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Embedding Aluminum Polymer Capacitors

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The Push for Thin

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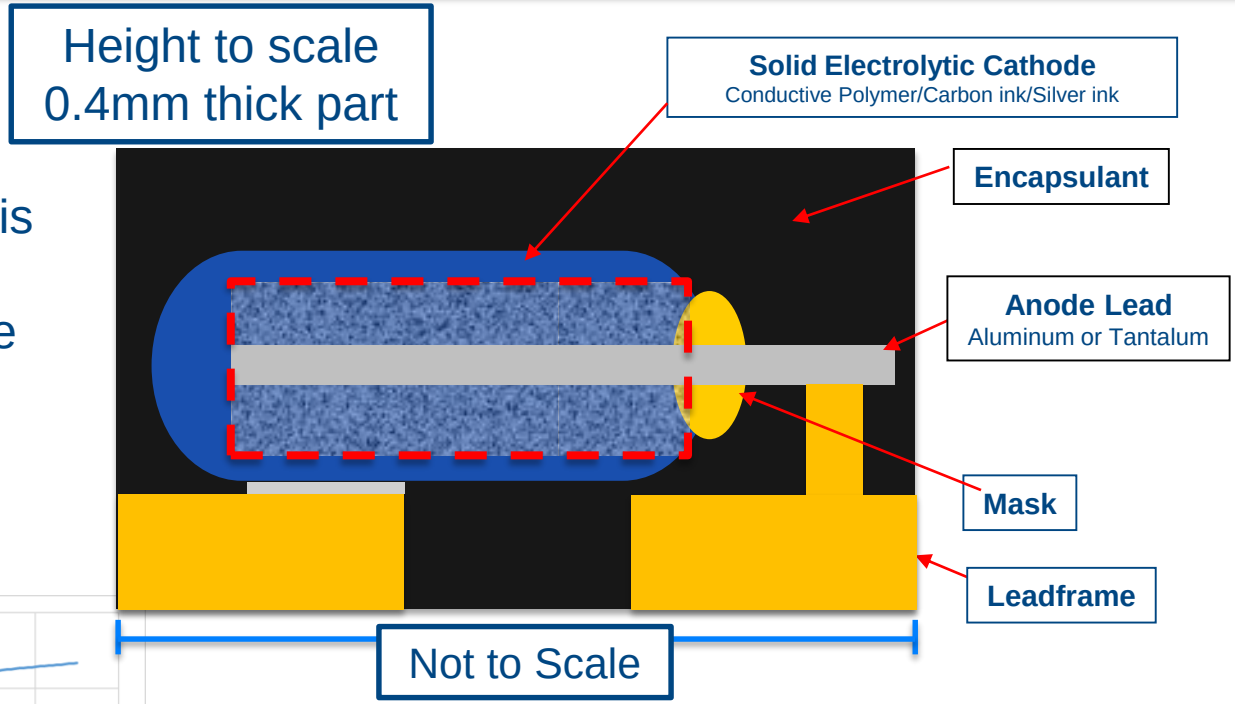
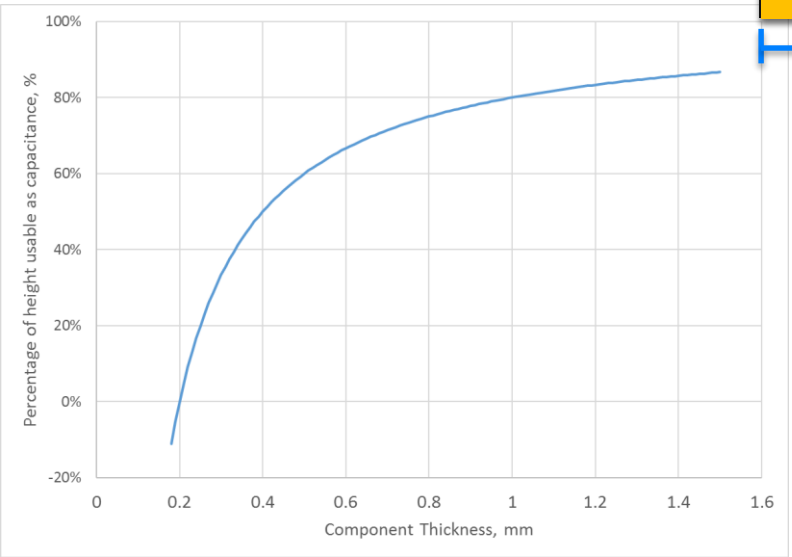
Goal of Thin

- Thin means something different for each application
  - Reducing overall device thickness
  - Components in unused space
    - Back of a board
    - Inside or Under Chip
  - Higher power density
- Goal: Provide the tools you need

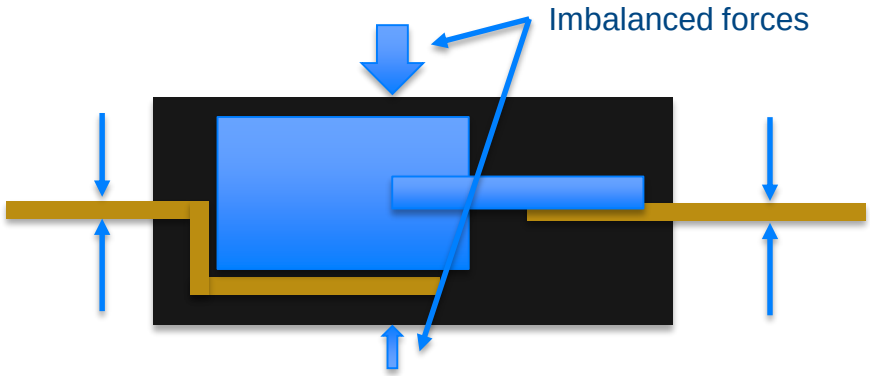
Where does the height go?

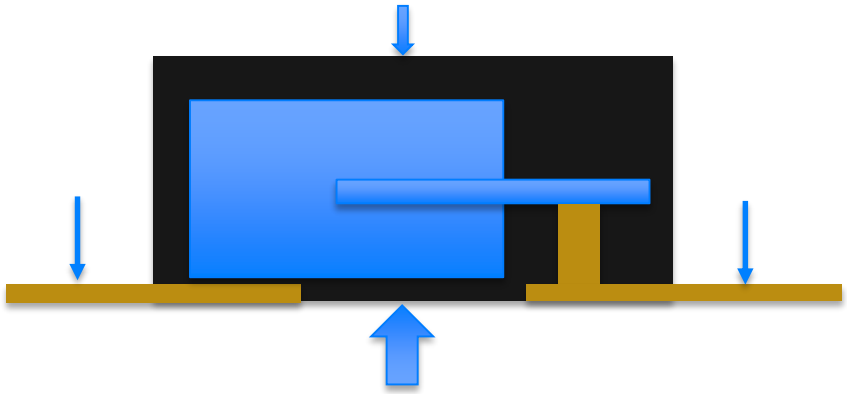
- As the thickness of device is reduced the percentage of height used for capacitance decreases quickly





Traditional Molded Capacitors



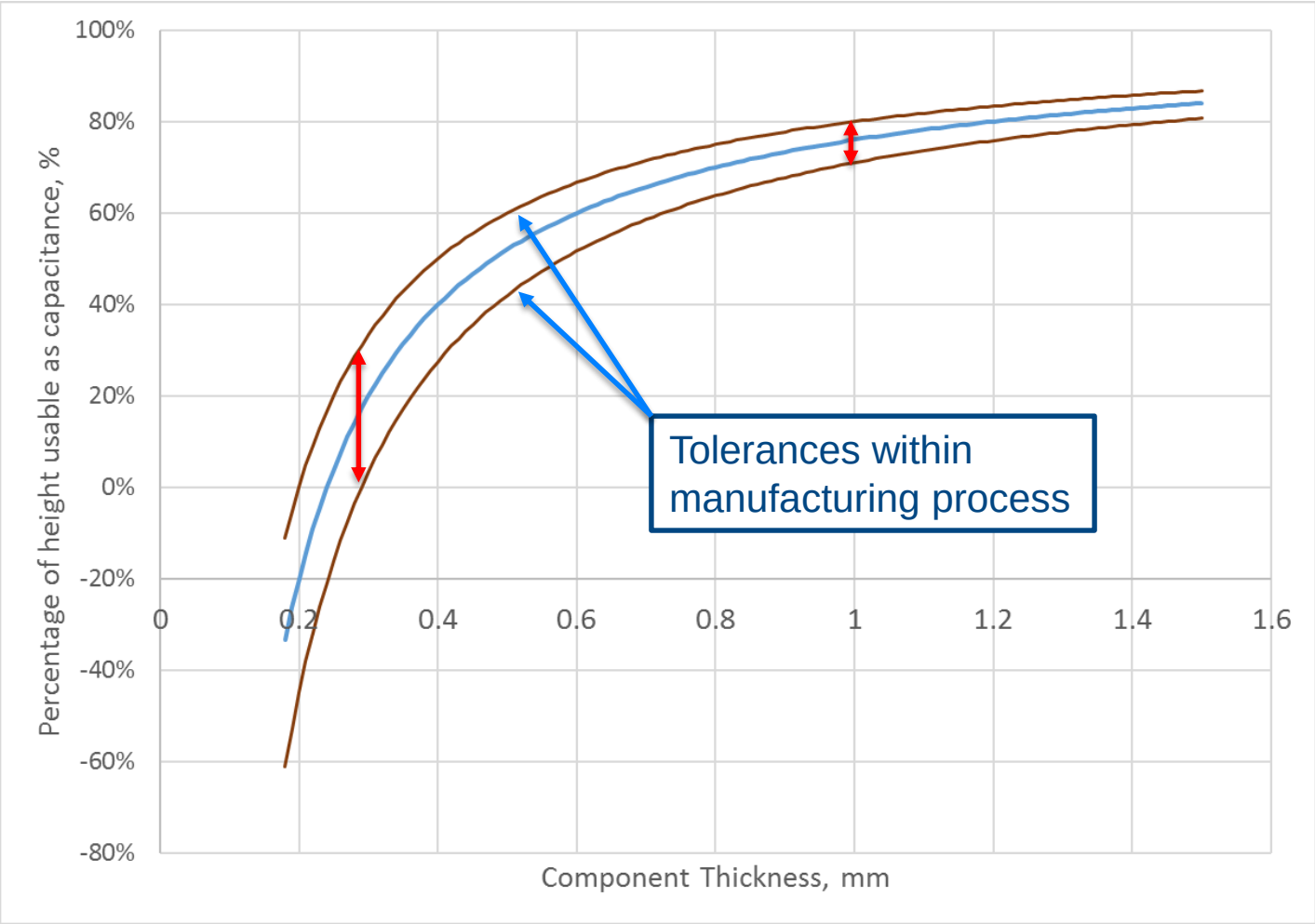


- Traditional SMT Aluminum and Tantalum capacitors are injection molded.
- Injection molding limits the minimum thickness
- Thinner encapsulant reduced the material flow across thinner regions, generating back pressure and irregular mixing

As the thickness of the encapsulant or leadframe is reduced there is less support for the capacitor element during molding, increasing the chance the capacitor elements may move

Where traditional methods run out

Usable capacitor height is decreased further when factoring in manufacturing tolerances



Advanced Packaging

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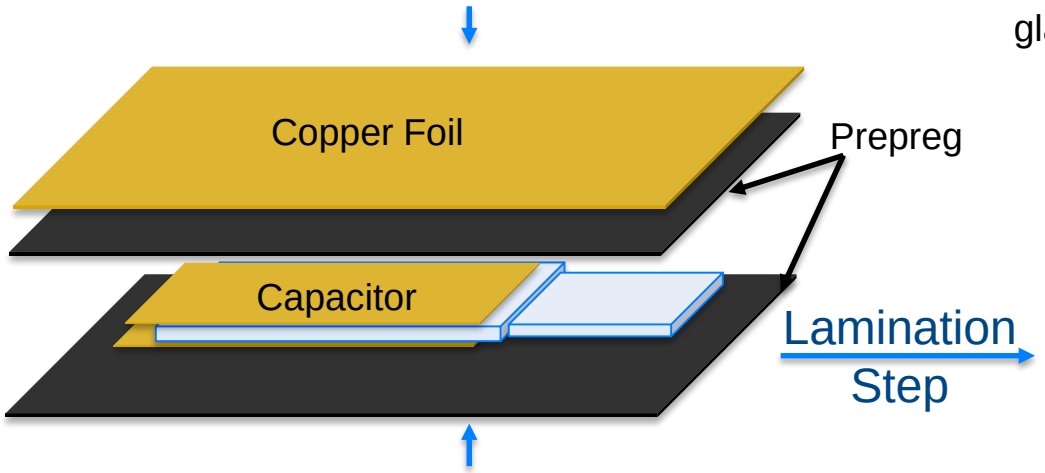
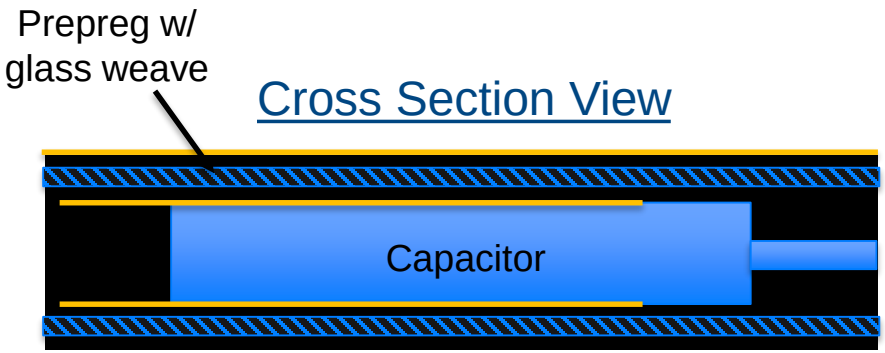
KEMET Advanced Packaging - Process





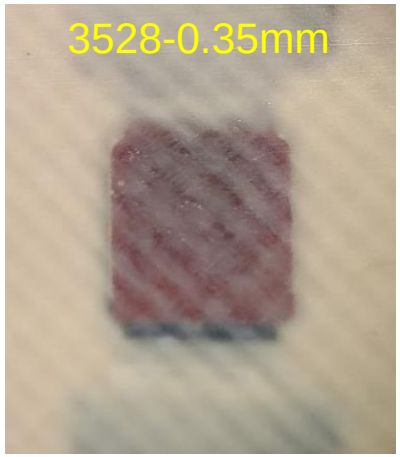
- Capacitor lamination processed in such a way as the glass weave is compressed to the capacitor elements and provides thickness limits

Capacitor Thickness (typical) – (180µm - 200µm)

Encapsulant Thickness (glass weave) – (30µm – 60µm)

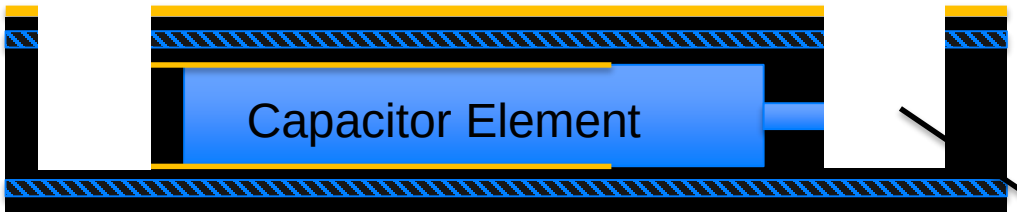
Copper foil (terminals) – (5µm - 10µm)

Total finished part thickness – 0.35mm – 0.25mm

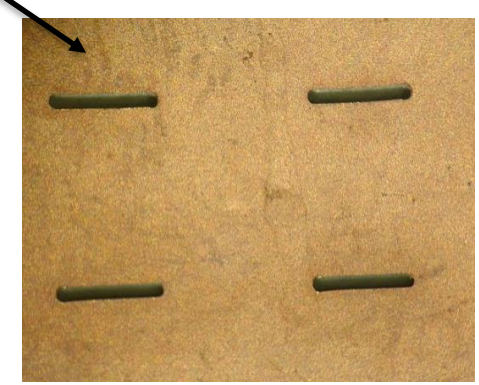


Current development samples
3528 - 0.27mm thick

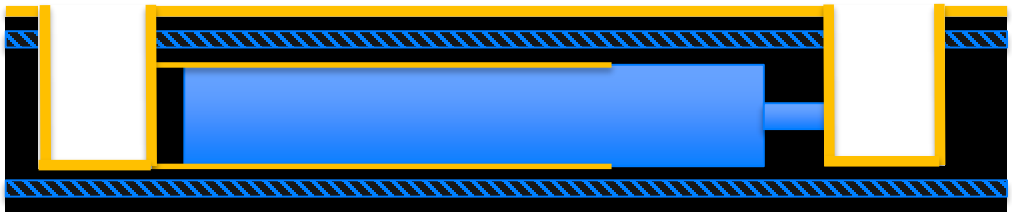
KAP - Terminal Forming



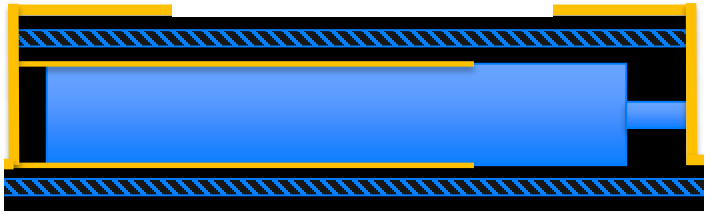
- Pockets cut into laminate form the basis for the terminals
- Copper plating is formed inside the pockets to connect the capacitor and the copper cladding layer

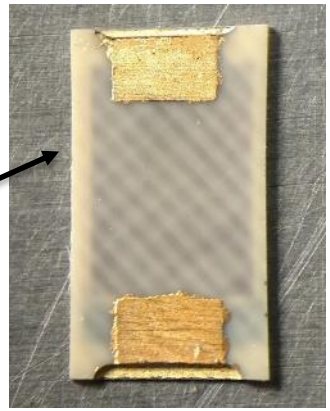


Copper plating into vias/pockets to form terminal connections



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



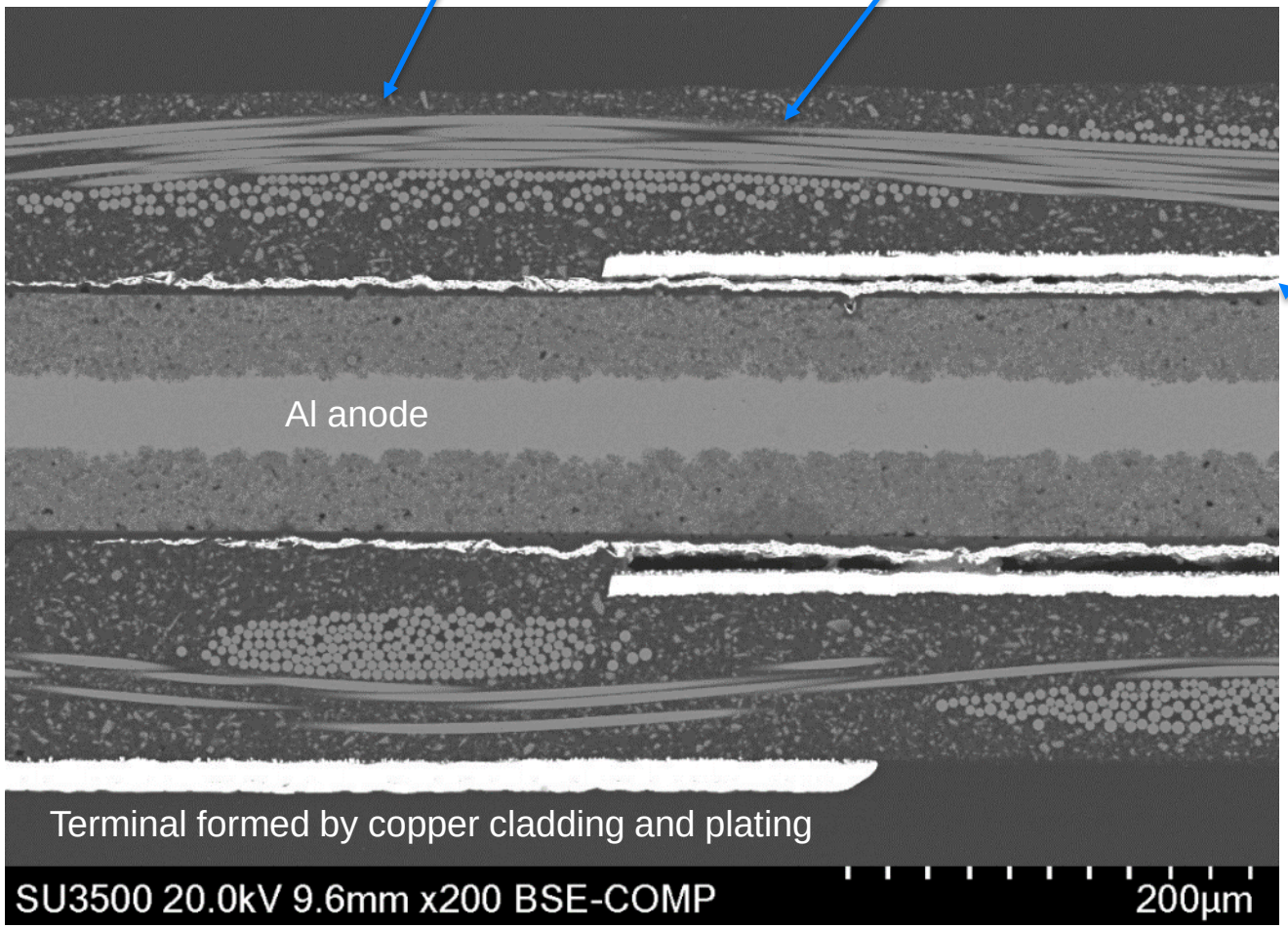


KAP - Construction

Resin with fillers form around the part during lamination

Fibers acting as spacing element to center the capacitor

350um



Polymer, carbon, silver and copper cathode layers

Target Capability of New Packaging vs. Traditional

Progression to lower case height

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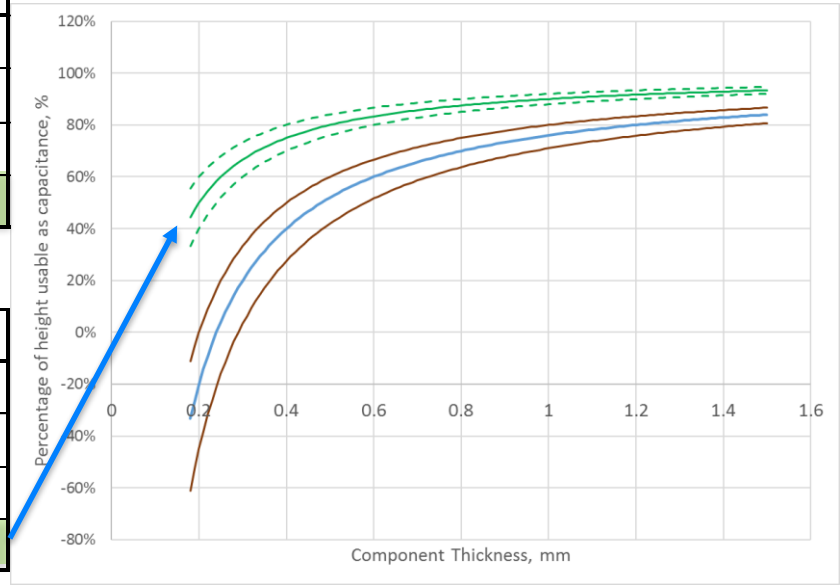
KEMET Advanced Package = KAP

Volumetric Efficiency of Different Packaging Designs

3528/Height*	1.0mm	0.8mm	0.6mm	0.4mm	0.2mm
Standard	16%	10%	1%	-19%	-76%
Facedown (Target)	48%	44%	38%	26%	-10%
Gen II	59%	54%	47%	32%	-12%
KAP	80%	77%	74%	67%	46%

Max Available Finished Anode Height (mm)

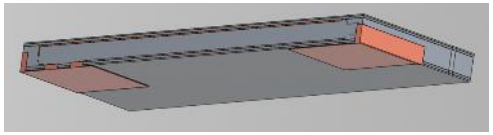
3528/Height *	1.0mm	0.8mm	0.6mm	0.4mm	0.2mm
Standard	0.41	0.21	0.01	-0.19	-0.38
Facedown (Target)	0.76	0.56	0.36	0.16	-0.03
Gen II	0.76	0.56	0.36	0.16	-0.03
KAP	0.89	0.69	0.49	0.29	0.10



Standard

Facedown

Gen II



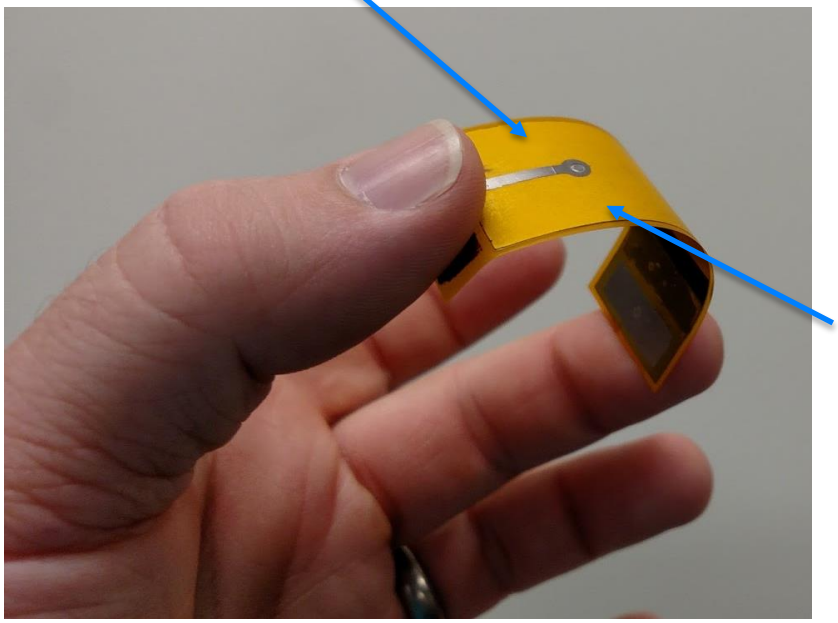
KAP

* Volumetric efficiency is based on construction design rules for ≤0.4mm, other limiting factors may exist above 0.4mm

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

Embedded/Integrated Capacitors

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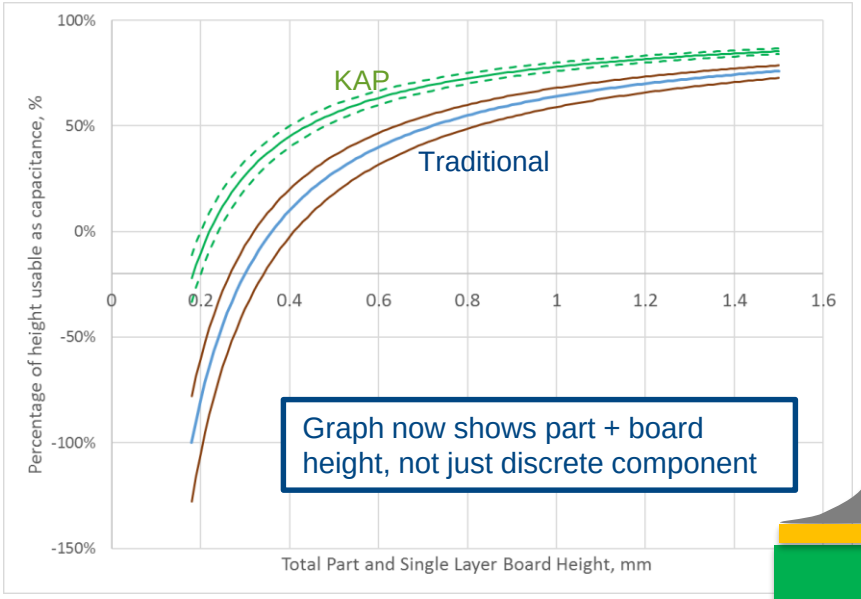
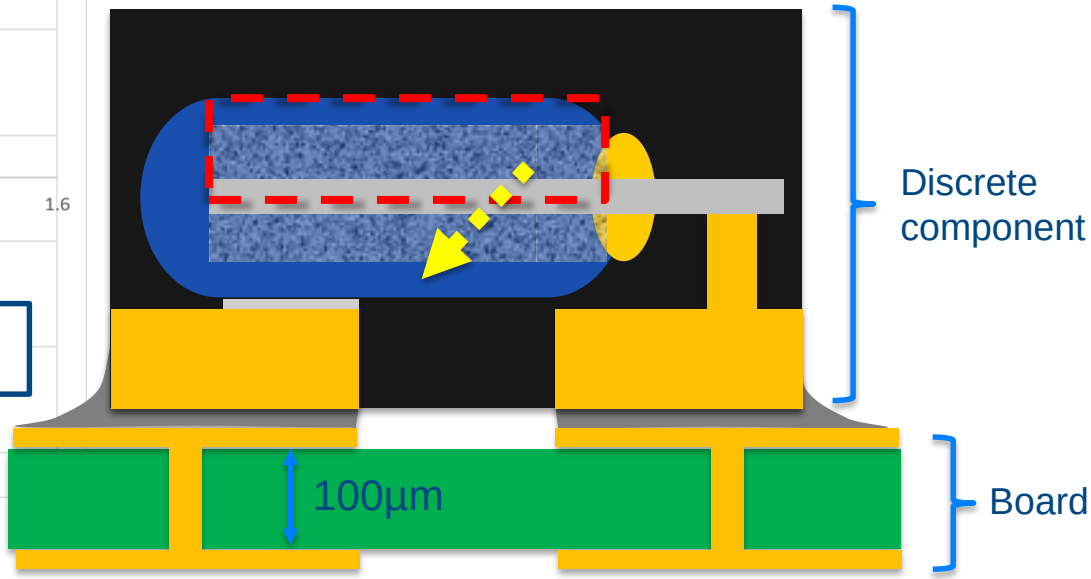
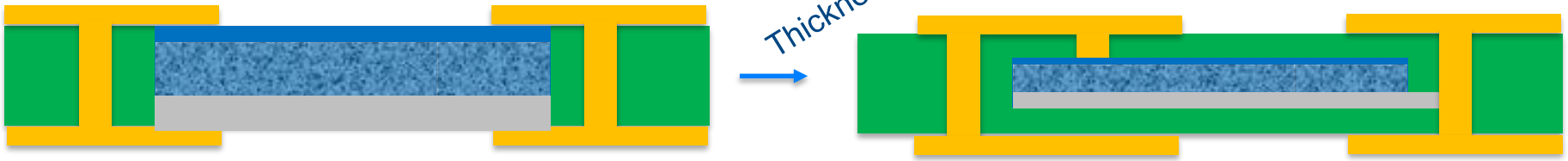
Removing the discrete component

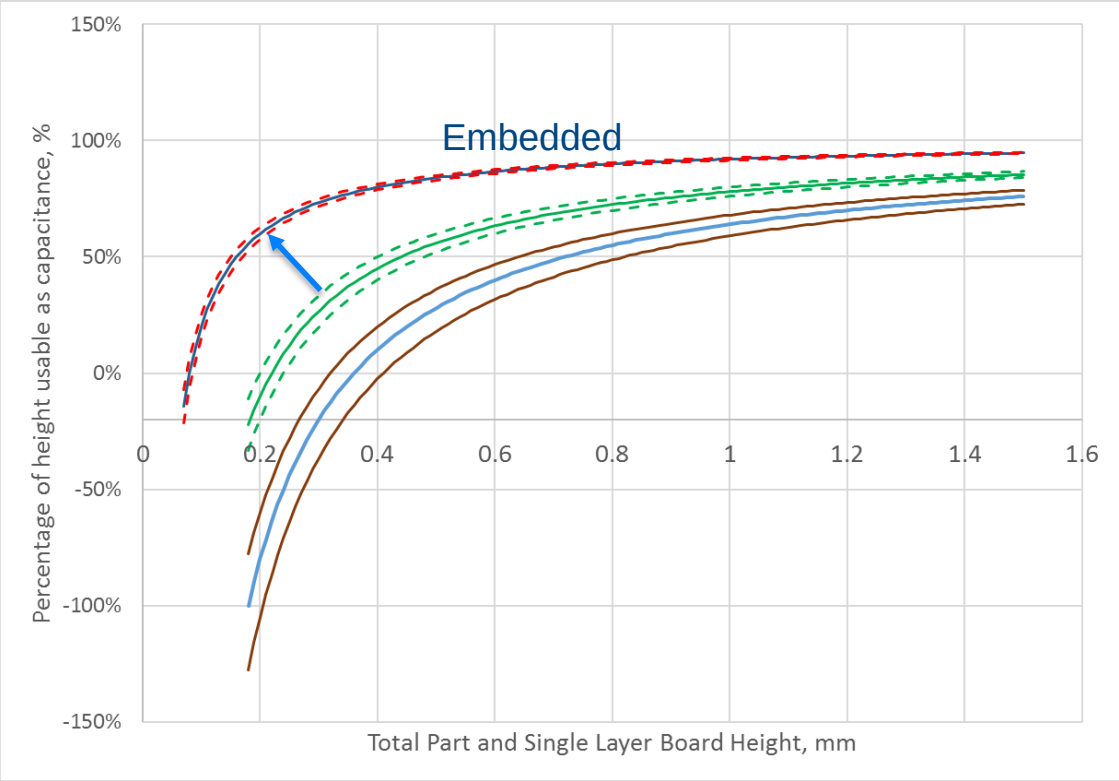




- When looking at the percentage of height used for capacitance and factoring the board level in, we can further improve the volumetric efficiency by incorporating the component in the board



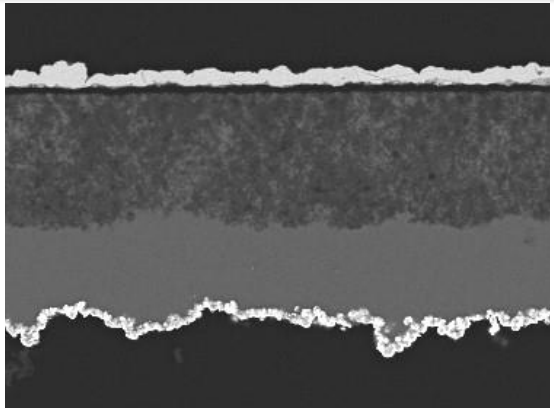
Board level height influence

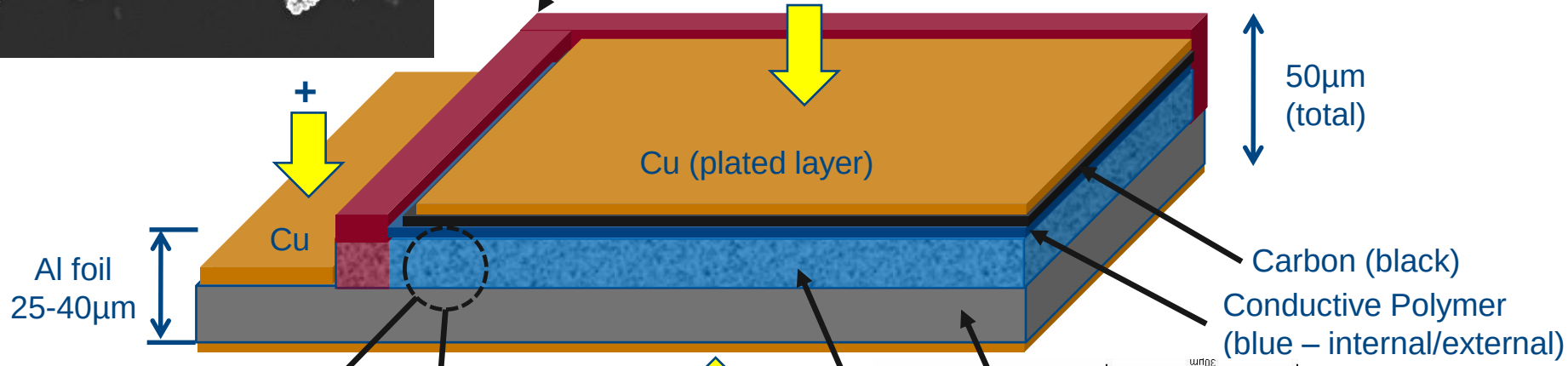


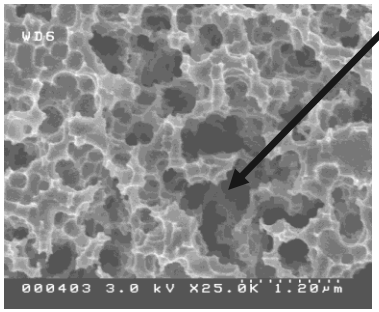
- With thickness reduction and embedding the percentage of height used for capacitance is significantly increased in a given board footprint

Embedded/Integrated Capacitor

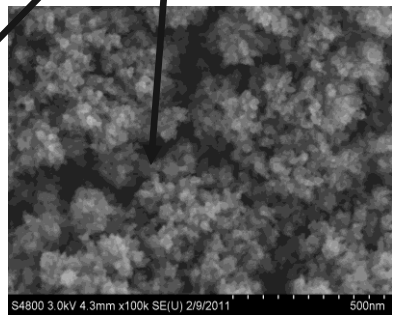
Construction



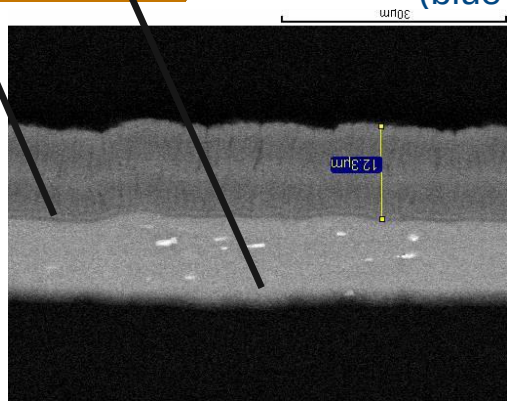




Etched



Physical Vapor Deposited



Embedded/Integrated

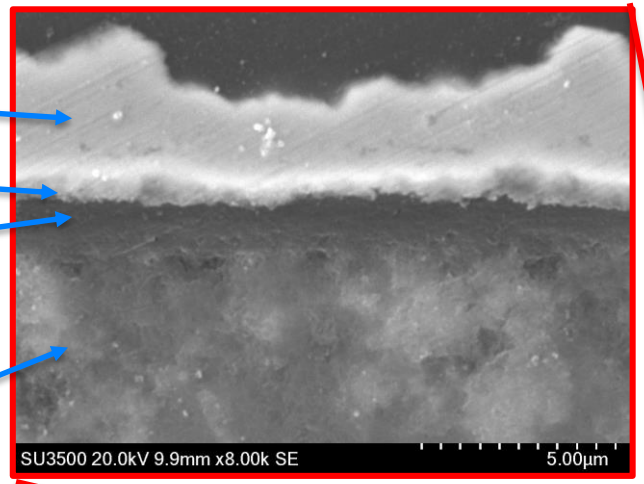
Current layer Construction

Copper plated layer

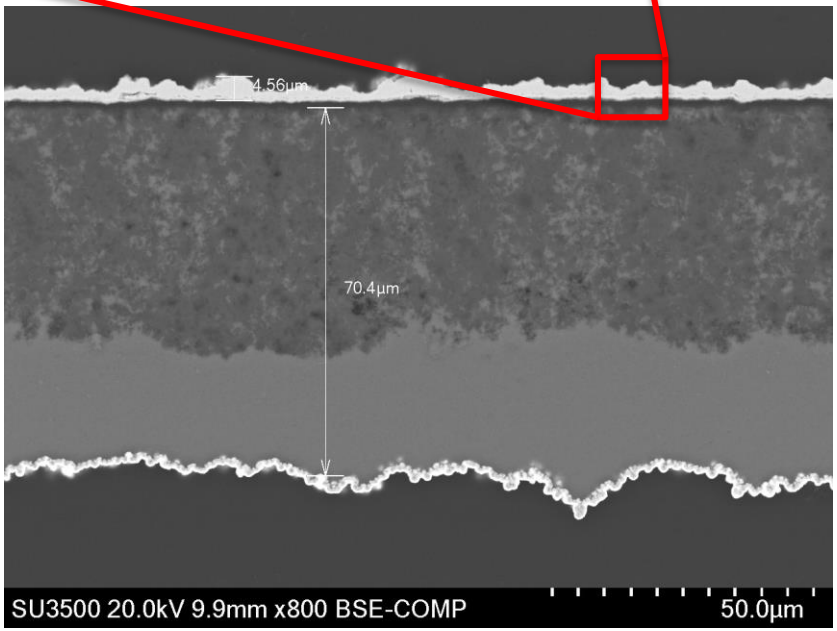
Ultra thin carbon ink

Thin Electro-Chemical Polymer layer (ECPoly)

Etched aluminum layer/internal polymer

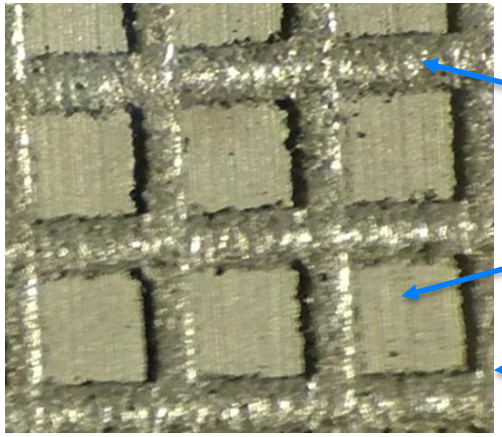


~80um



Embedded/Integrated Capacitor - Process

Aluminum capacitor foil is patterned by removing the etched layer



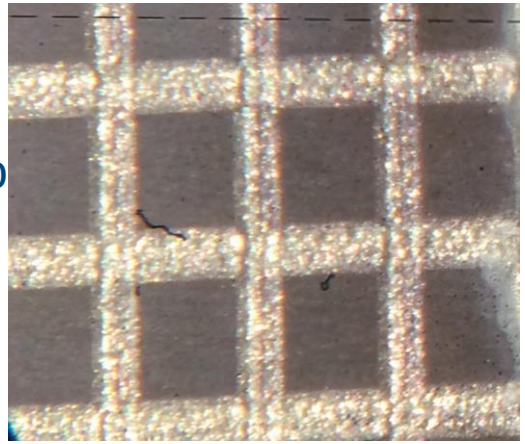
Etched layer removed and barrier layer applied inside troughs

Pads remaining include porous layer

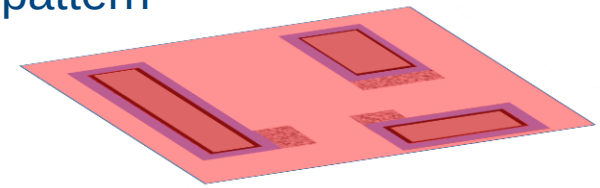
Reverse of foil plated with copper etc.

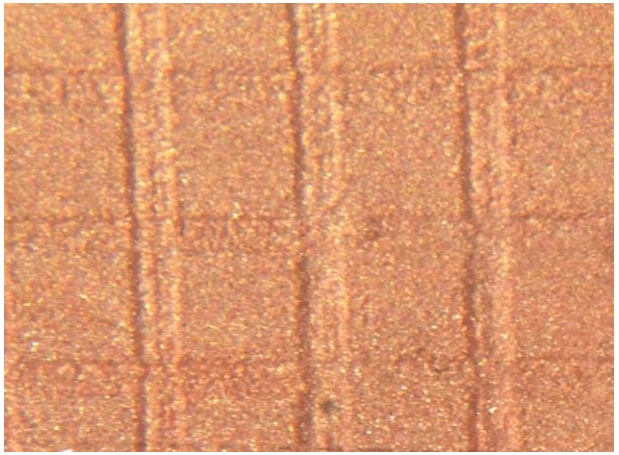
1mm

Conductive Polymer (ECPoly) is applied to the etched pads to form a thin dense external layer



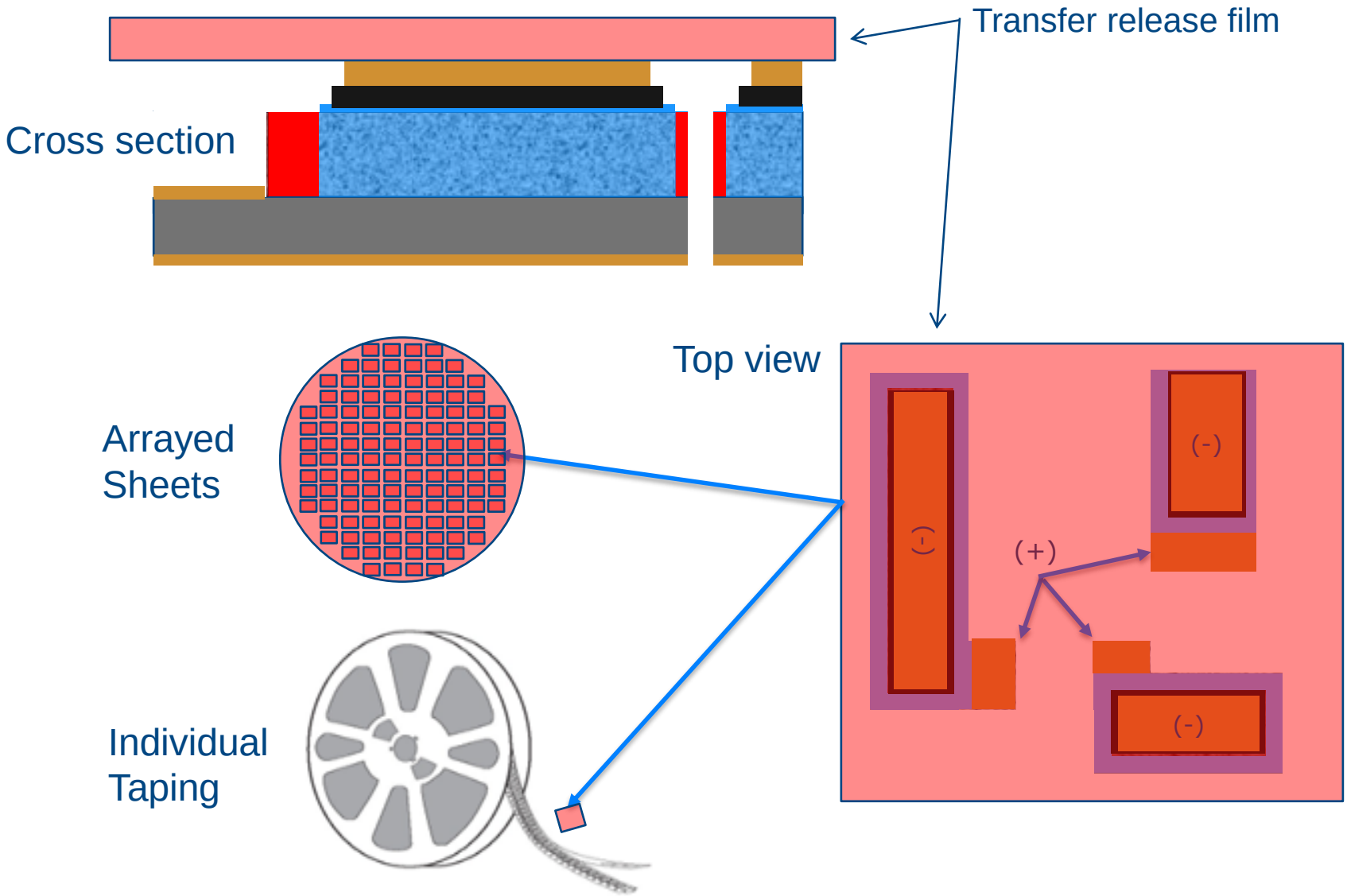
Sheet of capacitors is applied to a transfer film and the excess material cut away to leave individual capacitors in a pattern





Copper plating is applied over the external cathode layers

Patterning and Transport Concept



Embedding or Integrating Concepts

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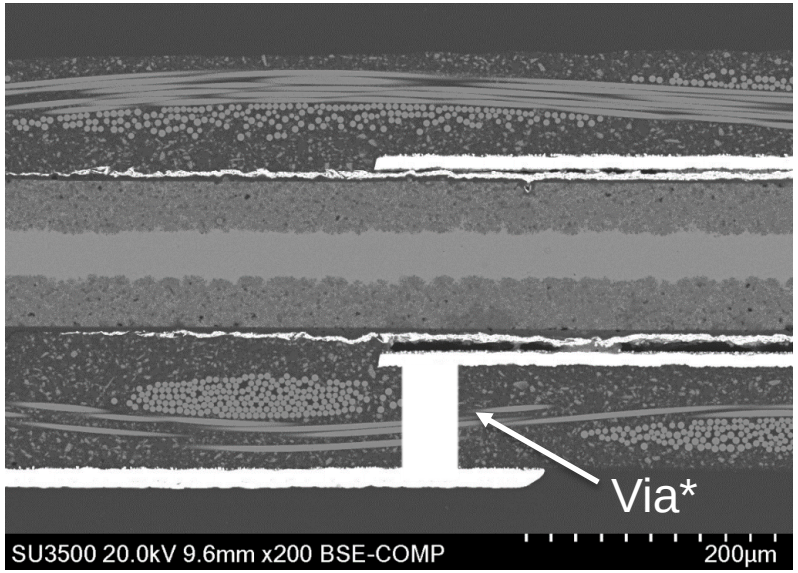
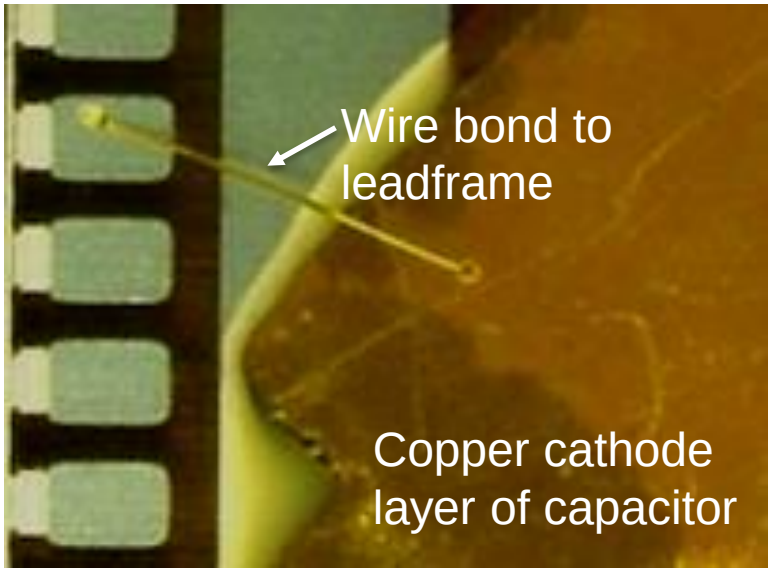
Embeddable in a circuit board



* Possible via location for cathode connection

Integrated into a chip



Possible connection methods:

- Wire bond
- Via plating
- Copper pillars
- etc.

Capability	Target
Rated voltage	2V-50V+
Capacitor size	≤1mm
Cap thickness	~50µm
Capacitance	≥100µF/cm^2
DC leakage	<50 nA/CV

* Capabilities table values are highly dependent on application design

Thank You!

Download at:

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