KEMET

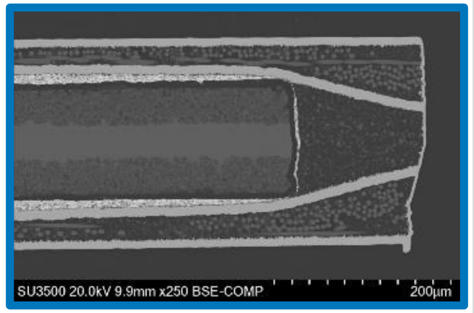
a YAGEO company

Aluminum Polymer as a Solution for Embedded Componentry

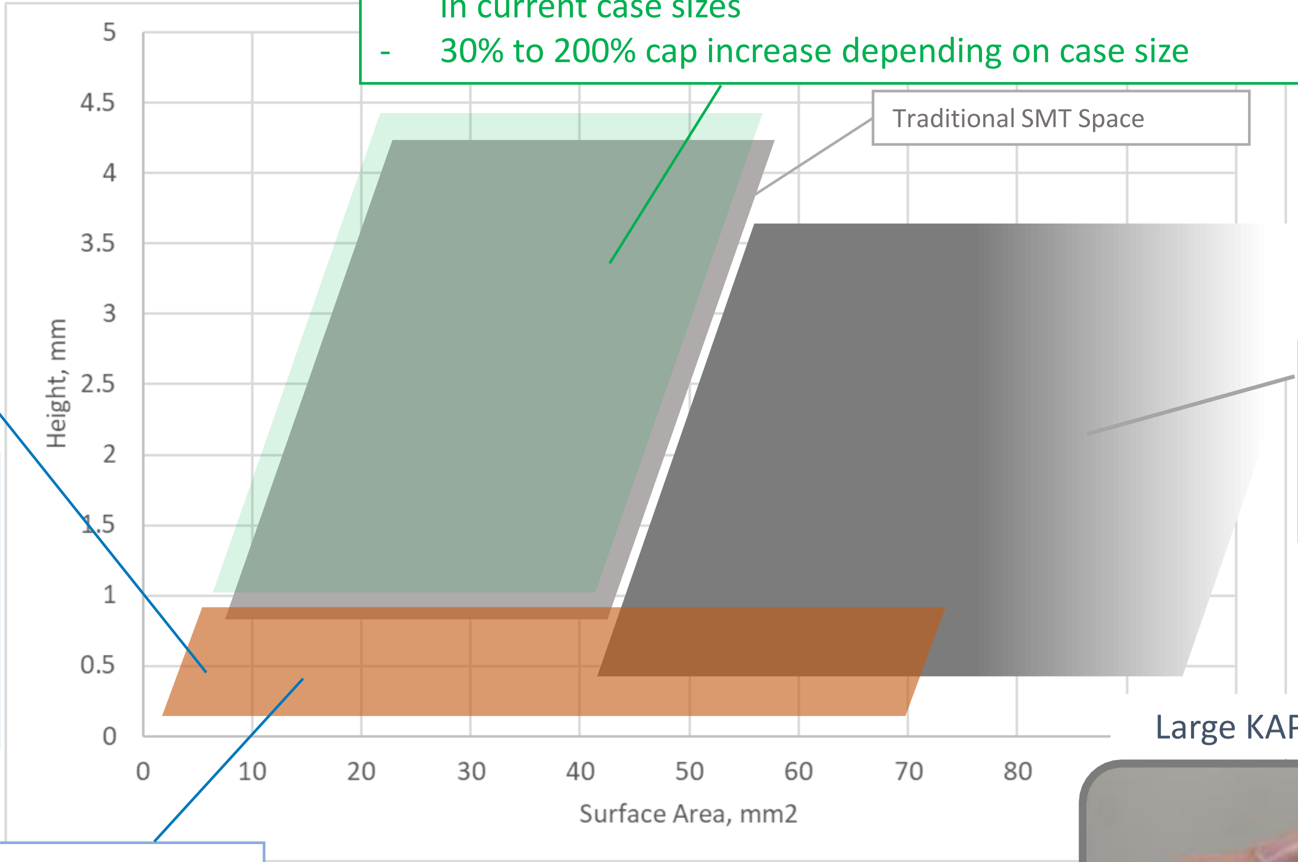
KAP: KEMET Advanced Packaging

KAP – 1515-025

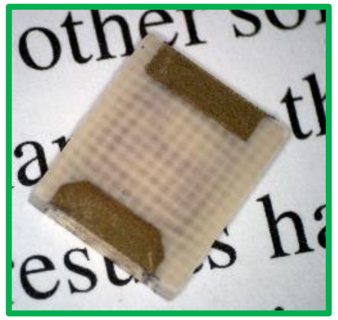
Embedded



<ins>KAP: EIA Sizes (High CV/cc)</ins>
- Better volumetric efficiency allows increased capability in current case sizes
- 30% to 200% cap increase depending on case size

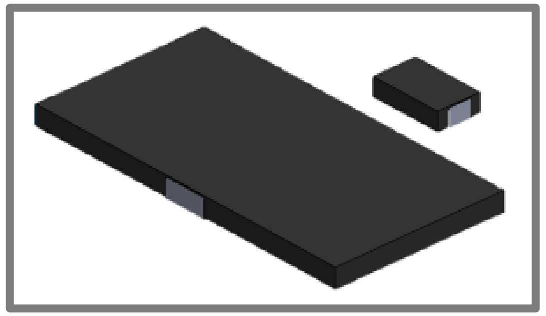


KAP – H Case 7360-20

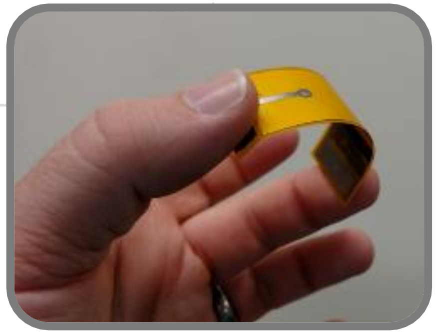


<ins>KAP: Large Footprint / Embedded</ins>
- These designs address customer needs for valve metal capacitors where large energy is needed, ex. SSD

Large Footprint



Large KAP Flexible



<ins>KAP: Low Profile / Embedded</ins>
- These designs address customer needs for valve metal capacitors in the low profile / height restricted areas

AGENDA & SPEAKER

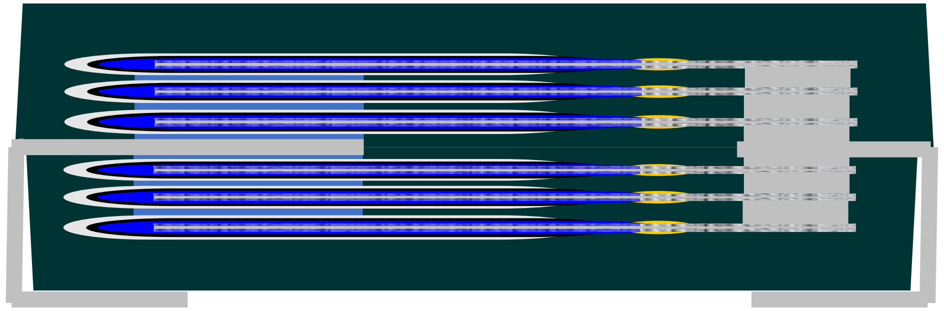
Agenda

1. The Technology Choices: Aluminum
2. Looking into the chip
3. The power of embedding

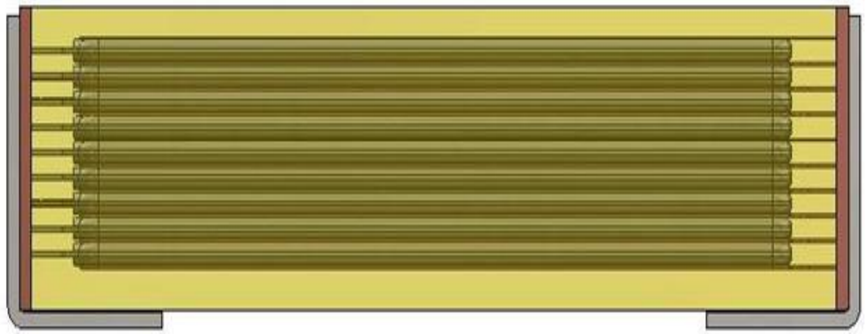
About the Speaker

Wilmer Companioni, Senior Technical Marketing Manger
BSEE University of Florida
15 years of industry experience
2 years in sales
7 years in marketing
10 years in engineering design

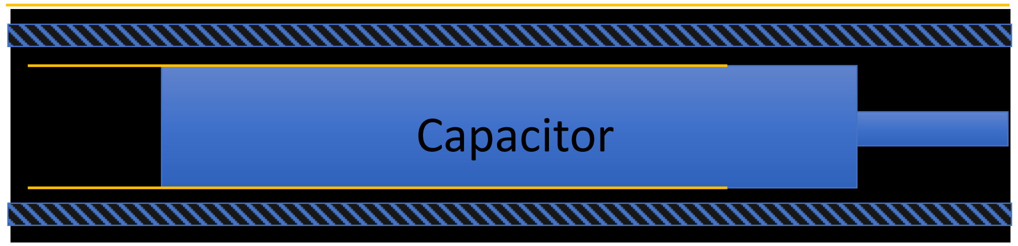
Evolution of Packaging



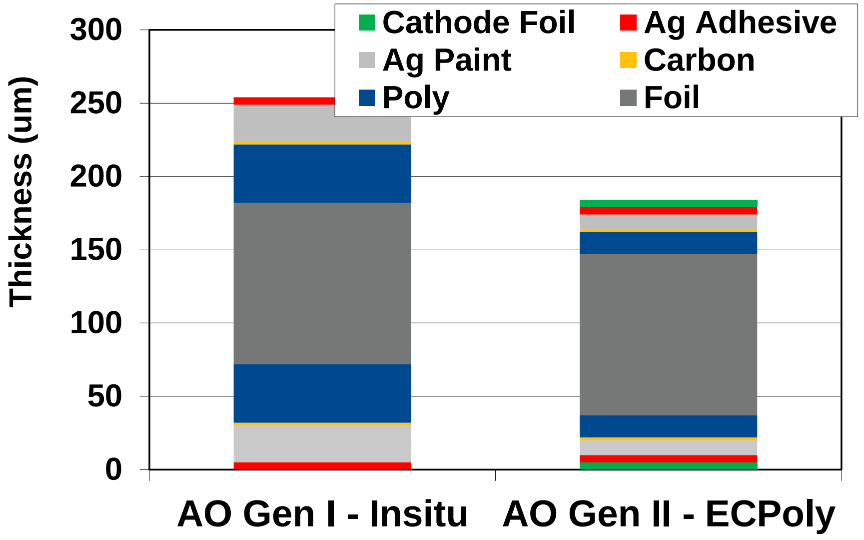
AO-CAP Gen I



AO-CAP Gen II



Embedded

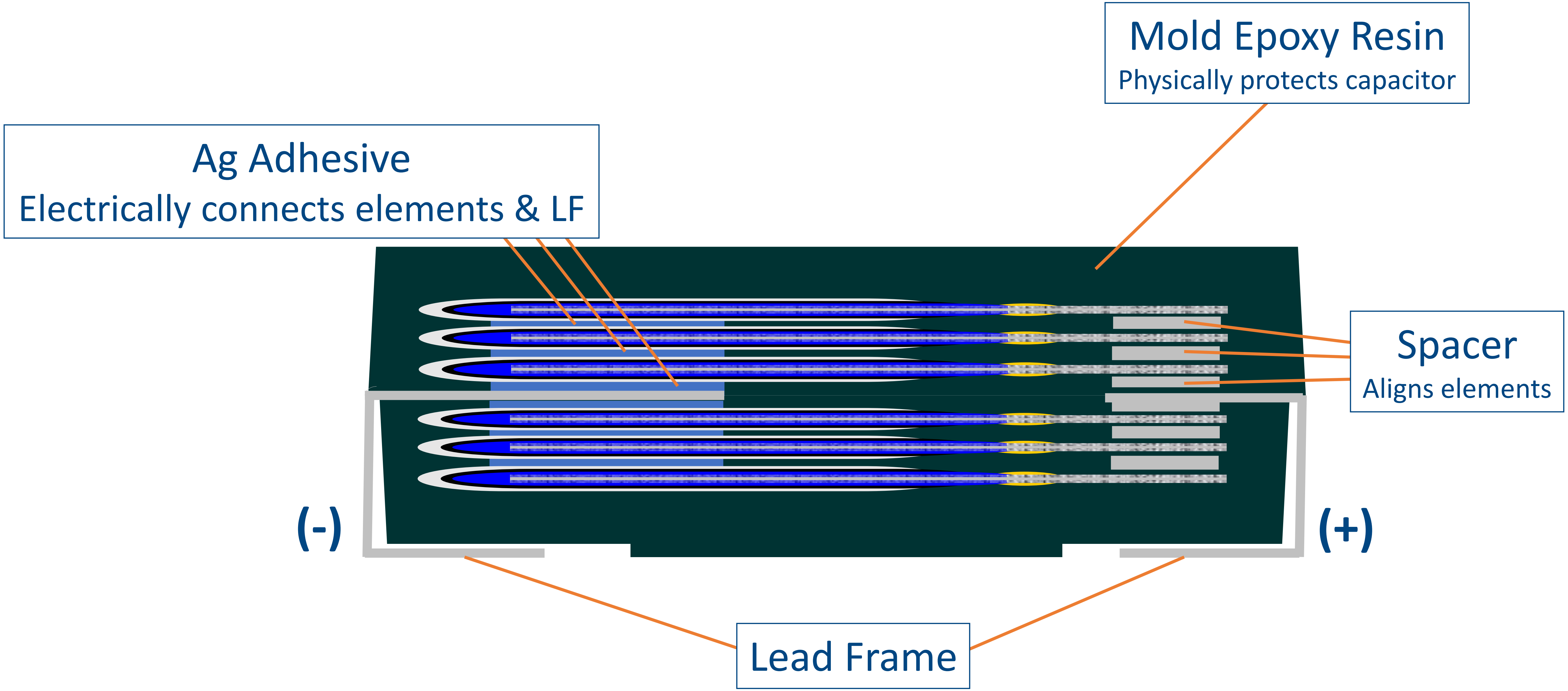


Comparative Properties

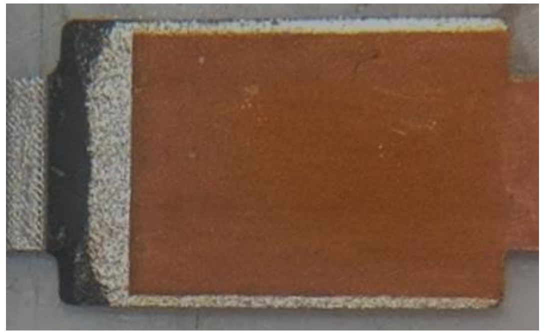
	AO-CAP	Ta-MnO_2 & KO-CAP
Physical Form of Metal	Etched Foil	Sintered Metal Powder Compact
Density of Metal, g/cc	2.7	16.6
Metal Oxide Dielectric	Al_2O_3	Ta_2O_5
Dielectric Growth Rate, Ǻ/V	10	20
Dielectric Constant	8.5	27
Anode Resistivity	26.5 nΩ-m	131 nΩ-m

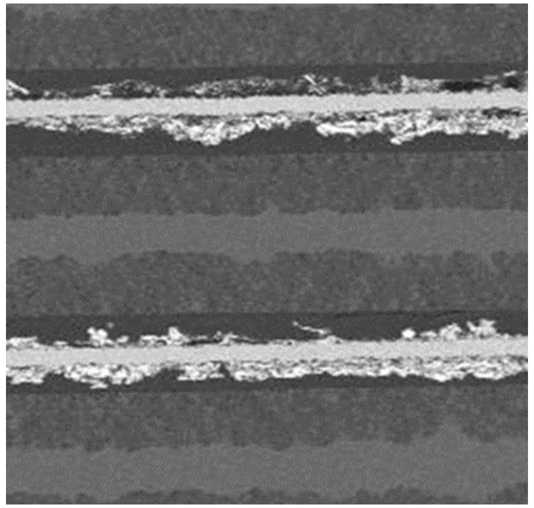
AO-CAP Construction

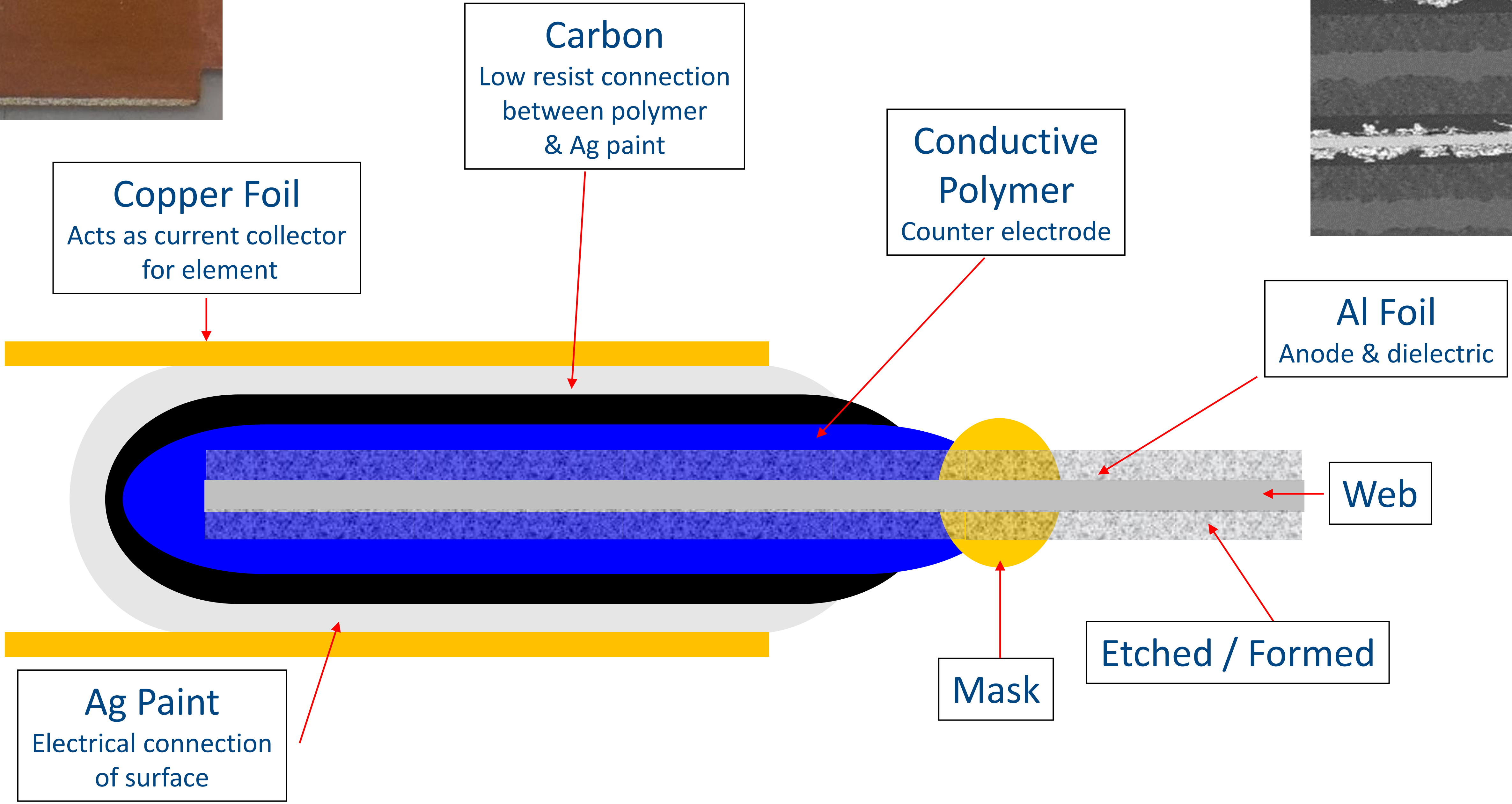
D-Case – 3 x 3



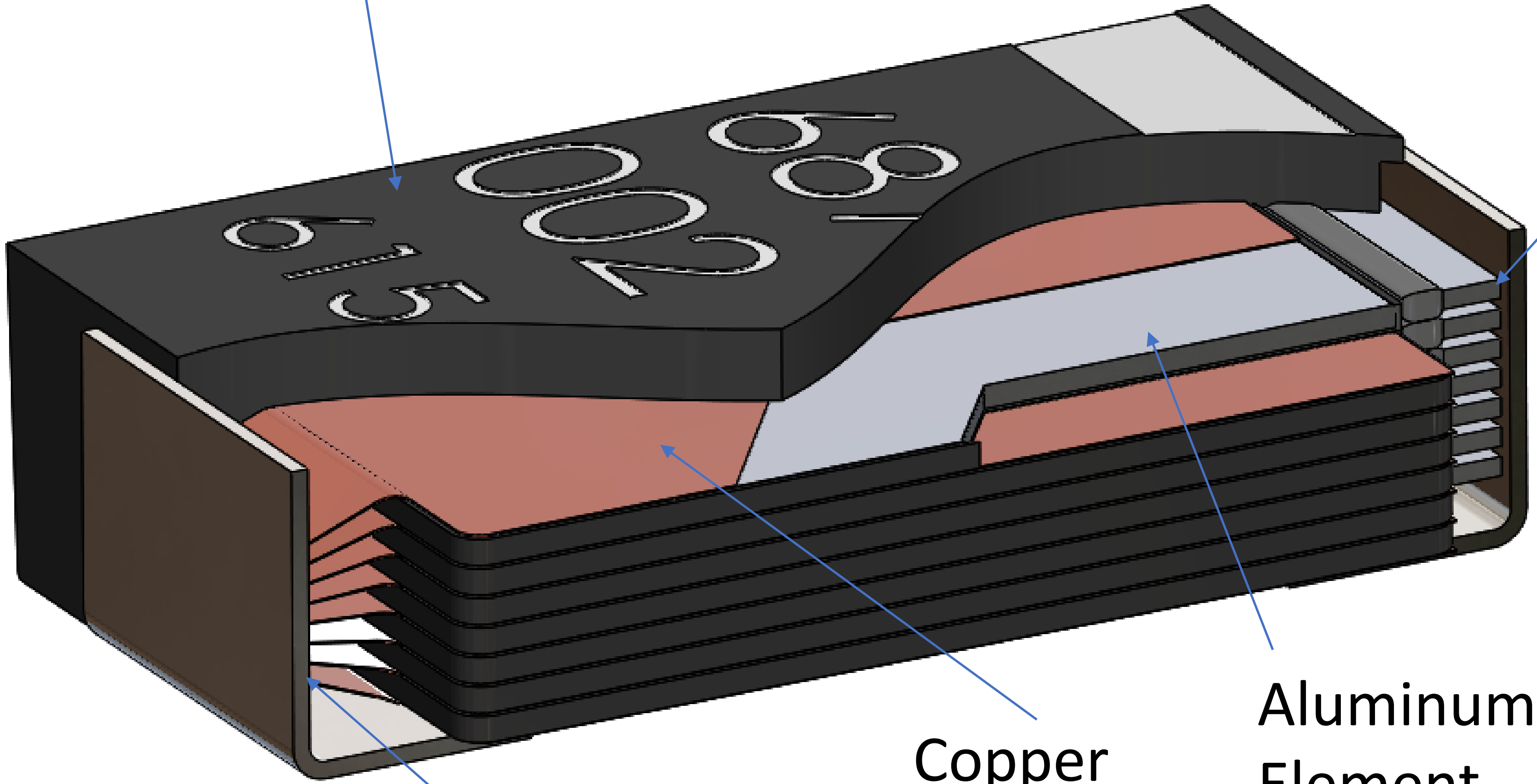
AO Gen II Element Construction



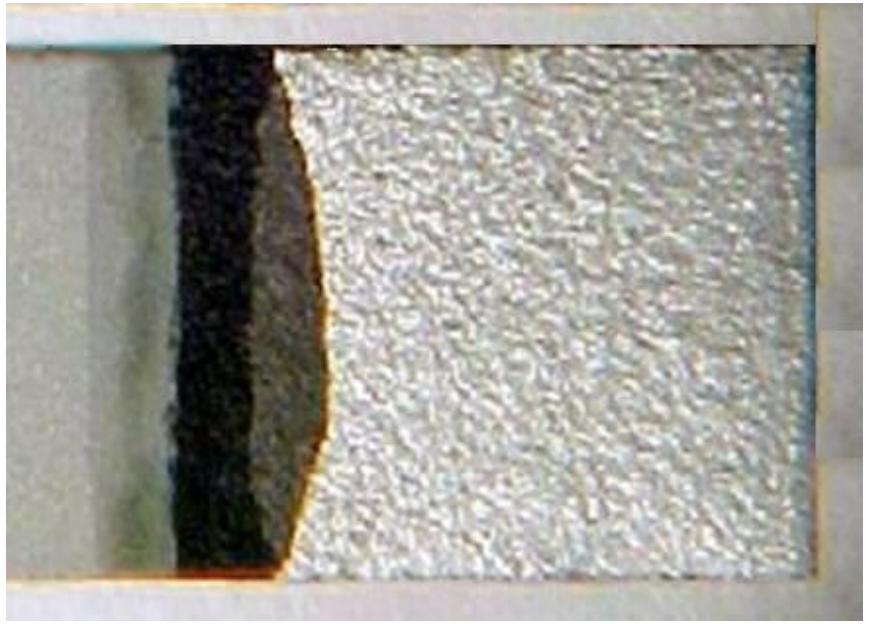


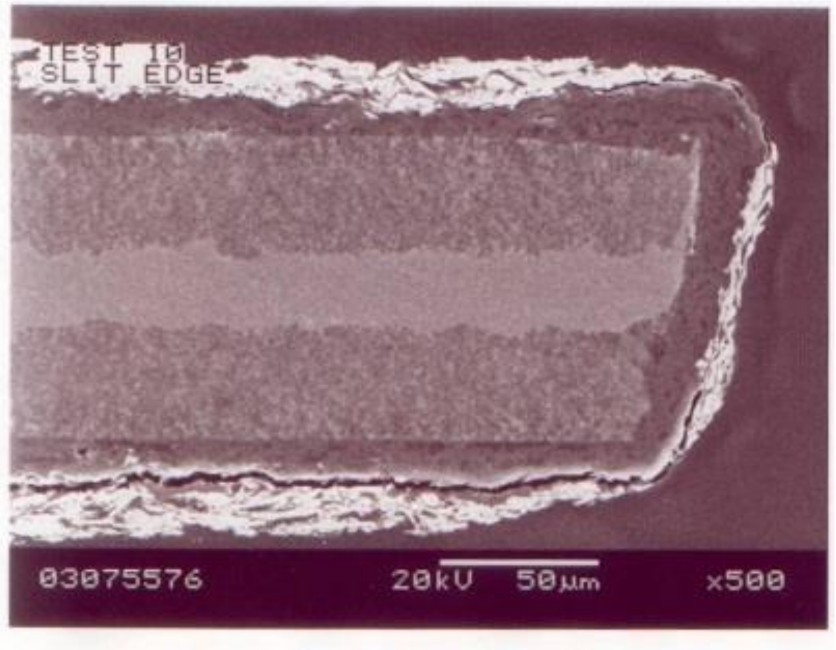


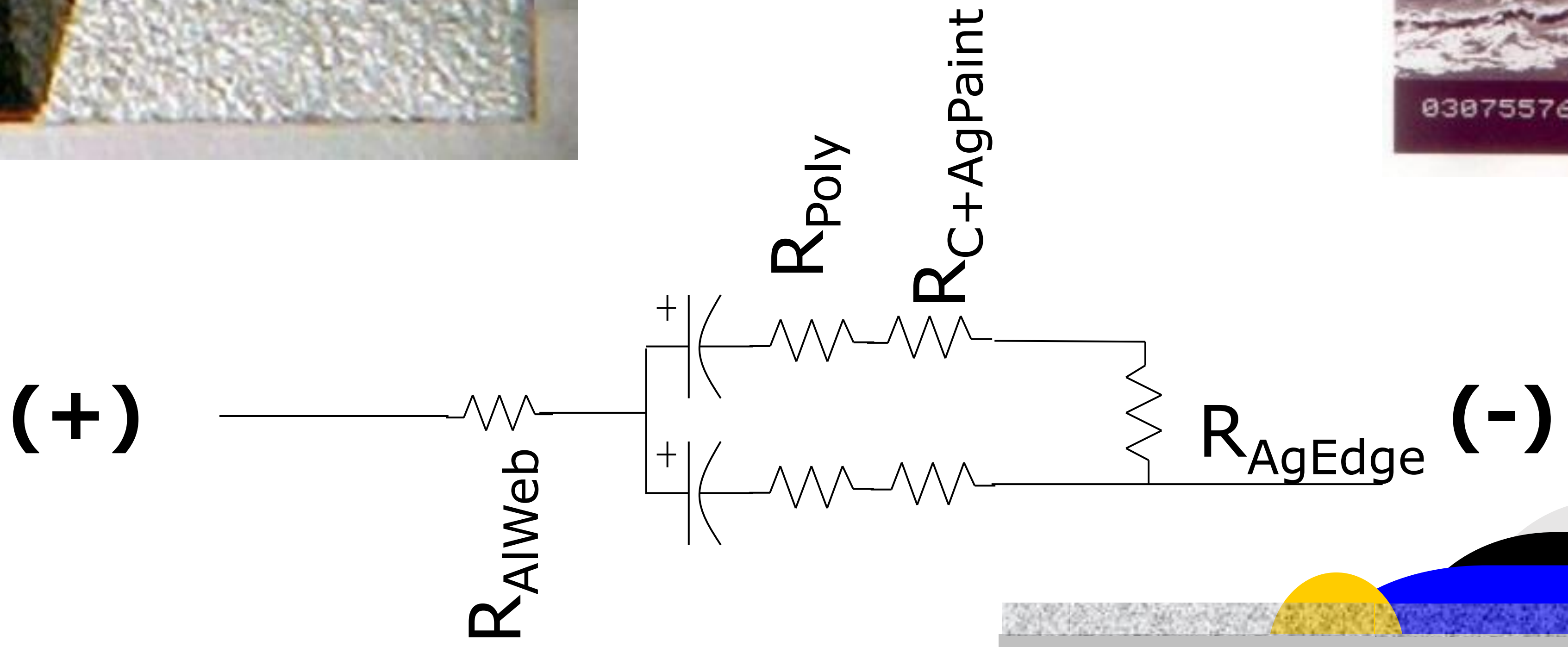
AO Gen II Construction



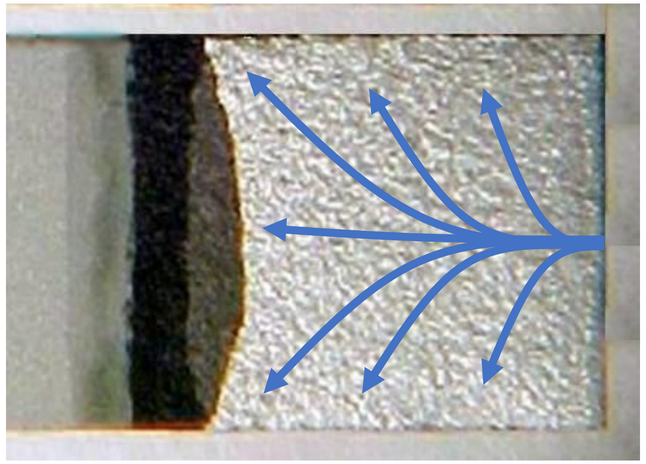
Simplified - AO Cap Element



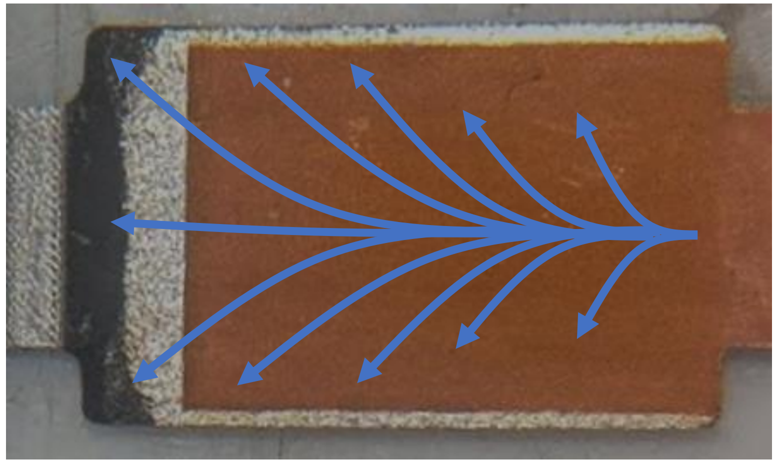




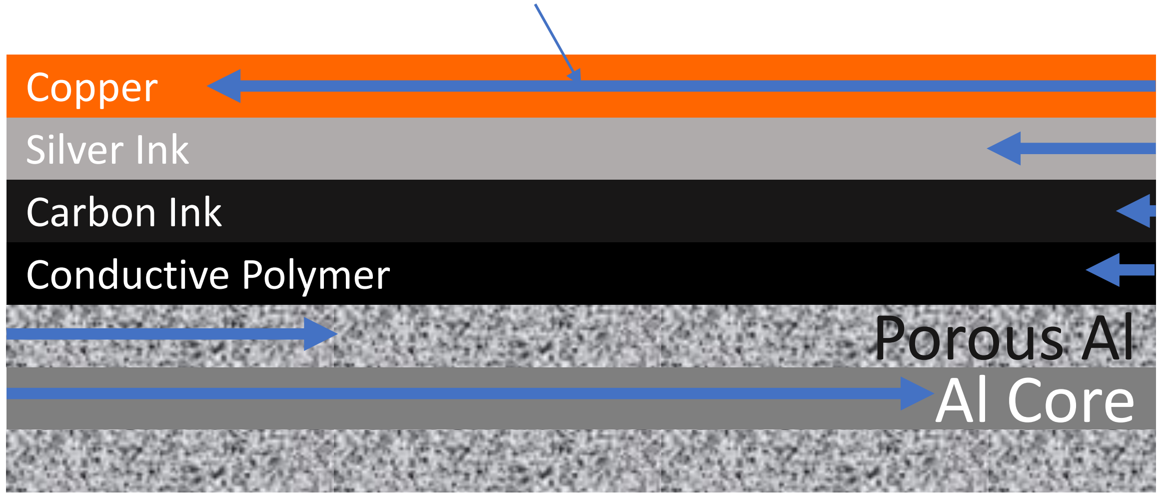
AO Gen II Element – Construction Benefit



- To reach the capacitance, regions of the part the current must traverse from one end of the element to the other end.



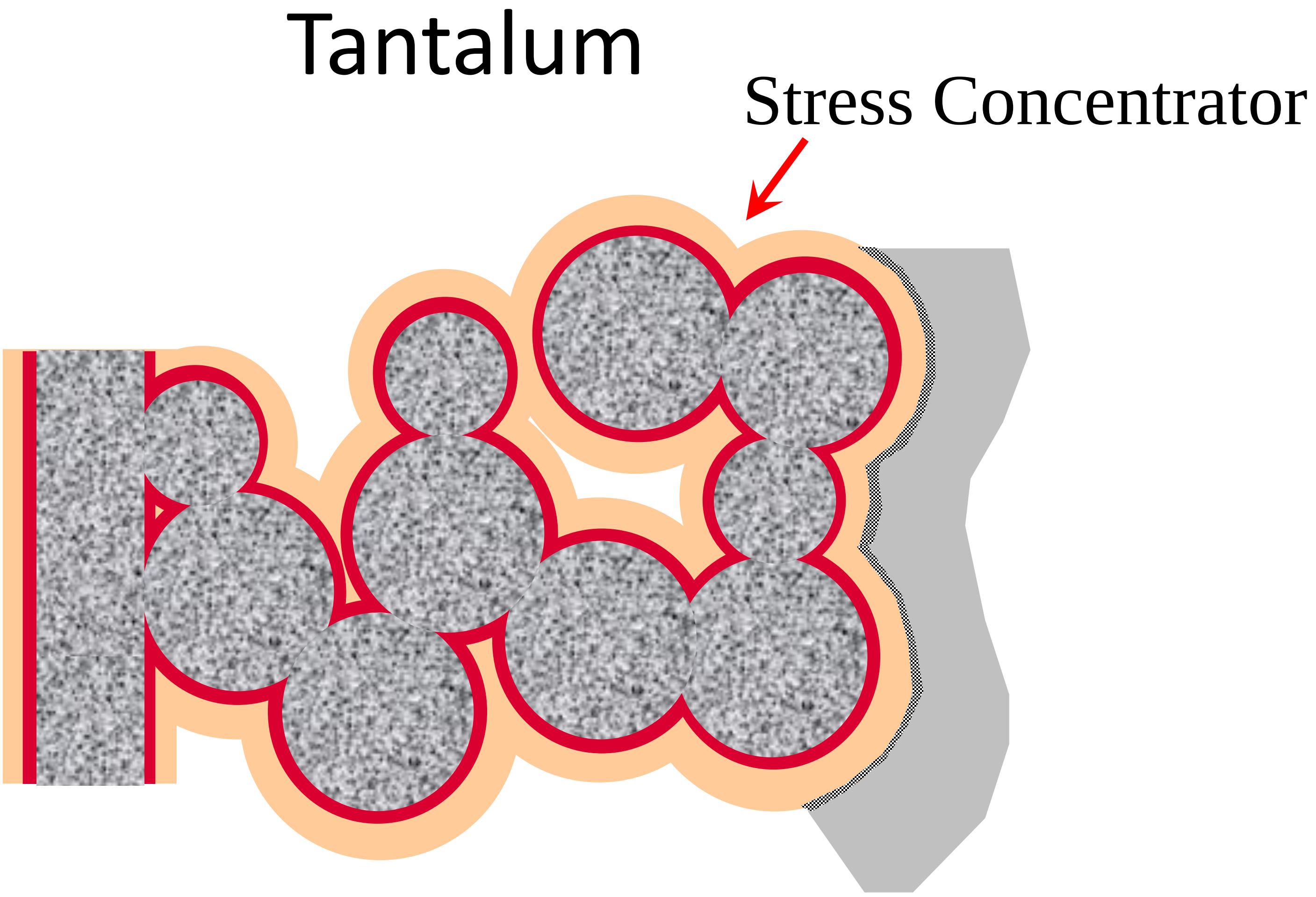
Copper: 5X+ more conductive than silver inks

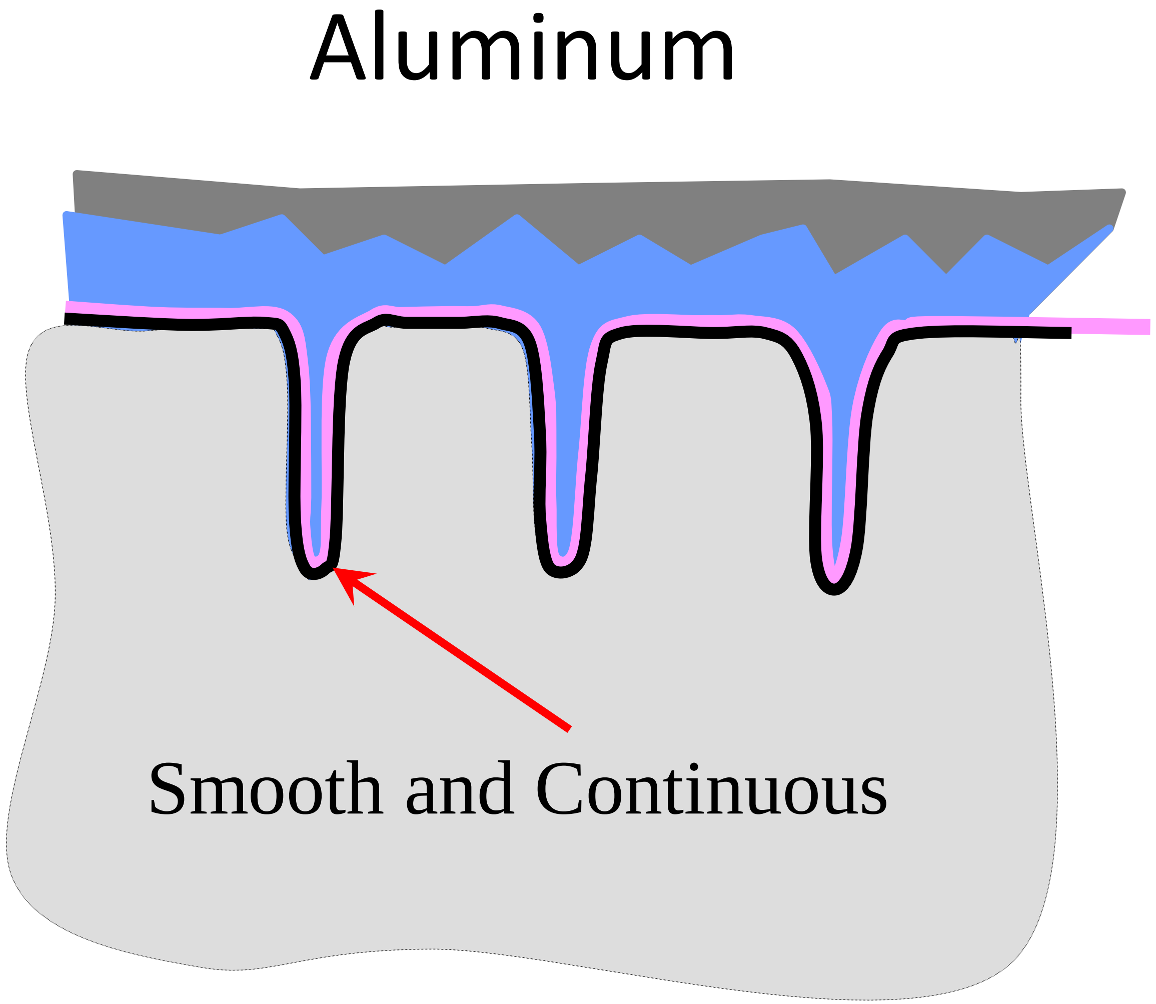


	Conductivity (S/cm)	Conductivity Relative to Cu
Polymer	10-1000S/cm	0.002-0.2%
Carbon	1-20S/cm	0.0001-0.003%
Silver	10,000-100,000S/cm	1.7-17%
Copper	600,000S/cm	100%

Differences in Ta Versus Aluminum Structure
No “Wedges” in Al Structure

- No derating is required at max temperature for aluminum polymers.





Voltage Derating Guidelines

	$Ta\text{-}MnO_2$	Poly KO V_R>10VDC	Poly KO V_R≤10VDC	Alum-Poly AO
100 PPM FR % V_{Rated}	68%	172%	199%	235%
@50% V_{Rated} FR(PPM)	9	0	0	0
@80% V_{Rated} FR(PPM)	458	0	0	0
@90% V_{Rated} FR(PPM)	1700	2	1	0
@100% V_{Rated} FR(PPM)	6310	5	6	0
Leakage Limit	0.01CV	0.1CV	0.1CV	0.04-0.06CV

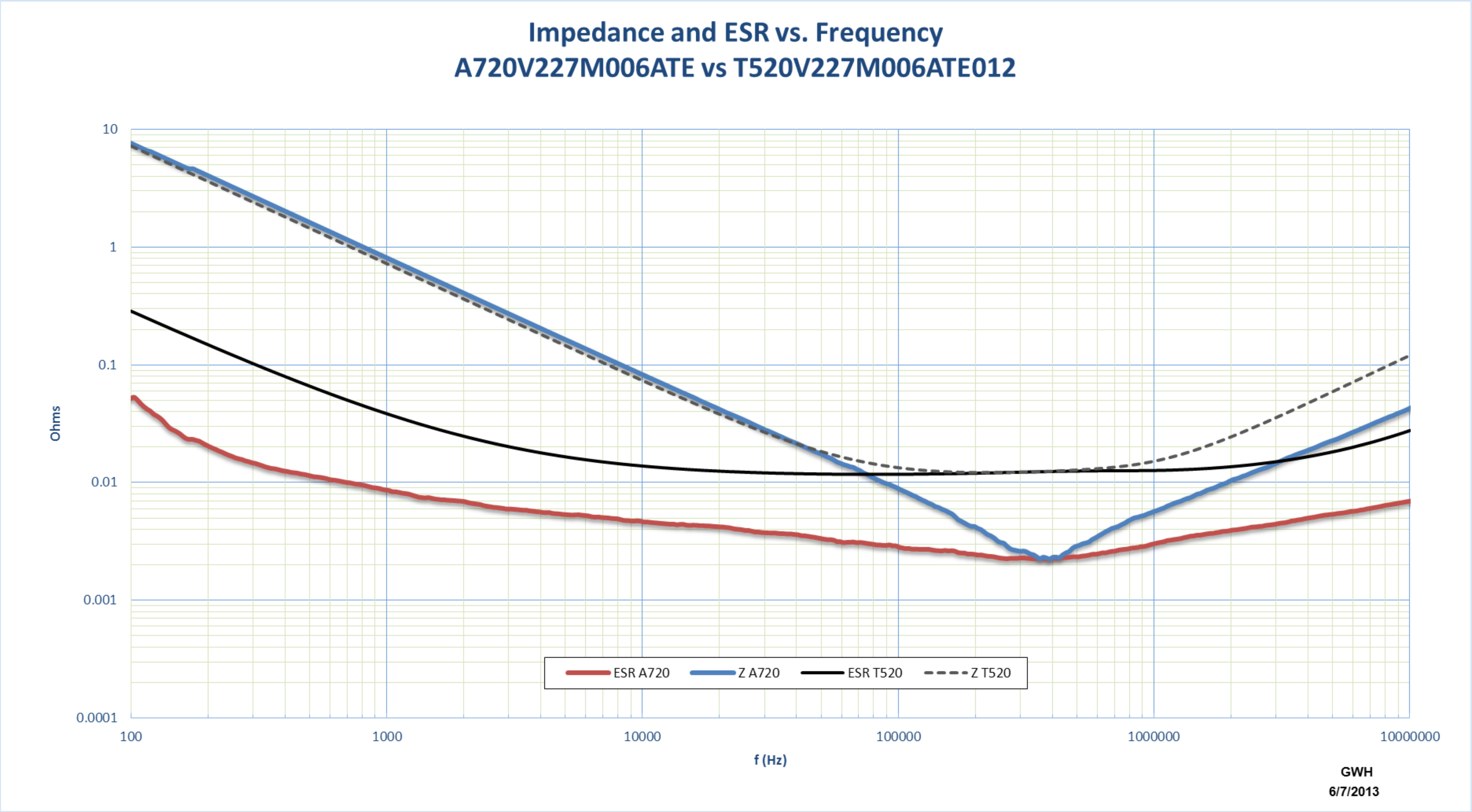
Typical derating guidelines:

- Tantalum MnO_2: 50%
- Polymer KO: 10%
- **Aluminum Polymer: 0%**

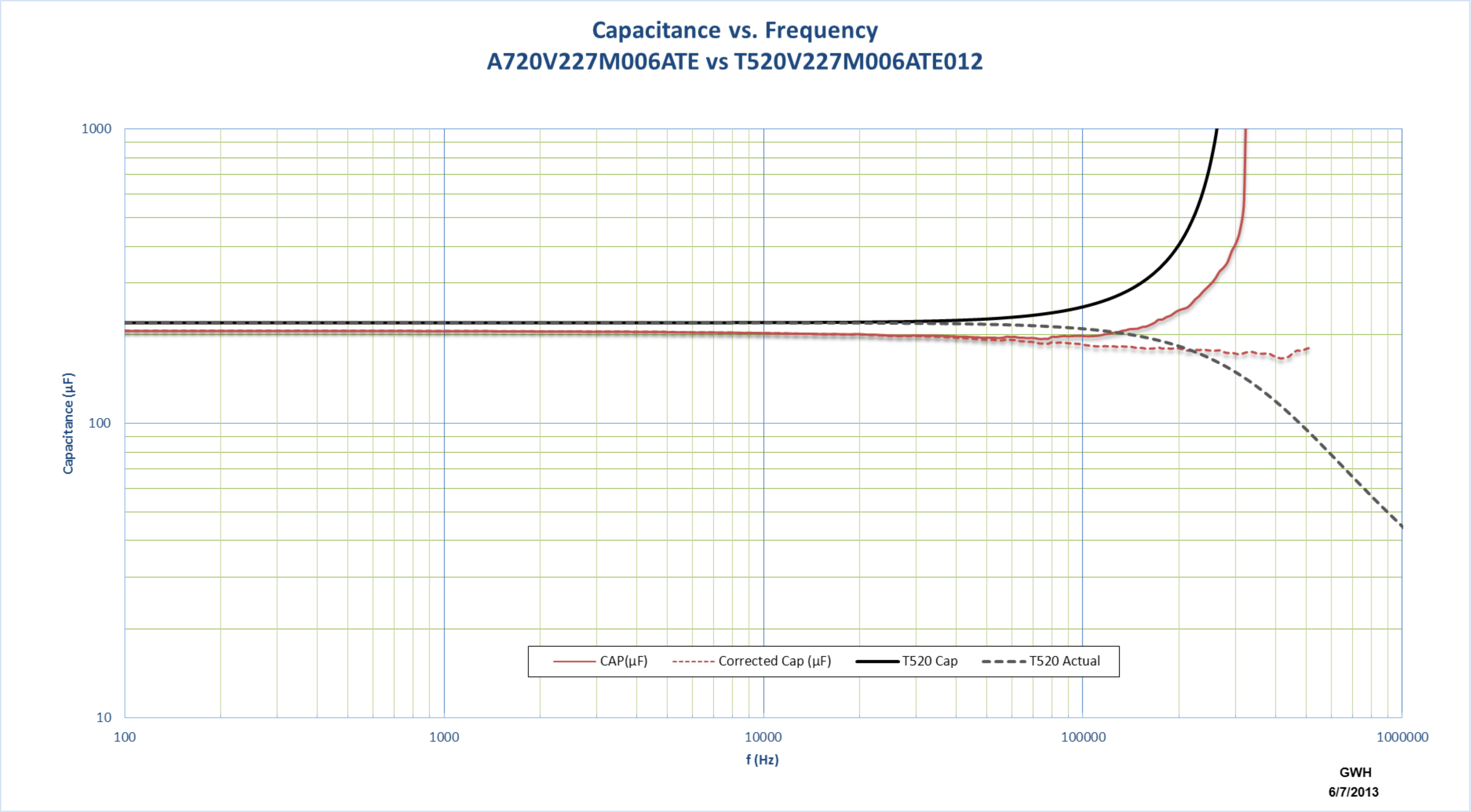
Temperature Ratings:

- Tantalum MnO_2: 125ºC up to 230ºC
- Polymer KO: 105ºC - 150ºC
- Aluminum Polymer Gen I: 125ºC
- AO Gen II: 105ºC - 125ºC (future)
- MLCC (X5R): 85ºC

ESR and Impedance vs. Frequency
AO Gen II vs. KO

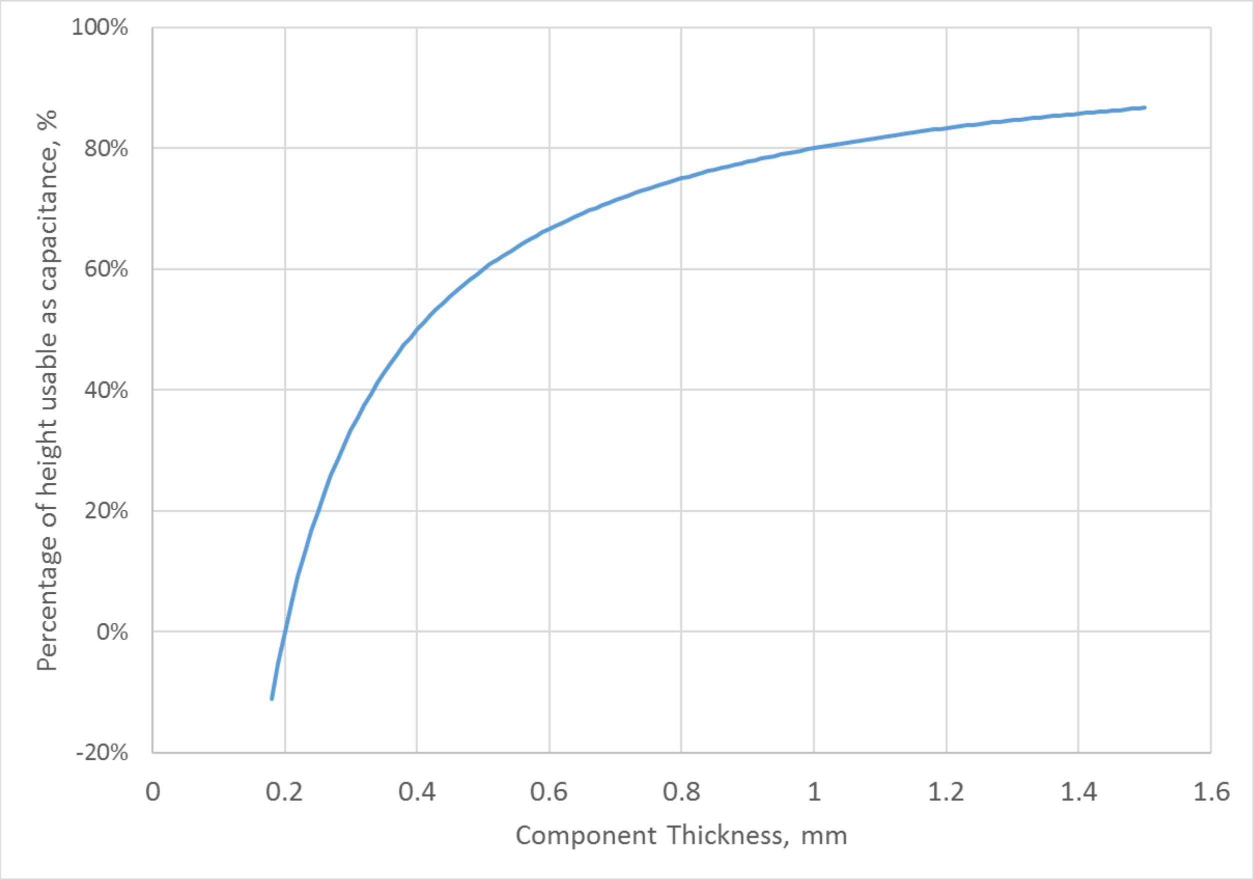


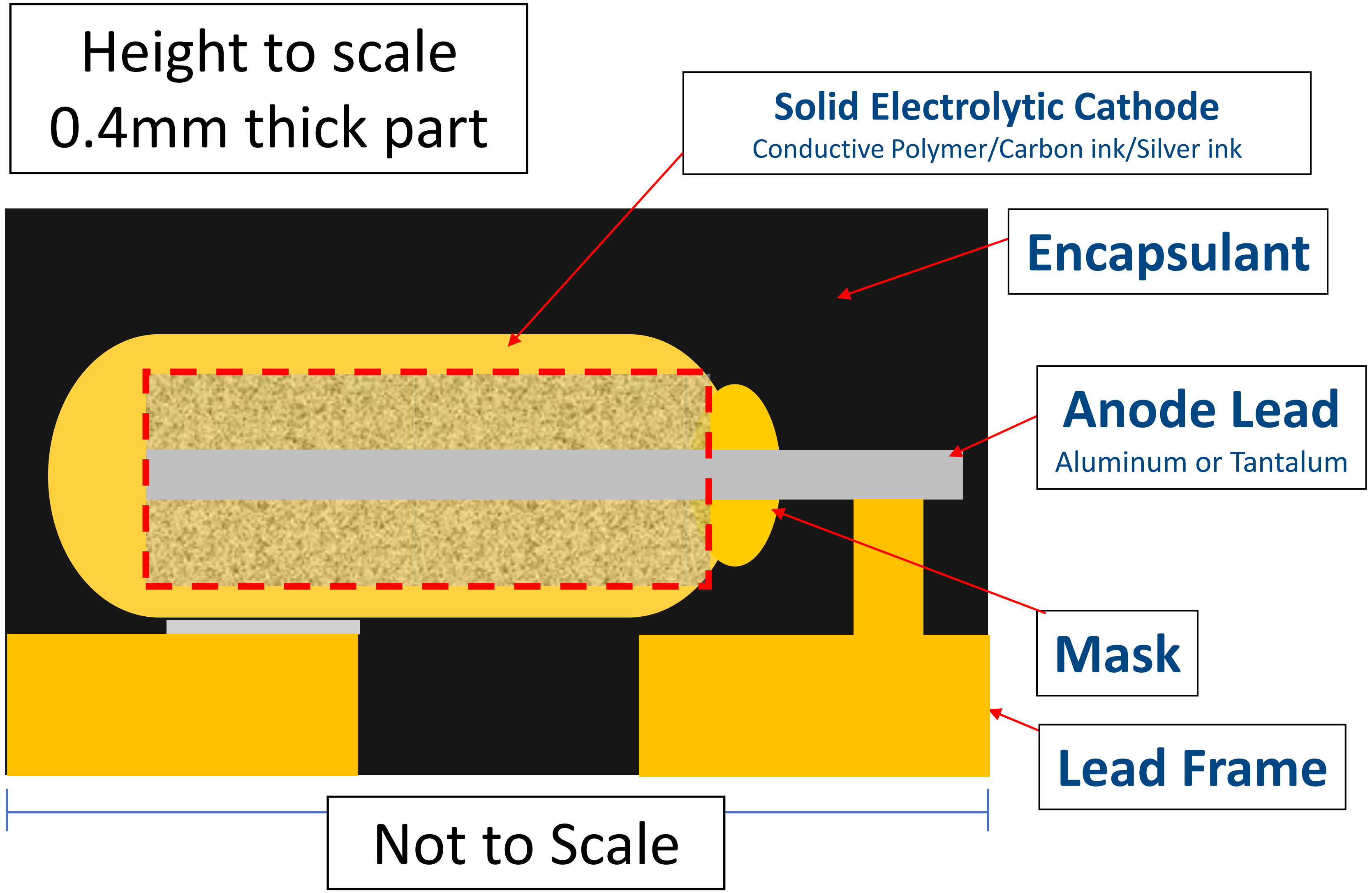
Capacitance vs. Frequency
AO Gen II vs. KO



Progression to Thinner Components

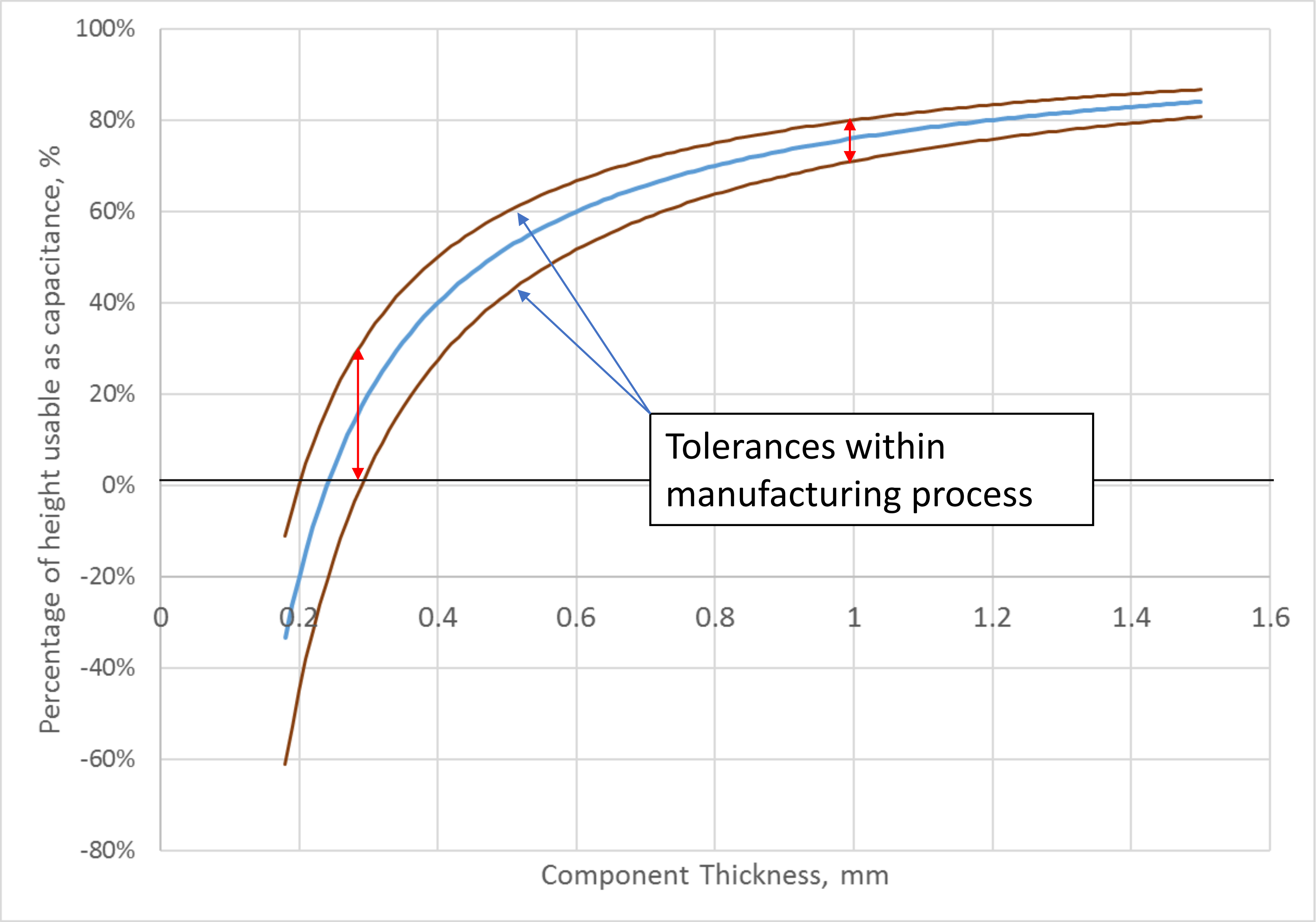
- As the thickness of device is reduced the percentage of height used for capacitance decreases quickly.



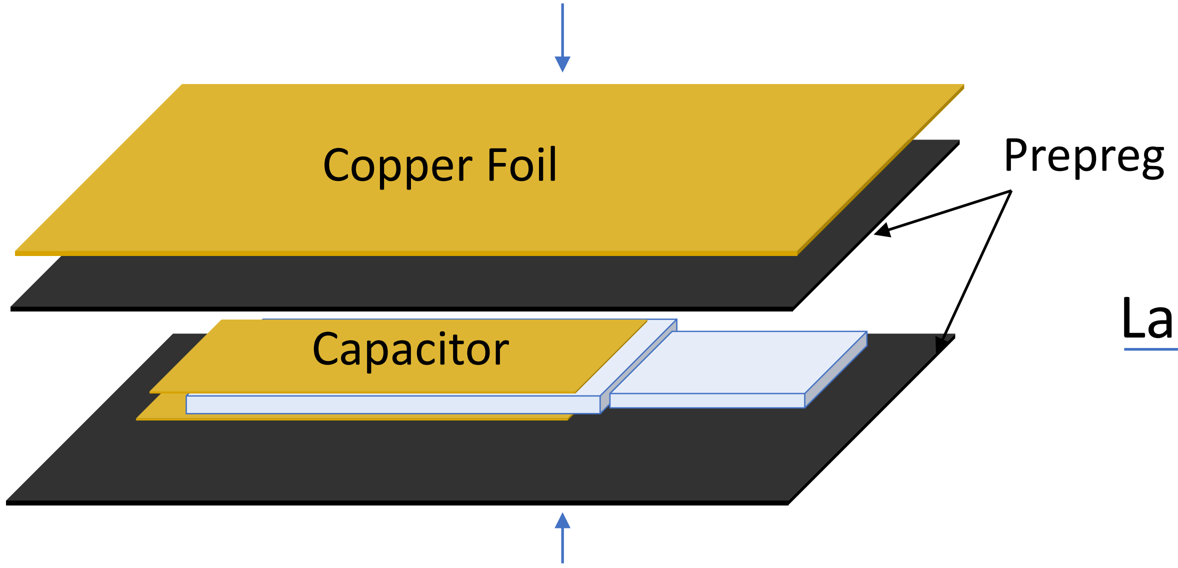


Where Traditional Methods Run Out

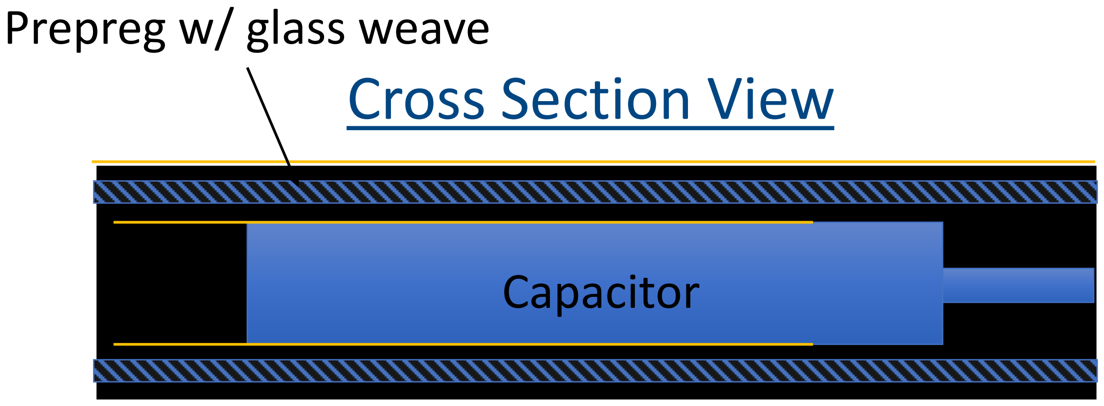
Usable capacitor height is decreased further when factoring in manufacturing tolerances.

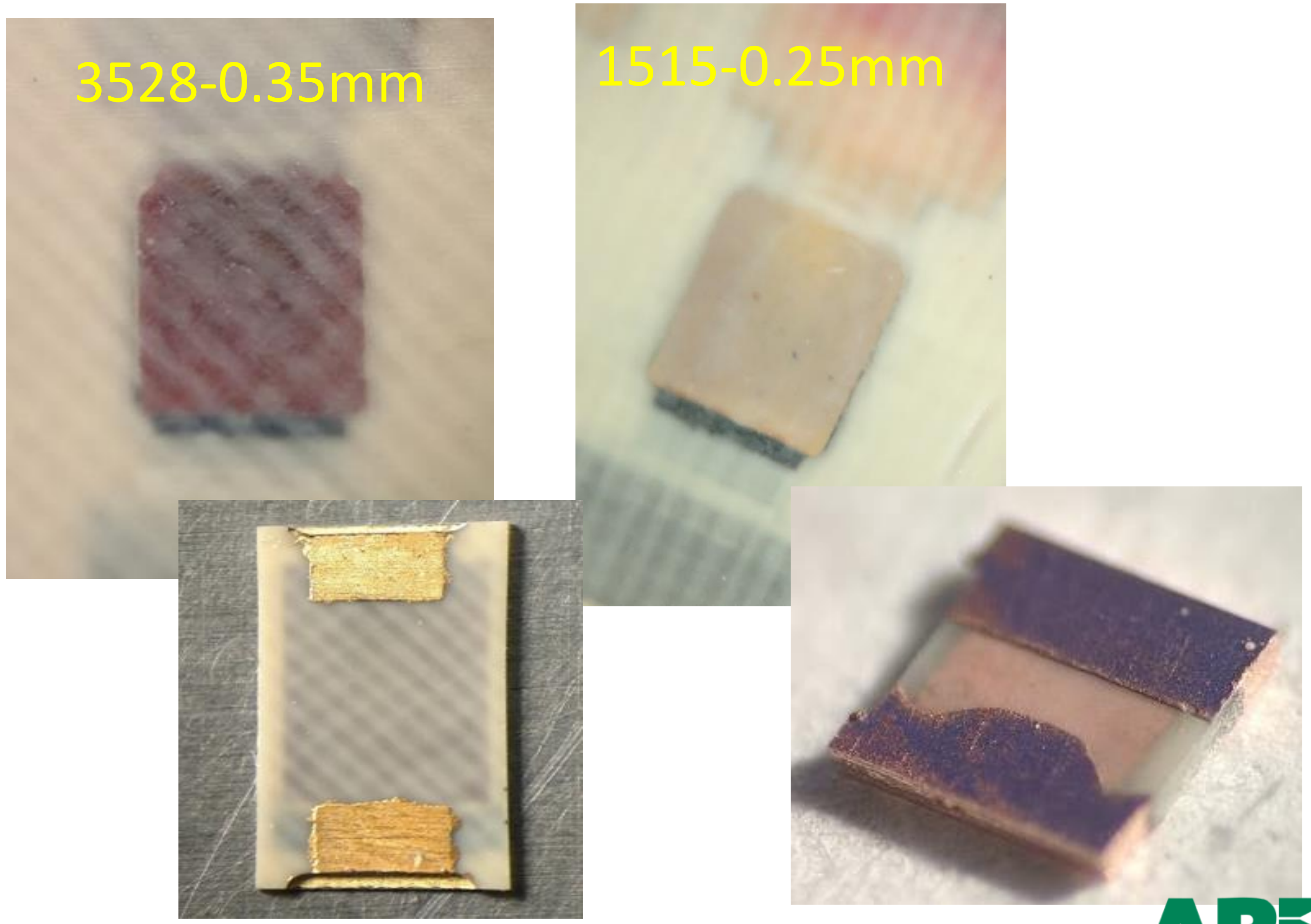


KEMET Advanced Packaging - Process



LaminationS
tep

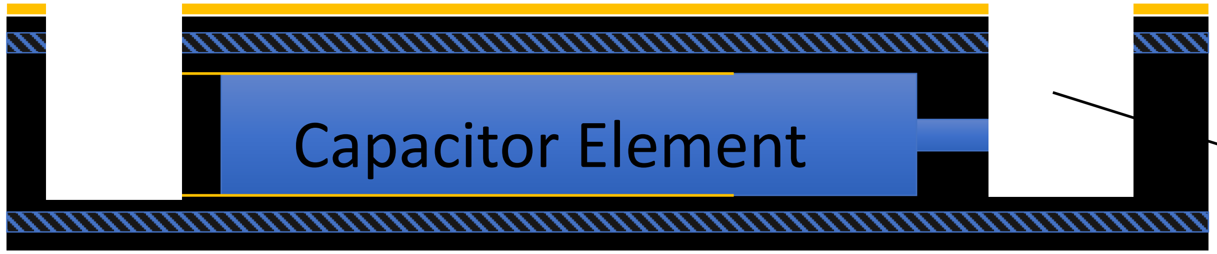




- Capacitor lamination processed in such a way as the glass weave is compressed to the capacitor elements and provides thickness limits.

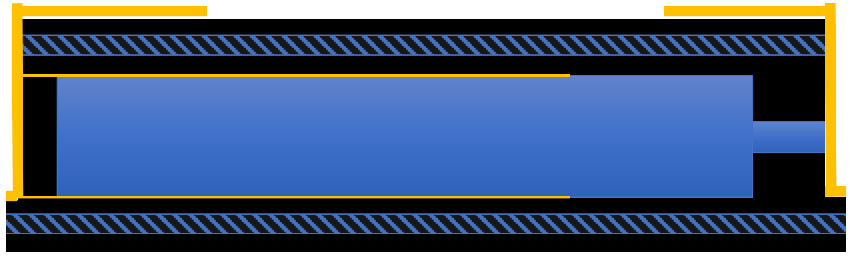
KAP - Terminal Forming

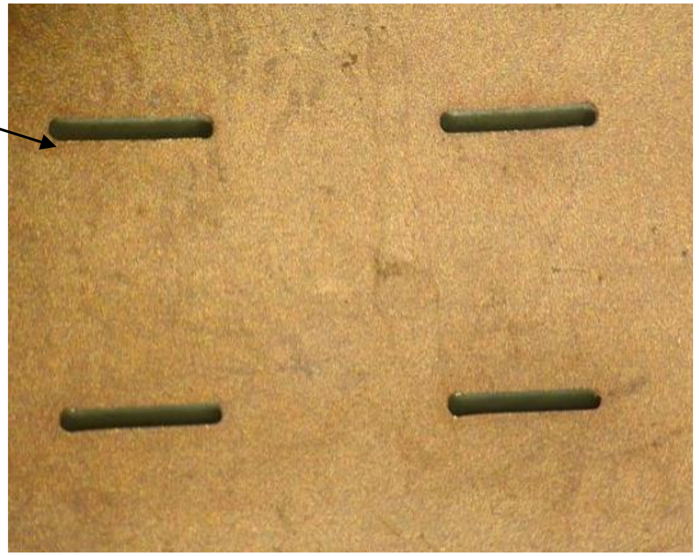
- Pockets cut into laminate form the basis for the terminals.
- Copper plating is formed inside the pockets to connect the capacitor and the copper cladding layer.

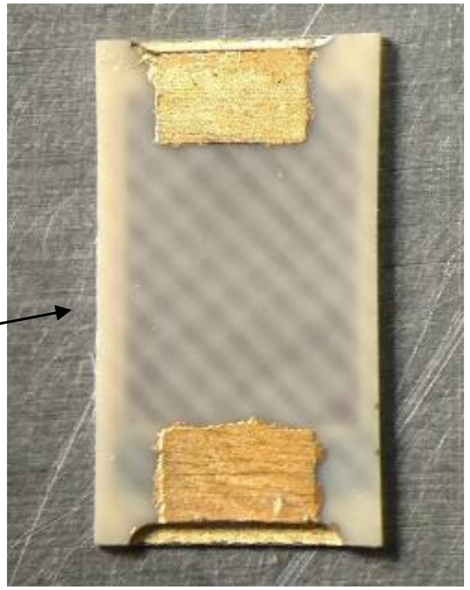


Copper plating into vias/pockets to form terminal connections

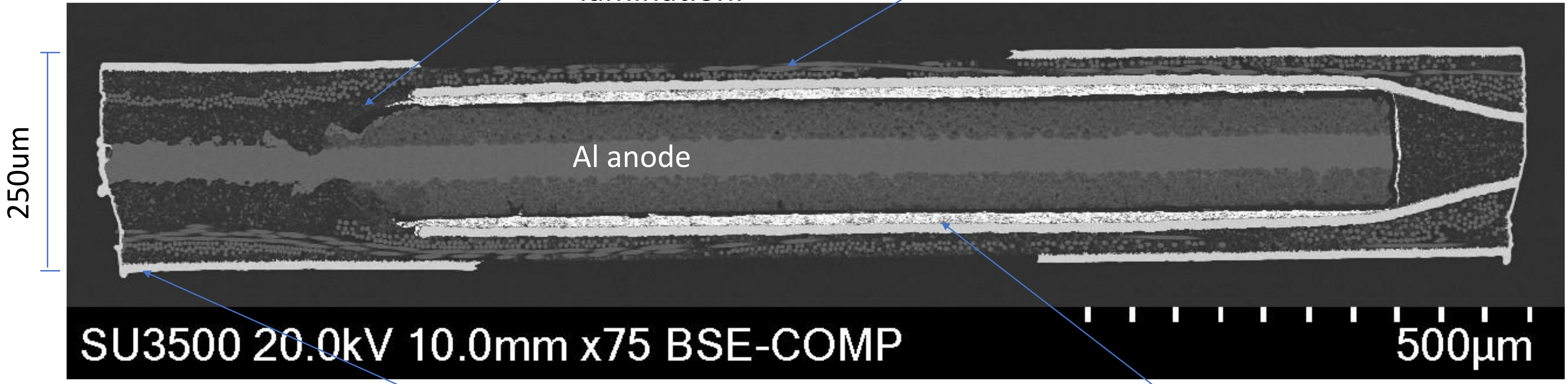
Copper etched to form discrete terminals and capacitors cut free from the laminate





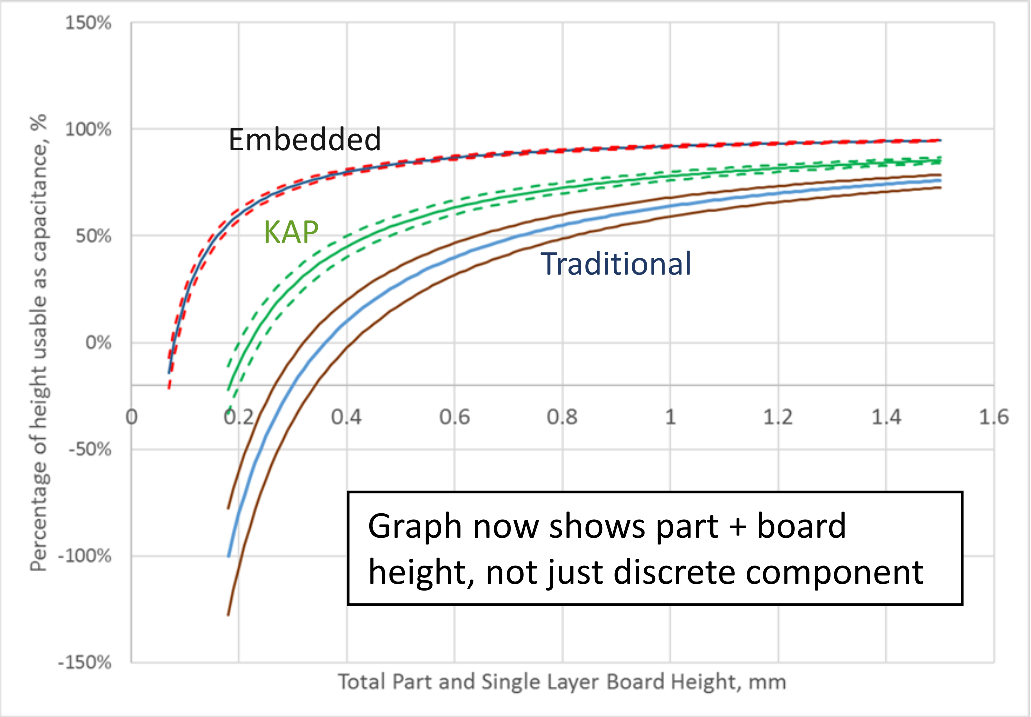


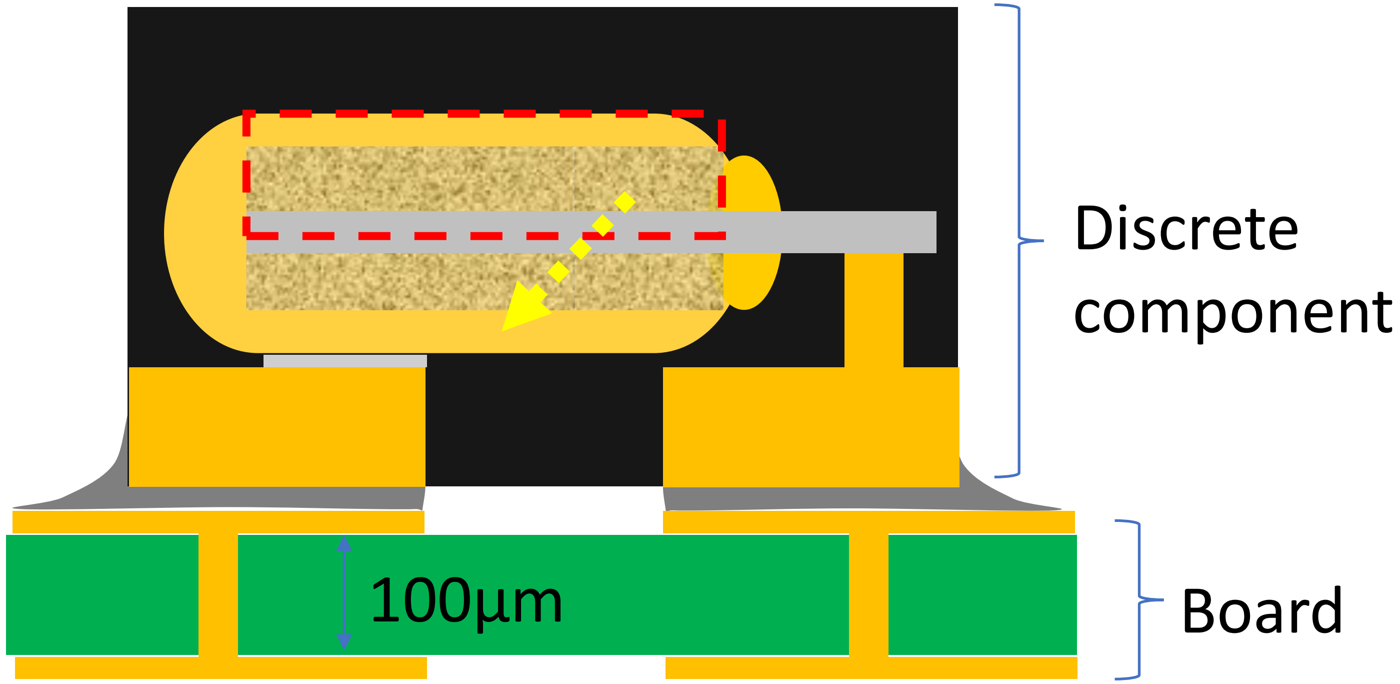
KAP - Construction



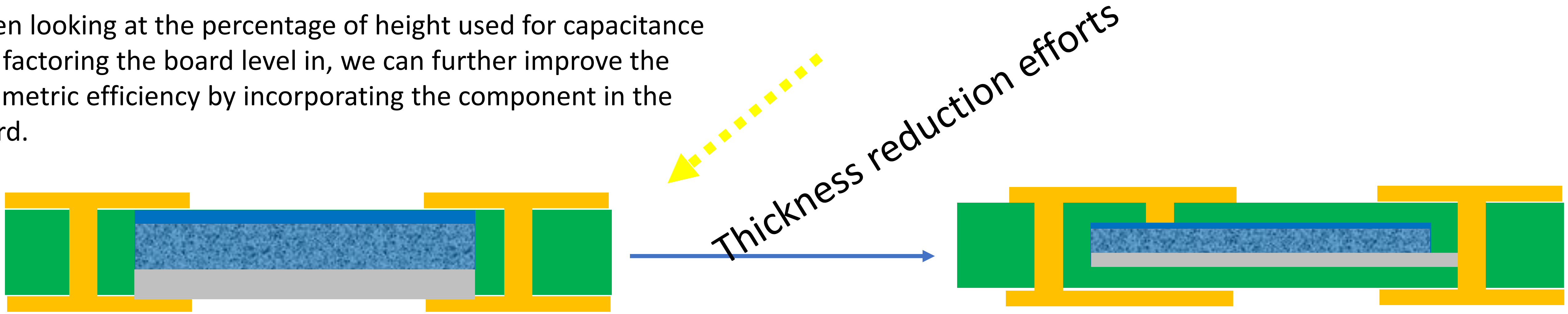
- Capacitor Thickness (typical) – (180µm - 200µm)
- Encapsulant Thickness (glass weave) – (30µm – 60µm)
- Copper foil (terminals) – (5µm - 10µm)
- Total finished part thickness – 0.35mm – 0.25mm

Removing the Discrete Component





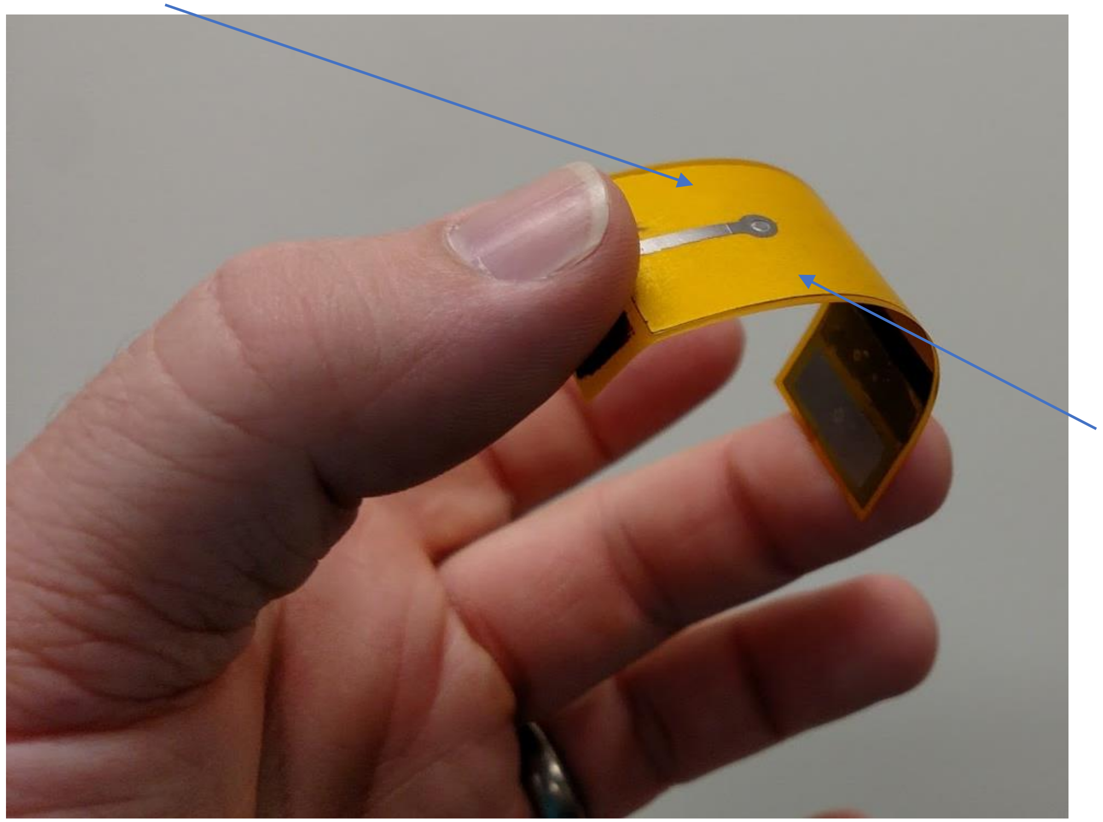
- When looking at the percentage of height used for capacitance and factoring the board level in, we can further improve the volumetric efficiency by incorporating the component in the board.



Flexibility

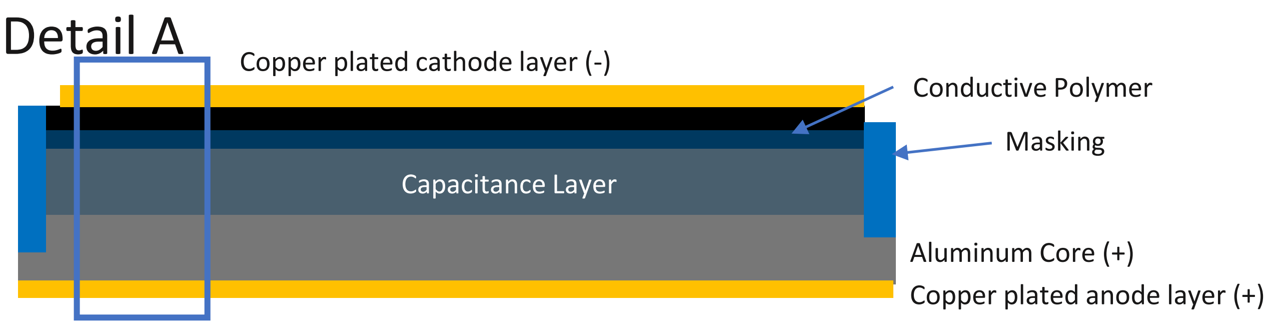
- An added benefit of thinner capacitors is flexibility.
- As the capacitor elements approach ~200µm or less they exhibit flexibility.
- These flexible elements can be combined with a flexible laminate to form a functional capacitor.

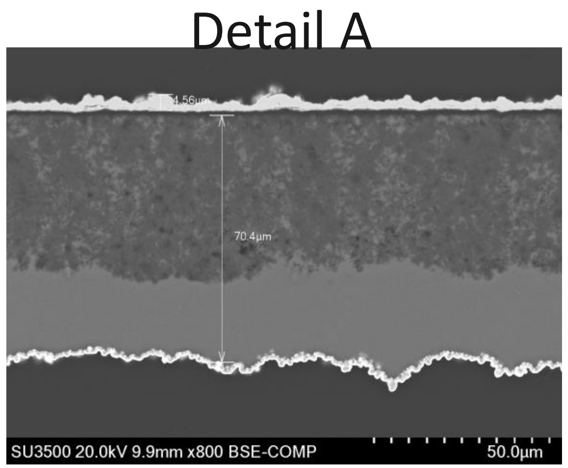
Flexible polyimide laminate



Large capacitor element

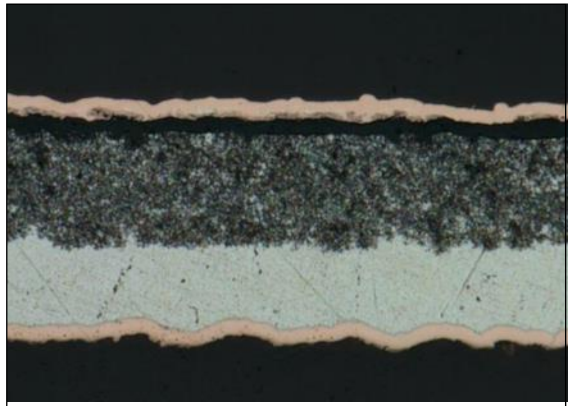
- Initial flexibility tests show stability in electrical performance of capacitor elements down to 5mm radius of bend.





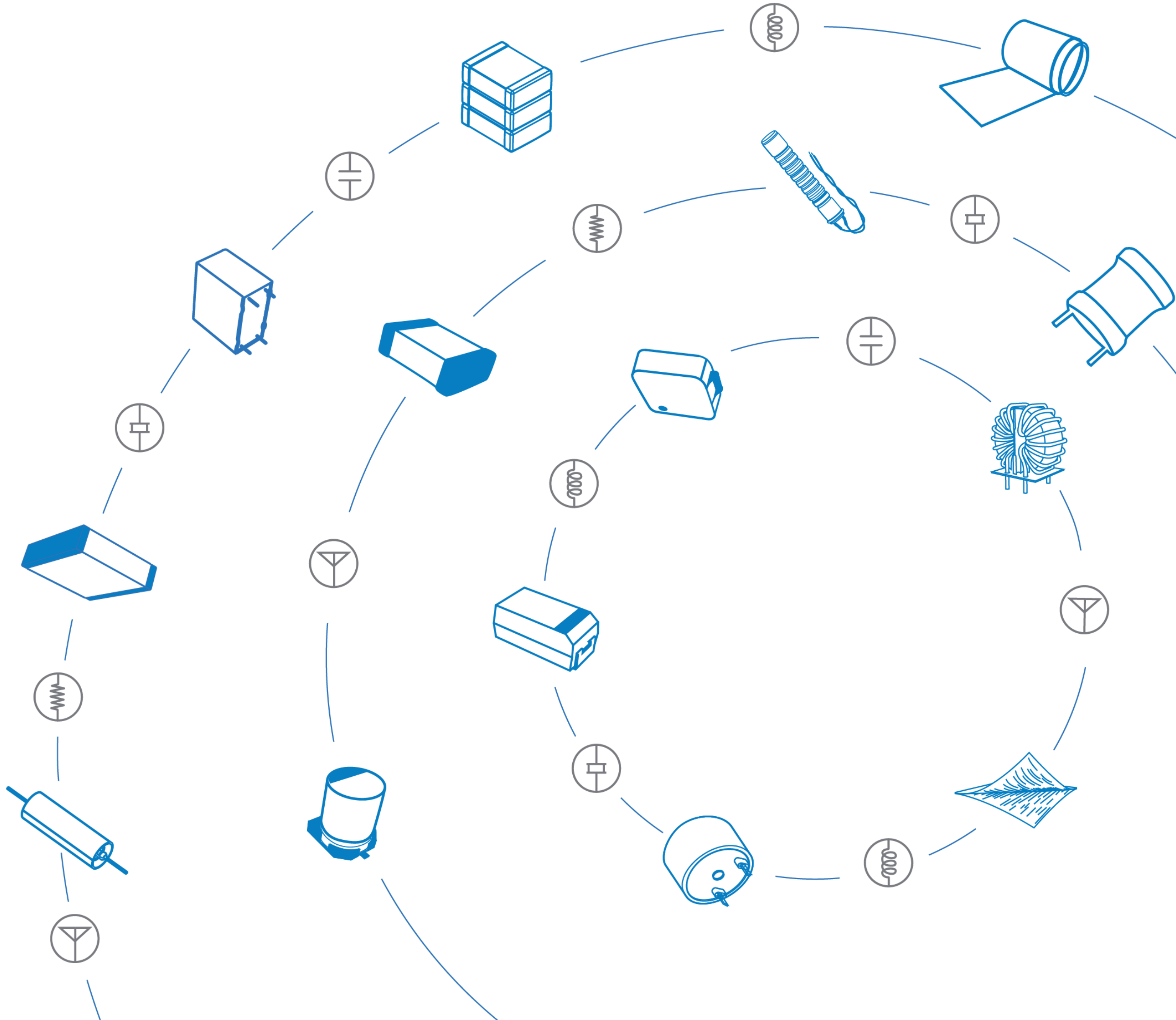
- Total thickness: ~70um (internal) + desired copper thickness

Kemet to provide internal capacitor element only with copper on both sides

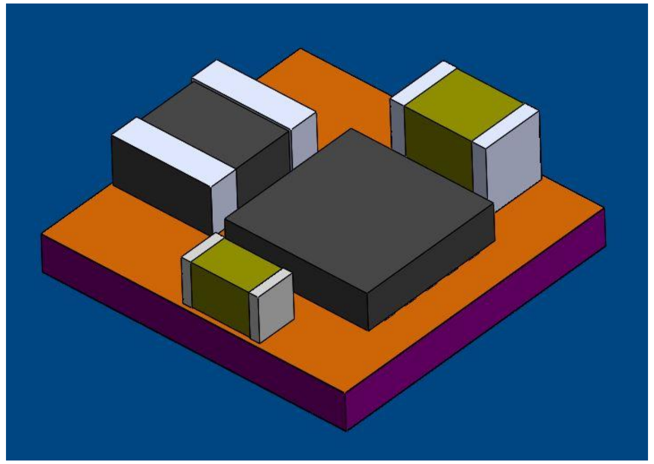


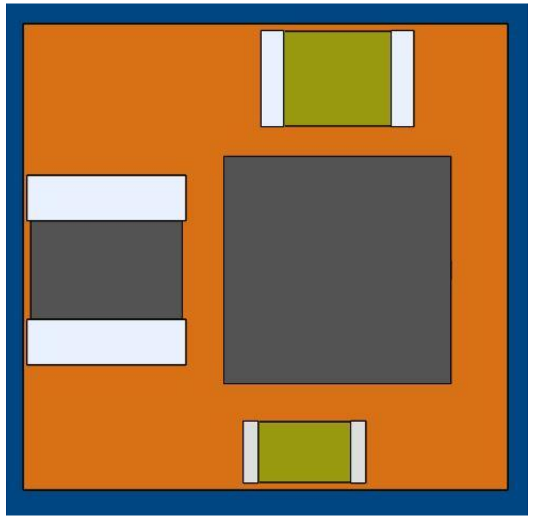
Cross Section

A Brief Case Study



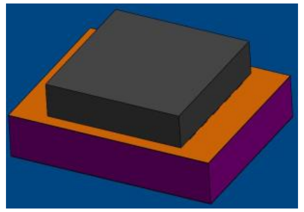
Discrete Solution

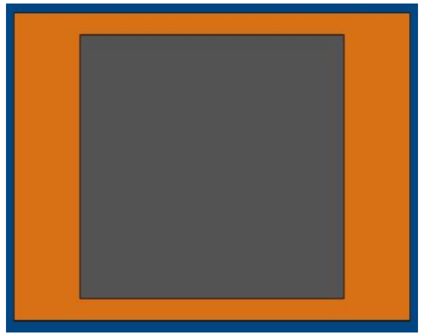




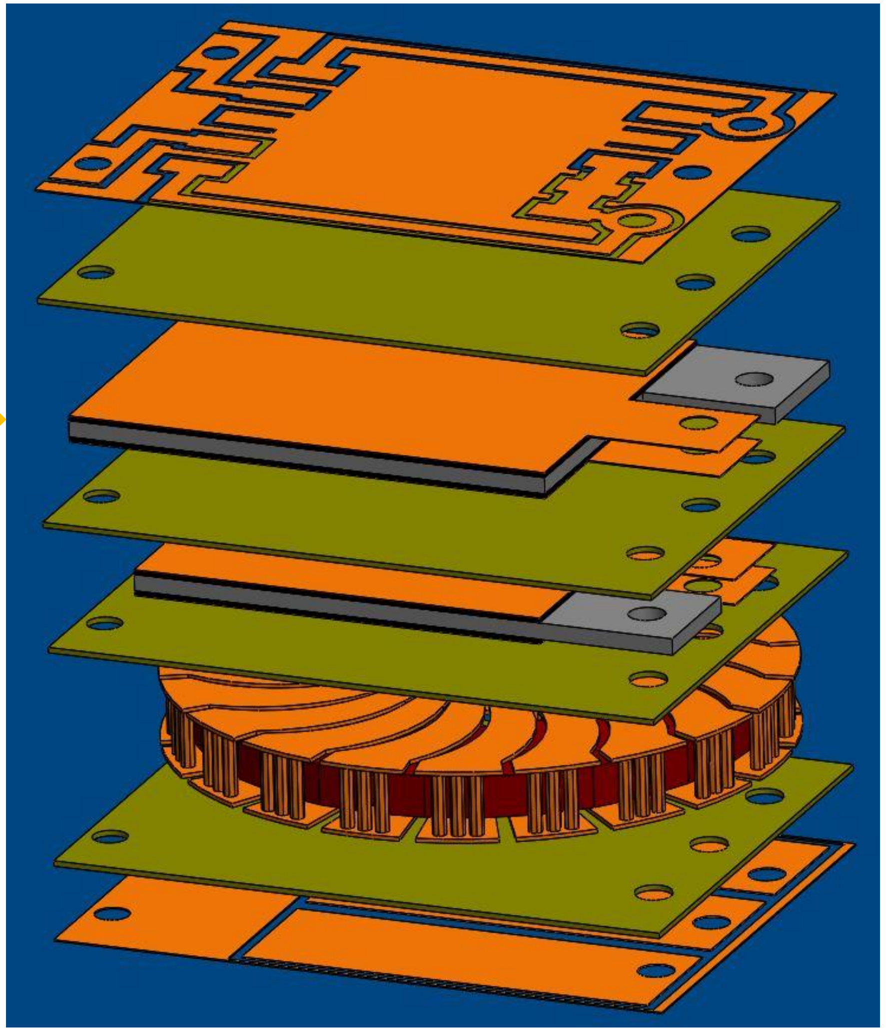
<u>Board Area</u>
39.4mm2

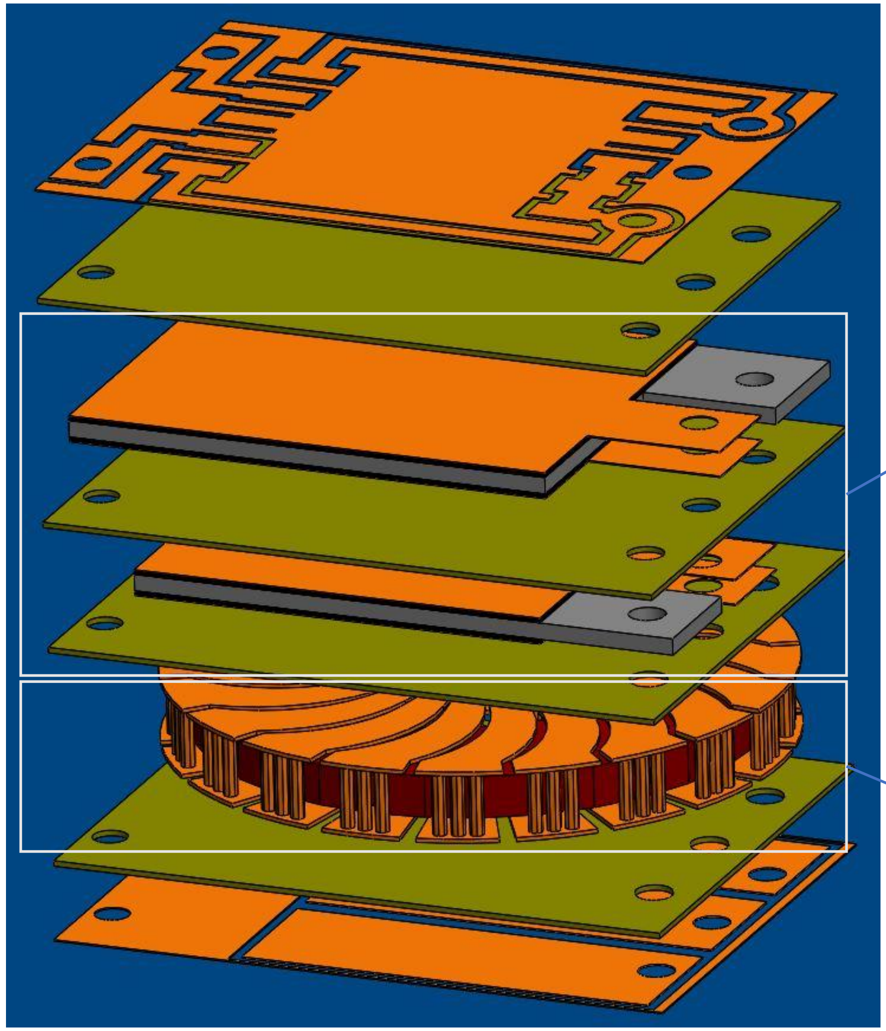
Embedded Solution



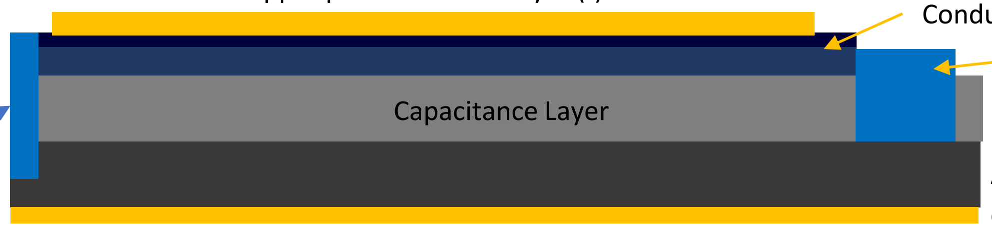


<u>Board Area</u>
15.75mm2
(**60%** reduction)

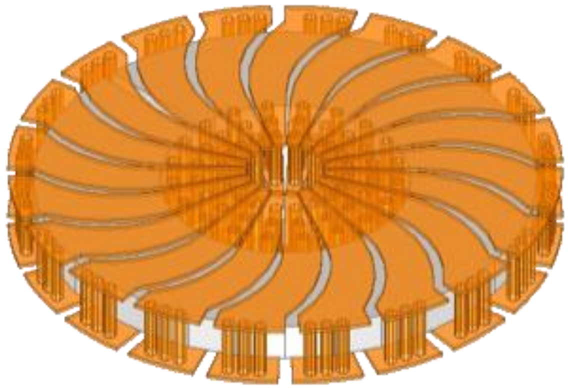




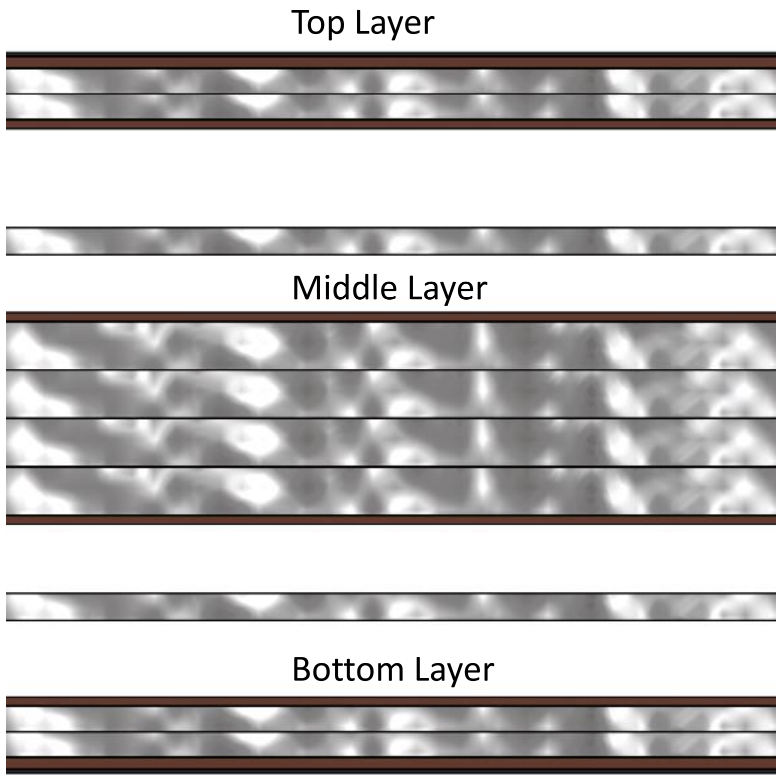
Embedded Capacitor based on Polymer-Aluminum Technology



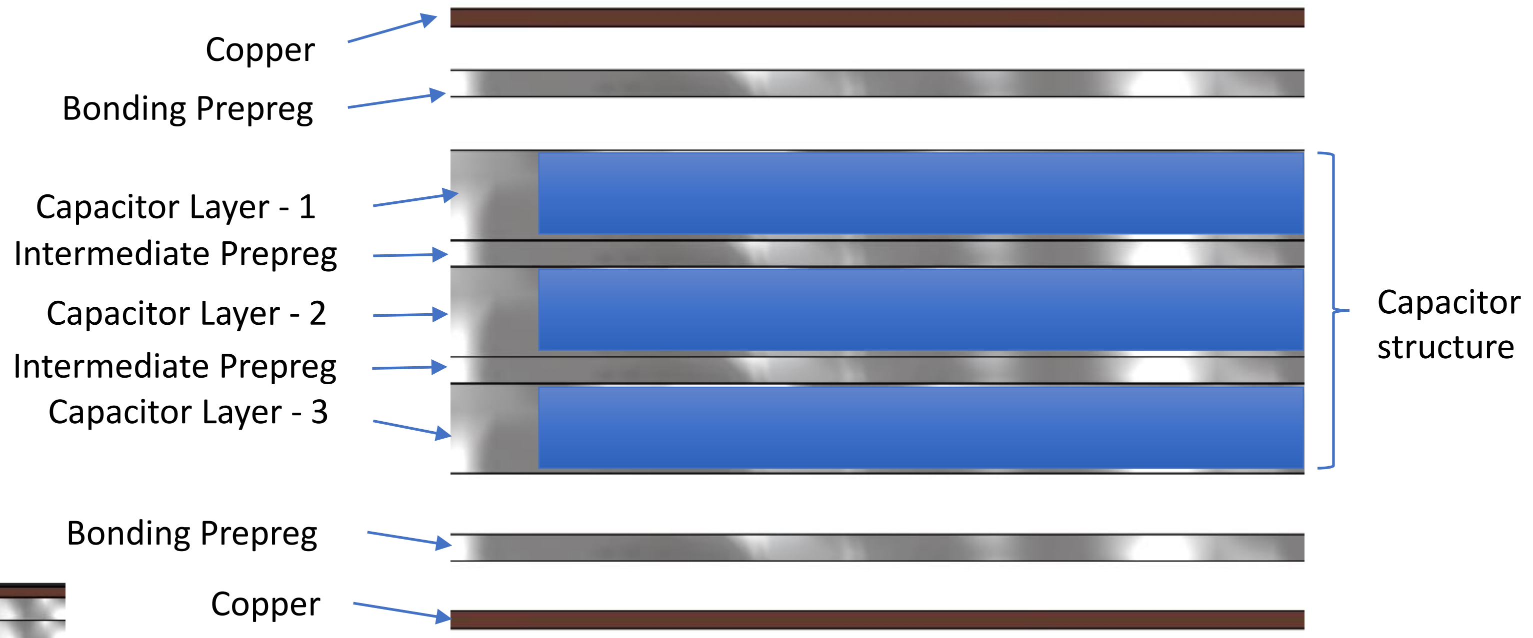
Embedded Inductor based on FlakeComposite Technology

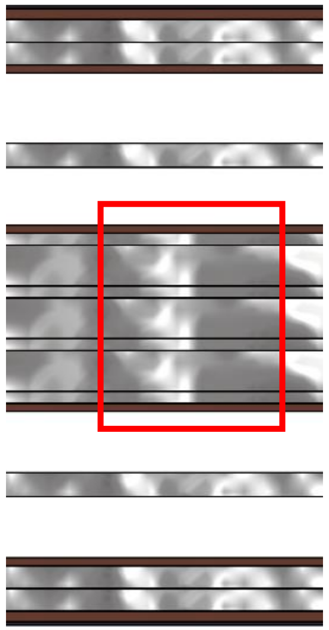


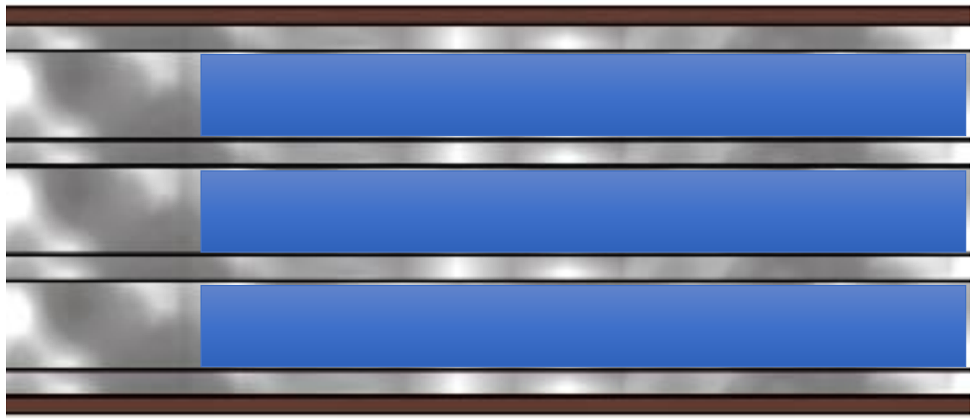
- Exploded view of incoming layers



- Three incoming layers with copper clad on each layer
- Traces/pads etched on incoming boards before bonding the three layers together
- Through vias formed after bonding layers to connect the three layers

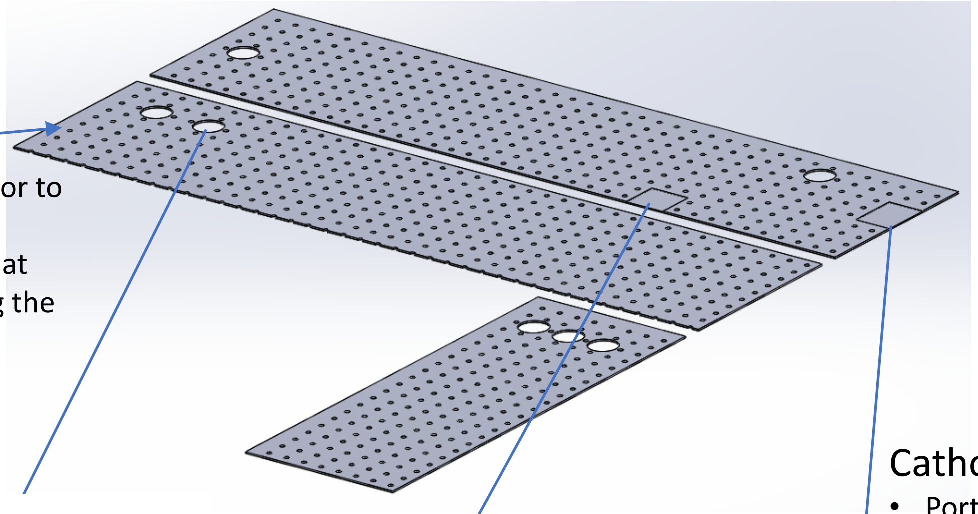

Copper
Bonding Prepreg
Capacitor Layer - 1
Intermediate Prepreg
Capacitor Layer - 2
Intermediate Prepreg
Capacitor Layer - 3
Capacitor structure
Bonding Prepreg
Copper





Structural Via

- Holes formed in the capacitor to allow the prepreg resin to bridge between layers so that the capacitor is not carrying the full attachment stress



Passthrough

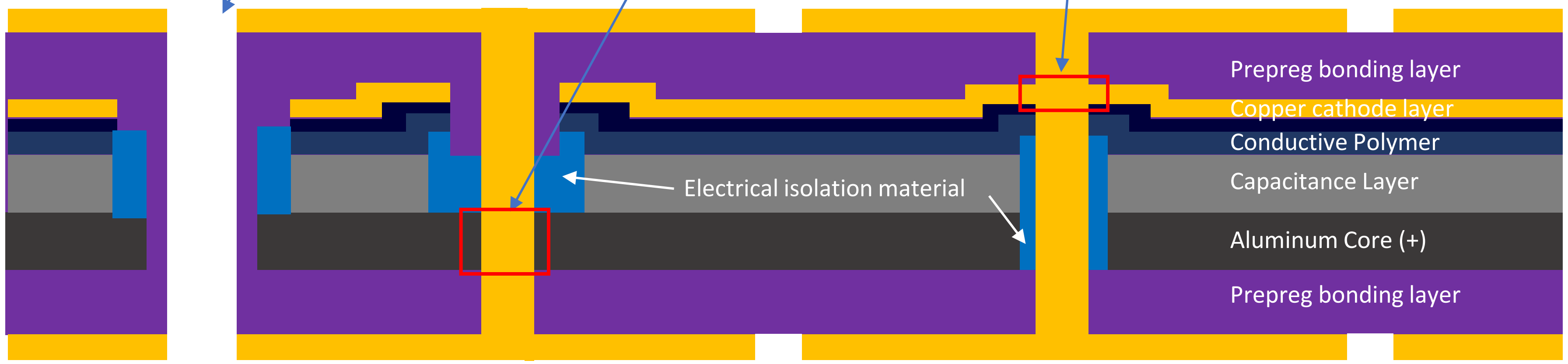
- Regions left open to allow through vias for other board connections

Anode connection

- Portion of capacitor area that allows for a through via to connect to the anode layers but not the cathode

Cathode connection

- Portion of capacitor area that allows for a through via to connect to the cathode layers but not the aluminum core (anode)



SUMMARY

- Aluminum is a leading choice for embedded capacitors
- Aluminum polymer elements can be embedded or integrated as a discrete element into PCBs
- Space savings come without sacrificing performance

THANKS!

For More Information Contact:

KeithMoore@KEMET.com