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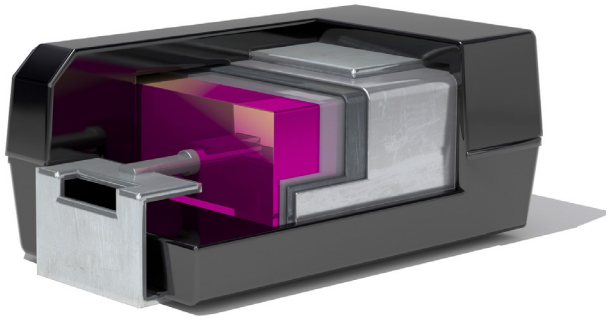
A New Dawn for Tantalum Capacitors



Tantalum capacitors hold significant technical advantages over other types, but sustainability issues slowed their adoption. A new generation of sustainable tantalum capacitors is now appealing to designers at the cutting edge of today's most demanding electronics applications in all kinds of products from smartphones and the cloud to satellites and implantable devices.

By Fernando Spada, Vice President Tantalum Product Marketing, KEMET Corporation

The rapid advances in automotive, telecom and industrial electronics from the late 1980s have been founded partly on the outstanding performance advantages of tantalum capacitors. The unbeatable high volumetric efficiency of these devices helped engineers achieve aggressive miniaturisation while significantly increasing functionality. In addition, low noise and stability over time have supported relentless progress towards ever-higher data rates and lower analogue and digital supply voltages. Moreover, high-temperature capability, unmatched longevity and proven reliability make tantalum the 'Number One' choice for applications likely to experience harsh operating conditions, including aerospace electronics as well as automotive and industrial equipment.

As tantalum technology matured and the supply base consolidated, a number of factors including materials shortages slowed the adoption of tantalum capacitors. At the same time, improvements in ceramic, electrolytic and polymer film capacitor technologies saw these types of devices offer a credible alternative in some applications. Subsequently, the arrival in the late 2000s of new legislation aimed at preventing conflict minerals entering the supply chain challenged component manufacturers to verify that tantalum in their capacitors is from conflict-free sources. This could potentially have closed off the advantages of tantalum technology to all but a few low-volume, highly demanding market sectors.

Addressing Sustainability

KEMET has addressed issues in the supply of raw materials and capacitor production, while at the same time developing advanced tantalum capacitor technologies to deliver even more capable and compelling products for customers. These initiatives have transformed the outlook for tantalum capacitors, introducing sustainability alongside the technical advantages of its unparalleled combination of superior energy density, high stability, outstanding electrical performance and self-healing capability.

KEMET's "Partnership for Social and Economic Sustainability" initiative is an extremely important aspect of the company's work aimed at ensuring a reliable source of audited conflict-free tantalum. This initiative is a benchmark for the industry. KEMET is working closely with a certified conflict-free mine in DRC (Democratic Republic of Congo); the company also supports projects in the local community to help establish a path to self sufficiency. The policies at the mine have been implemented in conjunction with experienced partners such as Mining and Mineral Resources (MMR) and the Kisengo Foundation, and follow known best practices. These ensure proper recording of mined coltan (tantalum ore), fair trading that rewards workers' productivity, and the safest possible working conditions for the miners. This has enabled KEMET to establish a reliable and sustainable source of conflict-free tantalum.

To complete the supply chain, KEMET has also acquired enterprises capable of performing all the post-mining processes such as smelting and refining to produce capacitor-grade tantalum powder and pure tantalum wire. These feed KEMET's capacitor assembly plants, creating the industry's only vertically integrated supply "closed-pipe" supply chain, giving unrivalled control over supply, quality and pricing of raw materials and finished capacitors. It has also been recognised as being compliant with the new conflict minerals legislation (The Dodd-Frank Act 2010) now in force in the USA. KEMET recorded the industry's first, and so far only, successful filing under the Dodd-Frank law in June 2014.

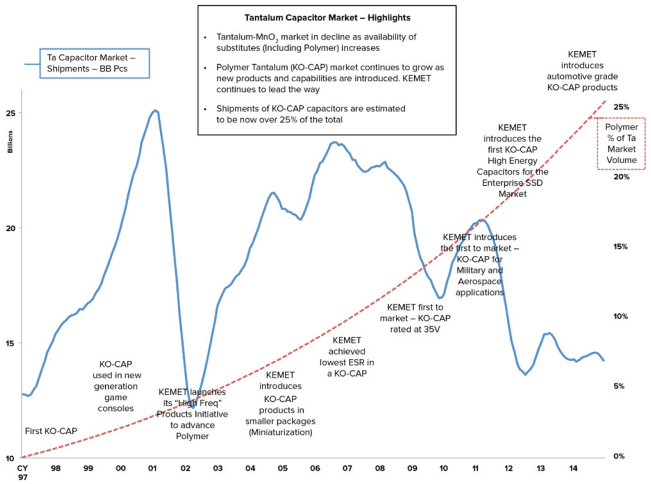


Figure 1: The Tantalum Market

Technical Advancement

Alongside these improvements in the supply chain, technological advances have enabled the emergence of the KEMET Organic Polymer Capacitors (KO-CAP) product line. Continued development has delivered successive generations offering market-leading low Equivalent Series Resistance (ESR) in a range of voltages in package configurations that no other capacitor technology can match. Low ESR minimises internal energy losses and self heating of the capacitor, thereby helping to enhance energy efficiency as well as reliability.

Dedication to technological progress has propelled KEMET to a position where it now holds a large number of material and chemistry patents and related intellectual property that serve to boost the reliability of KO tantalum capacitors. This simplifies design-in to applications where reliability is a key concern, such as military and medical equipment as well as automotive systems, telecom equipment and commercial avionics and radar.

Tantalum capacitors provide a competitively priced and superior-performing alternative to traditional capacitor types, and the KO-CAP product line is particularly popular. In fact, adoption and use of these devices has accelerated in fast-growing industry sectors such as mobile computing, telecom infrastructure and cloud services, as well as industrial automation and also in automotive, military and aerospace.

Type	MLCC	Aluminum (Electrolytic)	Tantalum (MnO_2)	KO-CAP (Polymer)	Aluminum (Polymer)
Rated Voltage	4V~3KV	4V~500V	4V~50V	2.5V~63V	2V~35V
Application Voltage	100%Vr	50~100%Vr	33~50%Vr	80~90%Vr	100%Vr
Working temperature	85~125~150~200℃	85~125℃	85~125~150~175~200℃	105~125℃	105~125℃
Capacitance	1p~100uF	0.1uF~8,200uF	0.1~1500uF	10~1000uF	10~680uF
Working Frequency	~GHz	~100KHz	~100KHz	~10MHz	~10MHz
Reflow (Peak Temp.)	260 ℃	240~260℃	260 ℃	260 ℃	260 ℃
Size (Mini)	01005	Φ5mm	A(1206)	P(0805)	B(3528-20)
Size (Max)	2225	Φ35mm	E(7260-38)	H(7260-20)	X(7343-43)
MSL	1	1, 3	1	2a, 3, 4	3
ESR	Lowest (2~500mohm)	Middle 9mohm~5ohm	Middle 25mohm~7ohm	Low 3~150mohm	Low 3~45mohm
ESL	Lowest	Highest	1.0nH~2.7nH	130pH~2.7nH	1.1nH~2.3nH

Figure 2: Capacitor Type comparison

The New Dawn

In April 2014, KEMET announced a breakthrough in polymer tantalum capacitor technology, having demonstrated stable electrical performance levels throughout high temperature and high humidity in testing based on AEC Q200 guidelines. Polymer tantalum capacitors are well-suited for use in automotive infotainment systems. KEMET's T591 series of high-performance automotive grade polymer tantalum devices features operating temperatures up to 125°C and is available in capacitances up to 220µF and rated up to 10V. The series is manufactured in an ISO TS 16949 certified plant. KEMET is currently developing further additions to its automotive-qualified tantalum family, to offer even greater choice for customers. In the second half of 2015 KEMET plans to release the T598 series with AEC-Q200 qualified and compliant components, with this, the automotive industry will be able bring the advantages of polymer tantalum capacitors to bear in more critical applications such as active safety systems and Advanced Driver Assistance Systems (ADAS).

In addition to this, KEMET will soon announce new smaller and thinner capacitors conceived especially to meet the demands of next-generation mobile devices and wearable electronics. The very high volumetric efficiency of these new devices will also make them ideal for space-constrained telecom equipment, as well as high-performance computer servers.

The advance of polymer tantalum technology will also bring benefits into the military domain, to help meet the demands of procurement agencies seeking to minimise the costs associated with new equipment. KEMET's technological development is enabling the emergence of new families of polymer tantalum capacitors offering higher reliability, not only for the military but also for civil aviation and space applications.

Leveraging the advantages of its vertically integrated tantalum supply chain, KEMET is also driving the development of new tantalum powders and capacitor internal components, optimised to deliver improvements such as higher energy density. The advances gained enable improved performance in applications such as the supply-voltage holdup circuitry of solid-state drives, which helps ensure data retention in the event of main power-supply failure.

Many polymer tantalum capacitor families are able to operate up to 125°C. On the other hand, MnO2 cathode technology produces capacitors that have very low leakage current and high maximum temperature capability, reaching as high as 175°C or over 200°C with KEMET's high-temperature families.

Type	MLCC	Aluminum (Electrolytic)	Tantalum (MnO_2)	KO-CAP (Polymer)	Aluminum (Polymer)
Ignition failure mode	•	•	•	--	--
Flex Crack	•	--	--	--	--
Piezo Noise	• Except C0G	--	--	--	--
Voltage Effect	• Except C0G	--	--	--	--
Polarity	--	•	•	•	•
Reverse Voltage	--		15%(25℃)	15%(25℃)	60%(25℃)
Surge Current	Best		Normal(10A~)	Good(20A~)	Good(20A~)
Surge Voltage	Best	Great (1.75X)	Good(1.3X)	Good(1.3X)	Good(1.3X)
ESD	Normal <300pF/50V has higherRisk	BEST	BEST	BEST	BEST

Figure 3: Comparison of Devices

Conclusion: Three Critical Success Factors

KEMET has led the industry's response to the sustainability challenges associated with the tantalum supply chain, resulting in a stable and reliable supply of certified conflict free tantalum products and tantalum capacitors.

Continuing development of organic polymer capacitor technology, and expansion of the KO-CAP product ranges, is making highly cost-effective and high-performing devices more readily accessible to an increasing variety of designers targeting diverse applications.

Finally, KEMET's new Technology and Operations partnership with NEC TOKIN creates a new power that will continue to invest in market leading technologies and capabilities that match or exceed the requirements of engineers, maximising the advantages of tantalum's unrivalled energy density compared to all capacitor technologies.

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