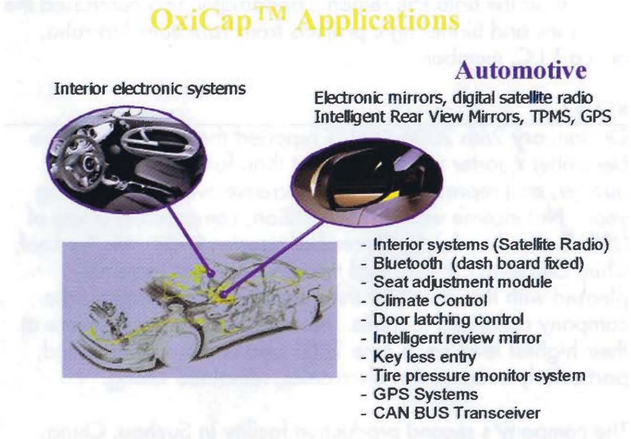


Figure 18: Automotive applications of AVX NbO capacitors

Usage of tantalum polymer and niobium oxide technologies in automotive designs has grown significantly in 2005 despite the relatively conservative nature of the automotive industry. The positive features of NbO capacitors in safety, high reliability, cost saving and lead-free process capability are resulting in very fast adoption in cabin electronics such as telematics, infotainment, electronic mirrors, seat electronics. NbO capacitors are replacing also the traditional positions of aluminium capacitors in critical applications like airbag controllers and dashboard control circuits providing an increase in safety and long lifetime performance.

LCD and PDP TVs

One of the latest technologies creating major interest in the past two years is LCD and PDP (Plasma) TVs. More than 15Mu of LCD TVs were sold in 2005 and the forecast for 2006 is as high as 24Mu, and it is still in its early growth market phase. There are more than 200 aluminium capacitors used in each LCD and PDP TV. Major manufacturers of these devices are facing two major issues: first, to secure a component supply chain to react to the high production expansion and, second, to increase customer trust in a new and expensive technology by extension of guaranteed lifetime from the current 1-3 years to 5-10 years. Aluminium electrolytic capacitors are of concern in both cases as one of the most popular parts on the board together with the limited lifetime. NbO capacitors can replace up to 80% of aluminium electrolytic capacitors on the board and they are one of the best alternatives to increase reliability and lifetime of this equipment.

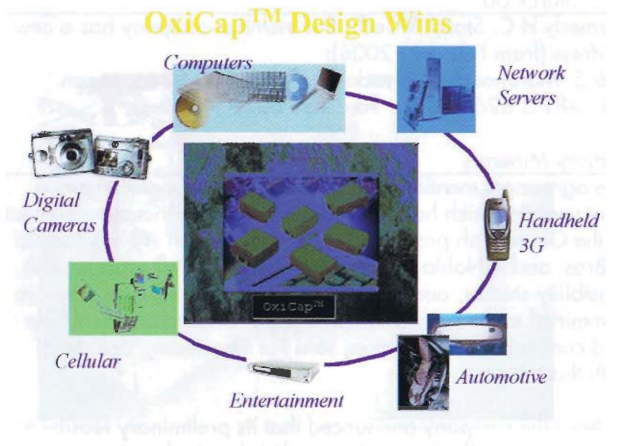


Figure 19: Applications of NbO capacitor

SUMMARY

Two new technologies have been developed based on the conventional tantalum MnO_2 technology to answer the requirements for reduced ESR and improved safety. Tantalum polymer technology has reduced ESR by a factor of four compared with the conventional MnO_2 tantalums. Niobium oxide (OxiCap™) capacitors offer a new technology with no dependence on the narrow tantalum supply chain, with a unique non-short-circuit failure mode providing new, higher levels of safety and reliability.

The notebook consumer market has shown a great level of flexibility in adopting the new technologies in order to provide the best performance versus cost value to its customers. The six notebook models introduced into production during 2005 used 94% of these higher capacitance devices with these two technologies: tantalum polymer (70%) and niobium oxide (OxiCap™) (24%). NbO capacitors can also represent a significant step up in safety and reliability for critical applications such as airbag computers or extend guaranteed operational time in LCD and PDP TVs.

Acknowledgments

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REFERENCES

1. T. Zednicek et al., 'Niobium Oxide Technology Roadmap', AVX, CARTS EUROPE 2002 Nice, France, Proceedings
2. T. Zednicek et al., 'Tantalum and Niobium Technology Overview', AVX, CARTS EUROPE 2002 Nice, France, Proceedings
3. Y. Pozdeev-Freeman et al.,'Niobium Based Solid Electrolytic Capacitors', Vishay, CARTS USA 2002, New Orleans, Louisiana, USA, Proceedings
4. H. Zillgen et al., 'New Niobium Capacitors with Stable Electrical Parameters', Epcos, CARTS USA 2002, New Orleans, Louisiana, USA, Proceedings
5. J.D. Prymak, 'Replacing MnO_2 with conductive polymer in tantalum capacitors,' Kemet Corp., CARTS EUROPE 1999 Lisbon, Portugal, pp. 169-173
6. J. Gill, 'Surge in solid tantalum capacitors', AVX technical paper, www.avx.com
7. T. Zednicek, J. Gill,: 'Voltage Derating Rules of Tantalum and Niobium Capacitors', AVX, CARTS EUROPE 2003, Stuttgart, Germany, Proceedings
8. Z. Sita, M. Biler,: 'Ta Capacitors with Conductive Polymer Robust to Lead-Free Reflow', AVX, CARTS USA 2005, Proceedings

Figure 20: New opportunities for tantalum capacitors

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The T.I.C. is an association internationale under Belgian law.

MEMBER COMPANY NEWS

AVX

For the quarter ended March 31st 2006 AVX announced an increase in sales to US$338.4 million from the figure of US$306 million for the preceding quarter. Unaudited net sales for the fiscal year ended March 31st 2006 were US$1333.2 million, 3.9% higher than the preceding year. CEO and President John Gilbertson stated 'Our results for the year reflect the highest revenue and net income since the end of the tech bubble in fiscal 2001. Overall demand for our products has improved throughout the year and increased the industry capacity utilization, which in turn, has helped stabilize prices.'

Cambior

Sales from the Niobec mine in 2005 were 35% higher than in 2004, for the first complete year in which Cambior owned the whole of the Niobec Mine. Capital investment of US$6.1 million financed an expansion programme which increased capacity by 20%, completed in September 2005. Proven and probable mineral reserves, estimated at the end of 2005, are 24.3 million tonnes at an average of 0.66% Nb_2O_5. With this programme, Cambior aims to maintain its market share of world supply, noting that demand for niobium remains strong.

Commerce Resources

Commerce Resources continues to explore its Fir and Verity properties, and is commissioning a pre-feasibility study for the project. On February 22nd the company announced the formation of an advisory board to assist with the development of its Blue River project, including members who should be able to contribute from their rich experience.

Commerce Resources/Fogang Jiata Metals

These two T.I.C. members announced on May 8th 2006 that they have entered into a strategic alliance for Commerce to deliver 20 tonnes of tantalum/niobium concentrate to Jiata for processing. 50% of the end products will be returned to Commerce, and technical information obtained by Jiata from the separation process will be shared with Commerce for the pre-feasibility study.

Commerce Resources/Kazatomprom

On June 7th a strategic alliance of Commerce with yet another member of T.I.C. was announced, with a letter of intent which covers delivery of 50 tonnes of concentrate to Kazatomprom's Ulba Metallurgical Plant. Commerce will receive part of the processed products and, again, technical information from Ulba's processing will be shared with Commerce for its study.

Sons of Gwalia

The nominated delegate of Sons of Gwalia, Mr Michael Tamlin, has left the company, and has therefore resigned from both the Executive Committee and the Transport Committee of the T.I.C. We thank him warmly for all his contributions to the T.I.C. activities, and wish him well in his new ventures.

The Deed of Company Arrangement (DOCA) of Sons of Gwalia has been extended to August 30th 2006, the Administrators announced early in May. Restructuring of the tantalum and lithium minerals business has been proposed and is under way but not yet completed, say the Administrators, and Sons of Gwalia should emerge from the DOCA 'in the next few months'. In anticipation of this step, a new Chief Executive Officer has been appointed, Peter Robinson, with effect from July 10th 2006. Mr Robinson has many years of experience in several countries and with various metals and with mineral sands, including responsibility for the Wodgina operation before it was acquired by Sons of Gwalia.

Haddington Resources

The company's process plant is currently on care and maintenance, and has undergone upgrading during the March quarter. An alliance with Mitsubishi and Zinifex has meant the implementation of a significant exploration programme, focused on the Bald Hill region. Haddington has purchased the Mt Deans and Binneringie projects from Tantalum Australia, also a T.I.C. member.

KEMET

On January 26th 2006 KEMET reported that net sales for the December quarter were 8% higher than for the preceding quarter, and represented a 32% increase over the preceding year. Net income was US$6.1 million, compared to a loss of US$18.6 million for the December quarter 2004. Mr Per Loof, Chief Executive Officer, said the company was extremely pleased with the results for the quarter and the progress the company continued to make. He added that net sales were at their highest level since June 2001 and end market demand, particularly in consumer electronics, remained strong.

The company's second production facility in Suzhou, China, celebrated its official opening with a traditional Chinese Grand Opening ceremony on Friday May 19th, with welcome drums and the lion dance symbolizing prosperity and good fortune for the future. Special guests included local VIPs, top management of customers and suppliers, and the company was honoured with very high level attendance, reported Managing Director David Reynolds proudly.

NEC Tokin

Mr Masayuki Yamane, delegate of NEC Tokin, has a new address: 560 Nyuzen, Nyuzen-machi, Shimoniikawa-gun, Toyama 939-0626, Japan.
Tel.: +81 765 72 5941. Fax: +81 765 72 5997.

Sanyo Electric Co

Sanyo Electronic Components has been re-named Sanyo Electric Co., and the T.I.C. delegate is now Mr Hitoshi Ibuta, Capacitor Business Unit, Senior Manager, Engineering Dept. Address: 1-1, Sanyo-cho, Daito City, Osaka 574-8534, Japan. Tel.: +81 72 870 6338. Fax: +81 72 870 6087. E-mail: ibut034273@dt.sanyo.co.jp.

H.C. Starck

Bayer Group announced at the end of March that it wished to sell H.C. Starck in order to finance its acquisition of pharmaceutical firm Schering, thereby increasing its focus on health care, its core business. It is understood that several groups are investigating a possible purchase of the metals company, which produces a range of other metals and metal products as well as tantalum and niobium.

H.C. Starck Ltd

Formerly H.C. Starck V-Tech, this member company has a new address (from February 2006):
1-6-5, Marunouchi, Chiyoda-ku, Tokyo 100-8266, Japan.
Tel.: +81 3 6266 7061. Fax: +81 5219 9739.

Tertiary Minerals

The agreement mentioned in Bulletin 124 has matured into a joint venture which has secured funding for further development of the Ghurayyah project. The consortium with A.H. Algosaibi & Bros. and AlNahla Trading & Contracting will proceed with feasibility studies, and these 'strong financial partners who are committed to the project' are already providing practical help and continuing co-operation, said Pat Cheetham, 'delighted' with this progress.

In April the company announced that its preliminary feasibility study will quantify the uranium and yttrium in the resource, in addition to the tantalum, niobium and zircon investigated so far.

Zinifex

Zinifex has moved to
Level 29, 2 Southbank Boulevard, Southbank, Victoria 3006, Australia.
Tel.: +61 3 9288 9138. Fax: +61 3 9288 9105.