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TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

Each year the Tantalum-Niobium International Study Center offers a varied programme of technical papers, plant tours and social events to complement the General Assembly. Your Executive Committee makes every effort to arrange a technical session with papers covering a wide range of subjects of interest to the delegates of the member companies and others attending the meeting.

In October 2003 EPCOS will be honoured to host the T.I.C. meeting in Lisbon, and to welcome the delegates for a tour of our company's capacitor plant in Évora. We believe that the city will prove an attractive place for the tantalum and niobium industry to gather, and we hope that as many of you as possible will come to Lisbon for our meeting.

The gala dinner will be a very special event, as we shall be holding it in the Carriage Museum, among the historic coaches and carriages which are the exhibits in the splendid former Riding School. There will be some other surprises during the evening, which you will discover when you join us for a remarkable occasion with a taste of Portugal, a delightful country.

Our staff at EPCOS look forward to welcoming the visitors from the T.I.C., showing them our factory with the latest technology for tantalum capacitors, and explaining the processes which are necessary to manufacture the first class components which today's world demands. The town of Évora is a World Heritage Site, and the group will tour the town and some of the charming spots in the region of Alentejo during the rest of the day.

Those accompanying the delegates to the business meeting will not be forgotten, and they will have their own sightseeing tours and social programme.

This will be a great opportunity to spend a few days in a charming city, so I hope you will register for this conference without delay. I shall look forward to seeing you all in Lisbon.

Josef Gerblinger
President

Tantalum-Niobium International Study Center
40 rue Washington,
1050 Brussels, Belgium.

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

GENERAL ASSEMBLY 2003

Monastery of the Jeronimos, Lisbon (JW)

Lisbon will be the focus of the tantalum and niobium world in October when the Forty-fourth General Assembly of the Tantalum-Niobium International Study Center will be held there. Business and technical sessions, and some social events, will be at the Hotel Le Meridien Park Atlantic, where rooms have been booked to accommodate the group.

A reception to welcome all the participants will be held on the evening of Sunday October 12th to open the conference. The registration desk will be open during the day on Sunday.

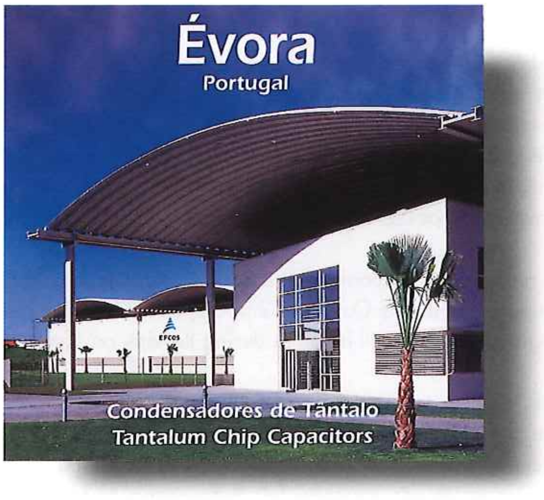
On Monday morning the General Assembly of the members of the association will conduct the organisation's business, including admission of new members. After a coffee break during which non-members join the meeting, technical sessions will continue for the rest of the day. An outline of the papers, which will cover a broad range of topics of direct interest to the industry, is shown below.

CONTENTS

Village of Monsaraj (JW)

The gala dinner on Monday evening, hosted by EPCOS and the T.I.C., will be held in the splendid Carriage Museum of Lisbon. With tables set amid the magnificent and historic exhibits, the dinner will undoubtedly be one of the highlights of the conference.

A tour of the EPCOS capacitor factory at Évora will be the objective of the field trip on Tuesday October 14th. A full day's programme will include a glimpse of the town of Évora, a Unesco World Heritage Site encircled by its protective wall, a visit to the charming medieval village of Monsaraj perched high on a precipitous hill overlooking the border with Spain, and lunch in a convent which has been delightfully converted into an inn. The history of Évora goes back to Roman times, a contrast with the sparkling modernity of the EPCOS factory producing impeccable components for tomorrow's electronics.



Social events and sightseeing tours for those accompanying the participants in the technical meeting will be arranged: the group will visit Lisbon old and new on Monday, and the Évora region on Tuesday, including Évora and Monsaraj. For delegates not visiting the plant, a tour will also be arranged. All the groups will meet for lunch.

Invitations will be sent by early July to the nominated delegates of member companies. Others interested in attending should contact the Secretariat for information without delay, telephone +32 2 649 51 58, fax +32 2 649 64 47, e-mail info@tanb.org.

TECHNICAL PROGRAMME

(The following papers are expected but the programme is subject to revision, as to both topics and order of presentation.)

Review of the year,
by Ed Mosheim, Technical Promotions Officer of the T.I.C.

Tantalum capacitors – challenges and developments,
by Philip Lessner, John Moore and John Prymak, Kemet

Tantalum industry in China,
by He Jilin, Zhang Zhongguo, et al., Ningxia Orient Tantalum Industry Corp.

A comparison of niobium, niobium oxide, tantalum and aluminium capacitor technologies,
by Dr T. Zednicek, Dr Z. Sita, Dr C. McCracken, S. Zednicek, W. Millman and J. Gill, AVX

With pick and pan – mining and processing of tantalum ores,
by Richard Burt, GraviTa

New developments in conductive polymers for capacitors,
by Dr Klaus Lerch, H.C. Starck, Electronics/Optics Business Group

Development of niobium metal for capacitor applications in Brazil,
by Solon Y. Tagusagawa, CBMM

Niobium in crystal ware
by A.T. Pereira and A.D. Menezes, CBMM - Companhia Brasileira de Metalurgia e Mineração, and F.W. Strauss and D. Silva, Cristallerie Strauss

Future of tantalum capacitors – technologies and markets
by Dr Werner Lohwasser, EPCOS SA, Portugal

Tantalum chip capacitors in the automotive arena
by Martin Rudert, Bosch

ADVANCED TECHNOLOGY FOR TANTALUM SPUTTERING TARGETS

by Ichiroh Sawamura and Shuichi Irumata, Innovative Materials Development Center, Isohara Plant, Nikko Materials Co., Ltd. This paper was presented by Mr Sawamura, General Manager of the Innovative Materials Development Center of Nikko Materials, at the T.I.C. meeting in Kyoto in October 2002.

1. INTRODUCTION

Conventional IC (Integrated Circuit) and LSI (Logic Semiconductor) devices employed aluminium alloys for interconnect material. As the device technology progresses, the scale of the device becomes increasingly smaller. The advanced logic devices, which were aimed at high-speed operations such as micro-processing units (MPU) and digital signal processors (DPU), require materials that accept higher current density and have lower resistivity.

Copper was the first candidate for advanced interconnect technology. However, there were various issues to resolve. One of the issues is that copper diffuses rapidly into silica (SiO_2) and insulation breaks down. In order to prevent this diffusion, the copper interconnect is enclosed by barrier layers. Tantalum (Ta) and tantalum nitride (TaN) are used as bottom and sidewall barriers, and a barrier layer of silicon nitride (Si_3N_4) is used for the top barrier layer, as shown in Figure 1.

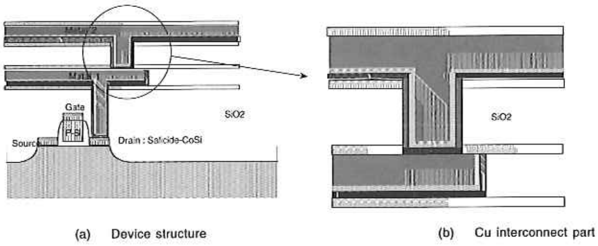


Figure 1: Structure of copper interconnect device

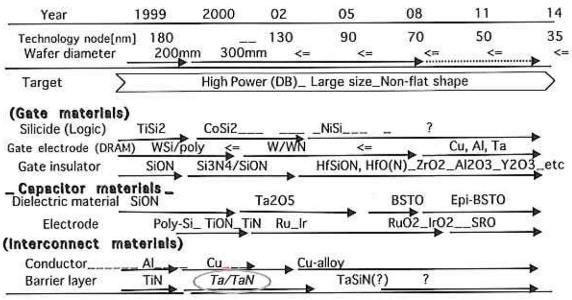


Figure 2: Roadmap of materials for advanced device

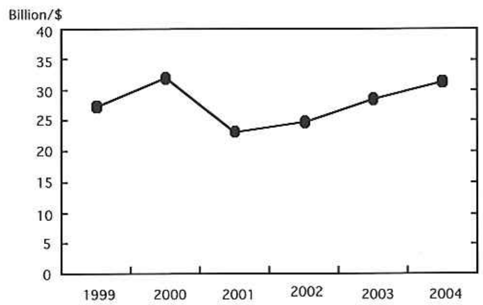
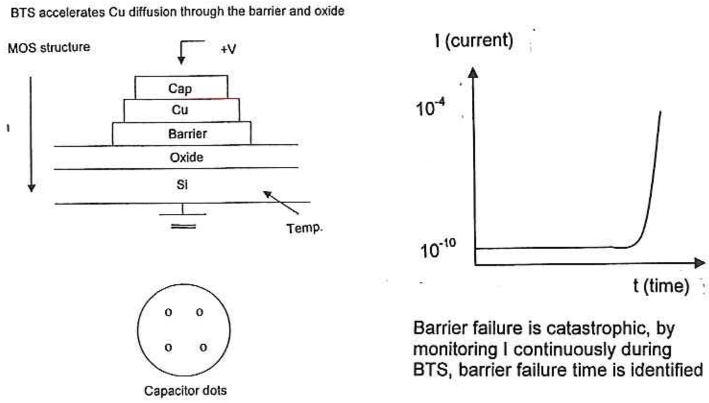


Figure 3: Product forecast for microprocessors
Source: Semiconductor Industry Association (SIA), November 2001

Figure 2 shows the technology roadmap of materials for semiconductor devices. Tantalum and TaN are ramped up as barrier layer materials with copper. Copper interconnect technology was introduced in 1997 and the copper interconnect device has been popular since 2000. A barrier layer of tantalum or a tantalum compound will be employed for some time. Figure 3 shows a production forecast for MPUs made in November 2001 by the Semiconductor Industry Association (SIA). It is expected that tantalum demand in the semiconductor industry will increase because of the increase of MPU production, as can be seen in Figure 3.

During the development stage of barrier materials for copper interconnects, the barrier properties of various materials were investigated. Titanium nitride (TiN) is used for a barrier layer in aluminium alloy interconnect technology and was one of the candidates for the barrier layer of copper alloy interconnect technology. Figure 4 shows one of the evaluation results of TiN, Ta and TaN films by Peijun Ding et al.(1) by the bias-thermal stress (BTS) test. They applied a field of 2MV/cm and measured the mean time to failure (MTTF) for 10 samples at 275°C. They show that TaN has excellent barrier properties and tantalum has enough barrier properties for the earlier technology mode for copper device.



Summary of Barrier Performance Mean time to Failure (Hrs)				
Thickness	STD TiN	STD TiN (O2)	Ta	TaN
50A			0.4	8.3
100A			1.8	26.5
200A	1.9	3	3	43

Figure 4: Comparison of barrier properties for copper interconnect (TiN, Ta and TaN) by Peijun Ding et al (1)

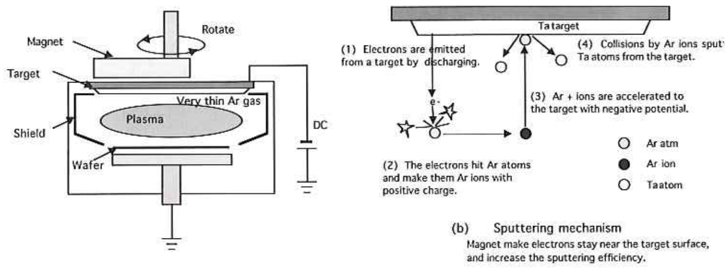


Figure 5: Basic mechanism of sputtering

Figure 5 illustrates a DC magnetron sputtering machine that is common in the semiconductor industry and used for tantalum and/or TaN barrier layer deposition. The sputtering mechanism is briefly described in the figure. The sputtering machine consists of a vacuum chamber, shield, wafer, target, magnet and power supply. The target provides film materials on the wafer. For TaN film deposition, nitrogen (N_2) gas is introduced into the vacuum chamber with argon (Ar) gas. The surface of the shield is roughened to restrain the removal of deposited film on it. The magnet holds electrons near the target and keeps the sputtering rate high. Figure 6 shows one example of tantalum targets.

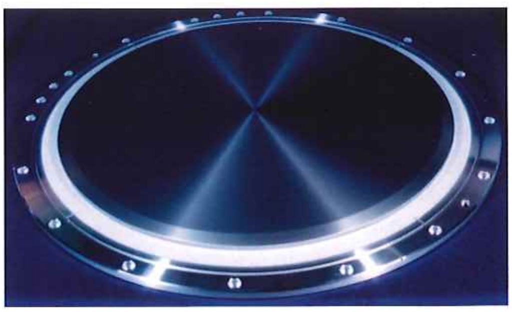


Figure 6: Appearance of tantalum target on backing plate

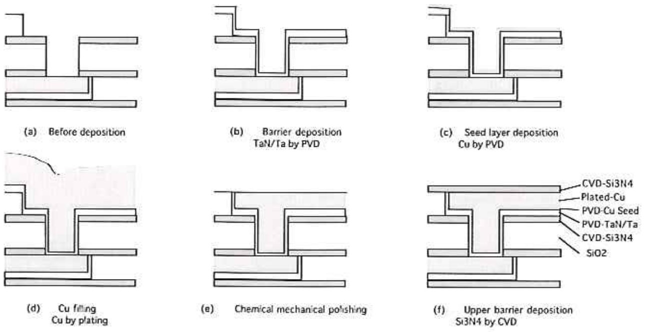


Figure 7: Formation of interconnect

Figure 7 shows procedures of copper interconnect formation. After patterning of the grooves and holes for the interconnect, Ta/TaN film is deposited by sputtering. Then a copper seed layer is also deposited by sputtering, and this is followed by copper electroplating. Electroplating is a good deposition method for conformal deposition to fine grooves and holes, however, it does need a seed layer. So the copper layer is formed by two-step deposition. The excess copper and tantalum is removed by chemical-mechanical polishing (CMP), and the Si_3N_4 barrier layer is deposited by chemical vapour deposition (CVD).

2. TECHNOLOGY OF TANTALUM TARGET FOR ADVANCED DEVICES

The tantalum barrier layer requires low defects (particles) and good uniformity of the film as well as good barrier and electrical properties. In order to achieve these requirements, the role of the tantalum target is important. There are five technical points which are important to the tantalum target, as shown in Figure 8.

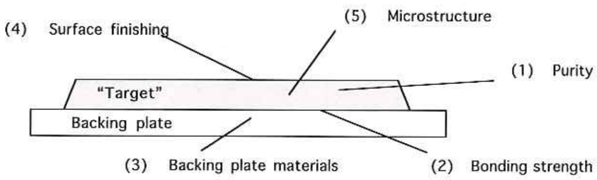


Figure 8: Required items for tantalum target

Purity of the tantalum material is important because impurities cause many problems. Uranium and thorium, with their alpha decay, are severely restricted for semiconductor materials, because alpha particles from the elements may cause electrical breakdown of the gate oxide. Alkaline metal elements such as sodium and potassium content must also be kept low, because these elements easily diffuse to the insulator layer, SiO_2, as ions. The ions work as an electrical carrier in the insulator. A transition metal element such as iron makes an energy level in the band gap in Si, and lowers the device properties. Refractory metals such as tungsten, niobium and molybdenum are not expected to lessen the properties of the device, however, the effects of these impurities are not completely clear. In addition, if the content of these elements is high and unstable, the process parameters for the barrier layer formation might be adjusted to the content of these elements in order to obtain certain device and barrier properties. Therefore, it should be favourable to keep these impurity elements as low as possible. Table 1 shows a typical assay of a tantalum target. Purity is higher than 4N-5 (99.995%) excluding gas elements (carbon, nitrogen, oxygen and sulphur).

Element	[ppm]	Element	[ppm]	Element	[ppm]	Element	[ppm]
U	<0.0005	Al	<0.1	Zn	<0.1	Pt	<0.1
Th	<0.001	Cu	<0.1	Ga	<0.1	Au	<10
Na	<0.1	Mg	<0.1	Ge	<0.1	Hg	<0.1
K	<0.1	Si	<0.1	As	<0.1	Tl	<0.1
Fe	<0.1	Li	<0.1	Se	<0.1	Pb	<0.1
Ni	<0.1	Be	<0.1	Br	<0.1	Bi	<0.1
Cr	<0.1	B	<0.1	Rb	<0.1		
Co	<0.1	Ca	<0.1	Sr	<0.1	C	10
W	<1	Sc	<0.1	Y	<0.1	N	<10
Nb	<1	V	<0.1	Zr	<0.1	O	20
Mo	<1	Mn	<0.1	Ba	<0.1	S	<10

Table 1: Typical assay of 4N-5 tantalum target

With progress in the semiconductor industry and demands for higher performance, the device and the interconnect structure become finer. Sputtering machine manufacturers design high power sputtering chambers in order to obtain a conformal layer on such fine grooves and holes. Formerly, the target was bonded to its backing plate by solder such as indium (In). However, the temperature of the target during a sputtering process rises to levels above the melting point of solder (for example, the melting point of indium is 156°C). Consequently diffusion bonding (DB) has been introduced for bonding a target to a backing plate. The bonding strength of diffusion bonding is much higher than that of solder bonding, as shown in Figure 9. Hence these materials have sufficient strength even at higher temperatures, since materials that have lower melting points are not employed for diffusion bonding. Figure 10 shows the line profile analysis result of the diffusion bonding interface between a tantalum target and the copper alloy backing plate. The analysis was carried out by electron probe micro-analyzer (EPMA). Inter-diffusion between the tantalum target and copper alloy backing plate is negligibly small.

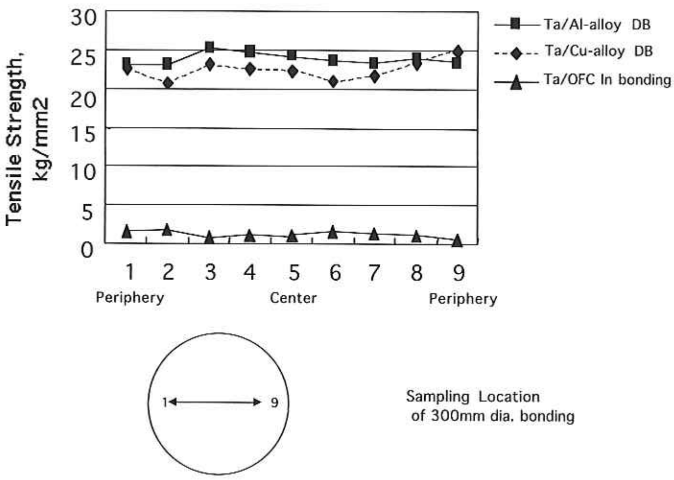


Figure 9: Comparison of bonding strength

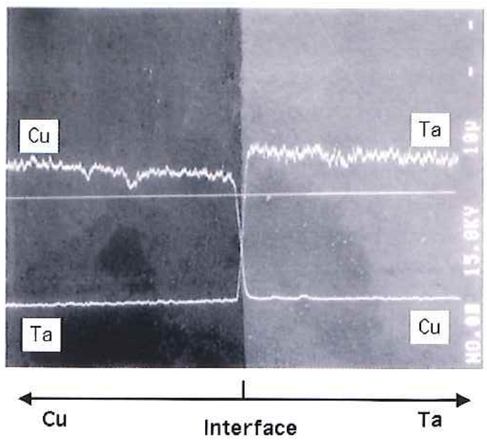


Figure 10: Line profiles of copper and tantalum at DB interface (Analysed by EPMA)

In the early stages of diffusion bonding, aluminium alloy was employed for the backing plate because this alloy has good thermal conductivity and its density is low enough to reduce the workload in the installation of the target. Recently, in the last two years or so, the sputtering power has been increased to much higher levels and the warp of a target during sputtering cannot be ignored for stable sputtering. Figure 11 shows a simulation result of deformation by the finite element method (FEM) for both Ta/Al alloy and Ta/Cu alloy diffusion bonding target. The copper alloy backing plate can reduce the distortion of the target to about a quarter of that on an aluminium alloy backing plate during sputtering.

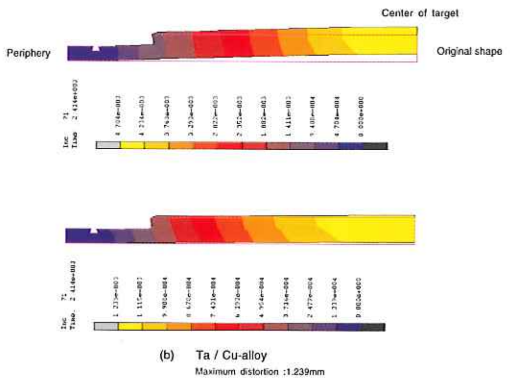


Figure 11: FEM comparison of distortion between Al-alloy BP and Cu-alloy BP
After 15 cycle sputtering (On: 34 sec., off: 134 sec.), input power: 24kW

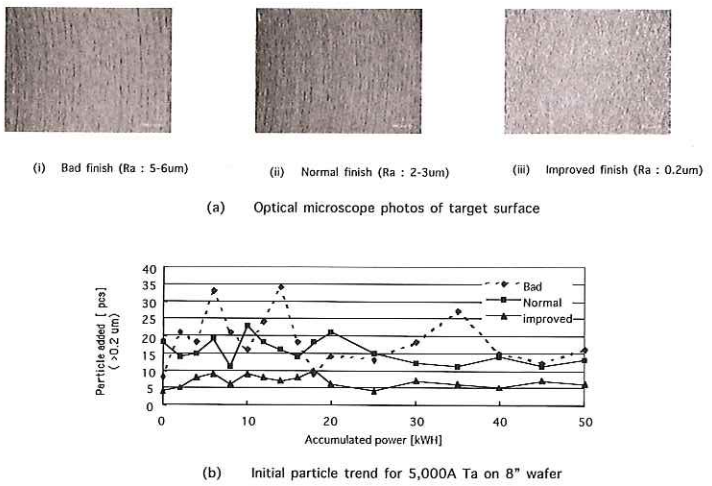


Figure 12: Benefit of improved finish for sputtering target

Surface finish affects the particle level in the initial stage of target life. Figure 12 shows the morphology of targets with three different surface finishes and the particle levels on 8-inch wafers on which tantalum film was deposited by using these targets. The average roughness (Ra) of each finish is shown in the figure. The particle is a defect like dust on the wafer, which reduces the production yield of the LSI chip. The target with the improved finish showed the lowest particle level among the three targets.

Microstructure is always an issue not only for tantalum targets but also for targets of other materials. Basically, fine grain size and uniform microstructure are preferred. However, in the case of a tantalum target, the relation between microstructure and sputtering performance is not exactly clear in the field. Tantalum targets are mainly used on ionised sputtering machines, and ionised sputtering may reduce the effects of target microstructure.

3. SUMMARY

Tantalum (Ta) has been successfully employed for the films in microchips since copper interconnect technology was introduced

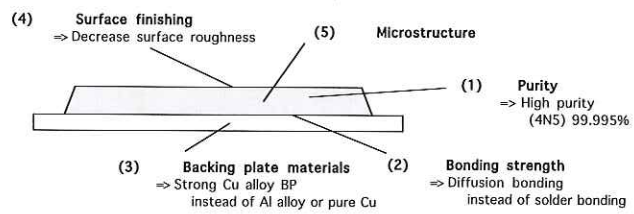


Figure 13: Summary of tantalum target technology

to logic devices in 1997. The main role of the tantalum film is to form a barrier layer against copper (Cu) diffusion, and it is formed by sputtering. This presentation focused on the technologies of tantalum sputtering targets for advanced device manufacturing, as shown in Figure 13. Technologies for targets of tantalum and its alloys are still developing in order to assist further advances in the devices, and demand for tantalum for the semiconductor industry is increasing.

Reference

(1) Peijun Ding et al, 'Copper Barrier, Seed Layer and Planarization Technology', VMIC 87 (1997)

THE EARLY TANTALUM CAPACITOR INDUSTRY IN JAPAN

by Mr Ed Mosheim, Technical Promotions Officer of the T.I.C.

Information for this article was provided by the following, to whom we are most grateful for their contribution:
Mr Susumu Wada, retired, Hitachi AIC Inc.
Mr Yoshio Yamauchi, retired, Pure Material Laboratories, Ltd.
Mr Kazuyuki Iida, R & D Division, Hitachi AIC Inc.

The earliest known use of tantalum in Japan (1935) was as a nozzle (spinneret) for the production of synthetic fiber by three different companies. Mitsubishi Kogyo in Osaka was producing tantalum metal up through the war years when the equipment was destroyed.

In 1958, Showa-Denko and Komatsu-Seisakusho began the production of tantalum metal through the support of a grant from the Ministry of International Trade and Industry (MITI).

The 1960s saw the involvement of twelve companies in the tantalum industry, which included the development of powder (6), oxide (3), carbide (2), and metallurgical products (5) with individual companies participating in more than one product area. The involvement of the MITI non-ferrous metal division of the government provided a spark for the aggressive development of the industry. In 1960, the actual sales demand was only 4.4 tons with a prediction that it would grow to 32 tons in 1964. Actual sales in 1964 of 30 tons resulted in complaints of poor forecasting and concerns regarding excess capacity. Business conditions in Japan were declining and some of these early companies withdrew from the tantalum business. Tokyo Denki discontinued tantalum powder manufacturing in 1966 and Shinetsu Chemical terminated operations in 1976.

Examples of the MITI forecasts and actual sales for 1966 and 1967 are shown in Table 1.

Year	1966		1967	
Tons / year	Forecast	Actual	Forecast	Actual
Electronics (Powder, Wire)	24.5	9.5	30.1	12.2
Mill Products	7.0	3.3	8.1	5.0
Alloy additives (Carbide)	16.5	10.7	19.0	14.5
Optics, ceramics (Oxide)	1.5	2.8	1.6	3.0
Total	49.5	26.3	58.8	34.7

Table 1: MITI forecasts and actuale sales, 1966 and 1967

The large differences in Forecast and Actual Sales were the basis for the concerns.

The two largest product categories were for powder and for carbides and alloy additives with these consuming 77 to 78 % of total sales. Most of the tantalum powders for this capacitor production were imported from Norton Inc., Kawecki Chemical Co., and Fansteel Metallurgical Co.

A list of tantalum capacitor manufacturers in 1961 is shown in Table 2.

Manufacturer	Capacitor types	Main application areas
Sankosha	Sintered slug	Audio sets Tape recorders Radio communication
Annaka Denki	Foil, sintered slug	Industrial equipment Cable communication
Nippon Denki	Foil, sintered slug	Computer Broadcasting equipment TV camera Train control systems
Matsuo Denki	Sintered slug	Audio sets Tape recorders Radio communication
Matsushita	Foil, sintered slug	Radio communication Audio sets Tape recorders
Nihon Chemical	Foil, sintered slug	Computer Radio communication
Tokyo Denki	Foil, sintered slug	Computer Radio communication
Hitachi Ltd	Prototype designs	Computer Automatic phone exchange system
Nihon Tsushin Kogyo	Foil, sintered slug	Computer Machine control systems Electrical test equipment
Nichicon	Foil, sintered slug	Machine control system Electrical test equipment
Fuji-Tsushinki (Fujitsu)	Foil, sintered slug	Computer Radio communication
Oki Denki	Unknown	Computer Radio communication
Taiyo Yuden	R & D	Unknown

Table 2: Tantalum capacitor manufacturers in Japan, 1961

We believe that four more companies were involved in this early capacitor industry, but their names are not known to us. The largest capacitor production known at this time was at NEC with a capacity of about 75 000 capacitors per month. The production of tantalum capacitors in Japan in 1960, 1961, and 1962 was 450 000; 1 027 000; and 3 694 000 on an annual basis respectively. Tantalum capacitors represented 2.5% of all capacitor production in the early 1960s. The market for tantalum capacitors did not grow rapidly as predicted, primarily due to the high price for the units for use in the consumer applications.

The tantalum processors in Japan were faced with significant raw material price volatility in the early 1960s. Their processing technology was based on limited sources of ore concentrates containing 60% tantalum oxide. A price increase from US$4 to more than US$12 in 1962, back to less than US$5 in 1964, and back up to US$14 in 1966 created a very unstable situation for the consumers of this raw material. The tantalum processors in Japan were dependent on high grade tantalite for their raw material supply and the price volatility created instability (+10 to 15%) in capacitor pricing for domestic production while imported tantalum capacitor prices remained stable.
The instability of the tantalum market in these early years of the industry in Japan was defined by slow growth and concerns about the future of the industry. There were too many companies trying to compete in this small market and, as a result, Komatsu-Seisakusho, Taiyo Metal, and Nihon-soda withdrew from the tantalum business in the mid-1960s. By 1968, the total demand for tantalum in Japan reached 48 tons with 13 tons of powder required for the capacitor applications. By 1970, tantalum capacitor production reached 4.8 million pieces per month and powder demand turned up to 31 tons per year with a total tantalum demand of 94 tons.

The early 1970s saw tantalum capacity increases installed by Showa-Denko and Shinetsu Chemical. Another company, Tokyo Denki, stopped powder production for capacitor applications and exited the business. Imported powders were obtained from KBI and Norton in the United States. Predictions at that time were that capacitance levels for powder would not exceed 6500 CV/g. That barrier was strongly exceeded with powders ranging from 10 000 to 20 000 CV/g.

The evolution of the technology of the tantalum powders has far exceeded those expectations of the early years. Today, capacitance levels of 60 000 to 70 000 CV/g are commonplace. Levels in excess of 100 000 CV/g can be attained and it is just a matter of time for the evolutionary forces of this industry to develop capacitor products with these very high surface area tantalum powders.

DLA/DNSC

Offering

The Defense Logistics Agency (DLA) Defense National Stockpile Center (DNSC) is soliciting offers for the sale of tantalum/columbium (niobium) concentrates with 624 442.90 pounds tantalum pentoxide contained (total weight 1 738 565.25 pounds). Offers are to be received by 10a.m. on June 10th 2003, an extension from the first announced date of May 27th. The relevant web site is at https://www.dnsc.dla.mil.

BOA meeting

Following the meeting on March 20th to discuss the DNSC's Draft Basic Ordering Agreement (BOA), a summary of the comments made by those who took part in the discussions and the subsequent changes was circulated. No two materials would be offered at the same time, and maximum annual sales were quoted as follows: tantalum carbide powder: 4000 lb Ta; tantalum metal ingots (vacuum grade): 40 000 lb Ta; tantalum metal powder (capacitor grade): 50 000 lb Ta; tantalum oxide: 20 000 lb Ta; tantalum concentrates: 500 000 lb Ta; columbium metal ingots (vacuum grade): 20 000 lb Cb (Nb). A comment was added to the effect that market demand would 'be the "driver" for an offering'.

Regarding the practical arrangements, offers would be posted on Wednesdays at 11.30a.m., potential purchasers would have three business days to enter their offers (so quotes would be due no later than 11.30a.m. on the next Monday provided there was no public holiday or other closing), and the DLA/DNSC would have two business days to respond to the quotes. Successful bidders would have 30 calendar days to remove the materials, except in the case of concentrates when the time would be 90 calendar days.

MEMBER COMPANY NEWS

Angus and Ross

Final conditional agreement to acquire alluvial tantalite and gold resources of Queensland Tantalite Pty has been reached by Angus and Ross in April. Subject to approval by the Foreign Investment Review Board of the Australian Government and by the shareholders of Angus and Ross at an extraordinary general meeting, properties at Grant Gully and Rutherford's Table in North Queensland will be acquired in time for bulk sampling to begin shortly.

Angus and Ross remains committed to its project in Greenland, but at the same time it is also investigating potential tantalite and gold deposits in Brazil.

AVX

AVX Corporation reported net sales of $282.6 million in the quarter ended December 31st 2002, and a net loss for the quarter of $0.7 million. CEO and President Mr John Gilbertson commented 'Our reorganization of certain European manufacturing facilities initiated last year and the transfer of production to our China facility are on schedule. These actions, coupled with our strong financial position, have positioned us well to capitalize on an economic recovery'.

Net sales in the quarter ended March 31st 2003 (the final quarter of the company's fiscal year) were $261.2 million – the drop was attributed to increased seasonal demand in the period before Christmas. The net loss for the quarter was reported as $11.1 million. Customers placed orders based on near-term requirements, thereby limiting visibility for the next quarter, said Mr Gilbertson, adding that 'indications are that revenues should improve in the June quarter'. The company expected to take additional steps to reorganize and streamline operations and reduce operating costs.

Cabot Supermetals

The name of Cabot Performance Materials was changed to Cabot Supermetals in February 2003.

The operating profit of this division of Cabot Corporation increased to $23 million for the quarter ended March 31st 2003 from $14 million in the equivalent quarter of 2002, $5 million more than for the previous quarter. Higher volumes than the 2002 quarter were credited to 'a combination of contracted tantalum powder, wire and intermediate products and some improvement in Asia Pacific volumes'. Mr Burnes, Cabot Chairman and CEO said 'Cabot Supermetals had an excellent quarter, benefiting from higher sales volumes'.

Commerce Resources

The final phase of initial metallurgical investigations into the processing and beneficiation of tantalum and niobium at its Fir and Verity properties had been completed, announced Commerce Resources on March 5th 2003. International Metallurgical and Environmental Inc. had reported that there was no impediment to the development of a full-scale process for the recovery and upgrading of the contained tantalum and niobium, and had recommended larger pilot scale testing to provide confirmation. 'The use of industry standard gravity recovery equipment has resulted in the production of tantalum and niobium concentrates that have good overall recoveries. It is predicted that overall recoveries will be in the range of 80 to 85 per cent for both tantalum and niobium'. Combined oxides exceeding 40 per cent Ta_2O_5 plus Nb_2O_5 were expected. Inferred resources are estimated as more than 2.24 million lb Ta_2O_5 for the Fir Carbonatite and 1.32 million lb for the Verity deposit.

On May 13th Commerce Resources had agreed to acquire the Paradise Property, adjoining the Verity site to the east, and covering the extensions of the Verity carbonatite. Paradise would be exchanged for the Sunro Property on Vancouver Island, a deposit with copper, silver and gold, and the transfer would maintain the focus of Commerce Resources on exploration for tantalum and niobium.

Sons of Gwalia

The company's report for the quarter ended December 31st 2002 recorded 'solid production, costs and sales statistics'. Production at Wodgina continued at a rate close to full capacity. In adjustment to market conditions, output from Greenbushes had been reduced and further capital expenditure on the underground project had been deferred, although it could be reinstated at short notice as soon as an improvement in the global market warranted this. Production of 508 805 lb Ta_2O_5 contained, and sales of 477 610 lb, in line with forecasts, were reported.

From March 10th Mr Phil Lockyer, a mining engineer and metallurgist, took over as Acting Chief Operating Officer. Mr Mark Cutifani left the post of Managing Director in February.

For the quarter ended March 31st 2003 production was 432 687 lb Ta_2O_5 contained, in line with the company's current plan. Contracted sales were 540 463 lb. An additional joint venture sale of 200 000 lb was made, although special accounting arrangements meant that the proceeds had not yet been treated as a sale. Inventory had been reduced by 300 000 lb to some 150 000 lb by the end of the quarter. Sons of Gwalia reported that 'there were signs that the demand for tantalum is slowly improving'.

Haddington Resources

Haddington Resources continues to produce some 40-45 000 lb 'tantalite' per quarter. Of 69 893 tonnes of ore mined, and 80 168 tonnes of ore treated in the March quarter 2003, 42 620 lb 'tantalite' was produced. Exploration drilling is being carried out on the Bald Hill site, and pegmatites are being located.

Kemet/Cabot

Kemet announced on December 10th 2002 that it had agreed to an extension of the term of its tantalum supply agreement with Cabot Corporation (see Bulletin 112). The extended agreement called for 'reduced prices, higher volumes and a term through 2006, and relates to both tantalum powder and tantalum wire products', said Kemet. This settled all claims in the litigation regarding the supply agreement, and Kemet welcomed the stability brought to the supply chain by this arrangement.

Kemet

On January 2nd Kemet announced plans to begin manufacturing operations in the People's Republic of China during the course of 2003. Potential plant sites and product lines had been evaluated, and Mr Kirk Shockley had been appointed to the newly created position of Director of Operations PRC. As the reasons for this move, Mr Maguire, Chairman and CEO, explained that a quarter of Kemet's revenue was generated in Asia, the manufacturing operations of many European and American based customers were tending to migrate to Asia and to China in particular, and global leaders in electronics manufacturing were emerging in Asia. It supported the company's philosophy of being 'easy-to-buy-from'.

Cost savings at two of Kemet's plants in South Carolina were announced on January 6th, in the form of a reduction of the work force of approximately 280.

Financial results for the quarter ended December 31st 2002 showed net sales of $103.7 million, a decrease of 12% compared with $117.3 million for the December 2001 quarter. Net loss, prior to non-recurring pre-tax chares, for the December quarter was $3.6 million. Sales of Kemet products had been 'adversely affected all year by the continued decline in shipments of electronic infrastructure, such as corporate information technology and telecommunication equipment', stated Mr Maguire. He foresaw an improvement in these markets in 2003 and 2004. In spite of the challenging situation of the preceding year, cost reduction efforts had enabled Kemet to maintain a strong financial position, he added.

Net sales for the quarter ended March 31st 2003 were $106.5 million, and the net loss, prior to non-recurring pre-tax charges, was $3.6 million. For the fiscal year ended March 2003 net sales were $447.3 million, compared to $508.6 million for the year ended March 2002. The net loss was $3.7 million, compared to net earnings of $16.5 million in 2002.

On March 25th Mr David Maguire retired as CEO, remaining as Chairman. Mr Maguire has been a major figure in the tantalum industry for very many years, and his support of the T.I.C. over this time has been greatly appreciated. Dr Jeffrey Graves was named President and CEO with immediate effect.

Metallurg

For the year ended December 31st 2002, Metallurg reported an operating loss of $6.8 million on revenue of $345 million. For the March quarter 2003 a net loss of $2.9 million on revenue of $89 million was reported. In addition to the weak economic situation worldwide, production of superalloys was cut sharply when the aerospace sector was adversely affected by the events of September 11th, noted the company, and also numerous land-based turbine power generation projects were cancelled or deferred. An improvement in results was expected as cost reduction programmes were implemented and the benefits of capital investments were felt.

AS Silmet

Metal Pages reported that Silmet made only a 'marginal profit' in 2002, and does not expect to make a profit in 2003, quoting Silmet's CEO and co-owner Tiit Vähi. Sales fell 30% between 2001 and 2002, as some of the firm's main consumers declined, such as the aviation, electronics and energy industries. Nearly 200 workers would be laid off, to save on costs.

Sogem

The telephone and fax numbers for Mr Bruno Deliens, delegate of Sogem to the T.I.C. have been changed:
telephone +32 2 227 23 20, fax +32 2 227 23 76.

Tantalum Australia

Further significant advances in Tantalum Australia's search for a new processing method at low cost were reported in February 2003. A continuous feed of tantalum oxide to the SOM reactor had permitted tantalum metal to be deposited directly on the cathode. Analysis of the metal had shown it to be 99.9% pure, with 'practically no detectable impurities'. Boston University, charged with carrying out the research, was planning a further advance in design, and integration of all the various stages into a new process.

In March the company reached agreements to acquire two more tantalum and niobium projects. A project covering 400 square kilometres was acquired from Rare Resources NL in the Gascoyne Mineral Field. The Brockman project, in the Kimberley region of Western Australia, which includes rare earths, niobium and tantalum was the subject of a joint venture with Aztec Resources.

Tertiary Minerals

The company is pursuing its studies on the Ghurayyah deposit in Saudi Arabia as its main project, while also investigating other potential mines in Scandinavia, with a variety of minerals. Tertiary reported a loss of £134 085 for the six months ended March 31st 2003.

Vishay

Sales for the fourth quarter of 2002 were reported as $459.4 million, compared with $381.2 million for the same quarter in 2001. A net loss for the quarter after restructuring charges and other non-recurring items of $123.8 million resulted, and the company described market conditions as 'continuing very difficult'.

The 2002 results reflected a write-down of its current inventory of tantalum powder and wire and an accrual for contracts of supply of tantalum at prices in excess of market. In June 2002, stated Vishay, it 'agreed with Cabot to amend two agreements for the supply of tantalum powder and wire. The parties agreed to reduce volumes, and starting in 2003, prices of tantalum products under the agreements and to extend the loger-term agreement by one year through 2006'.

For the first quarter of 2003, sales increased 23% over the corresponding quarter of 2002, to $532.1 million.

http
@
www.tanb.org
e-mail to info@tanb.org