KEMET
a YAGEO company

Choosing the Right Polymer Capacitor

A Guide for the Perplexed

May 10, 2021

PRESENTER

DR. PHIL LESSNER

Ph.D in Chemical Engineering

33 years in Electronics Industry

25 years at KEMET

KEMET's Chief Technology Officer

Product, Material, and Process Development

Agenda

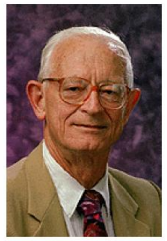
- Introduction to Polymer Capacitors
- KEMET's Polymer Capacitor Portfolio
- Polymer Capacitor Applications and Segments
- Selecting a Polymer Capacitor
- Polymer Capacitor Roadmaps

What is Polymer?

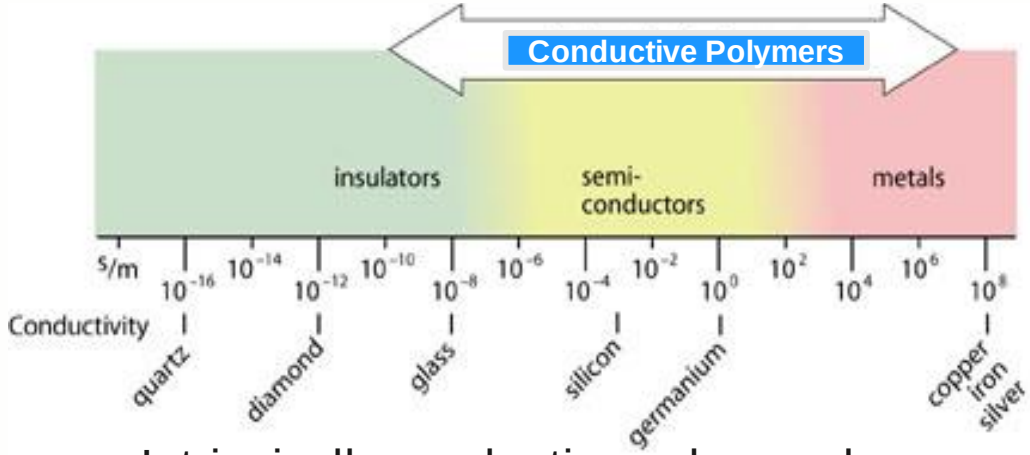
"For the Discovery and Development of Conductive Polymers"

Alan Heeger
University of California at Santa Barbara

Hideki Shirakawa
University of Tsukuba

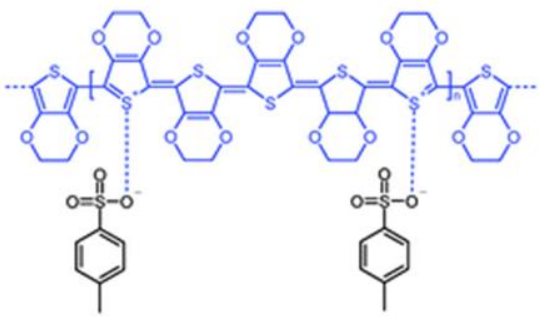


Alan MacDiarmid
University of Pennsylvania



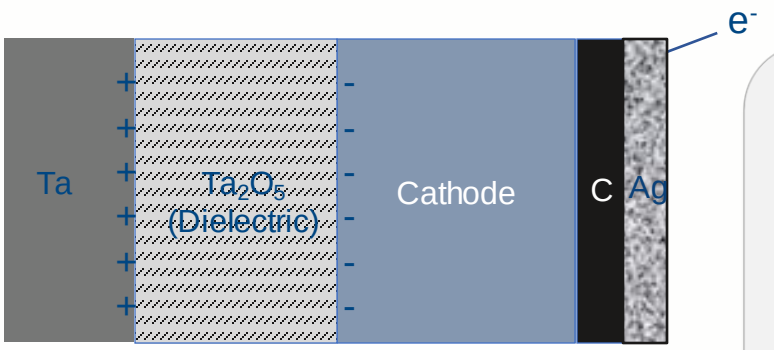
Intrinsically conductive polymers
Were discovered in the late 1970's
Three scientists won the Nobel Prize
In 2000 for this discovery.

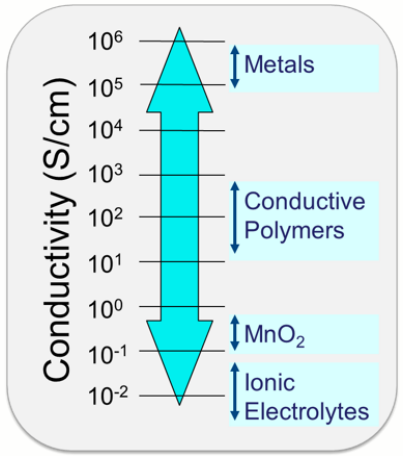
Intrinsically conductive polymers have Conductivities between those of Semiconductors and metals.

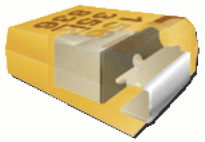


The primary polymer we use is PEDOT. It was invented by Bayer in the 1980's. It is a **pure organic material** that contains no metal. The polymer itself is conductive. That is why it is **intrinsically** conducting unlike silver-polymer pastes which are a mixture of a metal and polymer.

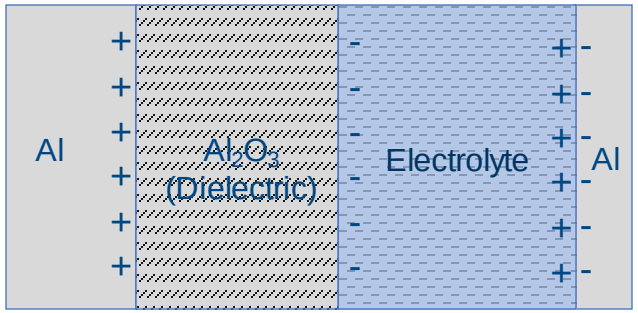
Why Use Polymer in Capacitors?

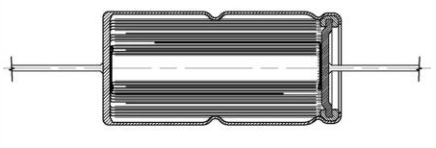


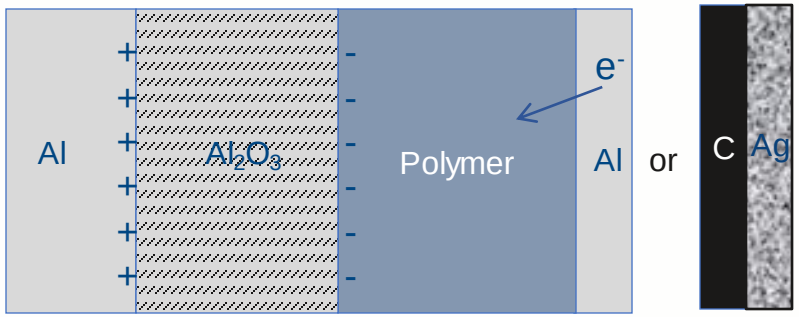




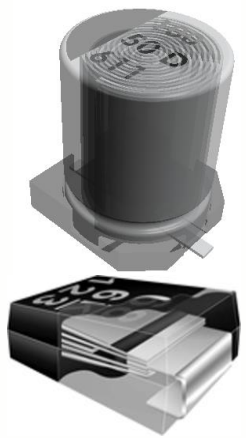
MnO_2
Polymer







or



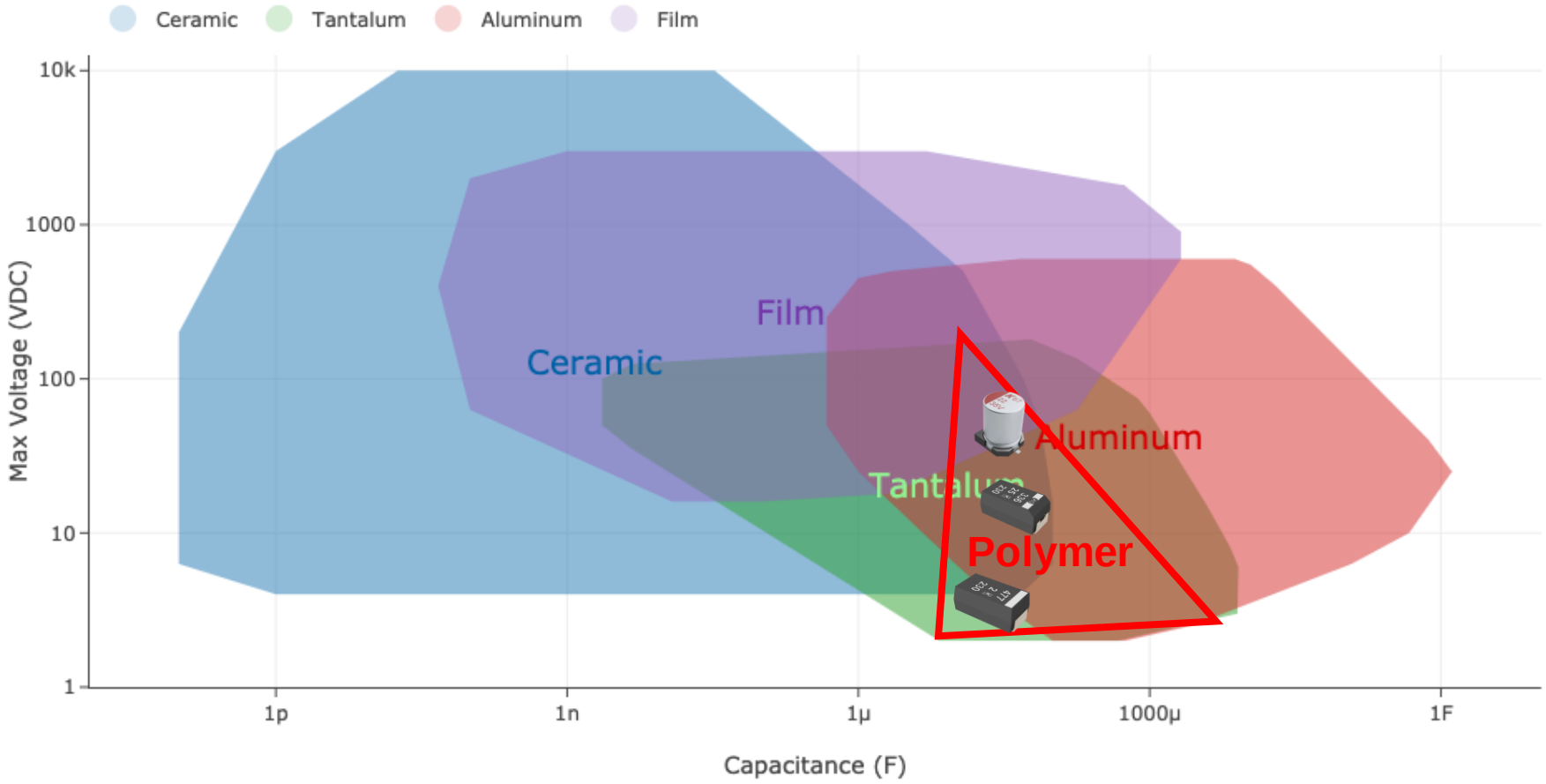
Solid Tantalum Capacitors were invented in the 1950's. They used manganese dioxide (MnO_2) as the cathode because of its self-healing properties: it becomes non-conductive at defects in the dielectric and this is one of the reasons these capacitors are reliable.

Conductive polymers began to replace MnO_2 in the Mid-1990's. They are more conductive than MnO_2 and, thus, have much **lower ESR**. They also have a self-healing mechanism.

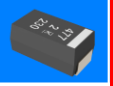
Conductive Polymers are also used in Aluminum Capacitors to replace the wet electrolyte. These Capacitors have much lower ESR and don't dry out over time.

There are also hybrid Polymer-Wet capacitors that Combine the low ESR of Polymer with the low Leakage of Wets.

Polymer in the Capacitor Landscape



KEMET's Polymer Capacitor Portfolio

Factor	Ta Polymer KO-CAP NEOCAP 	Al Polymer AO-CAP 	Al Polymer EO-CAP 	V-Chip Hybrid 	Thru Hole Hybrid 
CV/cc	△	◎	◎	◎	◎
Total Cap	△	◎	△	△	△
VoltageRange	◎	X	△	◎	◎
ESR	◎	△	△	◎	△
Ripple (heat Sink)	◎	◎	◎	◎	△
Height	△	△	X	X	X
Footprints Available	△	X	◎	◎	X
Temperature Range	△	◎	△	△	△
AEC-Q200	△	X	◎	△	△
Cost	X	◎	△	◎	X
Number of Suppliers	◎	◎	△	◎	◎
	High Cap Low ESR Low Profile High Cost	Med Cap Very Low ESR Low Profile Med Cost	Med-High Cap Higher Voltage Low ESR Low Cost	Med Cap Med Voltage Low ESR Low Leakage	High Cap Med Voltage Low ESR Low Leakage High Temperature

△ Excellent

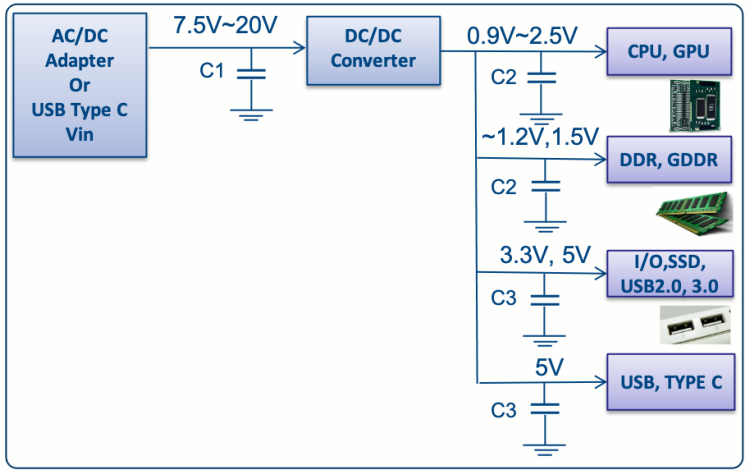
◎ Good

X Fair/Poor

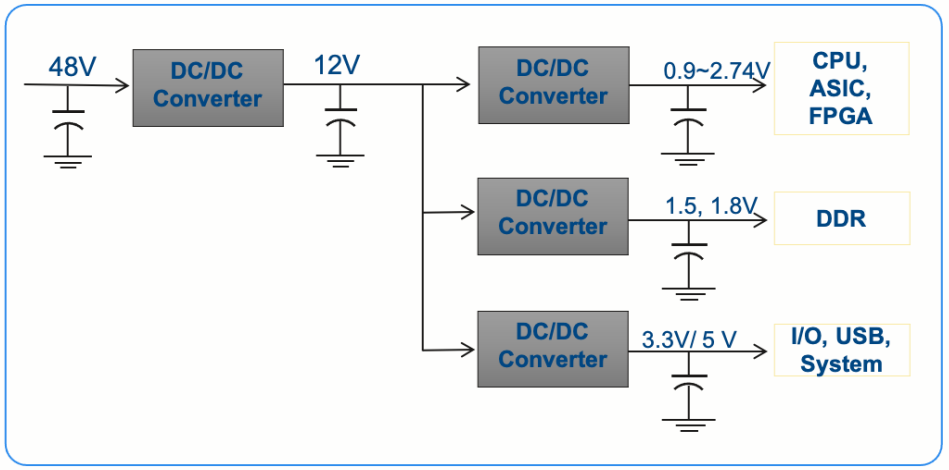
Polymer Capacitor Applications

DC-DC Conversion/Decoupling

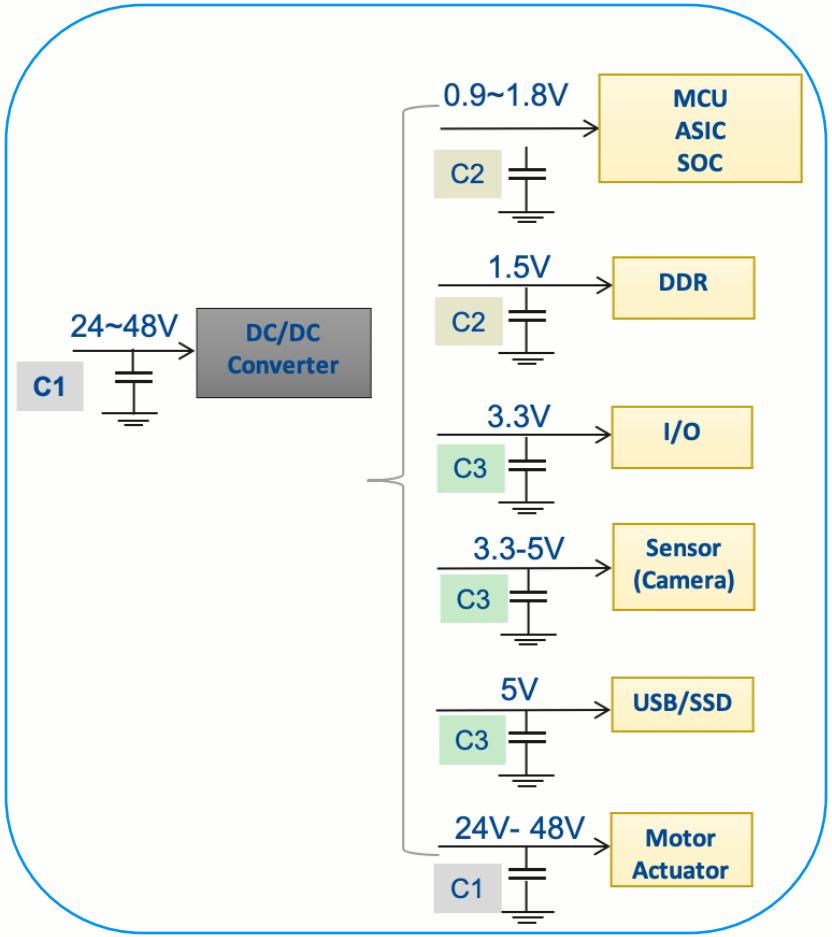
Desktop/Laptop



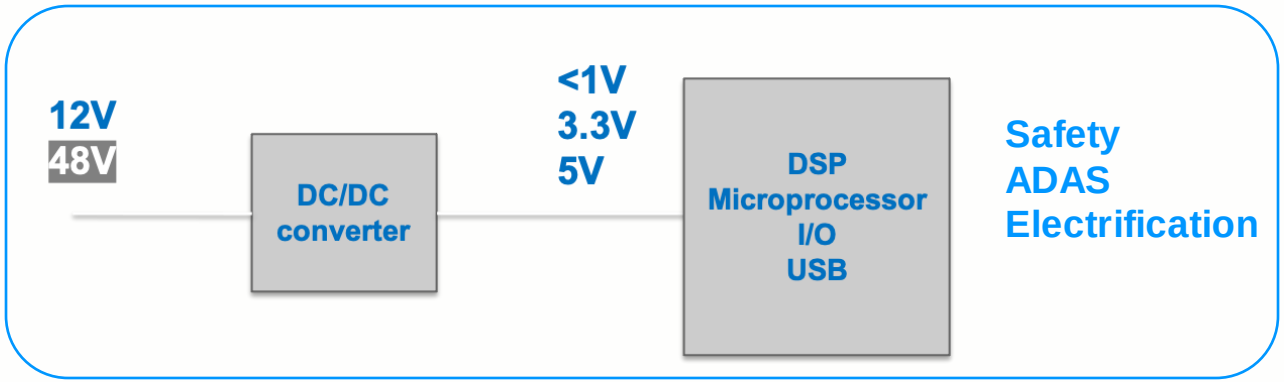
Server/Base Station



Industrial Robot

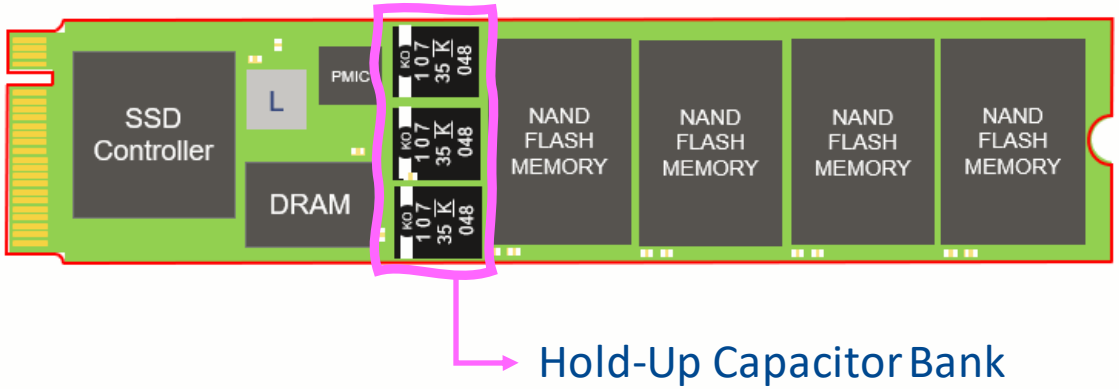


Automotive

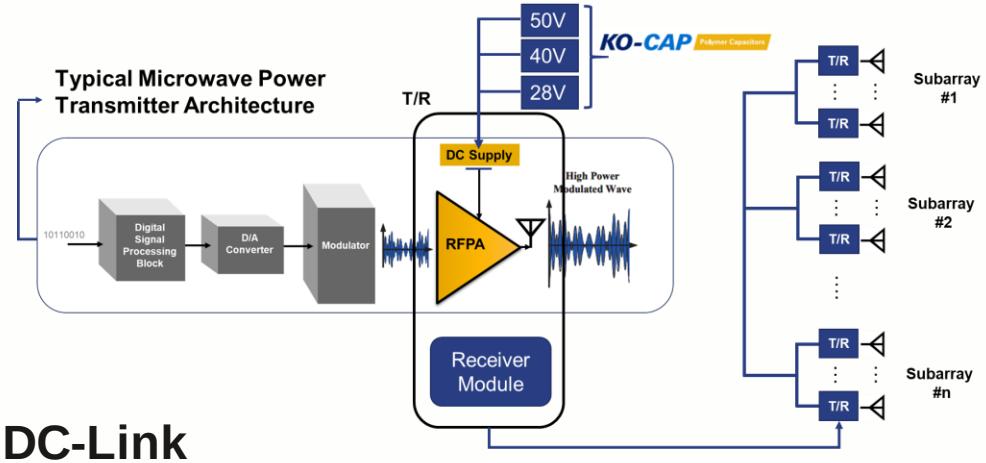


Polymer Capacitor Applications

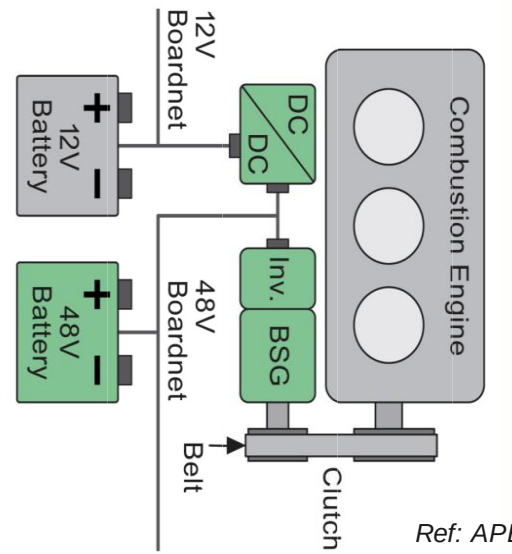
Power Backup in Solid State Drives



Pulse Energy



DC-Link



Ref: APEC 2017, Steven Kowalec, Continental AG

Resources

- Datasheets
- Online Tools
  - Component Edge
  - K-Sim
- Technical Papers, Blog Posts
- FAE/Sales/Technical Product Managers

Polymer Series Selection Guide

General Purpose

	KO-CAP/NEOCAP	AO-CAP	EO-CAP	
	Surface Mount Ta	H-Chip Al	V-Chip Al	Thru Hole Al
105°C/2000hr	T52x* PS/L 2-75V 1-1500µF	A720 2-35V 22-470µF	A765 A767 2.5-100V 10-2700µF	A750 2.5-63V 47-2200µF
	*Check data sheet for temperature rating.			
105°C/5000hr			A766 4-25V 10-560µF	A755 A758 2.5-25V 10-1200µF
125°C/1000hr	PS/H 2.5-16V 22-330µF			
125°C/2000hr	T525 2.5-16V 10-680µF	A700 2-25V 8.2-470µF		A759 6.3-250V 2.2-2200µF
Face Down	T523 F/PS 4-35V 6.8-470µF			
Face Down Substrate	G/PS 6.3-25V 4.7-47µF			

Polymer Series Selection Guide

Harsh Environment and Hybrid

	KO-CAP/NEOCAP	AO-CAP	EO-CAP		
	Surface Mount Ta	H-Chip Al	V-Chip Al	Axial Thru Hole Al	Radial Thru Hole Al
AEC-Q200 105°C/1000hr	T591 2.5-50V 1.5-470µF				
AEC-Q200 125°C/1000hr	T597 2.5-10V 22-100µF				
AEC-Q200 125°C/2000hr	T598 2.5-50V 2.2-680µF	A798 2.5V 470µF	A768* 16-80V 18-1000µF		
AEC-Q200 150°C/1000hr	T599 4-50V 10-150µF				
Hybrid AEC-Q200 125°C/3000hr			A780 63V 56-100µF	PHA225 40-63V 370-1100µF	PHH225 40-63V 370-1100µF

*Some ratings available in Anti-vibration configuration

Polymer Series Selection Guide

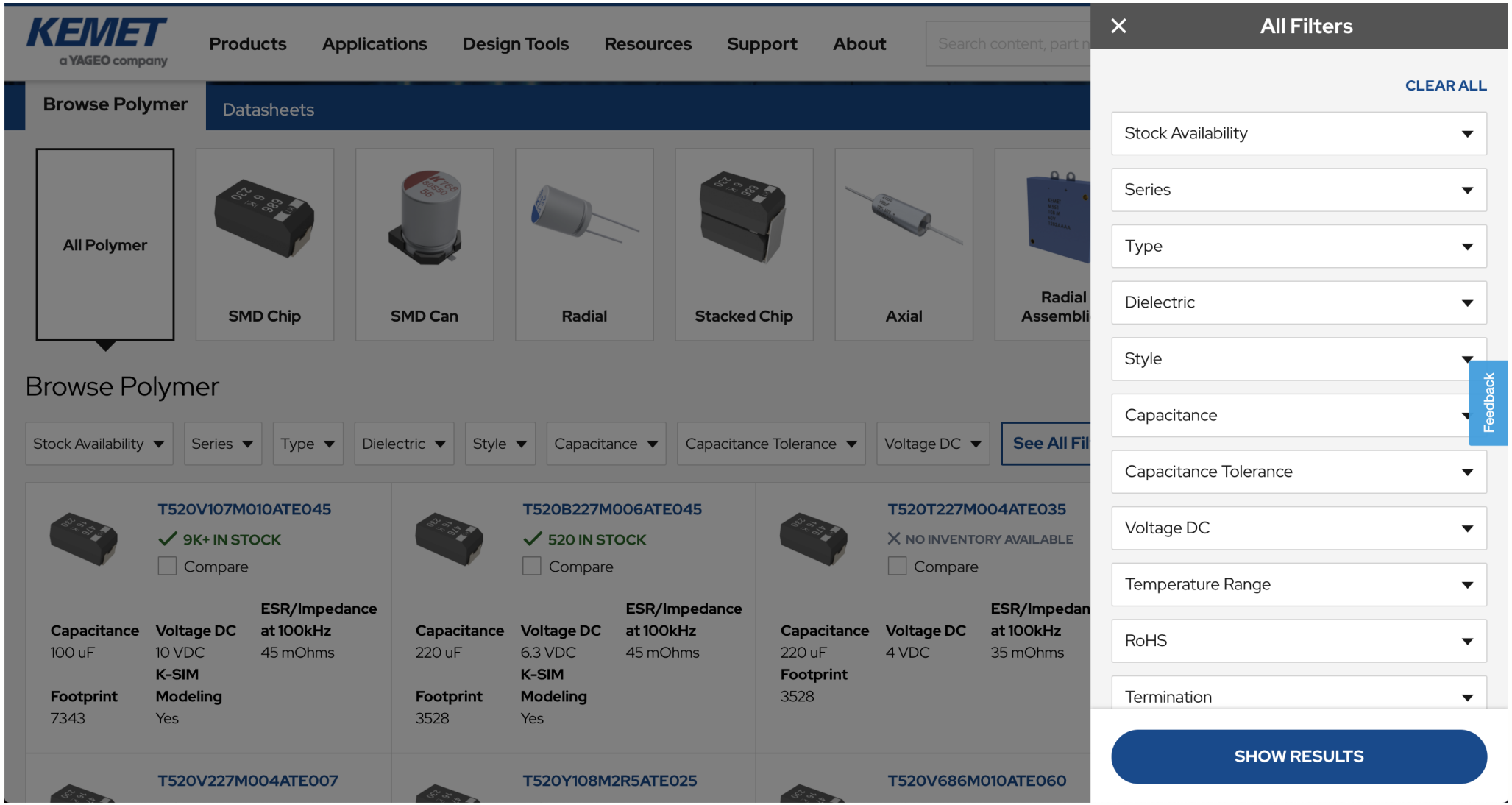
Special Purpose Tantalum Polymer

KO-CAP/NEOCAP

		Surface Mount	Stacks	Thru Hole	Modules
Commercial	Low ESL	T528 2.-6.3V 150-470µF			
	Ultra Low ESR	PS/G T530 2.5-16V 150-1500µF			
	Low Leakage	T522 6.3V 150-470µF			
High Reliability	High Energy	T545/8 6.3-20V 47-1500µF	TSP 3-63V 20-8000µF		
	HRA	T540 T541 2.5-63V 4.7-1500µF	T543 6.3V 150-470µF		
	Hermetic Seal	T555 T556 6.3-100V 20-680µF		T550 T551 6.3-100V 20-680µF	M55 6-180V 60-6800µF

Tools For Further Exploration

Component Edge



Tools for Further Exploration
Component Edge

Compare Products

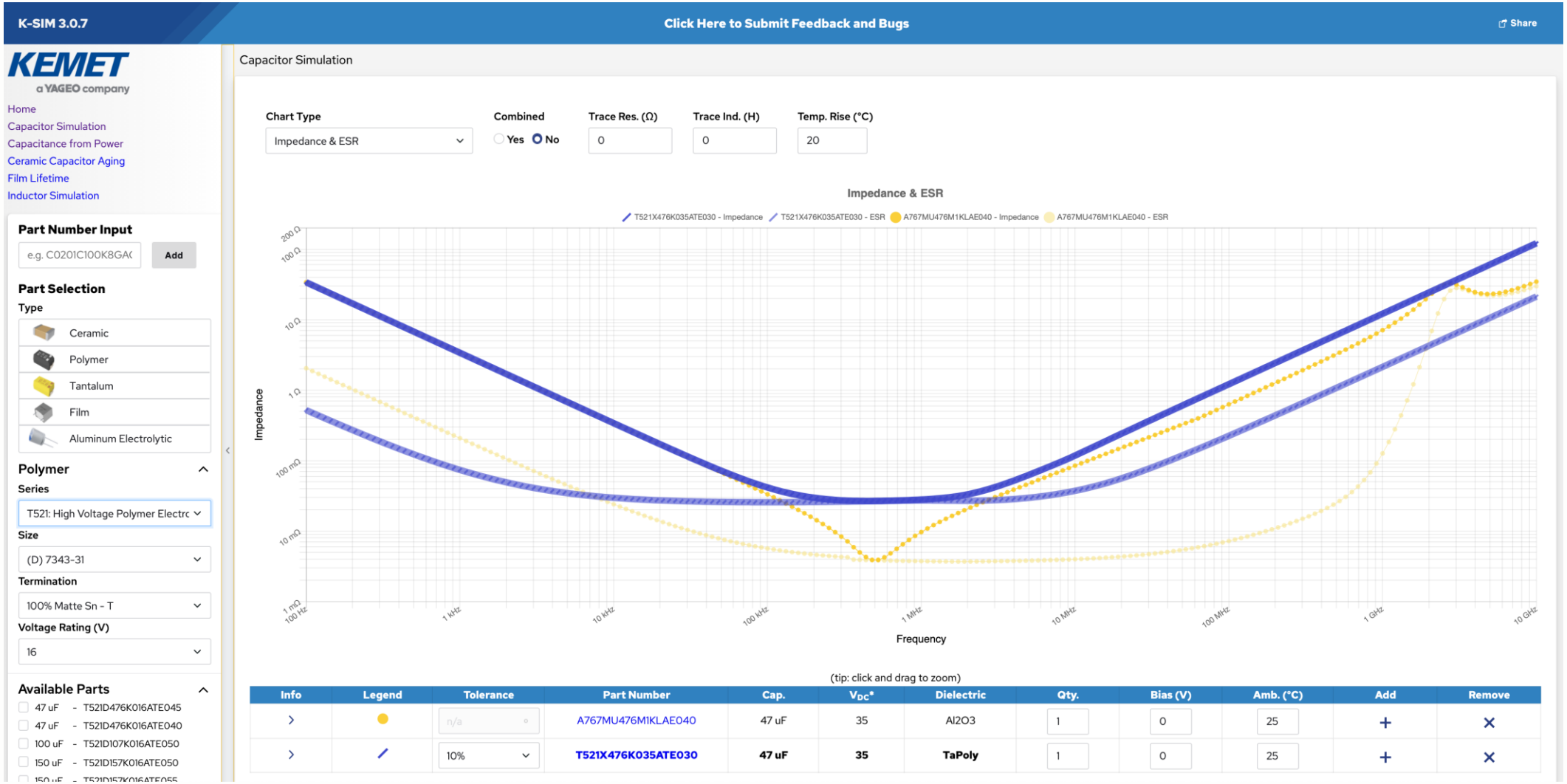
	 T521X476M035ATE030 ✓ 612 IN STOCK Specsheet Datasheet VIEW DETAILS	 T523W476M035APE100 ✓ 8K+ IN STOCK Specsheet Datasheet VIEW DETAILS	 A768EB476M1VLAS042 ✓ 495 IN STOCK Specsheet Datasheet VIEW DETAILS
Series	T521	T523	A768
Type	Tantalum	Tantalum	Aluminum
Dielectric	Polymer Tantalum	Polymer Tantalum	Polymer Aluminum
Style	SMD Chip	SMD Chip	SMD Can
Capacitance	47 uF	47 uF	47 uF
Capacitance Tolerance	20%	20%	20%
Voltage DC	35 VDC	35 VDC	35 VDC
Temperature Range	-55/+125°C	-55/+105°C	-55/+125°C
Temperature Maximum	125°C	105°C	125°C
Temperature Minimum	-55°C	-55°C	-55°C
Rated Temperature	105°C	105°C	125°C
RoHS	Yes	Yes	Yes
Termination	Tin	Nickel Palladium Gold	--
Dissipation Factor	10 %	10 %	--
ESR/Impedance at 100kHz	30 mOhms	100 mOhms	42 mOhms

Compare Products

	 T521X476M035ATE030 ✓ 612 IN STOCK Specsheet Datasheet VIEW DETAILS	 T523W476M035APE100 ✓ 8K+ IN STOCK Specsheet Datasheet VIEW DETAILS	 A768EB476M1VLAS042 ✓ 495 IN STOCK Specsheet Datasheet VIEW DETAILS
Leakage Current	164.5 uA	164.5 uA	329 uA
AEC-Q200	No	No	Yes
Weight	553.96 mg	222.95 mg	--
Footprint	7343	7343	--
Height Max	4.3mm	1.5mm	--
Packaging	T&R, 178mm	T&R, 178mm	T&R, 380mm
Packaging Quantity	500	1000	1000
Shelf Life	52 Weeks	52 Weeks	--
MSL	3	3	--
Length	7.3mm	7.3mm	5.7mm
Lead	--	--	V-Chip
Diameter	--	--	6.3mm
Life	--	--	2,000 Hrs

Tools For Further Exploration

K-Sim



Digging Deeper

KEMET ENGINEERING CENTER

Reliability of Tantalum Polymer Capacitors

Advances in Reliability of Conducting Polymer Based Capacitors in High Humidity Environment

New Reliability Assessment Practices for Tantalum Polymer Capacitors

Solid Electrolytic Capacitors Designed for High Temperature Applications

Aluminum Hybrid Polymer Capacitors: Application Overview

Is It Hot and Humid in Your Application? A798 Aluminum Polymer Capacitor Can Solve Your Challenges

KEMET's Aluminum Hybrid Polymer SMD Capacitors

High Vibration Applications with KEMET's Solid Polymer Aluminum Capacitors

T599 Tantalum Polymer Capacitors in Automotive Designs

Polymer Capacitors Protect Data at the Last Gasp

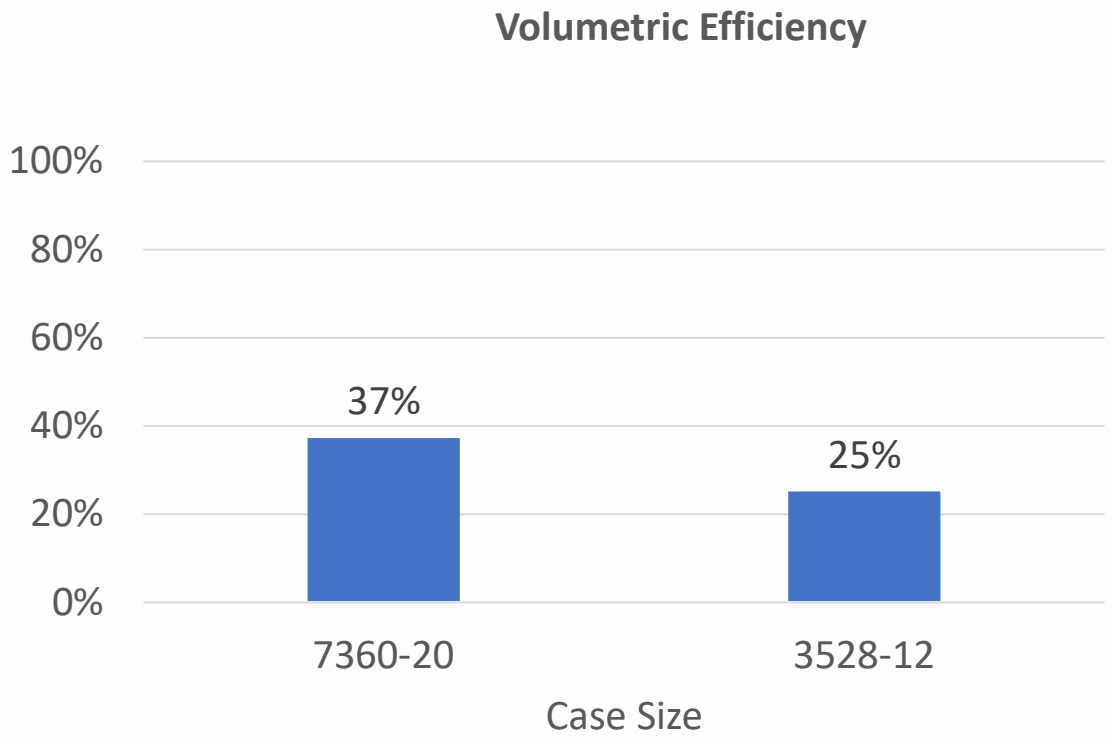
A Solution for ADAS Miniaturization and Reliability Requirements

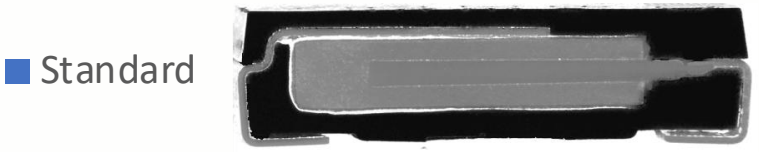
Product Roadmap

- CV Extensions
- Parasitics Reduction
  - ESR
  - ESL
- Reliability
  - Harsh Environment Capability
  - High Reliability Applications
- Packaging
  - New Sizes
  - Efficiency
  - New Geometries

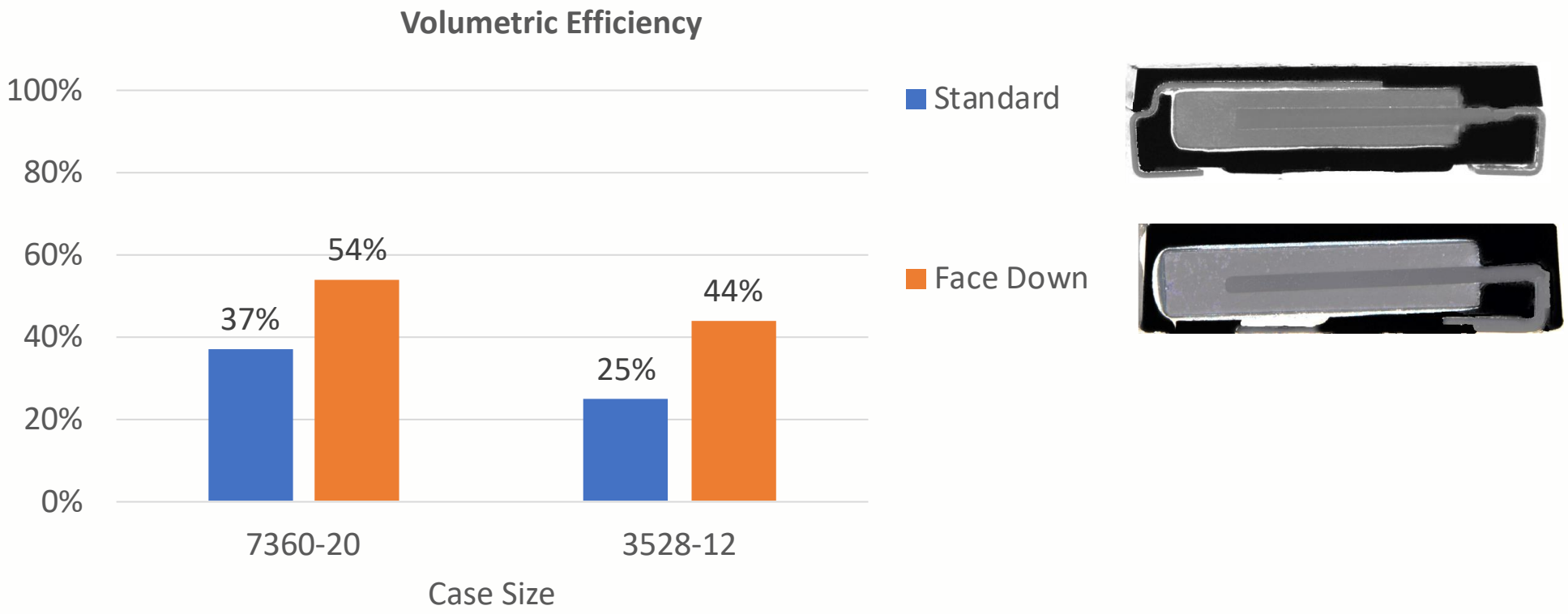
Tantalum Polymer Packaging

Trend Smaller Footprints, Lower Heights, Need for Higher Capacitances

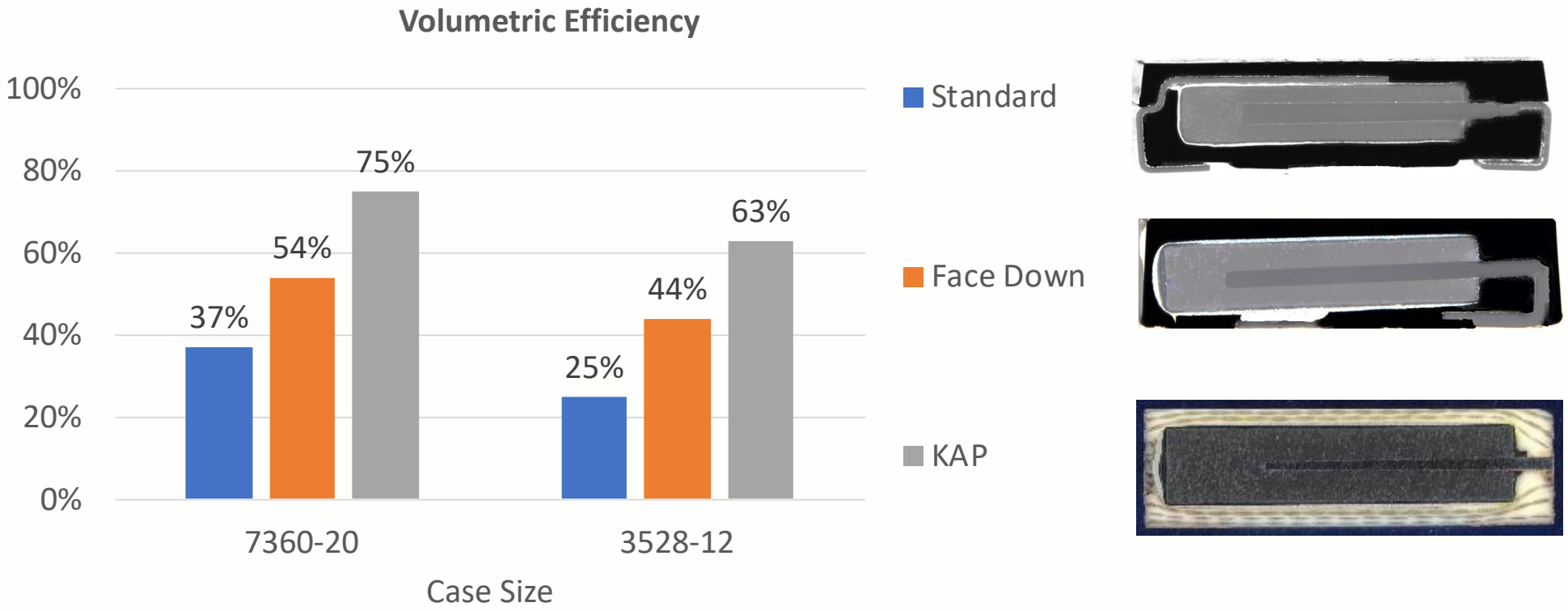




Tantalum Polymer Packaging

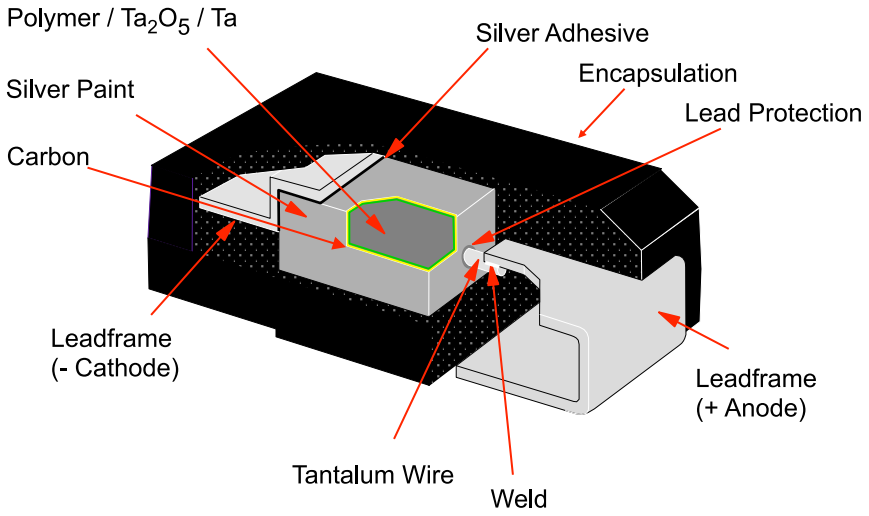


Tantalum Polymer Packaging

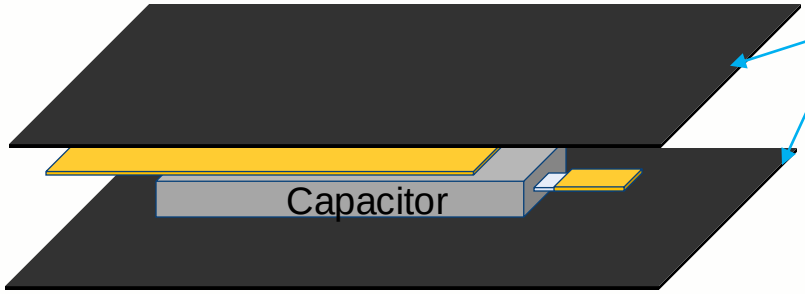


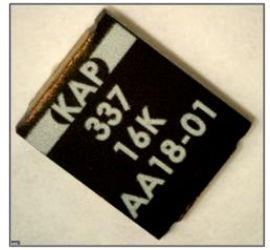
KEMET Advanced Packaging (KAP)

Replaces



With





KAP Product Waterfall Chart

Height (mm)	Nominal Capacitance (µF)					
	7343 Footprint, 35 V_r			7360 Footprint, 35 V_r		
	Std	FD	KAP	Std	FD	KAP
1.5	33	**47**	**68**	47	68	100
2.0	47	68	100	68	**100**	**150**

Height (mm)	Nominal Capacitance (µF)		
	3528 Footprint, 25 V_r		
	Std	FD	KAP
1.2			**22**
1.5		22	33
2.0	**22**	33	47

Current Volume Drivers
KAP Target Growth Drivers

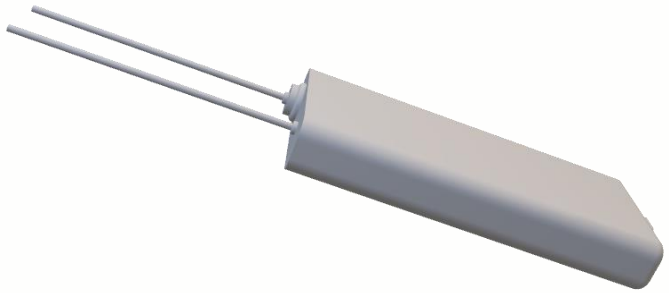
Engineering Samples 1st Half CY22
Production 2nd Half CY22

Aluminum Polymer Packaging

Traditionally, Aluminum Capacitors Are Round

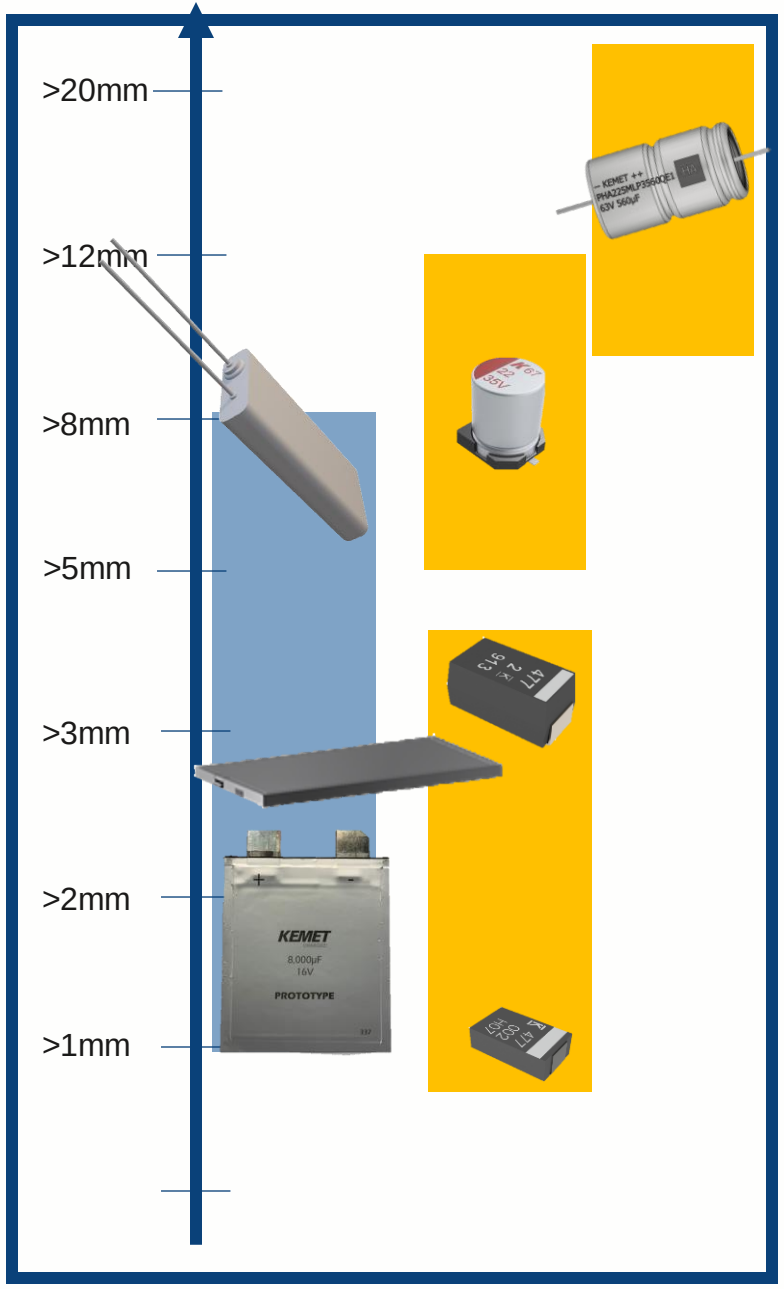
Multiple Placements, Wasted Space, Poor Heat Transfer

A Rectangular Form Factor Can Be The Solution



Aluminum Polymer Rectangular Roadmap

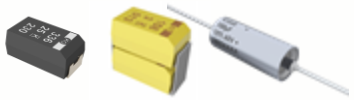
Series	Height	Cap Range	Voltage Range	Rating	Availability
ALL	8mm	120-8200µF	25-200V	105°C, 2khrs	Samples: Now Production: CY21
ULT	2mm 3mm	500-24000µF	4-63V	125°C, 2khrs	Samples: CY22 Production: CY23
PPC	1mm	700-20000µF	6.3-63V	125°C, 2khrs	Samples: Now Production: CY22



Summary

- KEMET has a complete portfolio of Polymer capacitors

KO-CAP/NEOCAP
Tantalum Polymer



AO-CAP
Al Polymer H-Chip

EO-CAP
Al Polymer V-Chip/Thru Hole

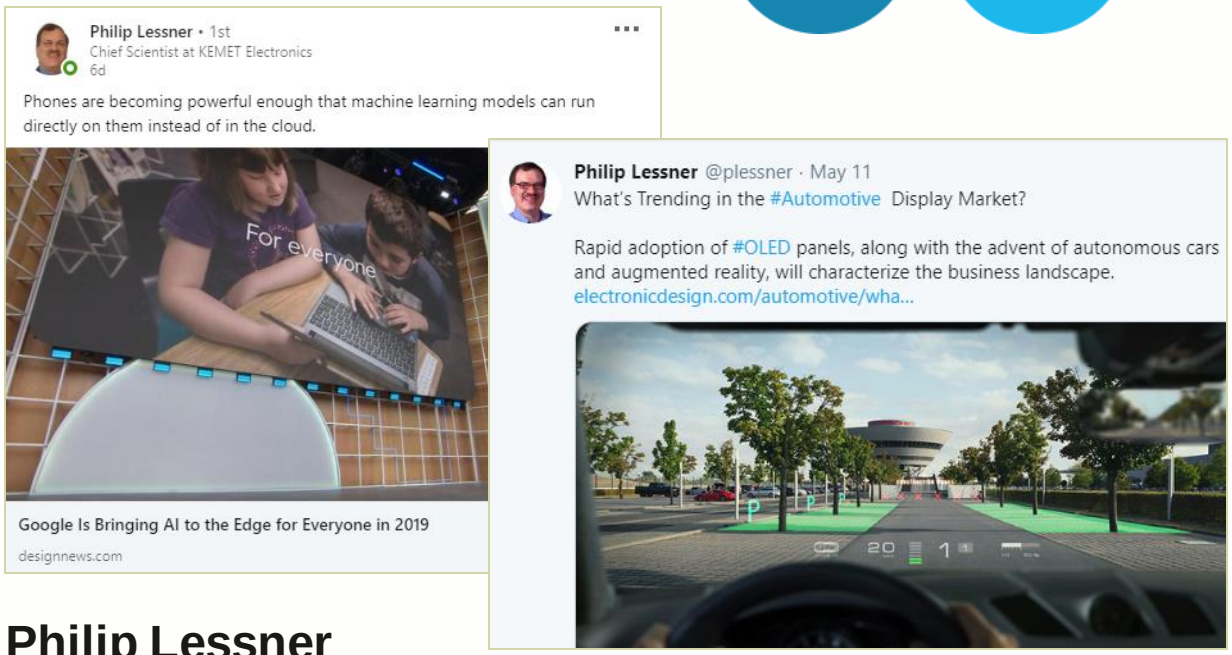
EO-CAP
Al Polymer Hybrid

- Choosing the right Polymer capacitor depends on many technical factors and total solution cost
  - KEMET's technical collateral and tools like K-Sim and Component Edge can help with the selection

- KEMET has a robust roadmap for new products across all the Polymer product lines

Connect With Me

@plessner



Philip Lessner
Chief Technology Officer
philiplessner@kemet.com
Mobile: +1-864-350-3563