Paumanok Publications, Inc.

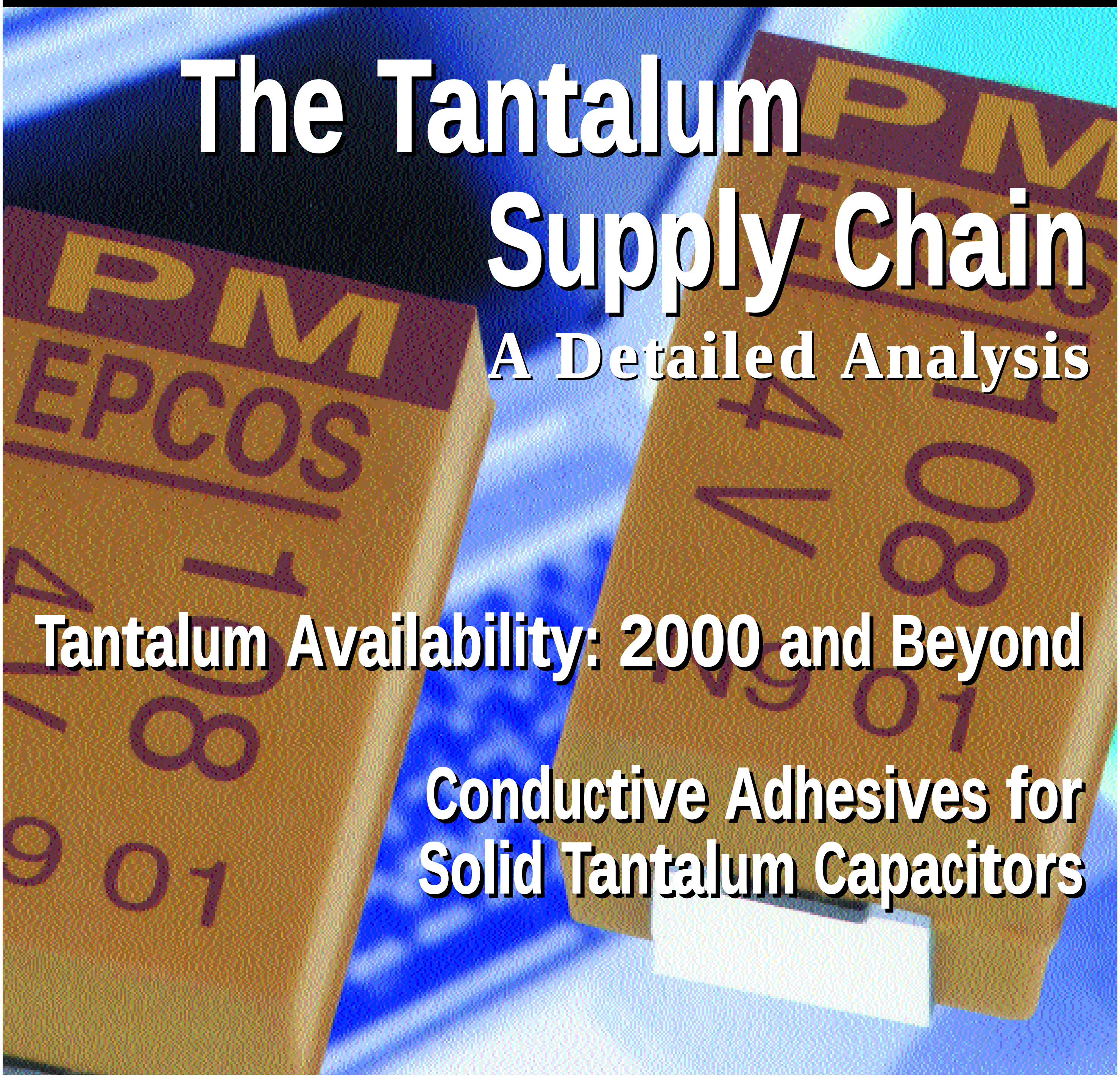
March/April 2002

Passive Component Industry

Electronic Industries Alliance

An affiliate publication of the ECA
A sector of the Electronic Industries Alliance

The Only Magazine Dedicated Exclusively To The Worldwide Passive Electronic Components Industry



The Tantalum Supply Chain
A Detailed Analysis

Tantalum Availability: 2000 and Beyond

Conductive Adhesives for Solid Tantalum Capacitors

VISHAY

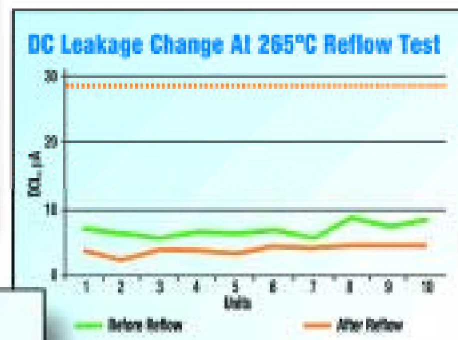
BREAKTHROUGH

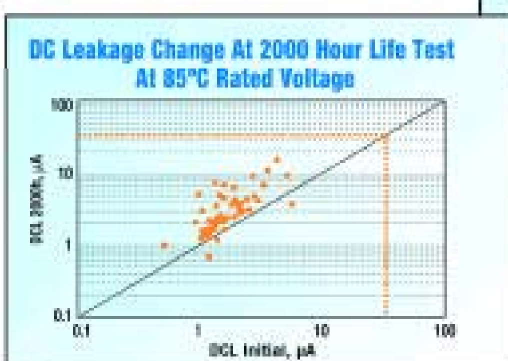
from VISHAY INTERTECHNOLOGY

Niobium: An Alternative to Tantalum?

Niobium is three times more abundant in nature than Tantalum; lighter in weight than Tantalum; less expensive than Tantalum.

Parameter	Molded Niobium Capacitors	Molded Tantalum Capacitors
Operating Temperature Range	-55°C – +125°C	-55°C – +125°C
Capacitance Range	4.7µF – 680µF	0.1µF – 680µF
Voltage Range	4V – 16V	4V – 50V
DCL, µA, Limit	<0.01 CV	<0.01 CV
Max. ESR @ 100kHz, 470µF, 6.3 Volts (D case)	0.050 Ω	0.050 Ω





Overvoltage
Protection
VARICON
Widest SMD Varistor Range
SMD Varicons = Multilayer SMD Varistors
Common features:
Low Clamping Voltage
Fastest Response Times
Maximum Operating Temperature +125 C
ZV - SMD Low Voltage Varicons
Voltage Range: 3 V to 170 Vdc
Max. Surge Current: up to 1,200 A, 8/20 μs
6 Chip Model Sizes: 0603, 0805, 1206, 1210, 1812 and 2220
ZVE - ESD Suppression Varicons
4 Chip Model Sizes: 0603, 0805, 1206 and 1210
Response Time < 500 ps
ZVX - Low Capacitance/Low Energy Varicons
Voltage Range: 3 V to 38 Vdc / Low Energy Rating: 0,1 J
3 Chip Model Sizes: 0603, 0805 and 1206
Medium Voltage SMD Varistors - SMD Choice to Replace 5 mm & 7 mm Radial Discs
Common features:
Operating Voltage: 11 to 300 Vrms
Max. Surge Current: up to 1,200A, 8/20 μs
2 Chip Model Sizes: 3225 and 4032
PV - SMD Plastic Encapsulated Varistors
Robust, Thermoplastic Molded Cases
Approvals: UL1449 & CSA 22.2 (60 V to 300 V)
DV - Low Profile Medium Voltage SMD Varistors
Low Profile SMD Chip: Thickness < 2 mm
Maximum Operating Temperature +125 C
ZV
ZVE
ZVX
KEKO PV 300 K 4032
DV
At least 10 %
- better performances,
- shorter delivery time,
- faster custom design,
- .....
...not the biggest,
simply the best !
For more info contact:
KEKO VARICON, Slovenia
SI-8360 Žužemberk,
Phone: +386-7-3885-120
Fax: +386-7-3885-158
e-mail: info@keko-varicon.si
web site: www.keko-varicon.si
strategic partner for marketing and distribution in North America:
SEI ELECTRONICS, Raleigh, NC
Call toll free: 1-888-sei-sei-sei
e-mail: marketing@seielect.com
web site: www.seielect.com

TABLE OF CONTENTS

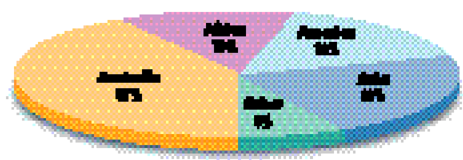
Passive Component Industry

MARCH / APRIL 2002 — Volume 4, No. 2

The Only Magazine Dedicated Exclusively To The Worldwide Passive Electronic Components Industry

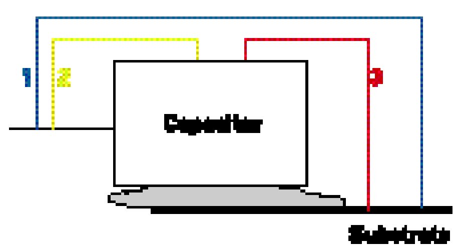
FEATURE Stories

Tantalum Concentrate
Courtesy: Sons of Gwalia



Estimated Worldwide Resources of Tantalum Ore

DEPARTMENTS



Cover Photo: Courtesy of EPCOS

LETTER FROM THE DIRECTOR

March/April 2002

During the past two-and-a-half years, I've had the pleasure of meeting many wonderful people in the industry. *Passive Component Industry* magazine has been a great success, and I want to personally thank all the individuals and companies who have helped us along the way.

Special thanks are owed to those advertisers who have been with us since the first issue, and who still advertise with us today. They are

Haiku Tech
NIC Components
Vishay

Thank you for your support.

I also would like to acknowledge our partners, ECA/EIA. Thank you, Bob Willis.

To our advisory board: Thanks for your expertise and guidance.

Thanks to our staff. Without Amy, Pam, and Heidy, the magazine would not be possible.

Special thanks to Dennis Zogbi, whose knowledge of and experience in the passive component field provide the magazine its insight and direction.

I look forward to the next two-and-a-half years and to meeting more of the people who make up this $60 billion industry.

Advertisers are our lifeblood. They provide the necessary income so that we can deliver *Passive Component Industry* magazine to you, free of charge. If you've ever wondered why your company does not advertise, ask your marketing department. I extend an invitation to all interested advertisers. Contact me. There's an opportunity for everyone, regardless of budget, to advertise in *Passive Component Industry*.

Also, I welcome hearing from anyone with comments, suggestions, or story ideas.

Let's work together to make the next 16 issues as good as the first.

— Sam Corey
Director
***Passive Component Industry* Magazine**

(919) 468-0384
(919) 468-0386 [fax]
sam@paumanokgroup.com

Passive Component Industry

PUBLISHER
DENNIS M. ZOGBI

DIRECTOR OF ADVERTISING
SAM COREY

EDITOR
PAMELA GABRIEL

MARKETING
HEIDY WEGERSKI

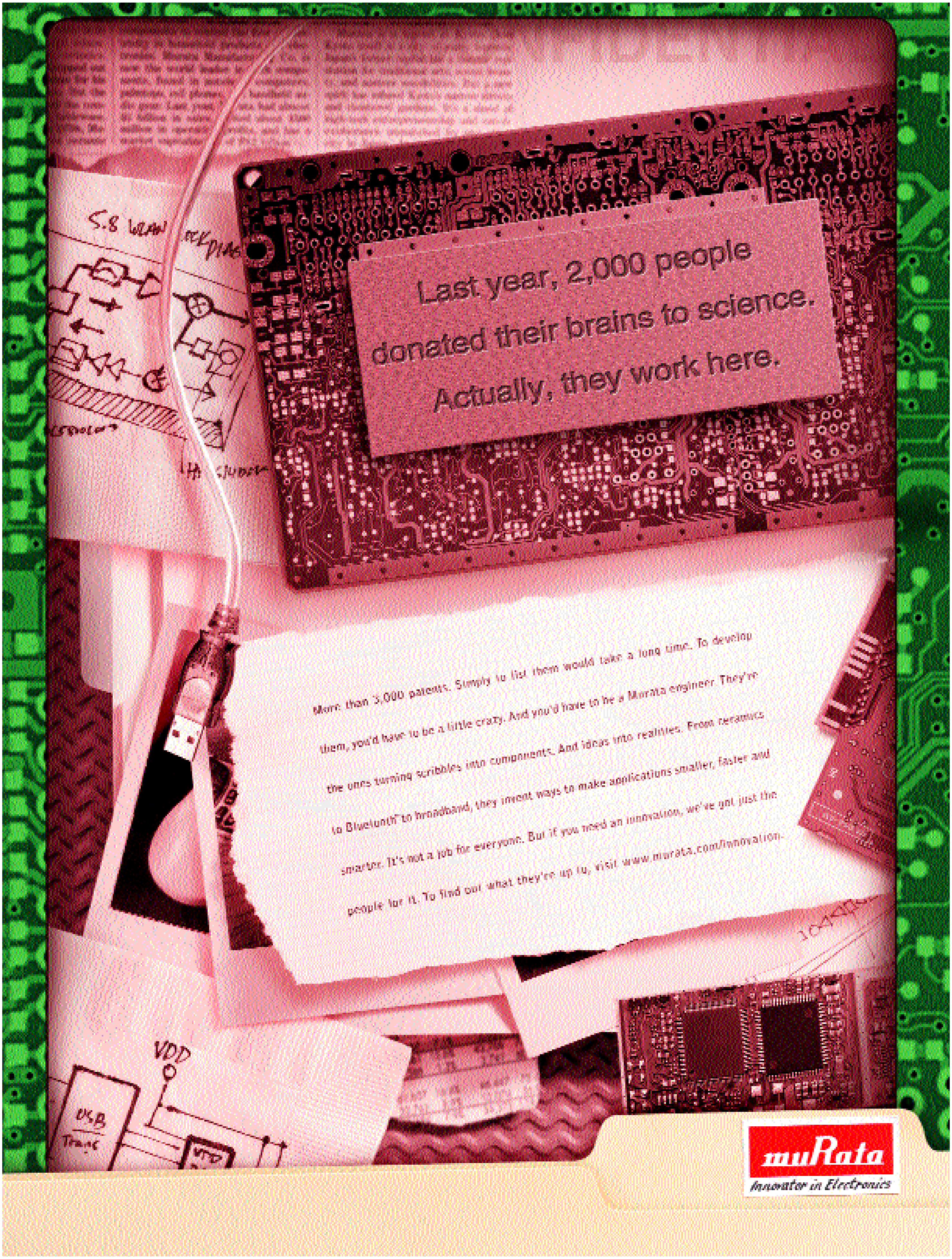
ART DIRECTOR
AMY DEMSKO

Editorial and A dvertising Office
130 Preston Executive Drive, Suite 101
Cary, North Carolina 27513
(919) 468-0384 (919) 468-0386 Fax
www.paumanokgroup.com

The Electronic Components – Assemblies – Materials – Association (ECA) represents the electronics industry sector comprised of manufacturers and suppliers of passive and active electronic components, component arrays and assemblies, and commercial and industrial electronic component materials and supplies. ECA, a sector of the Electronic Industries Alliance, provides companies with a dynamic link into a network of programs and activities offering business and technical information; market research, trends and analysis; access to industry and government leaders; standards development; technical and educational training; and more.

The Electronic Industries Alliance (EIA) is a federation of associations and sectors operating in the most competitive and innovative industry in existence. Comprised of over 2,100 members, EIArepresents 80% of the $550 billion U.S. electronics industry. EIA member and sector associations represent telecommunications, consumer electronics, components, government electronics, semiconductor standards, as well as other vital areas of the U.S. electronics industry. EIA connects the industries that define the digital age.

ECA members receive a 15% advertising discount for *Passive Component Industry.* For membership information, contact ECA at (703) 907-7070 or www.ec-central.org; contact EIAat (703) 907-7500 or www.eia.org.


Last year, 2,000 people donated their brains to science. Actually, they work here.
More than 3,000 patents. Simply to list them would take a long time. To develop them, you'd have to be a little crazy. And you'd have to be a Murata engineer. They're the ones turning scribbles into components. And ideas into realities. From ceramics to Bluetooth™ to broadband, they invent ways to make applications smaller, faster and smarter. It's not a job for everyone. But if you need an innovation, we've got just the people for it. To find out what they're up to, visit www.murata.com/innovation.
muRata
Innovator in Electronics

Get Under the Cellphone's Skin at ECA's SUPERCOMM Pavilion

The cellphone is everywhere. It's almost to the point where if you don't have one, you're making a statement. In business, it is an extension of the hand of people on the go. Everywhere else, it's taken for granted as an everyday accessory.

Two groups that don't take cellphones for granted are those who design, manufacture, and sell them, and those who provide the electronic components underneath the plastic cases.

What Makes Them Work?

While cellphones are ubiquitous, few understand the role of electronic components in making them work. Consumers only see a case with a display screen and output and input interfaces. The only time someone might get a glimpse at the inner workings is if the product falls from a certain height onto a hard surface. Then, of course, you just want to get the phone replaced as soon as possible with one that has a shiny, new plastic case. In a way, we have the same attitude toward our cellphones as we do toward our bodies. The inner workings are what make the body tick, but we would rather not have it opened up. It looks a whole lot better (and is a lot more functional) when it's encased in skin.

Even to the technically inclined, the interaction of many pieces and parts that create products remains a mystery. Electronic components, particularly passive electronic components, appear to have little in common with the expected results. When it comes to cellphones and the infrastructure of the systems that make up cellphone networks, the role of electronic components can be easily overlooked. ECA is planning to address this issue at the upcoming SUPERCOMM conference and exposition.

The Technology Behind the Cellphone

The Electronic Components pavilion at SUPERCOMM will be more than an exhibit for ECA and its member companies. ECA plans to clearly illustrate the functionality of electronic components in telecom products. Portelligent, a global product and technology intelligence firm that provides detailed product teardowns for personal and consumer electronics, will provide a physical layout of cellphone technology. The teardown will define the functionality of components and component assemblies in a typical cellphone.

To further the education, ECA and its member companies in the pavilion will provide descriptions and definitions for each component and point attendees toward exhibits that display the technology. ECA will also feature a library of publications and books on components and component technologies.

The overall educational experience will help SUPERCOMM attendees realize how component technology enables telecom products to work and how to better specify requirements for their products. The Electronic Components pavilion at SUPERCOMM will be a first stop for many designers and engineers who develop components and assemblies that allow telecom products to meet the requirements of the consuming public.

Catch the Recovery

The 2002 telecom market is expected to begin its slow recovery from the disastrous downturn it took in 2001. According to Bear Stearns, worldwide handset production is estimated at 435 million units and worldwide infrastructure may reach $56 billion. While the numbers might not represent the growth that the telecom industry would like to see, there is ample opportunity for electronic component manufacturers. SUPERCOMM is the premier event for the communications and information technology professional. It is also the place for electronic component manufacturers to present their side of the story.

Will the Mystery Remain?

SUPERCOMM will be the first forum to explore in depth the close connection between the electronic component and telecommunication industries. ECA and Portelligent will visually demonstrate the role of electronic components in telecommunications; electronic component manufacturers will feature the products and technologies that serve the telecom industry. Even given all that, however, the role of electronic components in cellphone technology might remain a mystery. Electronic components are a bit like the thermos bottle—the seemingly simplistic container capable of keeping a hot liquid hot and a cold liquid cold. The basic question lingers: How does it know? ❑

— Bob Willis is president of ECA, the electronic components sector of the Electronic Industries Alliance (EIA). He can be reached at robertw@eia.org.


DAEWOO capacitors,
contact DAECOM !

The Tantalum Supply Chain: A Detailed Analysis

Each phase of the tantalum capacitor supply chain has its own competitive environment. Beginning with the raw material, following is an in-depth analysis of that chain and the players involved in moving the product along to its final end market.

Tantalum Ore

Sons of Gwalia in Australia is the premier supplier of tantalum ore to powder and metal processors. In 2000, Gwalia mined and sold about 1.3 million pounds of tantalum ore, which suggests that they controlled about 25% of the total tantalum supply and 40% of the primary supply (i.e., without ore coming from stockpiles, recycling, or the Defense Logistics Agency). Also, Gwalia sold 1.6 million pounds of tantalum ore from June 2000 to June 2001, denoting a higher production capacity. The company notes that its tantalum output will be about 2.3 million pounds by June 2002. Sons of Gwalia is a modern operation in a stable region of the world, giving it a perceived monopoly in tantalum ore supply.

Major Global Customers for Tantalum Capacitors: 2000–2001

Wireless	Infrastructure	Computer Motherboard	Computer Disk Drive	Consumer A/V	Automotive	Manufacturing Services Companies
Nokia	Nortel	IBM	Seagate	Sony	Robert Bosch	Solectron
Motorola	Cisco	Dell	Western Digital	Hitachi	Visteon	Sanmina-SCI
Ericsson	Lucent	Compaq	Quantum	NEC	Delphi	Celestica
Panasonic	Alcatel	HP	Panasonic	Panasonic	Nippondenso	Flextronics
Samsung	Ericsson	Apple	IBM	Nintendo	Marelli	Jabil
Siemens	Siemens	Fujitsu	Others	Sega	VDO	Others
Sony	Nokia	Toshiba		Others	Others	
Sagem	Others	Intel				
Kyocera		Others				
Others						

Table Note: There is general debate over who is the largest consumer of tantalum capacitors in the world. The Japanese generally conclude that Sony is the largest global consumer because of the large number of applications the company has for tantalum capacitors (e.g., handy phones, camcorders, and the PlayStation), while Western companies argue that Motorola is the largest consumer because of its analog phones and chipsets. Regardless, both Sony and Motorola consumed about 2 billion pieces in 2000. Matsushita/Panasonic is also a major user, although it should be noted that 45% of Matsushita's Circuit Capacitor Division's production of tantalum capacitors is consumed captively, so its merchant market needs are less than others. The fastest growth portion of the business is tantalum capacitor sales to manufacturing services companies, with emphasis on Solectron, Sanmina-SCI, and Flextronics.

Source: Paumanok Publications, Inc.

Africa is also a premier source of tantalum ore. The ore is collected by thousands of individual miners and assayers and sold to a few major African ore traders. Those traders are actually owned and operated by the Rwandan, Ugandan, and Democratic Republic of the Congo (DRC) governments, who, in turn, sell the ore to such international distributors as Sogem and A&M Metals. African ore sales are also made directly to Cabot Corporation, tracked via IM145 shipment data from Africa to Pennsylvania, where Cabot maintains its tantalum processing plant.

Ore from mines located in the DRC's Lake Kivu region is collected by the Congolese government and Mai-Mai rebels, who are backed by the governments of Uganda and Rwanda. (Before 1998, Uganda exported no tantalum ore.) Congolese ore sources are plentiful; two mines in the Congo have extremely high concentrations of tantalum ore per parts per million of earth, which makes extraction extremely economical. The Kenticha Tantalum Mine is another

Continued on page 10


Think buying resistors has to be complicated?
SEI
We make it easy with our Bill of Material Cross-Reference System.
• E-mail us the BOM in any format.
• No need to sort. Our system only recognizes and references resistors.
• We cross major competitors part numbers and descriptions.
• We auto-populate the file with price, lead-time and stock position (upon request).
• We guarantee a 24-hour turn-around with most requests.
Passive Components. Active Service.
SEI Electronics, Inc P.O. Box 58789 Raleigh, NC 27658-8789 Tel: 1-888-sei-sei-sei Fax: 919-850-9504 www.seielect.com

Continued from page 8

hard rock mine. The dispute between Midroc Corporation and Ethiopia over ownership of Kenticha has been resolved in Ethiopia's favor.

The Cabot-owned Morrua Mine in Mozambique, with its potentially enormous reserves of ore, is another source. Tantalum ore abounds in Africa because it is close to the surface and easily accessible with pick and shovel. However, in 2001, buyers trended away from African ore, regardless of its source, and more toward Australia and Brazil, because of its use as a funding source for the region's on-going civil war.

Brazil's Nazareno Mine is owned by Metallurg's CIF subsidiary. Nazareno is a major mine; it is the third largest mine in the world, behind Greenbushes and Wodgina in Australia (both owned by Sons of Gwalia). A second, smaller mine is the Mamore site (Pitinga), owned by Grupo Paranapanema. Grupo announced a ten-year supply contract with a U.S.-based processor (probably Cabot) to produce 80,000 pounds of tantalum ore per year.

Although the majority of them are small, tantalum mines in the People's Republic of China are another resource. The Yichun Mine is the largest and most productive and is a prime source of ore for Ningxia Non-ferrous Metals, a major engineered powder processor. The Yichun Mine has been associated with Vishay Intertechnology, the third largest tantalum capacitor manufacturer in the world. The smaller Nanjing Mine is also a major ore producer.

Canada's Lake Manitoba region is home to another major active mine, owned by Tantalum Mining Corporation (Tanco). Ore from the Tanco Mine is a desirable raw material because of its high tantalum concentration. Tanco is owned by Cabot, which opens and closes the mine as the market dictates. In 2001, Cabot increased shipments from Tanco to compensate for declining African shipments.

Tin slag operations, which produce tantalum concentrates, include Thailand's large Thaisarco operation that collects and processes tin from mine locations in Thailand. Thaisarco also imports tin from other Asian locations, including Malaysia and Indonesia, for tantalum extraction. The Nigerian Mining Corporation runs a large-scale tin mining plant in Jos that extracts tantalum from tin slag. That operation exports ore primarily to Cabot Corporation.

In summary, Australia, Africa, Brazil, and China are the primary resources of tantalum ore, with a noted movement in 2001 away from Africa to Australia and Brazil. Also, the Chinese are looking outside of China for ore resources; certain groups from China have expressed renewed interest in ownership in African mines. Finally, Vishay Intertechnology in the United States imports ore from Sons of Gwalia; that ore is then exported to Ningxia Non-ferrous Metals in China for processing.

Tantalum Powder and Wire

Tantalum ore must be processed into an engineered form for use in the capacitor industry. Powder requires a high purity level, with low additional content of oxygen, potassium, nitrogen, and other materials. Tantalum wire is extruded from high-purity tantalum powders and used as the anode connection on the tantalum capacitor. Based on primary observations, it is apparent that more wire is recycled in the tantalum capacitor production process than is powder.

H. C. Starck, a Bayer AG subsidiary, was the largest producer of engineered capacitor powder and wire for the capacitor industry in 2000. That obviously changed in 2001. Cabot emerged as the market leader due to the take-or-pay contracts the company initiated in 2000. H. C. Starck maintains many tantalum material engineering assets, some of which have been developed organically and others that have been acquired. Starck's organic operations include facilities in Goslar, Germany and Newton, Massachusetts. In recent years, the company purchased VTech in Japan and Thai Tantalum in Thailand.

Cabot Corporation of Boston, Massachusetts, maintains a very large tantalum material processing facility in Boyertown, Pennsylvania. The company also operates a joint venture in Japan with Showa Denko Corpo-

Anode/Capacitor Producers	Production Base
KEMET	USA
	Mexico
AVX	Czech Republic
	USA/Maine
	Mexico
	El Salvador
Vishay	USA (Sprague)
	Israel (Sprague)
	Portugal (Roederstein)
EPCOS	Germany
	Portugal
NEC/Tokin	Japan
	Thailand
Hitachi AIC	Japan
Matsushita	Japan
	China
Nichicon	Japan
Matsuo	Japan
Samsung	Korea
Elna	Japan
Towa	Japan
NCC/Marcon	Japan
PM Labs	Japan
Vikond	Russia
Shira Kawa	Japan
Shenzhen Capacitors	China
PARTSNIC (Daewoo)	Korea
	Vietnam
Welon Electronic	Taiwan
Haw Shuenn	Taiwan
Lelon (Elna)	Taiwan
Carey Industrial	Taiwan
Guizhou Xinyunli	China
Ningxia Xingri	China
Suntan	Taiwan
Monarch Engineers	India

Table Note: The ultimate market pull comes from the major end-use electronic markets that use tantalum capacitors for bypass, decoupling, and filtering circuits on their printed circuit boards. The major end-use markets that use tantalum capacitors include wireless communication devices, communication infrastructure equipment, computer motherboards and disk drives, automotive electronic subassemblies, and consumer audio and video imaging products.

Source: Paumanok Publications, Inc.

ration, known as Showa Cabot Supermetals KK. Cabot does not report the joint venture with Showa Denko in its annual report and 10-k statement, nor does it report its ownership of the Tantalum Mining Corporation.

Tantalum Ore Sources	Ore Source
Sons of Gwalia	Australia
Lake Kivu	Congo
Nazareno (Metallurg)	Brazil
Tanco (Cabot)	Canada
Thaisarco	Thailand
Nigerian Mining Corp.	Nigeria
Yichun Mine	China
Mamore (Pitinga)	Brazil
Other Hard Rock Mines	China
Other Slag Operations	Malaysia

Ningxia Non-ferrous Metals in China is the third major processor. Since 1995, Ningxia NFM has emerged as a major force in the raw material industry for tantalum capacitors. The company enjoys major operational accounts with, among others, Vishay Intertechnology. It is widely believed in the industry that Vishay was directly responsible for the development of Ningxia NFM as a primary force in the engineered materials business for the tantalum capacitor industry.

Among the smaller processors are VMC Corporation of Japan that produces tantalum wire only, and Solikamsk Magnesium Works in Russia, which has the capability to produce tantalum metal powder, but is not active in this market to any large degree. NAC Kazatomprom entered the capacitor grade powder and wire markets in 1999. Located in Kazakhstan, NAC Kazatomprom has a history with Ulba Metallurgical, a company associated for many years with tantalum processing.

Japan's Mitsui Mining & Smelting, a major supplier of raw materials to other electronic component industries (including copper termination powders for BME MLCC applications), reportedly has entered the tantalum raw material business.

Paumanok knows of two additional processors, one in the United States and one in Japan, who are actively developing capacitor-grade tantalum metal powders, as of this writing.

Continued on page 26

Tantalum Availability: 2000 and Beyond

William A. Serjak
H. C. Starck, Inc., Newton, Massachusetts

Dr. Hady Seyeda and Christian G. Cymorek
H. C. Starck, GmbH, Goslar, Germany

Tantalum Markets

Tantalum capacitors are pervasive in electronics because they add functions to circuits that other dielectrics cannot. Tantalum capacitors are used in laptop computers and cellphones because they have extremely high volumetric efficiency and are very reliable. They also reduce the weight in laptops and cellphones and make their batteries last longer. Tantalum capacitors have a stable oxide film at temperatures from –55ºC to +125ºC. That makes them ideal for automotive applications where under-the-hood temperatures can cause other capacitors to fail.

Tantalum metal is used in turbine engine alloys that allow aircraft and land-based turbines to operate at higher temperatures, thus giving them higher efficiencies. Tantalum is also used in corrosion-resistant applications such as heat exchangers, reaction vessels, and vessel liners for the chemical process industry.

Tantalum oxide is used in sputtering targets for chemical vapor deposition and is a major ingredient in fiber optics for making possible dense wavelength divisional multiplexing.

Nearly 80% of tantalum material is used in electronic end markets. Consequently, when electronic markets grow by 10%, the entire tantalum supply chain must grow by about 8%. Few other supply chains are so greatly affected by a single segment of their business.

Tantalum shipments for 2000 were 2,267 metric tons, or more than 5 million pounds—a record-breaking performance for the tantalum supply chain. From 1992 to 2000, tantalum production grew 242%, or 17% per year.

End Markets for Tantalum Materials

Applications	Percentage
Capacitor Products	68%
Other Electronic and Optic	11%
Superalloys	8%
Carbides	5%
Chemical Process	2%
Sputtering Process	2%
Military	1%
Other	3%

Figure 1

Tantalum Supply Chain

The tantalum supply chain begins with tantalum ore in a mine. Mines may take from one to two years to respond to changes in the end market. Response time depends on the type of deposit, the resources of the miner, and the magnitude of the change.

OEMs and CSMs who make cellphones, computers, and automotive electronics see the supply chain primarily as it involves their customers, their suppliers, and tantalum capacitors. That is because the entire supply chain normally works very well, and processors

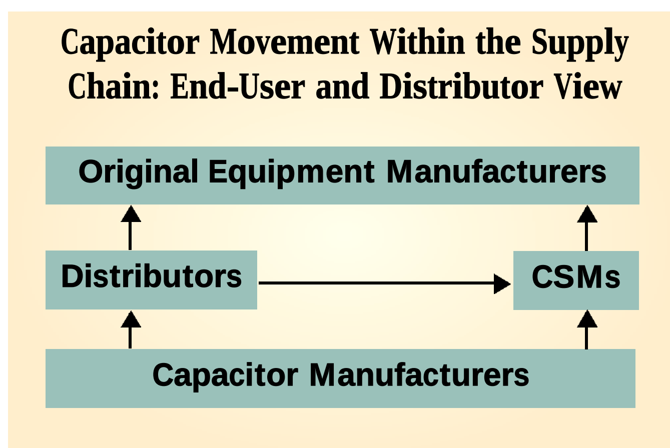


Figure 2

Continued on page 14

Continued from page 12

and miners do not make the news. But the supply chain also includes the tantalum metal processors and tantalum miners.

Processors buy the ore, concentrate it, refine it into an oxide, convert the oxide into a chemical compound (K_2TaF_7), and then reduce the K_2 to the pure metal form. Processors sell powder and wire based on the needs of capacitor makers.

Processors translate end-user needs into long-term, take-or-pay contracts with the miners. Contracts are needed because mining requires large capital expenditures. Processors are responsible for tying the two ends of the chain together; they assume the majority of financial responsibility for continuity of the supply chain. A more realistic view of the supply chain is shown in Figure 3. Ores and scraps are sometimes handled through brokers.

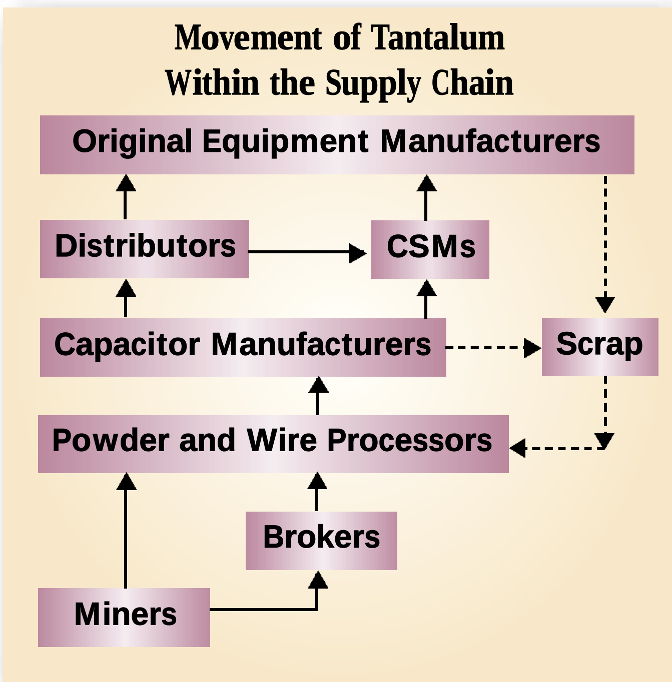


Figure 3

Nearly 20% of tantalum powder, wire, and furnace hardware is recycled as scrap; the scrap stream is important to nonelectronic applications.

Shortage: Real or Perceived

Was the shortage of tantalum capacitors real or perceived? To end-users who could not buy all the capacitors needed to meet demands, it made no difference if the shortage was real or perceived. But in order to understand the performance of and return credibility to the supply chain, the question is extremely important. Were supplies of tantalum capacitors and tantalum powder sufficient to meet the real demand for the electronic equipment being sold?

In 1997, capacitor manufacturers were not expanding because profits were low. With prices for tantalum capacitors at all-time lows, OEMs were encouraged to design tantalum capacitors into new products because they provided outstanding performance for the price.

During the 1998 recovery, inventories of tantalum capacitors (and nearly all passive components) fell to very low levels. Coincidentally, cellphone, hardwired communications, Internet capital spending, and computer markets all began double-digit expansion. At the same time, OEMs were moving significant amounts of their business to CSMs. All of these events had a significant impact on the tantalum and other electronic supply chains.

In 1999 and 2000, the supply chain became more complex than usual. Media reports highlighted the tight supplies and increasing prices, precipitating a scramble for capacitors and tantalum across the chain. Double ordering started. Worst of all, speculators entered the supply chain, disrupting the normal flow of material by bidding prices that were higher than existing supply chain prices.

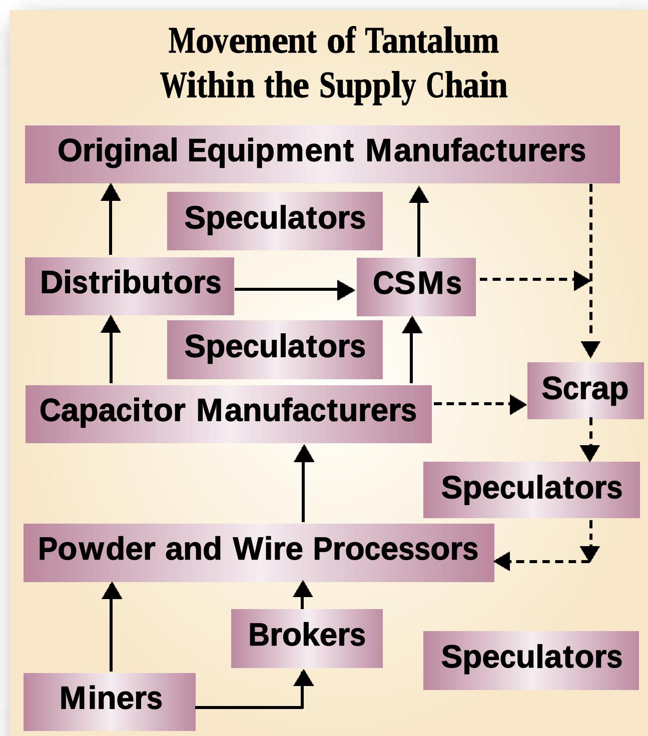


Figure 4

Speculators penetrated every level of the supply chain: They bought/sold outdated tantalum capacitors; they bought/sold tantalum scrap; and they bought/sold

Continued on page 16


Samsung passives will add zest to your products
ENGINEERS JUST LOVE OUR MLCCS
Samsung Electro-Mechanics is emerging as a major producer of passive components for surface-mounted devices. Our latest offerings include high-capacitance & high-voltage MLCCs low ESR tantalum capacitors, high-wattage chip resistors & chip arrays, high-frequency chip inductors and chip beads, and SMD electrolytic capacitors.
Sample our small, high-performance SMD components, and you'll be delighted at how they spice up your product designs.
sem.samsung.com/passive
MLCC & Array
Chip Resistor & Array
Chip Inductor/Bead
Chip Electrolytic Capacitor
Tantalum Capacitor
SAMSUNG
ELECTRO-MECHANICS
San Jose 408-544-5211 Chicago 847-969-9606 New Jersey 201-229-6903 San Diego 858-277-4559 Dallas 972-761-7388
Houston 281-477-9011 Potland 502-690-9303 Head office 82-31-210-6181 e-mail : ki1082@samsung.co.kr

Continued from page 14

tantalum ore. The market in 2000 looked more like the representation in Figure 4: both cluttered with speculators.

Supply Chain Model

To determine if there were enough tantalum capacitors to meet the true demand, a model of the tantalum capacitor supply chain was built. Worldwide shipments of tantalum capacitors are directly related to the dollars of electronic shipments. The period from 1992 to 1997 was relatively stable, so it serves as the baseline.

Once established, the relationship between U.S. electronic shipments and worldwide tantalum capacitor shipments will be used to formulate the real (calculated) demand for tantalum capacitors between 1998 and 2002.

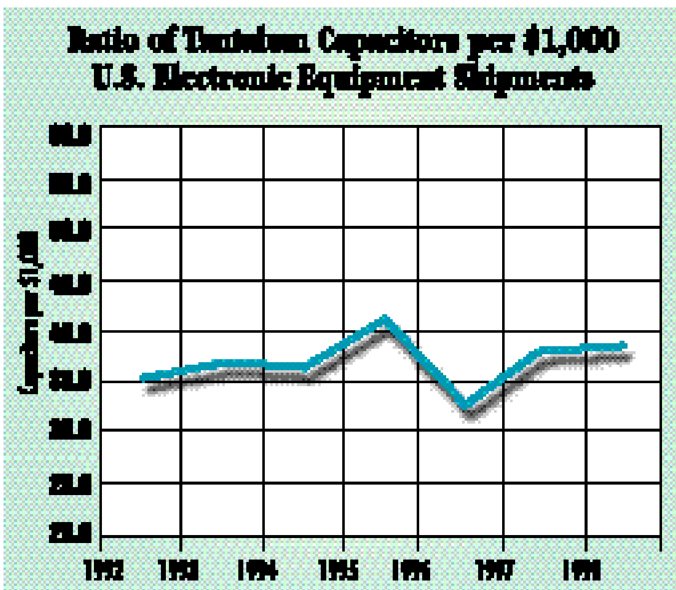


Figure 5

Figure 5 shows that from 1992 to 1997, there were about 38 tantalum capacitors used worldwide per $1,000 of U.S. electronic equipment shipments, making 38 the base calculation. Data for the U.S. electronic equipment shipments are available from the U.S. Department of Commerce. Capacitor shipment estimates are by H. C. Starck, Inc.

In Figure 6, the 38-capacitors-per-$1,000 base is used to calculate the worldwide demand for tantalum capaci- tors from 1998 through 2000. The calculated demands for worldwide shipments are 15, 17, and 19 billion in 1998, 1999, and 2000, respectively. The figure also shows that actual shipments were 15, 18, and 26 billion. Thus, the surplus was 1.0 billion in 1999, and perhaps as much as 6 billion in 2000. That is an accumulated surplus of over 7 billion in two years. The 7 billion excess capacitors represent as much as a 12-month supply of tantalum capacitors. Those "surplus" capacitors are in OEM and EMS equipment, DSL boards, cellphones, Internet equipment, and other products that have not yet been "shipped to the consumer."

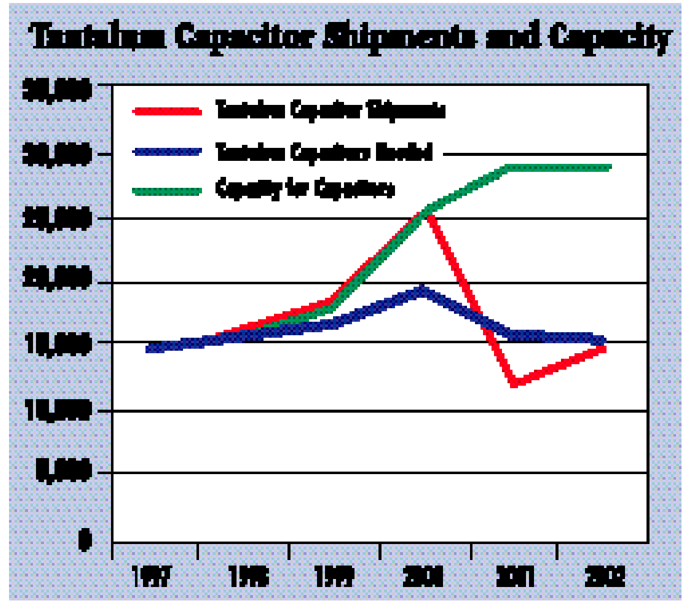


Figure 6

Because of shortages in 1999 and 2000, capacitor manufacturers (Fig. 6) added capacity that raised industry levels to 29 billion capacitors. Some believe the present capacity could be 36 billion pieces, which should be sufficient to meet the demands of a market growing at 20% AAGR until the year 2005 and at 10% AAGR until the year 2010. There is plenty of capacity in the tantalum capacitor supply chain, which responded very well by shipping 6-to-7 billion more tantalum capacitors that were actually sold in end markets.

Tantalum Powder Shortage

The situation in the tantalum powder industry before 1998 was nearly the same as that for tantalum capacitors. Powder prices and profits were low and the processors were not adding capacity. When end markets began to grow late in 1998, inventories of powder fell and demand began to increase. In 1999, end-market demand estimates increased significantly. By 2000, demand was met only because processors and miners liquidated their WIP and strategic inventories. New take-or-pay contracts were signed with miners to ensure continued supplies.

The calculation for tantalum powder is based on its relationship to U.S. electronic equipment shipments. The period between 1992 and 1997 was the standard and stable period. Figure 7 shows that during that period about 1.8 grams of tantalum powder were shipped for every $1,000 of U.S. electronic equipment. The Tantalum and Niobium Information Center, a trade association in Brussels, provided the tantalum

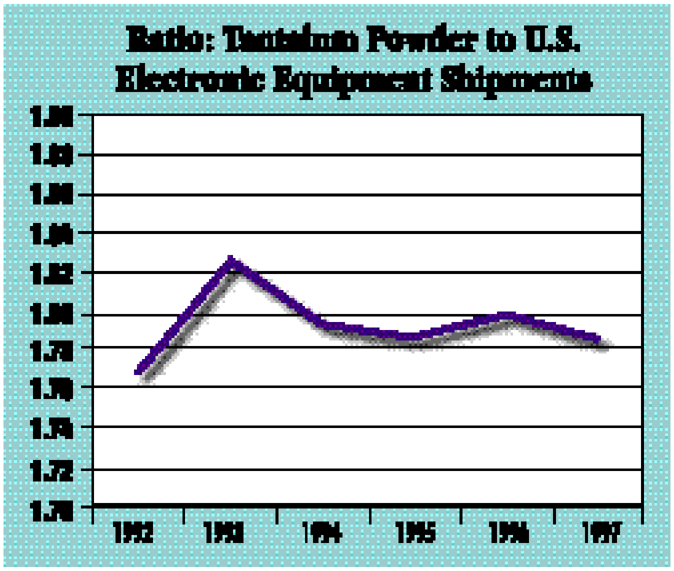


Figure 7

powder shipment data.

Tantalum powder demand can be calculated using the following relationship. During 1998, the calculated demand was 670 metric tons (1.47 million pounds); in 1999, the calculated demand was 820 metric tons (1.8 million pounds); in 2000, the calculated demand was 925 metric tons (2.04 million pounds).

The calculated demand for tantalum powder, the actual shipments of tantalum powder, the excess tantalum powder, and the new capacity added by the tantalum powder processors are shown in Figure 8. The calculated demand for tantalum powder was much less than actual shipments. In 1999, 1,000 metric tons (2.20 million pounds) of powder were sold by processors, while the calculated end-market demands were only 820 metric tons (1.8 million pounds). In 2000, 1,360 metric tons (3 million pounds) of powder shipments were sold, with the calculated demand only 925 metric tons (2.04 million pounds).

A tantalum powder surplus of nearly 900 metric tons (2.0 million pounds) was produced in 1999 and 2000. That powder was used in capacitors making up inventories of routers, cellphones, computers, circuit boards,

Continued on page 27

Conductive Adhesives for Solid Tantalum Capacitors: Process and ESR Optimization by Material Selection

Dr. G. Dreezen; E. Deckx; Dr. G. Luyckx
Emerson & Cuming
Belgium

Introduction

With the dramatic growth in electronic circuitry applications, more demands are being placed on those systems' integrity and reliability. More circuits require use of higher frequencies and smaller space to miniaturize products. The next-generation microprocessors require lower voltages and increased supply currents. Over the past 3.5 years, microprocessor current has increased five times and equivalent series resistance (ESR) requirements have dropped by a factor of seven. Therefore, capacitors must have high capacitance and low ESR [1]. Tantalum capacitor manufacturers have been developing novel technologies, such as new anode design and process optimization, in order to achieve the lowest possible ESR [2–7]. Conductive silver adhesives used for bonding the tantalum anodes onto the lead frame have an impact on both the electrical and mechanical performance. As a supplier of such adhesives, Emerson & Cuming conducted a research program in order to identify and develop silver adhesives that combine a very high throughput with excellent electrical and mechanical performance.

This paper investigates the effect of different adhesives combined with different lead frame metalizations on ESR and mechanical strength. The effect of the cure schedule is also evaluated. It is concluded that the selection of a conductive silver adhesive depends on the metalization of the lead frame and the preferred cure method.

Background

A tantalum capacitor design was discussed in detail in a previous publication [8]. From that study it was concluded that both the graphite and silver coating used to connect all the MnO_2 to the external cathode can have a strong impact on the tantalum capacitor's ESR performance. Material selection and process optimization recommendations were proposed.

After dipping and curing of the graphite and silver coating, the cathode terminals are joined to the cathode lead frames using a silver-loaded conductive adhesive. The anode wires are welded to the anode lead frame. Finally, the element is molded in an epoxy resin case to ensure pick-and-placeability and tight control over the component dimensions.

The electrically conductive adhesives used are typically epoxy-based, containing 70%–80% by weight of silver in order to achieve electrical conductivity after cure. These adhesives are available as two-component, premixed, frozen systems or as real, one-component materials, and can be applied by pin transfer, dispensing, or printing. Both oven-cure (slow) or snap-cure (fast) processes can be used, depending on the adhesive type. Lead frame metalizations typically used are silver, tin or tin/lead.

Resistance losses occurring in a capacitor are expressed in the ESR, one of the primary parameters characterizing these products [9]. ESR decreases as frequency increases. At high frequencies, commonly used in most circuit applications, contributions to ESR from the tantalum anode and the Ta_2O_5 dielectric are negligible. Tantalum capacitor manufacturers ascribe the bulk of the ESR contribution to the MnO_2 layer [2,10]. The MnO_2 contribution is related to both resistivity and geometric factors, depending strongly on manufacturing procedures. Capacitor manufacturers expend considerable effort to keep resistance low and repeatable.

ESR performance of electrically conductive adhesives is seldom discussed in literature. In this paper, the performance of different chemistries is considered. ESR numbers on semifinished capacitors combined with different lead frame metalizations are compared. The effect of curing conditions on ESR is studied as well. Additionally, the mechanical strength of the silver adhesives as a function of the lead frame metalization is studied; these mechanical data are compared with the ESR data. Finally, recommendations for conductive silver adhesive selections are made.

Experiment Setup

Capacitors

Semifinished B- and E-case capacitors were used.

Continued on page 20

First Choice Supplier of Adhesives, Coatings and Encapsulants to the Passive Components Industry

Emerson & Cuming
a National Starch & Chemical Company

E-Mail: emerson.cuming@innet.be **URL:** http://www.emersoncuming.com

Europe
Nijverheidsstraat 7
B-2260 Westerlo
Belgium
☎ +(32)-(0) 14 57 56 11
Fax: +(32)-(0) 14 58 55 30

North America
46 Manning Road
Billerica, MA 01821
☎ 800-832-4929
☎ 1 (978) 436-9700
Fax: 1 (978) 436-9701

Asia-Pacific
100 Kaneda, Atsugi-shi
Kanagawa-ken, 243
Japan
☎ (81) 462-25-8815
Fax: (81) 462-22-1347

Continued from page 18

The capacitors were received with graphite coating, dipped with a silver coating, and cured in the lab. E-case capacitors were used to evaluate ESR performance; the adhesive strength study was performed using B-case capacitors.

Conductive Silver Adhesives

Seven silver adhesives were selected for this study; some were not typical epoxy chemistries, as described in Table 1. Two materials were chosen because they can be cured in both oven-cure and snap-cure processes. The cure temperature was, where possible, kept at 150ºC. For some materials, higher and lower cure temperatures were studied as well. The cure time used was as recommended for each material. Table 1 also indicates possible application methods for those materials.

Material	Chemistry	Application Method	Cure Schedule
A1	Epoxy	1 or 2	60 s @ 180˚C
			30 min @ 150˚C
			45 min @ 120˚C
A2	Epoxy	1	60 s @ 180˚C
			30 min @ 150˚C
			45 min @ 120˚C
A3	Epoxy	1	30 min @ 150˚C
A4	Epoxy	1 or 3	1 h @ 150˚C
A5	Epoxy Silicone	1	30 min @ 150˚C
A6	Silicone	1	1 h @ 150˚C
A7	Epoxy	1	1 h @ 180˚C

Table 1: Studied conductive silver adhesives. Application methods: 1–dispensing, 2–printing, 3–pin transfer.

Termination Materials

Three different substrates were used: silver, tin, and solder (Sn/Pb 62/38). All substrates were cleaned with ethanol before use.

Sample Preparation and ESR and Adhesive Strength Measurement

Silver adhesive was applied by stencil printing in order to obtain a controlled thickness of approximately 150 µm for all materials. All capacitors were placed manually, and the adhesives were cured according to the required schedule.

ESR measurements were made with an HP4284A LCR meter at the semifinished E-case capacitors, using Kelvin clip, gold-plated test leads. ESR measurements were performed at 1 VAC, 100 kHz by clamping one clip to the anode wire and the other to the termination substrate as shown by (1), Figure 1. Further analysis was done by evaluating the ESR number from the anode wire to the silver coating (2) and from the silver coating to the substrate (3). It was proven that a sample 15 capacitors from one single batch give a reliable ESR number. A typical measurement of 70 mΩ showed a standard deviation of approximately 3 mΩ–4 mΩ. The adhesive strength was measured using a die shear test of semi-finished B-case capacitors and recorded in newtons.

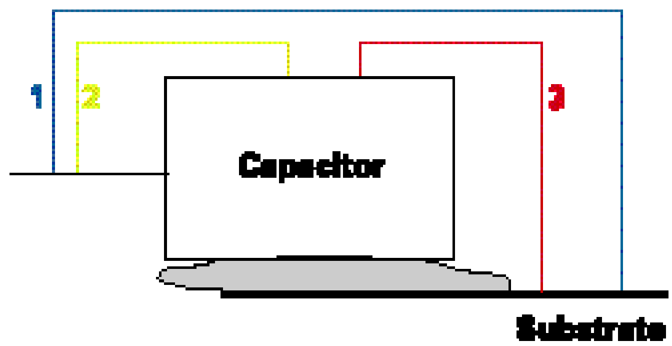


Figure 1: Schematic drawing of ESR measurements on a capacitor bonded on the substrate with a conductive adhesive: (1) from anode wire to substrate; (2) from anode wire to Ag coating; (3) from Ag coating to substrate.

Results and Discussion

ESR performance and the mechanical strength of the electrically conductive adhesives were evaluated. Below, the ESR level on different metalizations is considered first, followed by the relation between ESR and volume resistivity and the effect of the cure schedule on ESR. Next, the shear strength on different substrates is studied, which includes a discussion of the influence of using different cure schedules and a more detailed investigation of the failure mechanism. Finally, additional particulars on the ESR contribution of the different interfaces are discussed.

ESR Performance

ESR on different substrates

The ESR of the different silver adhesives on silver (Ag), tin (Sn), and solder (SnPb) substrates was evaluated. Adhesives A1 and A2 were evaluated using three different cure profiles. All data are presented in Table 2.

The lowest ESR numbers were obtained using silver terminations. All adhesives show ESR values between 63 mΩ and 75 mΩ, indicating that the ESR on a Ag substrate is not very dependent on the applied adhe-

Continued on page 22

Continued from page 20

sive. The low ESR number obtained with the silicone adhesive A6 was remarkable, but might have been related to the pressure-sensitive contact resistance of that material. When excluding that result, the ESR spread from different adhesives reduced to 69 mΩ–75 mΩ. Further, the variation in ESR became smaller when similar cure temperatures were compared: at 180ºC from 72 mΩ–75 mΩ and at 150ºC from 69 mΩ–73 mΩ. That indicates that the ESR on a Ag substrate depends more on the cure schedule than on the Ag adhesive.

Material	Cure	Volume Resistivity (Ω.cm)	ESR (mΩ)		
			Ag	Sn	SnPb
A1	60 s @ 180˚C	1.4×10^{-4}	75	125	132
	30 min @ 150˚C	7.2×10^{-4}	72	259	202
	45 min @ 120˚C	1.6	69	610	135
A2	60 s @ 180˚C	1.1×10^{-4}	75	89	74
	30 min @ 150˚C	1.0×10^{-4}	71	87	89
	45 min @ 120˚C	6.9×10^{-3}	72	99	84
A3	30 min @ 150˚C	2.8×10^{-4}	73	167	160
A4	1 h @ 150˚C	5.5×10^{-4}	70	164	81
A5	30 min @ 150˚C	1.2×10^{-4}	70	1082	157
A6	1 h @ 150˚C	3.2×10^{-3}	63	187	75
A7	1 h @ 180˚C	4.9×10^{-5}	72	81	83

Table 2: Volume resistivity and ESR numbers on different substrates .

When using Sn substrates, pronounced differences in ESR performance between the various adhesives were observed. Best results were obtained with A7 and A2, showing values of 81 mΩ and 87 mΩ–99 mΩ. Moreover, ESR values were significantly higher, as compared to the Ag substrate. Poor performing adhesives displayed a significant contribution to the ESR number of the semifinished capacitor, with ESR values ranging from 125 mΩ–1,000 mΩ, as observed for all other materials.

Clearly, when bonding on Sn substrates, a proper selection of one of the above-mentioned low-ESR adhesives is necessary.

A similar conclusion can be made for the SnPb substrate, although in general, lower data were reported, as compared to Sn substrates. For SnPb substrates, a proper adhesive selection is necessary to achieve the best ESR performance Moreover, changes from solder to tin metalizations might have a significant impact on ESR data, depending on the adhesive used.

<u>ESR vs. volume resistivity</u>

When comparing ESR numbers with the volume resistivity of the conductive adhesives, it becomes clear that there is no direct relationship. Materials with poor volume resistivity display good ESR numbers (e.g., material A1 on Ag after 45 minutes, curing at 120ºC) and vice versa (e.g., material A5 on Sn), which indicates that most probably it is not the bulk resistance of the adhesive, but the poor contact resistance between the adhesive and the substrate that has the highest impact on ESR.

<u>ESR vs. cure schedule</u>

The ESR numbers on the different substrates using different cure profiles for adhesives A1 and A2 indicate that significant differences in ESR levels can be obtained. Clearly, optimization of the cure schedule can give significant ESR improvement. Production speed and capacity is, of course, another major issue that influences the required cure schedule.

Adhesive Strength of Conductive Adhesives

Shear test results of the different silver adhesives on silver (Ag), tin (Sn), and solder (SnPb) substrates were evaluated. All data are presented in Table 3.

Material	Cure	Capacitor Shear Strength (N)			Failure Mechanism
		Ag	Sn	SnPb	
A1	60 s @ 180˚C	16.7	10.1	9.6	Capacitor Failure
	30 min @ 150˚C	19.2	15.4	16.2	Capacitor Failure
	45 min @ 120˚C	20.4	16.1	16.0	Capacitor Failure
A2	60 s @ 180˚C	9.5	10.6	10.3	Capacitor Failure
	30 min @ 150˚C	14.6	12.1	11.9	Capacitor Failure
	45 min @ 120˚C	15.2	11.6	9.8	Capacitor Failure
A3	30 min @ 150˚C	9.8	13.6	13.7	Capacitor Failure
A4	1 h @ 150˚C	11.1	11.4	7.8	Capacitor Failure
A5	30 min @ 150˚C	11.6	8.8	7.5	Adhesive Failure
A6	1 h @ 150˚C	2.7	2.0	2.2	Adhesive Failure
A7	1 h @ 180˚C	15.01	12.0	9.9	Capacitor Failure

Table 3: Shear strength (B-case capacitors) of sil ver adhesives on different substrates.

<u>Shear strength on different substrates</u>

For most adhesives, the adhesion on Ag was

Continued on page 24

Continued from page 22

20%–50% higher than on Sn and SnPb substrates. In all cases, material A1 gave the highest results. Adhesives A2, A3, and A8 gave good results on Sn and SnPb as well. As expected, the silicone material A7 gave very low values. The adhesion of all epoxy-based materials was acceptable, and all epoxy materials performed similarly.

Shear strength as function of cure schedule

Both materials A1 and A2 gave better adhesion when cured at lower temperatures. At those lower temperatures, the reaction proceeded at a slower rate that resulted in higher adhesion and probably lower stress as well, which also improved shear strength. Snap-cure of the adhesives had a negative impact on the adhesion; such a snap-cure process may require materials with improved adhesion.

Shear strength and failure mechanism

In five out of seven cases, the failure mechanism concerned a capacitor failure at the MnO_2/graphite interface. Only the epoxy silicone and silicone-based materials showed an adhesive failure. It is remarkable that despite the appearance of capacitor failures between the MnO_2 and graphite layer (which is identical for all systems studied), differences in shear strength between the various adhesives were reported. A possible explanation for that phenomenon is that the shear strength of the capacitor depends on the stress relaxation mechanism of the adhesive.

Substrate	Cure	ESR (mΩ) Wire/ Substrate	ESR (mΩ) Wire/ Coating	ESR (mΩ) Coating/ Substrate
Ag	60 sec @ 180°C	75	79	42
	30 min @ 150°C	72	76	41
	45 min @ 120°C	69	74	38
Sn	60 sec @ 180°C	125	79	87
	30 min @ 150°C	259	80	226
	45 min @ 120°C	610	78	577
SnPb	60 sec @ 180°C	132	76	103
	30 min @ 150°C	202	79	176
	45 min @ 120°C	135	76	104

Table 4: ESR numbers from (1) wire to substrate, (2) wire to coating, and (3) coating to substrate measured, with adhesive A1 on different sub strates.

ESR Contribution of the Adhesives—Further Details

Typical (low) ESR readings from the anode wire to the substrate range from 70 mΩ–80 mΩ. In Table 4, additional ESR data measured from the anode wire to the Ag coating and from the Ag coating to the substrate (as described in Figure 1) are presented for adhesive A1.

In all cases, the ESR number from the anode wire to the Ag coating remained approximately constant at values between 74 mΩ and 80 mΩ. The ESR number from the coating to the silver substrate was in all cases lower than the anode wire/coating ESR number. On the contrary, Sn and SnPb metalizations showed higher ESR readings from the coating to the substrate than from the anode wire to the coating. Those higher ESR numbers on Sn and SnPb must be related to the contact resistance at the coating/adhesive/substrate interphase. Because the coating/adhesive composition and cure profile are similar in all cases, we can conclude that the high ESR values on Sn and SnPb are related to poor contact resistance between the adhesive and the metal substrate.

Conclusions

The purpose of this study was to obtain a better understanding of all aspects influencing the equivalent series resistance (ESR) performance and processing of electrically conductive adhesives. Different adhesives were applied; the ESR and capacitor shear strength were evaluated versus different processing parameters and metalizations used in the industry.

It is shown that no relation exists between the volume resistivity of the studied adhesives and the ESR of the capacitors (similar conclusion as for the silver and graphite coatings). The lowest ESR values are obtained on Ag-plated lead frames and show only minor differences between different adhesives. Sn and SnPb substrates require an appropriate adhesive selection in order to achieve acceptable ESR numbers. Silicone and epoxy silicone adhesives might be useful when looking at ESR data, but show very low mechanical strength, which would result in high yield losses.

It can be concluded that when the appropriate adhesive is used, the ESR contribution of the adhesive is very small. The following selection criteria are most important when choosing the best adhesive:

- Plating on the lead frame: Ag, Sn, or SnPb.

Continued on page 26

If Variety Is The Spice Of Life... Then Let NIC Add Flavor To Your Design!

NIC offers over 100 different product series of passive components! With so many choices, NIC gives you the options you need to spice up your designs...

If you need lower ESR, reduced package sizes, high frequency performance or extended temperature ratings, NIC has a series to meet your needs!

With so many component options to choose, NIC can show you the value and ease of reducing or consolidating your multi-supplier bill of materials.

With over 5 billion surface mount and leaded components in our global inventory we can support your expanded production requirements.

Check out NIC's full feature website:

www.niccomp.com

- *For the latest product updates*
- *On-line cross referencing*
- *On-line stock checks (distributor inventory)*
- *On-line sample requests*
- *Product selection guides*
- *Technical product info*
- *Quick look-up guides & tools*

Corporate Headquarters
70 Maxess Road
Melville, New York 11747
(631) 396-7500 / FAX 631-396-7575

Western Region
2070 Ringwood Avenue
San Jose, California 95131
(408) 954-8470 / FAX 408-954-0349

NIC Components Corp.

Technical Inquires: tpmg@niccomp.com
Sales Inquires: sales@niccomp.com

www.niccomp.com

ALUMINUM • TANTALUM • CERAMIC • FILM • RESISTORS • INDUCTORS • FERRITE CHIP BEADS • THERMISTORS • VARISTORS • DIODES

Continued from page 11

Tantalum Capacitor Production

Paumanok has counted 26 separate tantalum capacitor producers worldwide in 2001, operating 36 separate production facilities worldwide. Although it may appear to be more, many companies resell other manufacturers' tantalum capacitors, especially in Asia and the United States.

The major producers include KEMET Electronics, AVX Corporation, and Vishay Intertechnology in the United States. These three companies represent the top-tier suppliers of tantalum capacitors with respect to 2000 revenues: each earned more than US$700 million. Their activity affected the total market shares for all capacitor producers.

KEMET maintains major production facilities in South Carolina and Mexico. AVX Corporation supports major production operations in Lanskrovn in the Czech Republic, with minor operations in Maine, El Salvador, and Mexico. AVX also retains its tantalum administrative operations in Paignton, UK, and may take delivery of raw materials at that location. However, all front- and back-end production now takes place in the Czech Republic. Vishay maintains production facilities in Maine, Florida, and Dimona, Israel. In 2000 and 2001, the company purchased two U.S.-based tantalum producers (Tansitor and Mallory).

Continued on page 40

Featured Technical Paper

Continued from page 24

• Application method: dispensing, printing, or pin transfer.

• Cure conditions: oven-cure (batch process) versus snap-cure (in-line).

References

1. Toomey D., and J. Racine. *Powerconversion & Intelligent Motion: The Fusion of Power & Motion Technology.* 21.6 (1995).

2. Hahn, R., and B. Melody. "Process for Producing Low ESR Solid Tantalum Capacitors." *Passive Component Industry* 2.1 (2000): 17.

3. Winkler, G., J. Gerbingler, and M. Brenner. "Lowest and Stable ESR Values of Tantalum Capacitors with Improved Standard Technologies." *CARTS-EUROPE 1999 Proceedings.* East Sussex, UK: ECII, 1999. 79.

4. Ladd, J. "Lowest Available ESR Conformally-Coated Multiple-Anode Tantalum Capacitor." *CARTS-EUROPE 1999 Proceedings.* East Sussex, UK: ECII, 1999. 107.

5. Prymak, J. D. "Replacing MnO_2 with Conductive Polymer in Tantalum Capacitors." *CARTS-EUROPE 1999 Proceedings.* East Sussex, UK: ECII, 1999. 169.

6. Zednicek T., and Z. Sita. "New Family of AVX Tantalum Capacitors for 150ºC Operation." *CARTS-EUROPE 1999 Proceedings.* East Sussex, UK: ECII, 1999. 54.

7. Kobayashi A., Y. Saiki, and K. Watanabe. *Antec 1998 Conference Proceedings.* 1202.

8. Dreezen G., E. Deckx, S. Cheng, and G. Luyckx. "Carbon and Silver Coatings for Solid Tantalum Capacitors: ESR Reduction by Material and Process Optimisation." *CARTS-EUROPE 1999 Proceedings.* East Sussex, UK: ECII, 1999. 37.

9. Stroud, J.P. *Proceedings 40th Electronic Components and Technology Conference* 2 (1990). 1009.

10. Gill, J. AVX Technical Publication. See Web site at www.avxcorp.com. ❑

Continued from page 17

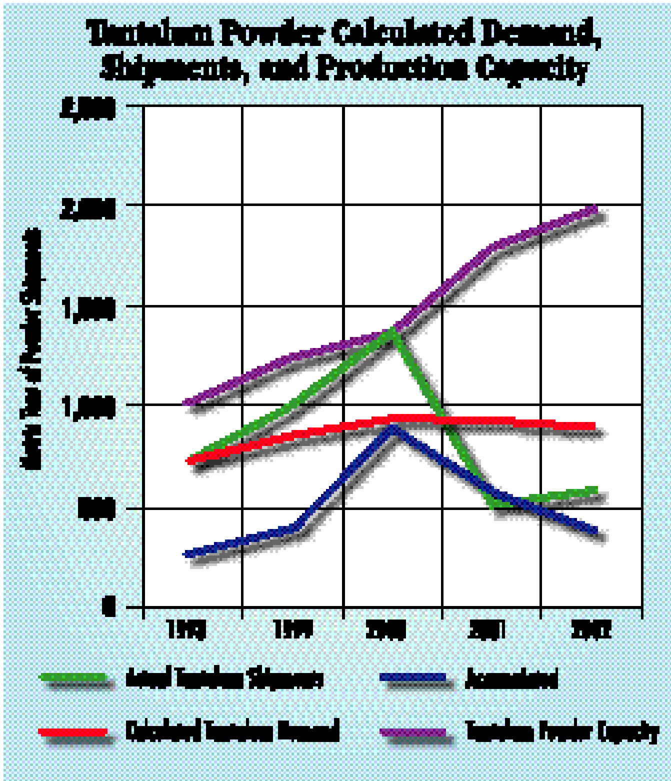


Figure 8

inventories at CSMs, and inventories of powder within the supply chain. Nine hundred metric tons (2 million pounds) represent nearly a one-year demand for tantalum powder at 2002 requirements. With the demand for all electronic products dropping in 2001, the surplus could last longer than one year.

Figure 8 shows the capacity of the tantalum powder industry. It increased to about 1,300 metric tons (2.9 million pounds) in 2000 and to 1,800 metric tons (3.97 million pounds) in 2001. The industry will have capacity to ship 2,000 metric tons (4.4 million pounds) in 2002. The increases in capacity are all part of long-term projects that had been planned and were initiated during 1999 and 2000. Even with no additional investment, enough capacity exists to meet electronics demands until 2006 or perhaps 2010.

The response of the tantalum powder processors was sufficient to meet real demand. Shipments of tantalum powder were in excess of calculated demand, which created an approximate one-year surplus. Tantalum processors added capacity to ensure the long-term viability of the tantalum industry.

The tantalum market in 1998, 1999, and 2000 was very near equilibrium. The inflated demand estimates, the double ordering, and the bad press enticed speculators to enter the market. When that happened, the supply chain failed to meet the needs of all its members. A real-life situation illustrates the same affect. Residents living along the East Coast of the United States are familiar with hurricanes. When the weatherman forecasts that a hurricane strike is imminent, people flock to the stores and buy every flashlight battery, every loaf of bread, and every bottle of milk, exhausting entire stocks of those products. When things return to normal, no one ever questions the supply chain for batteries, bread, or milk. Does anyone stop buying batteries, bread, or milk? In 1999 and 2000, the tantalum supply chain received a hurricane warning.

Tantalum Mining and Raw Materials

Sufficient quantities of tantalum capacitor and tantalum powder existed to meet real demand. Seven billion surplus tantalum capacitors were made. There must have been enough ore, whether in process or in inventories, but the shortage warnings in 2000 stimulated miners to take very positive actions to ensure there was enough raw material for the supply chain.

Tantalum raw material supplies are classified as either reserves or resources, based on degree of exploitation and value of commercialization. A commercial deposit is one that can be exploited at or near today's market value for the mineral. Commercialization changes as the value of the commodity in the market place changes. What is a noncommercial resource today can become a commercial reserve tomorrow. Market prices and availability are in control.

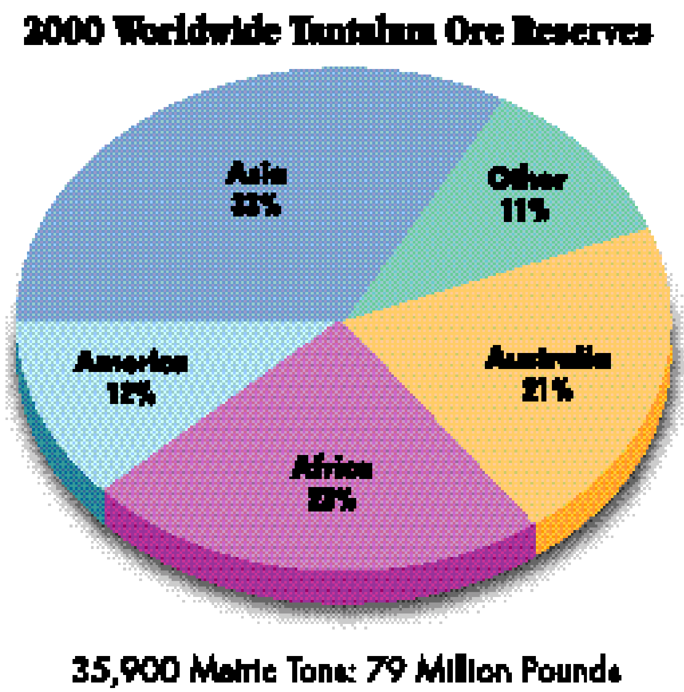


Figure 9

A reserve is a deposit whereby the quantity and quality are defined as commercial. The commercialization of deposits beyond 30 years makes poor economic sense because of market uncertainty and taxation practices.

Tantalum reserves, shown in Figure 9, contain 79 million pounds (36,000 metric tons) of tantalum. That is sufficient to supply the entire industry for 16 years. The two

Commodity	Years Life Span
Copper	63
Coal	230
Oil	35
Tantalum	125

Life span calculated with tantalum consumption based on 2000.

Figure 10

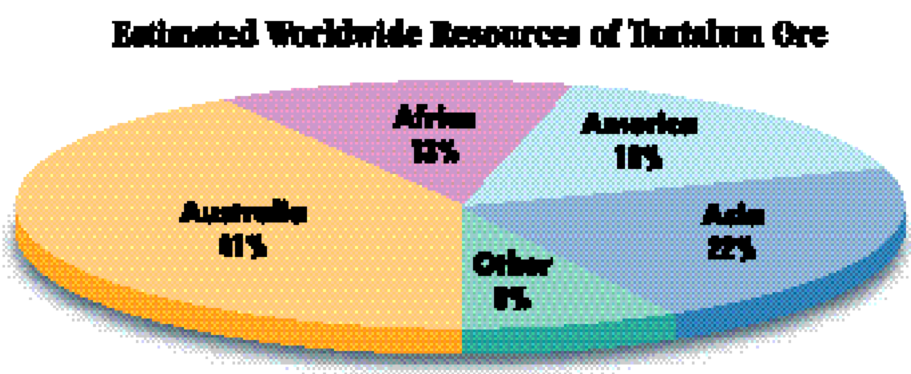
largest mines in the world are Greenbushes and Wodgina, located in Australia. Both are owned by Sons of Gwalia, primarily a tantalum mining company that has made major investments to create a secure, long-term supply of tantalum.

Resources are raw material deposits that have been roughly defined, but may not be of commercial value at the present time. Figure 11 shows the locations of resources and their approximate quantities, estimated at 633 million pounds (287,000 metric tons). This is a 125-year supply based on the consumption of 5 million pounds per year. Major resources are in Australia, Asia, Africa, and the Americas, with the largest resources in Australia.

Tantalum reserves are 16 years and resources are more than 125 years. The size of the resource makes tantalum a more dependable raw material than oil or copper (Fig. 10). Although copper reserves are significantly less than those for tantalum, copper remains a major raw material for the electronics industry. There are no concerns over copper shortages. Tantalum compares very favorably with other raw materials.

In 1997 and 1998, low ore prices and low demand for tantalum products greatly reduced exploration for tantalum ore. In 2001 and 2002, that changed greatly.

The tantalum supply chain has another source of raw material. The U.S. Defense Logistic Agency (DLA) has been buying, storing, and selling the government's tantalum stockpile for many years. The DLA's original purpose was to maintain a stable supply of key strategic materials, in case of war. Tantalum fits the defi- nition because it is used in military electronics, cutting tools, the nuclear industry, and because there are no significant reserves within the United States. The DLA may still have 580 metric tons in inventory.



287,000 Metric Tons: 633 Million Pounds

Figure 11

Tantalum Ore Production

Figure 12 shows actual tantalum ore production in 1998 and 2000. It also shows our estimate of capability for 2003. In 1998, the world's mines produced about 2 million pounds of tantalum per year. By 2000, the output had increased to over 3 million pounds. In 2003, the mines would be able to produce more than 5.5 million pounds, assuming demand is there today.

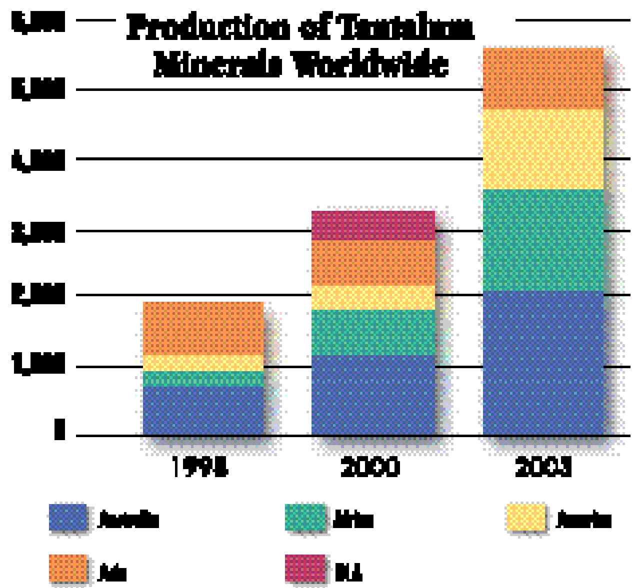


Figure 12

In 2000, the 3 million pounds of tantalum raw material produced were much less than the 5 million pounds shipped to tantalum capacitor manufacturers. The remainder came from inventories held by miners, processors, and the DLA. It is not unusual for miners and processors to carry an inventory that exceeds a twelve-month demand. In addition, scrap recycling increased to 25% or 30%. Shortages in the supply chain caused the major source of tantalum ore (i.e., Sons of Gwalia) to increase its production capability, so now Sons of Gwalia alone can produce nearly 2 million pounds of tantalum. In 2003, production capacity of the mines could be more than 5.5 million pounds; the supply chain demand in 2003 will not require production at full capacity.

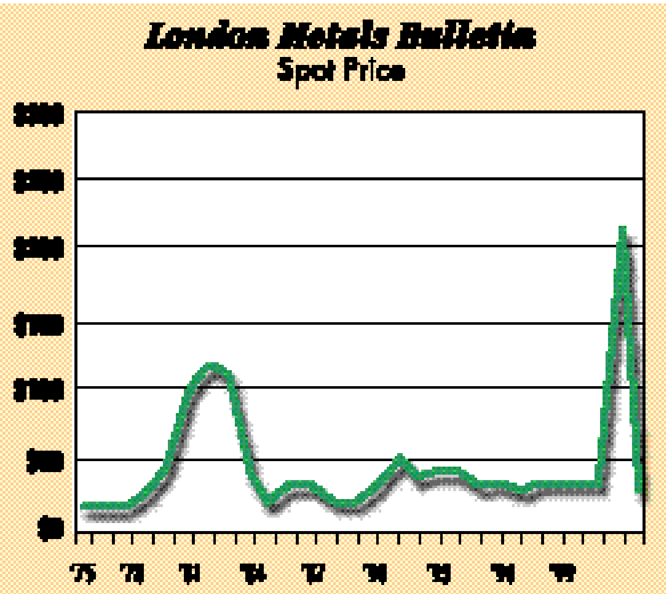


Figure 13

The shortage of material may only have been perceived, but there was a real increase in the price of tantalum materials. The spot price for tantalum ore is as reported by the *London Metals Bulletin* (Fig. 13). The *LMB* price is the number generally reported for sales and purchases of tantalum pentoxide content of ore in the spot market. It does not reflect the prices of long-term contracts.

In the last 30 years, there have been two short periods when the tantalum ore price was unstable. In the late 1970s, the price of ore jumped, then returned to nearly the same as that before the excursion. In 2000, the price rose quickly, then again returned to normal.

Figure 14 graphs the performance of tantalum powders from 1965 to the present. It shows how powder processors have made higher CV powders available to capacitor makers. Those improvements have been passed along to end-users by the continued increase in capacitance in each case size. The figure shows that tantalum powders

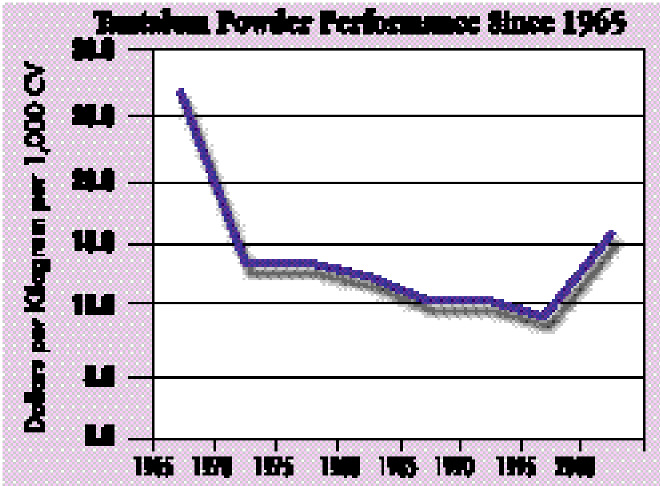


Figure 14

are proceeding down the price learning curve. The year 2000 was an anomaly. We can expect prices to return to the normal curve.

Conclusions

• The tantalum supply chain is long and complex.
• Production of capacitors and powder was in excess of calculated demand.
• During 1999 and 2000, the perceived or real shortage did not help the reputation of the tantalum supply chain.
• Tantalum capacitor manufacturers and powder processors have sufficient tantalum to meet a 20% AAGR until 2006 and a 10% AAGR until 2010.
• Tantalum resources are abundant for the next 125 years.
• Commercial deposits of tantalum are abundant for the next 16 years.
• By 2003, new ore production capacity will be 5.5 million pounds. That will cover the anticipated growth for 5–10 years.
• Increased demand for tantalum capacitors has spotlighted new mineral projects for development.
• The ore price excursions of 1999 and 2000 have returned to normal.
• Shortages of tantalum materials are a thing of the past.

Recommendations

• Miners and processors need to communicate their plans for capacity, expansion, stockpiles, and long-term pricing so as to ensure that all players understand that supply is secure and reasonably priced. Processors need to communicate technical improvements in their products that will benefit the supply chain.
• Capacitor manufacturers need to communicate their long-range plans to both ends of the chain.
• OEMs need to share their long-range plans and anticipated changes. They must also communicate their requirements for information from the supply chain.
• All segments must find a way to communicate openly about plans to ensure a stable supply chain, and to discuss cooperation and shared responsibility for a better-performing supply chain.
• Each segment of the supply chain has an important function; each needs to communicate its capabilities, plans, and long-term objectives for meeting the demands of the supply chain.
• Tantalum powder manufacturers must establish links to OEMs so that they understand the processing and mining parts of the supply chain, and to ensure them that the supply chain is there to support their long-term plans.
• Tantalum powder manufacturers must communicate to OEMs any changes in production capacities and reserves and resources.
• With such a degree of communication, it is possible that:

—speculation will be minimized;

—miners and processors will have incentive to expand their capabilities to meet market demands;

—capacitor makers will again fully utilize their production capacity;

—OEMs will design tantalum capacitors into applications that make technical and economic sense, bringing about a healthy supply chain with lower prices for everyone in the chain;

—there will never again be a shortage of tantalum. ❑

Meet face to face with communications & information technology professionals at the industry's premier annual event:

June 4-6, 2002

Georgia World Congress Center

Atlanta, Georgia

SUPERCOMM

Explore the Whole World of Communications

The Electronic Components Pavilion at SUPERCOMM 2002

Prime space is still available for the Electronic Components Pavilion at SUPERCOMM 2002. With the U.S. economy on the comeback trail, this is an opportunity you can't afford to miss.

Get the special attention, educational value and access to qualified buyers that only the Pavilion can give you.

Go to the ECA web site or call ECA for more information and to reserve your space.

703-907-7583

http://www.ec-central.org/conference/supercomm2002

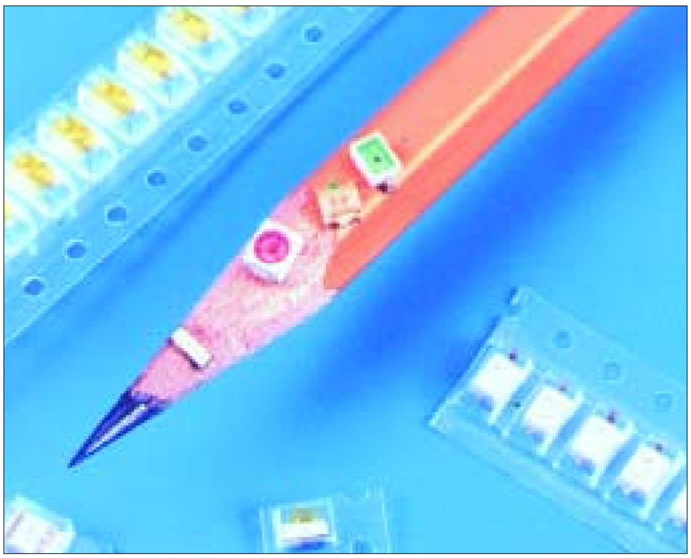
ECA — Electronic Components, Assemblies & Materials Association

EIA — Electronic Industries Alliance

Surface-Mount LEDs Available in a Variety of Packages and Colors

Gilway Technical Lamp offers a wide variety of surface-mount LEDs in industry-standard package styles. Gilway's surface-mount LEDs are designed to save space on printed circuit boards.

The surface-mount LEDs are suitable for IR reflow and vapor-phase reflow soldering and come in gull wing, SOT-23, 1206, 0603, 0805, and other industry-standard packages, as well as assorted styles. Supplied on tape-and-reel for automated placement equipment and available in a full range of colors (including red, yellow, green, orange, blue, white, and bicolor), Gilway



surface-mount LEDs can be provided with different viewing angles, intrinsic brightness, wavelengths, and voltages to match virtually any design requirement. One- and two-pin options and custom packages are available.

Gilway's surface-mount LEDs are priced from $0.11 each, according to style and quantity. Information, samples, and price quotes are provided upon request. Contact Pamela Matos, Product Manager, at (781) 935-4442; fax: (781) 938-5867; Web site: gilway.com.

EPCOS Offers New High Q-Factor Capacitors

EPCOS, Inc., has developed a new series of high-Q capacitors for wireless communications and radio frequency applications. This new series delivers superior performance and lower power consumption at higher frequencies, making it ideal for mobile phone, VCO, TCXO, RF amplifier, LNA, Bluetooth module, filter, satellite TV, cable TV, and GPS applications.

Key advantages include: Q-factor approximately three times higher than normal C0G capacitors with AgPd electrodes; ESR approximately three times lower than normal C0G capacitors; narrow tolerances; and higher SRF than normal C0G capacitors.

All parts have a rated voltage of 50 V. Incorporating a class 1 dielectric ceramic and copper inner electrode, the high-Q capacitors deliver higher conductivity, yielding lower ESR. The HQM class 1 ceramic utilized is a very stable dielectric, offering a temperature coefficient of capacitance of 0 ±30 ppm/°C. The nickel barrier termination ensures good resistance to soldering heat for reflow soldering. The advantage of higher Q-value and correspondingly lower ESR results in lower power consumption. Capacitances range from 0.3–22 pF in case size 0402 and from 0.4–82 pF in case size 0603, offered by standard E12 series.

Samples are available immediately. For additional information, call EPCOS Capacitor Marketing at (800) 888-7729.

New Surface-Mount Chip Capacitors with Poly mer Electrolyte

The new PXAseries from United Chemi-Con are surface-mount chip capacitors that incorporate a solid, functional polymer electrolyte. These capacitors feature an ultralow ESR, low impedance, and high ripple-current capability. The advanced design incorporates heavy-duty materials that can withstand two reflow soldering cycles when exposed to lead-free alloy melting points between 210°C and 230°C.

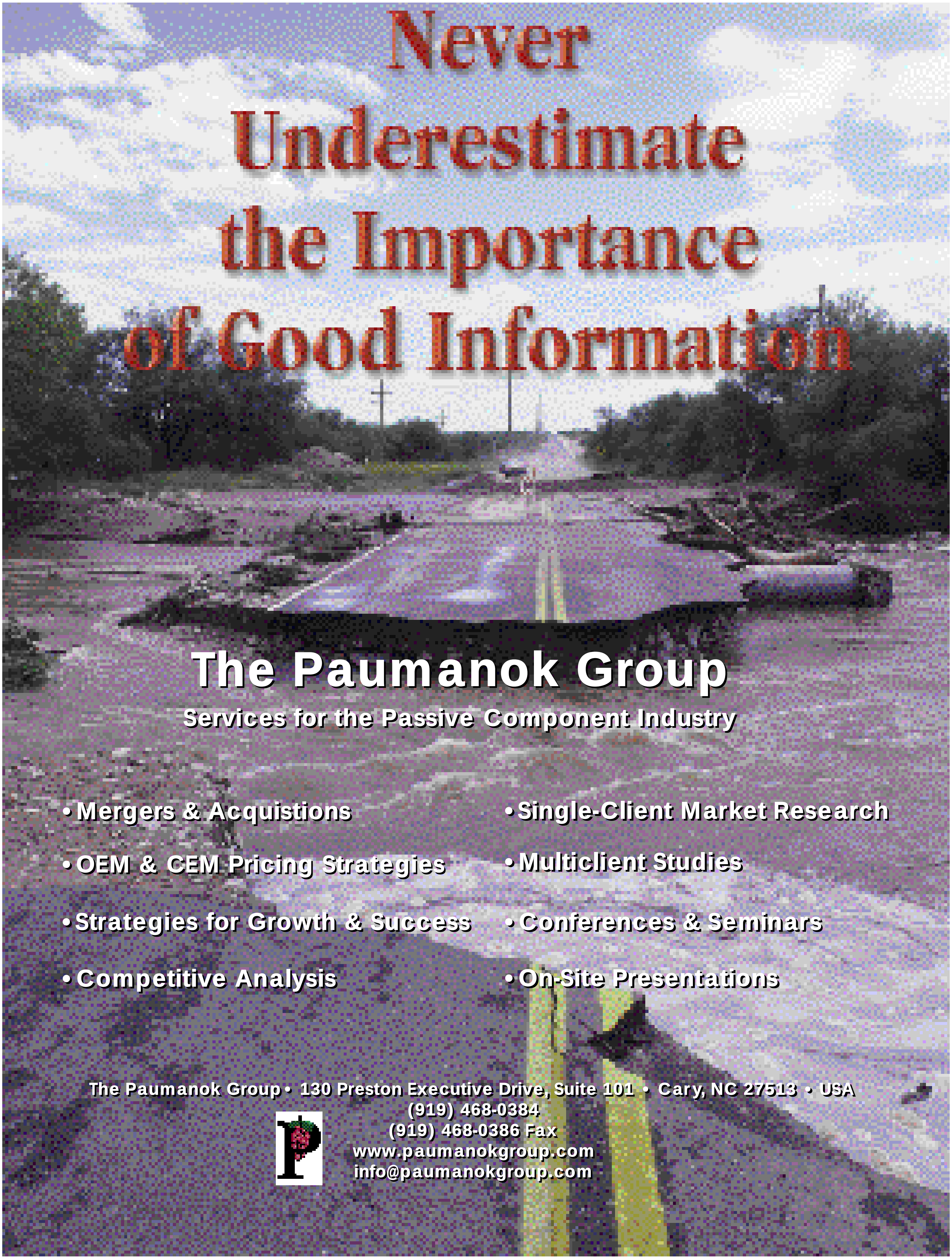
Electrically, the series has a capacitance range of

33–1,000 µF and a voltage range of 2.5–16 VDC. Leakage current is 0.2 CV maximum, after two minutes at +20°C. Operating temperature range is –55°C to +105°C. Rated life is 2,000 hours at +105°C. The PXA series is available in a variety of case sizes, from 6.3 mm x 5.7 mm to 10 mm x 7.7 mm.

Price: $0.25–$0.44 each, in 50,000 quantities; delivery: 12–14 weeks.

For additional information, call United Chemi-Con at (847) 696-2000 or visit the Web site at chemi-

Continued on page 34


Never Underestimate the Importance of Good Information
The Paumanok Group
Services for the Passive Component Industry
• Mergers & Acquistions
• OEM & CEM Pricing Strategies
• Strategies for Growth & Success
• Competitive Analysis
• Single-Client Market Research
• Multiclient Studies
• Conferences & Seminars
• On-Site Presentations
The Paumanok Group • 130 Preston Executive Drive, Suite 101 • Cary, NC 27513 • USA
(919) 468-0384
(919) 468-0386 Fax
www.paumanokgroup.com
info@paumanokgroup.com

Continued from page 32

con.com.

New Low-Inductance, Metalized-Film Power Capacitors Provide Industry's Highest RMS Current Rating, Longer Guaranteed Lifetimes, and Exceptional Reliability

Vishay Intertechnology, Inc., announced the release of a new series of low-inductance, metalized-film power capacitors. Intended for DC-linking, voltage conversion, frequency conversion, and impulse discharge applications, the new Vishay ESTA GLI series devices will be used in traction and industrial drives, uninterruptible power supplies, and other power electronics applications.

The GLI series capacitors feature the industry's highest RMS current rating as a result of an advanced metalized film on the polypropylene dielectric. With a lifetime expectancy of 100,000 hours at 60°C at voltages from 700–2,150 VDC and from 200–500 VAC, GLI series devices offer improved longevity, compared with aluminum electrolytic capacitors and even with competing devices having identical electrical specifications. The GLI power capacitors are resistant to high surge voltages, heavy-duty shock, and vibration, and feature a reliability rating of 300 FIT.

The new GLI devices provide extremely low losses, even at high frequencies, a low ESR, and an exceptionally low inductance value of <30 nH. Rated for operation over a temperature range of –40°C to +70°C, devices in the series are capable of operating at temperatures as high 100°C at half of the rated voltage.

The GLI series features a dissipation factor lower than 8×10^{-4} at a frequency of 1 kHz and a capacitance tolerance of ±5%. Terminal-to-terminal voltage is 1.5 times the rated DC voltage for 10 seconds.

In addition to offering standard voltage and capacitance ratings, the new devices may be customized with a wide range of dielectrics to meet specifications for a variety of AC and DC applications. Integrated flanges enable mounting in close proximity to multiplanar bus bars in IGBT applications. The capacitor casing is polyester with a resin polyurethane filling.

Samples and production quantities of the GLI series capacitors are available now, with lead times of 6–10 weeks for larger orders.

For more information, visit Vishay on the Internet at vishay.com.

EPCOS Launches First Volume Production of Niobium Chip Capacitors

EPCOS, Inc., is the first manufacturer worldwide to ramp up production of niobium capacitors. Volume production is initially focusing on case sizes D and V. In case size D, capacitors rated at 100 µF/10 V are already available. In response to strong market interest, production capacity is being rapidly expanded.

Development of capacitors in case size D, rated at 150 µF/10 V and 220 µF/6.3 V, and in case size V, rated at 68 µF/10 V and 100 µF/6.3 V, has been completed.

In addition, EPCOS will successively widen the product range in all case sizes. Components with higher capacitances and designed for higher rated voltages will be added during the coming year. Ongoing development at EPCOS aims to raise the temperature ceiling for niobium capacitors to 105°C–125°C.

Niobium powder is not only more abundant than tantalum but also considerably more stable in price. In the future, niobium capacitors can be implemented with a significantly higher volumetric capacitance than tantalum components. These features will open up new miniaturization and cost benefits to designers, who will be able to obtain either the same capacitance in a fraction of the space previously required or substantially higher capacitance in the same space. Typical applications include mobile phones and the complete range of communication and information systems.

For more information on niobium chip capacitors, visit EPCOS on the Internet at epcos.com.

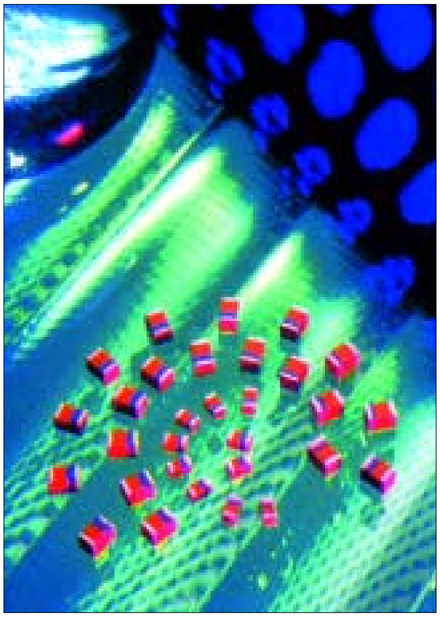
QuadTech Unveils New Handheld Insulation Resistance Meter

QuadTech, Inc., announced that is has expanded its popular line of benchtop insulation resistance testers with the introduction of the IR800 portable tester. The new meter adapts to a wide variety of applications in field installation, preventive maintenance and diagnostic testing, checking insulation resistance of wiring, communication cables, motors, appliances, and a host of other electronic products and controls. The handheld, battery-operated meter was manufactured in conjunction with strategic partner, Seaward Electronic Ltd.

For more information on the IR800 portable tester or other QuadTech products, visit the Web site at quadtech.com

AVX Introduces the World's Smallest Surface-Mount Tantalum Capacitor

AVX has expanded its extensive line of passive components with the addition of the 0402 TACMicrochip™,



the industry's smallest surface-mount tantalum capacitor. Offering design engineers the highest CV rating in an 0402 size, the TAC-Microchip provides enhanced high-frequency performance through superior ESR characteristics, with temperature and voltage stability. Part of the TAC series of capacitors, together with the 0805 and 0603 case sizes, these surface-mount capacitors offer the industry's highest volumetric efficiency.

This latest technology is targeted for applications where miniaturization is paramount, from cellular handsets to satellite systems. It is the world's first tantalum chip in a standard 0402 format. The TAC series capacitors achieve superior performance through innovative construction. Whereas conventional lead frame devices are comprised of only 30% active tantalum element, AVX's new process increases this volume to more than 70% in the TAC series, while dramatically reducing the overall size of the capacitor.

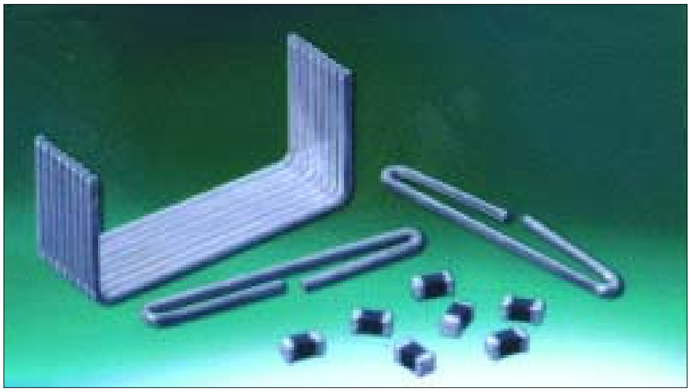
Typical CV specifications for the 0402 TACMicrochip include some of the industry's highest, such as 0.47 µF at 10 V; 1.0 µF at 6 V; and 2.2 µF at 3 V. Standard capacitance tolerances are ±20% over the operating temperature range of –55ºC to +125ºC. The TACMicrochip is also available in 0603 and 0805 case sizes in the following voltage options: 2, 3, 4, 6.3, 10, and 16. AVX offers a high-reliability version in the 0603 and 0805 case sizes, qualified for use in medical applications.

All TAC series are packaged on tape-and-reel and are compatible with automatic placement equipment. Typical pricing for the 0402 TACMicrochip capacitors starts at $0.90 in OEM quantities, with lead times from stock to 8 weeks.

For more information on AVX's tantalum chip capacitors, contact AVX Sales & Marketing at (843) 946-0414; fax: (843) 626-5186; Web site: avxcorp.com.

New 0603 High-Frequency Chip Inductors from Taiyo Yuden

Taiyo Yuden (U.S.A.) has announced the availability of its new LQ-LBH series of wire wound chip inductors



for high-frequency applications. Comprised of 20 models in the EIA 0603 (EIAJ 1608) case size, the series is designed to reduce EMI in cellphone antenna unit matching circuits, VCC circuits, high-frequency wireless LAN devices and modules, and other high-frequency circuit applications. Chief OEM design benefits include superior electrical characteristics that enable higher mounting density (pitch of 0.3 mm vs. 0.5 mm for typical competitor), high Q-values, and nondirectional surface mountability, a tremendous advantage in high-speed manufacturing.

Like other LQ series, LQ-LBH devices provide 100% silver wire wound internal conductors, advanced ceramics, and unique fabrication techniques for superior OEM price and performance characteristics. LQ-LBH series inductors provide wide L-value ranges of 2.7–100 nH and maximum current ratings of 200 mA to 1 A, depending on the part. In addition to extremely low-DC resistance values (typically 0.03 Ω–1.0 Ω) the LQ-LBH series offers OEMs excellent self-resonant frequency characteristics (2–10 GHz, minimum) and among the highest Q-values in the industry.

Q-value describes the degree of efficiency with which an inductor stores energy as a magnetic field. The higher the Q-value, the more effectively it operates as a filter. Q-value is typically expressed as a numerical value at a specific frequency. Minimum Q-values of 12–18 at 100 MHz, depending on the part, are typical for LQ-LBH series devices. At higher measured frequencies, median Q-values increase to approximately 44 (800 MHz), 46 (1.5 GHz), and 36 (2.0 GHz), depending on the part selected. Other LQ-LBH series features include:

• Tighter dimension tolerances than competitive models (typical ±0.004″ vs. ±0.006″).
• Lower, near-magnetic field effect on adjacent components and no degradation of coil characteristics (as demonstrated in comparative cross talk tests using a 50 Ω substrate and 1.47 GHz input).
• High-speed manufacturability, facilitated by the component's five-sided structure, which permits nondirectional surface mounting. All part numbers are available on 4,000-piece taped reels.
• High reliability with –25ºC to +85ºC operating temperature range.
• Price: from $0.085 per piece in OEM quantities.
• Availability/delivery: now (consult factory for lead times).

For additional information, visit the company on the Internet at t-yuden.com.

Introducing Vishay's New Solid Tantalum Chip Capacitors

Vishay Intertechnology, Inc., announced the release of two additions to the 592D family of solid tantalum chip capacitors, providing the industry's highest avail-

able capacitance in a low-profile case.

Designed for noise suppression and capacitive decoupling applications in slim-line products, including wireless PCMCIA cards and cellphones, the new 592D devices in low-profile X and Y cases feature exceptionally low equivalent series resistance (ESR) values, reducing power consumption while enabling thinner and lighter end products.

The new Vishay Sprague 592D devices, part of the

Continued on page 38

Plan now and budget now for the main event of the business year for:

Manufacturers • Distributors • Representatives of:

Components • Instruments • Datacom • MRO • Production

When the going gets tough...

The tough get going. Now more than ever you have to be aggressive about seeking new opportunities, shoring up critical relationships.

Constrained travel budgets?

At EDS, you see more people in less time, and accomplish more business, than any other way, any other place. One trip does the work of 30.

But nobody's buying anything!

That may be true today, but the smart money says that the recovery will begin by the middle of the second quarter, if not sooner. So EDS timing is perfect.

The future remains uncertain... but EDS is a sure thing!

EDS2002

Electronic Distribution Show & Conference

Tuesday-Wednesday-Thursday • May 14-15-16

Workshops and Keynote Monday May 13

Las Vegas Hilton Hotel • Las Vegas NV U.S.A.

What Manufacturers Accomplish at EDS

- Introduce new products and programs
- Recruit new distributors and reps
- Solve problems, review markets, set goals
- Network with colleagues and competitors
- Hold national sales meetings
- Meet the press at the key event for the channel media
- Get new ideas and new insight, in workshops, meetings, and casual conversation

What Distributors Accomplish at EDS

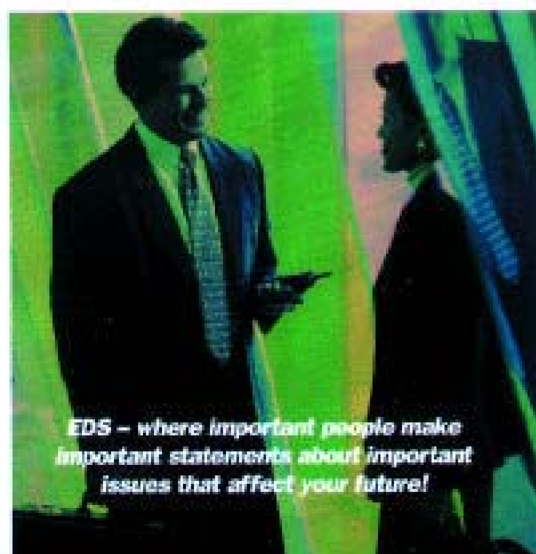
- See everyone in the industry who counts
- Meet vendors' top brass face to face
- Get fresh information on supplier strategic initiatives
- See new products, find new sources,
- Solve problems, review markets, set goals
- Network with colleagues and competitors
- Meet the press at the key event for the channel media
- Get new ideas and new insight, in workshops, meetings, and casual conversation

What Representatives Accomplish at EDS

- Meet with principals
- Get information on new initiatives and strategies
- Bring distributors and principals together
- Look for new lines
- Attend sales meetings
- Compare notes with peers
- Get new ideas and new insight, in workshops, meetings, and casual conversation

What Everyone Accomplishes at EDS

- Idea exchange
- Networking - with more opportunities than ever
- Updates on the hot industry issues
  - eCommerce
  - Globalization
  - Supply chain management
  - Impact of EMS
  - Authorized and independent distribution
- Meet with the Decision Makers
- See more people in less time and for less money than anywhere else!



ELECTRONIC DISTRIBUTION SHOW CORPORATION

222 South Riverside Plaza, Suite #2160 • Chicago, IL 60606

Voice: 312.648.1140 • Fax: 312.648.4282 • E-Mail: eds@edsc.org • www.edsc.org

Continued from page 36

TANTAMOUNT® product line, feature high capacitance ratings, ranging from 1,000–2,200 µF, with standard tolerances of ±10% and ±20%. The capacitors' ultralow maximum ESR values range from 0.035 Ω–0.04 mΩ at +25ºC and 100 kHz. The X and Y cases feature dimensions of 0.570″ (14.5 mm) by 0.290″ (7.37 mm), with maximum height profiles of just 0.078″ (2.0 mm) and 0.098″ (2.5 mm), respectively.

Working voltage options range from 4–6.3 WVDC. Maximum current leakage ranges from 60–95 µA; the maximum dissipation factor ranges from 16%–25% at +25ºC and 120 Hz. The 592D capacitors feature an operating temperature of –55ºC to +85ºC, up to +125ºC with voltage derating. The new devices are conformal coated and feature two standard 100% tin terminations.

The capacitors' low height profiles enable the design of more compact end products for increased convenience and portability. In some applications, these high-capacitance devices from the 592D family may be used to replace several capacitors with lower ratings.

Samples and production quantities of the 592D X- and Y-size capacitors are available now in tape-and-reel packaging, with lead times of 8 weeks for larger orders.

Vishay can be found on the Internet at vishay.com.

Broad Interest Sparks AO-CP Product Line Expansion

Citing broad market interest in its newly introduced AO-CAP aluminum polymer capacitor and a growing interest in lower voltage devices, KEMET Electronics announced an expansion of the AO-CAP line to include larger capacitance devices and extended voltage ranges. Introduced on September 24 with distributor partner TTI, the new product quickly reached the design tables of a broad range of customers in a wide gamut of industries. Consequently, KEMET went back to the drawing board to design production equipment to produce AO-CAPs for the widening expanse of requirements. That new equipment is now online, and new product values are beginning to flow through KEMET plants.

KEMET's initial AO-CAP thrust was with the 6-volt and 4-volt devices, in D- and V-case sizes with capacitance in the 47–220 µF range. However, requests for higher capacitance values, X-case size devices and 2-volt AO-CAPs have been increasing, causing KEMET to move forward with plans to produce these additional devices.

John Boan, KEMET AO-CAP Product Manager noted, "Within a month of the product launch we had many sample orders for the six initial values and sample requests for six additional values. TTI has filled all those orders and requests, and KEMET is further broadening the AO-CAP line to include devices with higher capacitance and devices with lower voltages.

We have noticed an industry trend migrating toward lower voltages with these extremely low-ESR devices. These capacitors will help extend battery life per charge, and that is a big deal. Based on the positive reception of the AO-CAP, KEMET is forging ahead to expand production capacity, despite the current slow market conditions." Boan also noted, "Engineers who have tried the new KEMET aluminum polymer AO-CAP capacitor are very enthusiastic about its attributes, particularly the improvement in capacitance retention and the product's considerably lower ESR." Lead times on the AO-CAP range from stock to 6 weeks, so product is currently available.

Desire to extend battery life along with the continued miniaturization of handheld products is driving the lower voltage/lower ESR requirements. At the same time, many telecom and networking applications are calling for higher capacitance AO-CAP devices, so KEMET is continuing to develop increased capacitance AO-CAP devices.

The quick, broad market acceptance of the new AO-CAP product has not been missed by TTI, who helped KEMET launch the new product. Craig Conrad, TTI Senior VP, Global Sales & Marketing, observed, "Our introduction of the AO-CAP was totally different from our introduction of the KO-CAP a year ago. With KO we targeted the power supply industry, but we knew the AO would have a much broader appeal. We are extremely pleased that such a broad range of customers is sampling the AO-CAP to test on both current and new products. OEMs from industries such as power supplies, telecom/networking, test and measurement, wireless, RF/microwave, digital projection, industrial automation, satellite communications, sonar and GPS instrumentation, even depth finders for fishing boats, have already been testing the AO-CAP. We have been very gratified that such a broad customer base has so rapidly moved to test KEMET's new aluminum polymer device."

For more information about KEMET's AO-CAP product line, visit the Web site at kemet.com. To learn more about TTI, go online at ttiinc.com.

TTI, Inc., Launches MarketEye Page on Web Site

TTI, Inc., the world's leading distributor of passive, interconnect, and electromechanical components, brings you MarketEye, a new source of market information now available only on the TTI Web site. MarketEye puts you in touch with top executives and industry leaders from premier IP&E manufacturers and customers. Each month, the site will feature exclusive commentary by noted industry analysts Dennis Zogbi, from the passives side, and Ron Bishop, with his insight into the connector sector, in addition to interviews with the top CEOs in the industry.

Craig Conrad, Senior Vice President, Global Sales and Marketing, made the following comments about the introduction of MarketEye. “We’re excited to bring such an impressive lineup of industry experts together to comment on the most important issues facing the IP&E industry today. It is our hope that the industry finds MarketEye the most helpful source in providing valuable insight on the key industry trends. We’ve been impressed with the response we have received so far from our customers and suppliers alike.”

Dennis Zogbi is president of the Paumanok Group, which is comprised of Paumanok Publications, Inc., Industrial Market Research Division, and *Passive Component Industry* magazine. Regarding the MarketEye program, Zogbi noted, “MarketEye is a new forum for getting analytical industry information and updates to those who want to be best informed on industry developments. I’m pleased to participate with TTI by providing an up-to-date analysis each month.”

Bishop is owner of Bishop & Associates, Inc., a market firm that specializes in the world electronic connector industry and publishes the newsletters *The Bishop Report* and *Connector Industry Yearbook*. Commenting on the MarketEye initiative, Bishop remarked, “This is a leading-edge program to get more important information to the market leaders and those who want to be as up-to-date as possible on the latest information. I’m excited about working with TTI on this program.”

Log on to MarketEye today at ttiinc.com/marketeye. For more information about this free service provided by TTI, Inc., contact Cathy Walensky at cwalensky@ttiinc.com.

AVX’s Hi-Q High-Power RF Multi layer Ceramic Chip Capacitors Delivery High-Frequency Performance

Providing system designers with high-voltage SMT capacitors, AVX introduces the Hi-Q™ series of MLC chip capacitors, offering superior electrical characteristics for various high-frequency applications. Ideal for use in high-power RF applications, these products feature ultralow equivalent series resistance (ESR) and excellent high-current handling capability in small case sizes. These high-voltage, surface-mount capacitors also offer

exceptional heat dissipation characteristics and superior high-frequency performance. The typical Q (quality factor) for this family is 10,000 minimum, making it ideal for high-current applications.

Hi-Q series capacitors are designed to handle high-power and high-voltage levels for applications in RF power amplifiers, inductive heating, high magnetic field environments (MRI coils), and medical and industrial electronics. They are available in case sizes 2325 and 3739 and feature capacitance values from 10,000 pF down to 10 pF, with tolerances to ±1%. Rated voltage ranges from 300–4,000 VDC, with a temperature coefficient of 90 ±30 ppm/°C over a temperature range from –55°C to 125°C.

Typical pricing for the Hi-Q series capacitors is approximately $2.00–$5.00 each in OEM quantities, with lead times from stock to 8 weeks.

For more information about the Hi-Q series capacitors, contact AVX Sales & Marketing at (843) 946-0414; fax: (843) 448-1943; Web site: avxcorp.com.

New SD Series Includes the Lowest Profile Surface-Mount Inductor Available

Next-generation cellular phones and PDAs can now be thinner and lighter because of the SD12, a low-profile inductor created by Cooper Electronic Technologies.

The Coiltronics SD series of shielded drum inductors features the SD12, with a component height as low as 1.2 mm. The footprint is only 5.2 mm square. It is the only surface-mount inductor in the market of this size and performance. SD series inductors can be used in a broad range of applications, including DC-DC converters, output inductors, filters, etc. The demand for small, convenient handheld electronics has fueled the search for low-profile components.

Despite its small size, the SD series offers high-power output. Inductor values for the SD12 range from 0.47 µH at 3.19 A to 1,000 µH at 0.86 A. Higher current ratings are available in slightly taller profiles of 1.8 mm (SD18), 2.0 mm (SD20), and 2.5 mm (SD25), with the same footprint.

Additional applications for SD series inductors include digital cameras, PCMCIA cards, MP3 and CD players, and GPS.

Available in t❑pe-and-reel packaging, the SD series

Analysis

Continued from page 26

The two primary second-tier suppliers include NEC Tantalum Corporation, and EPCOS, which holds many major capacitor assets in Europe and South America. With respect to tantalum capacitors, EPCOS maintains facilities in Heidenheim, Germany and Evora, Portugal.

NEC has long been considered a major unit pro- ducer of tantalum capacitors, concentrating on the smaller A- and B-case sized parts. In 2001, the company transferred ownership of its tantalum capacitors to Tokin Corporation, whose majority shareholder is NEC Corporation. NEC maintains tantalum capacitor assets in Toyoma, Japan and Pathumbani, Thailand. Paumanok believes that NEC's transfer of its tantalum operations to Tokin was designed to make Tokin more attractive for sale to a trade company or for an equity bank partner in Japan.

Tantalum Powder & Wire	Powder & Wire Source
H. C. Starck	Germany (Goslar) USA (Newton) Japan (VTech) Thailand (Thai Tantalum)
Cabot Corp.	USA (Boyertown) Japan (JV with Showa)
Ningxia NFM	China
Showa Denko	Japan (JV with Cabot)
VMC Corp.	Japan
Solikamsk	Russia
Mitsui Mining	Japan
NAC Kazatomprom	Kazakhstan

Third-tier tantalum capacitor manufacturers are almost exclusively Japanese, notably, Hitachi AIC, Matsushita Electric Industrial (Circuit Capacitor Division), Nichicon Tantalum Corporation, and Matsuo Electric. All of these companies maintain their tantalum production assets in Japan. However, Matsushita produces the majority of its tantalum capacitors in China and is considered by the Chinese government to be the largest tantalum capacitor producer in China.

Mention should be made of Pure Material Labs. This company produces finished anodes from purchased powder and wire, which it resells to many major capacitor producers, including, but not limited to, Hitachi AIC.

Fourth-tier suppliers are almost exclusively in Asia. The largest of these include Samsung EMCO, with operations in Korea; Elna Corporation, an Asahi Glass subsidiary, with operations in Japan and a tantalum capacitor joint venture with Lelon in Taiwan; and Towa Electron, a Fujitsu Media subsidiary, also of Japan. Other players include PARTSNIC (for- merly Daewoo Electronics) of Korea, as well as smaller sup- pliers scattered throughout China, Taiwan, and India. Shenzhen Capacitor of China is emerging as that country's premier domestic resource for tantalum chip capacitors. (Matsushita EIC has been identified by the PRC as the largest producer of tantalum capacitors in China, although, the Matsushita tantalum plant is a transplant from Japan). The remaining Asian suppliers produce older, dipped technology capacitors. Incidentally, the Chinese governmen❑has


20 years of Innovation
Just test our: high accuracy coat box, computer controlled slurry supply, dual winders, in-line scanners........
Web Coaters
- High accurracy
- LTCC, MLI, MLCC
- Li-Battery
Steelbelt Casters
- Length 7 to 35 m
- Width 0.30 to 1.20 m
- Modular
KEKO
KEKO EQUIPMENT
20 years of experience
in Tape Caster desig
Coversheet Makers
High Accuracy Screenprinters
Manufacturing consulting services
Fully Automatic Printer stackers
Tape Casters
Isostatic Presses
Pinpresses
Green Ceramic Cutters
Automatic terminator
Termination Drying Ovens
Specialty Component Testers
Vision Component Inspection
Chip Taping Equipment
Carrier plates
HAIKU Tech
Manufacturing Solutions for Ceramic Multilayer Components
Haiku Tech Inc.,
825 s.w. 8th Court
Miami, Florida 33130, USA
T: (305) 858 99 02
F: (305) 858 99 32
Haiku Tech Europe BV
Dorpsstraat 100A
674 NN Reijmerstok, The Neth
T: +31 (43) 457 8054
F: +31 (43) 457 8055
E-mail :
Website :