Technology with Vision

HF-7761EN_C (2014-07)

Termična optimizacija pri načrtovanju vezij

Delavnica

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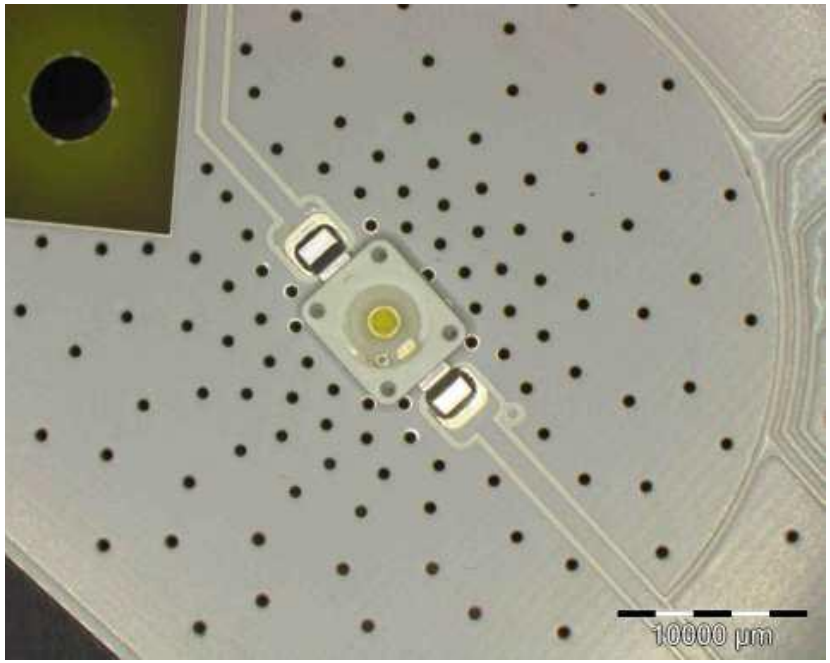
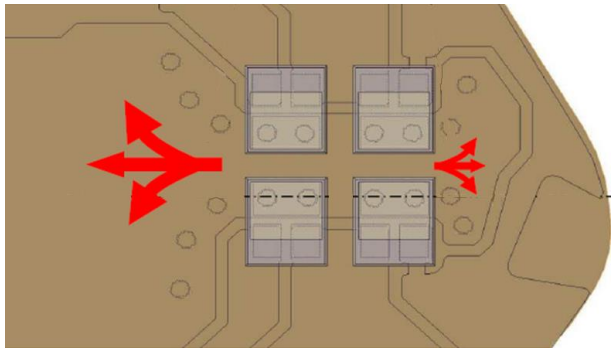
Termična optimizacija

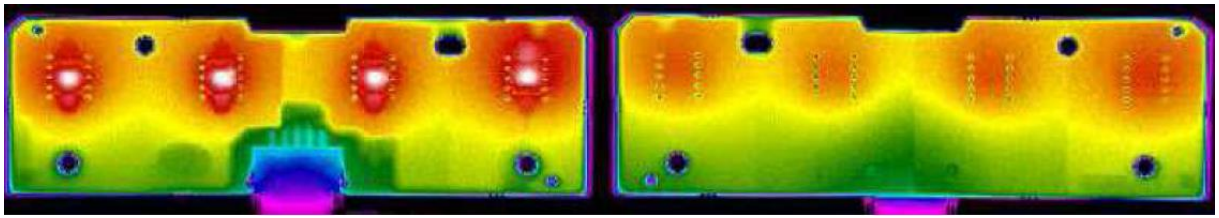
- Postavitev komponent
- Dobra optimizacija bakrenih površin
- Distribucija toplote po površini (horizontalna disipacija)



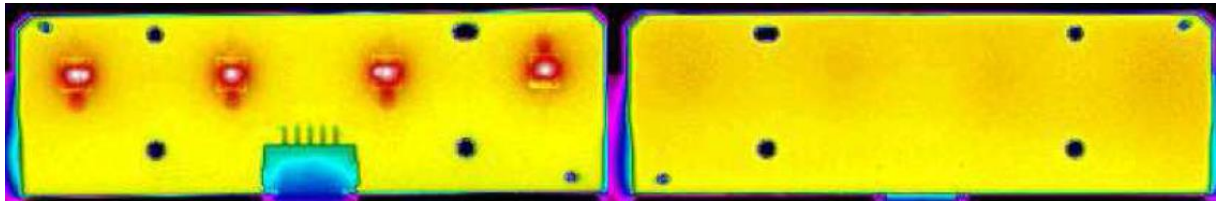


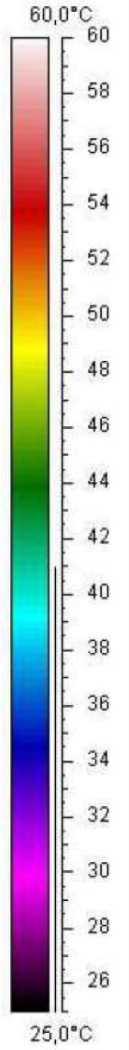
Termična optimizacija
Vertikalna disipacija (različni materiali)

- Temperaturne slike
- Distribucija in disipacija toplote
- FR4 2-slojni s termalnimi vijami:

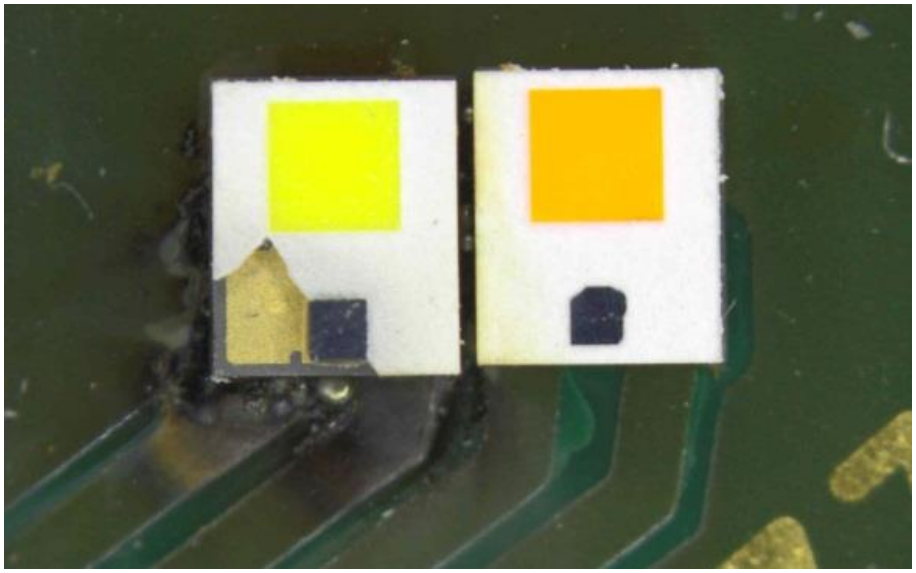


- IMS (Insulated Metal Substrate):

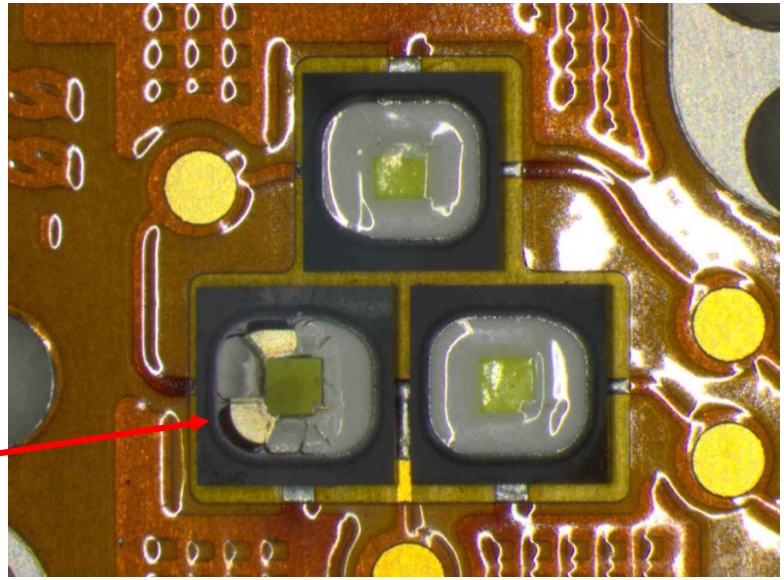




Poškodbe PCBjev

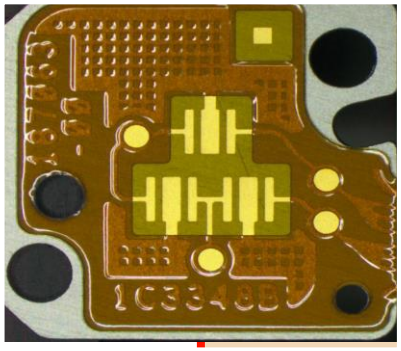


- Premajhna disipacija
- Napačna tehnologija PCB materiala



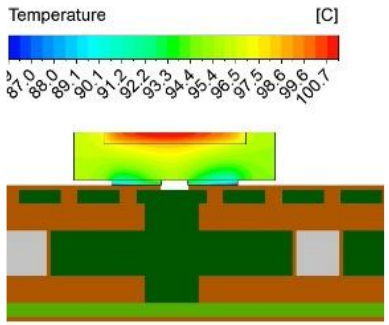
Poškodba zaradi temperature >200°C

Termična optimizacija pri načrtovanju vezij



Površina Cu

- Horizontalna disipacija

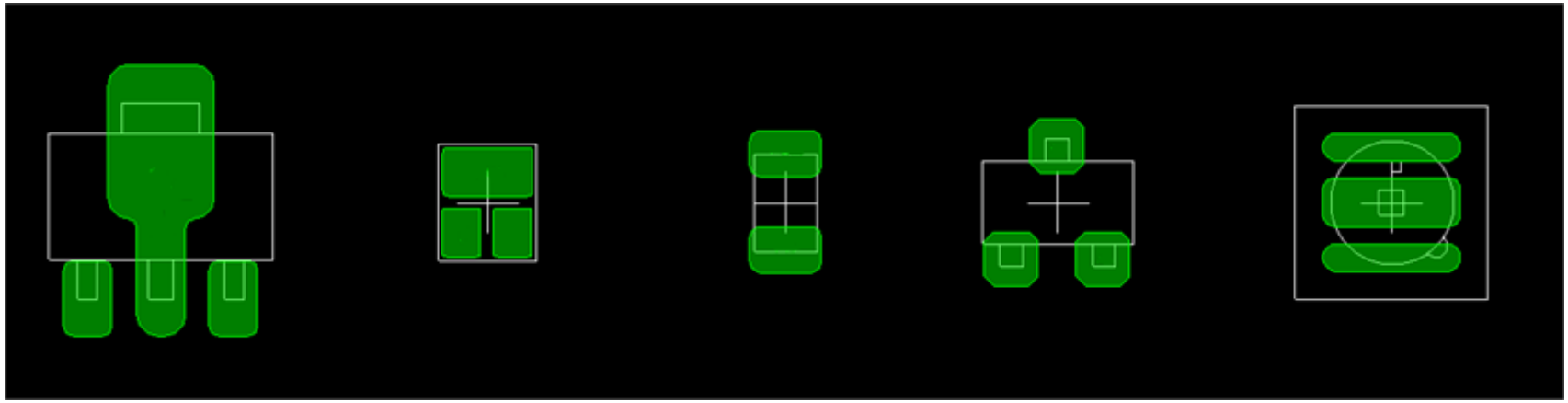


PCB material

- Vertikalna disipacija

Optimizacija PCBja po površini

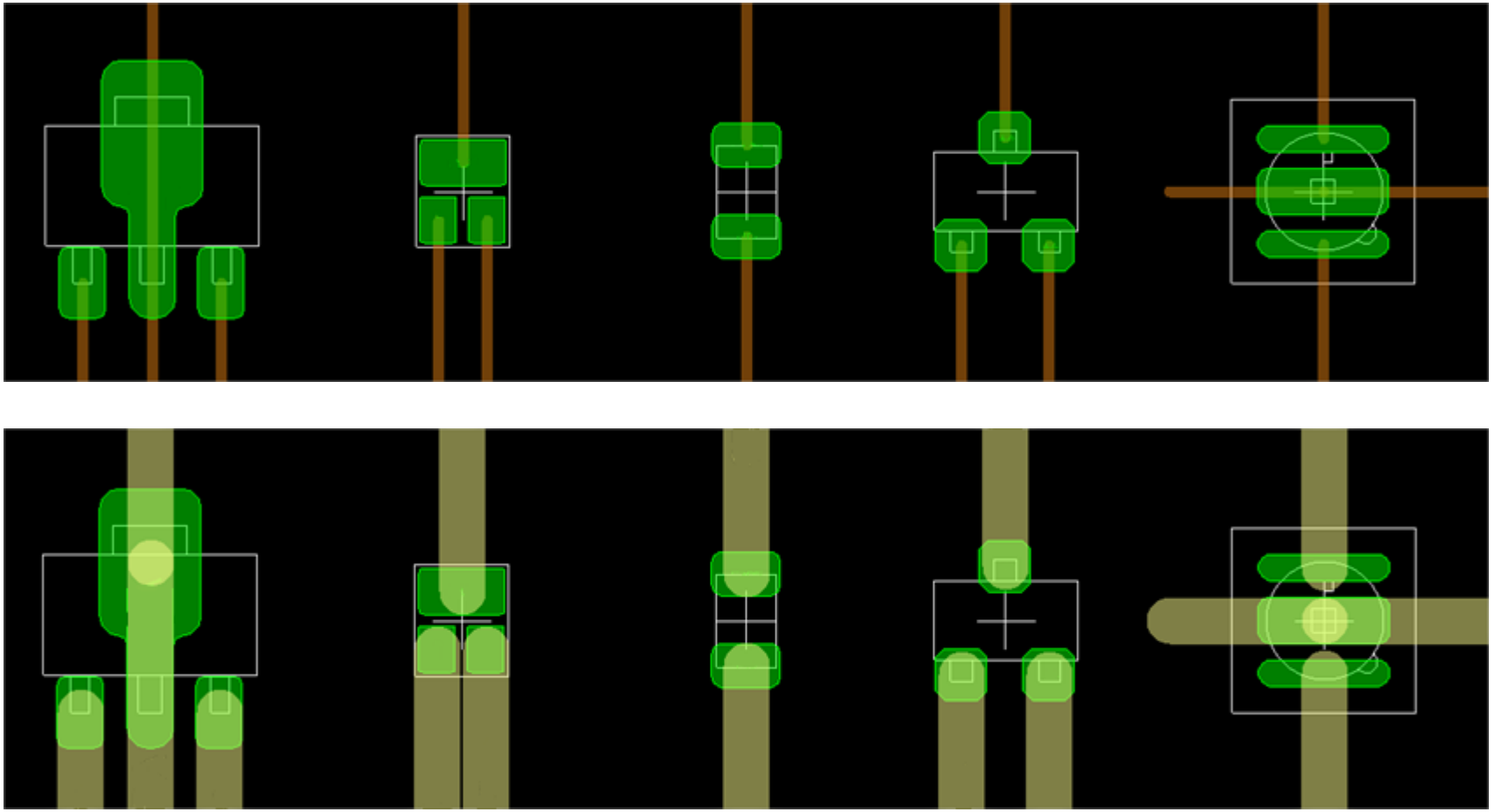
SOT89 0805 Oslon Black (3 pin)



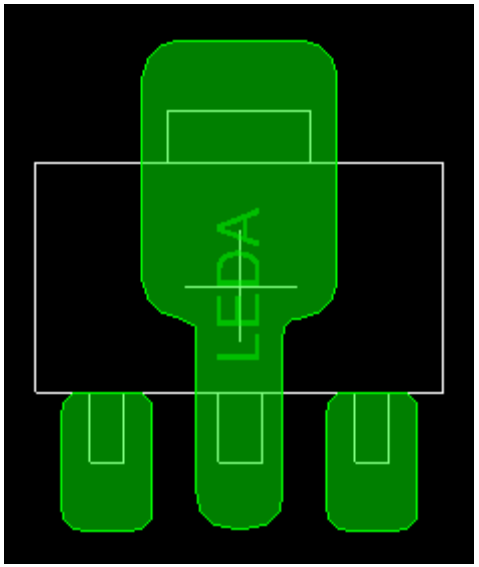
Luxeon F ES (3 pin) SOT23

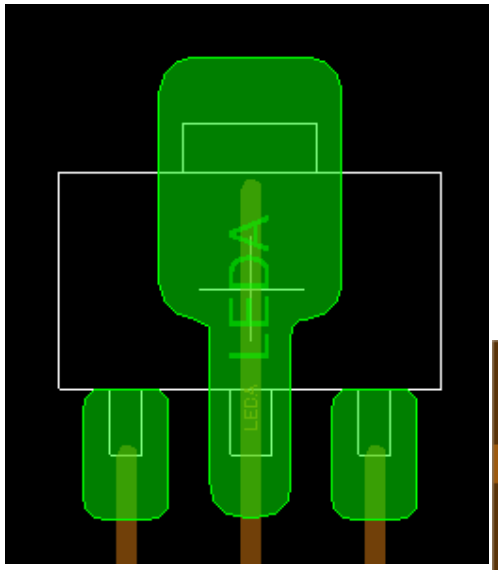
Optimizacija PCBja po površini povezava linij

SOT89 Luxeon F ES (3 pin) SOT23 0805 Oslon Black (3 pin)

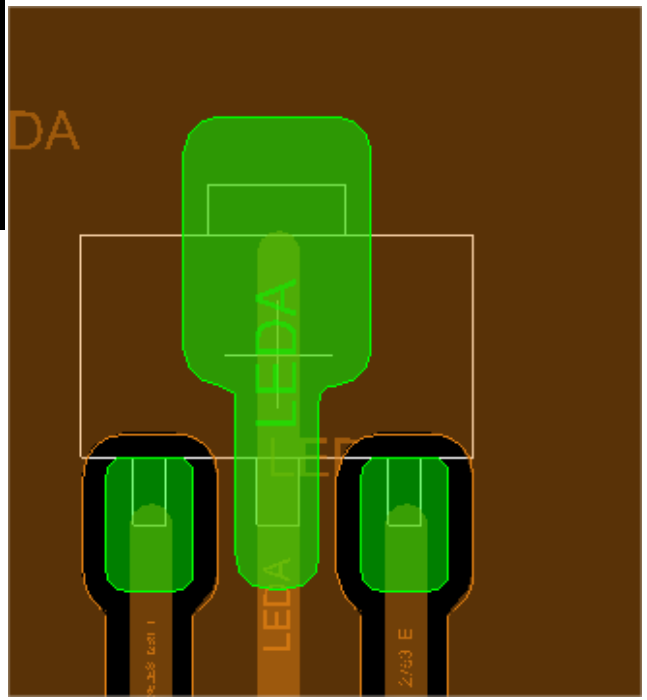


SOT89

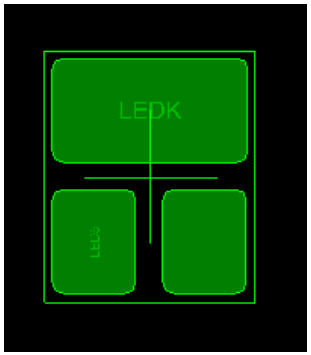




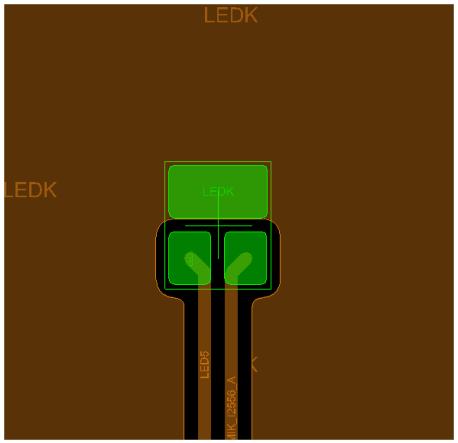
0,125 W/cm^2

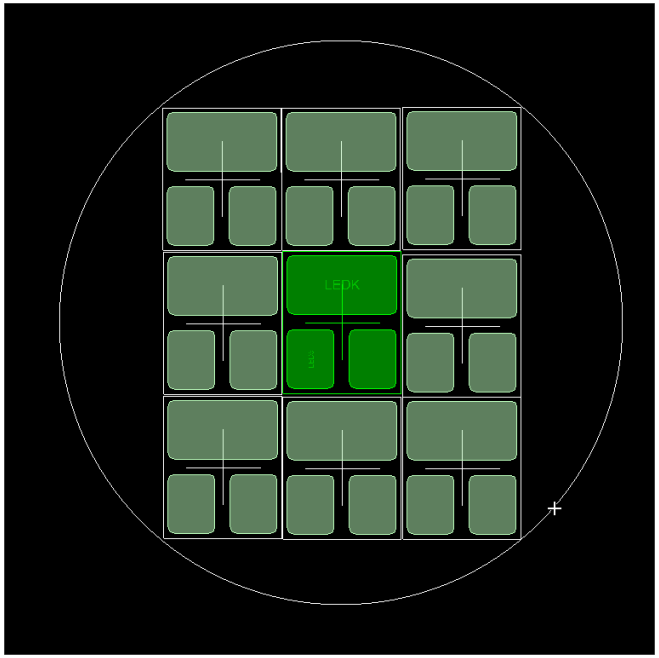


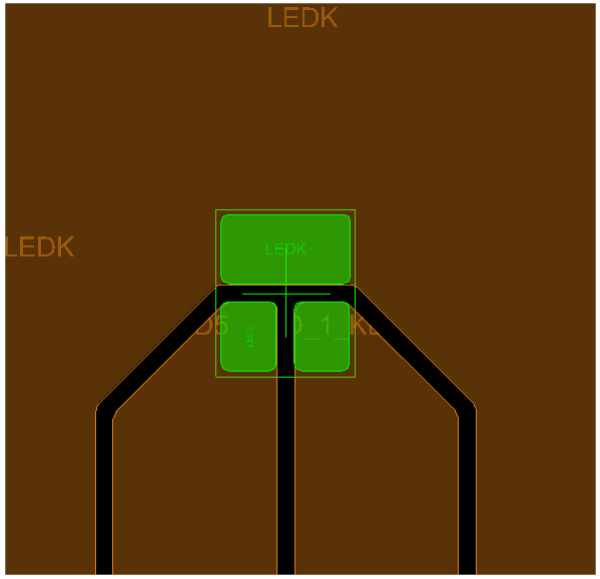
Luxeon F ES (3 pin)



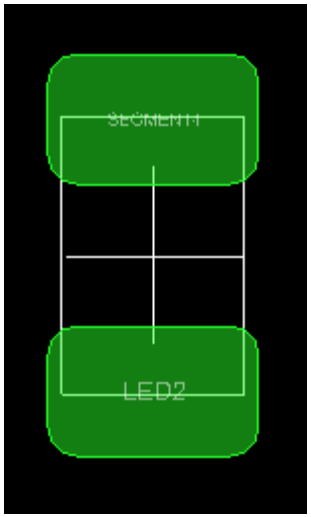
- Ozka grla
- Hlajenje preko ohišja

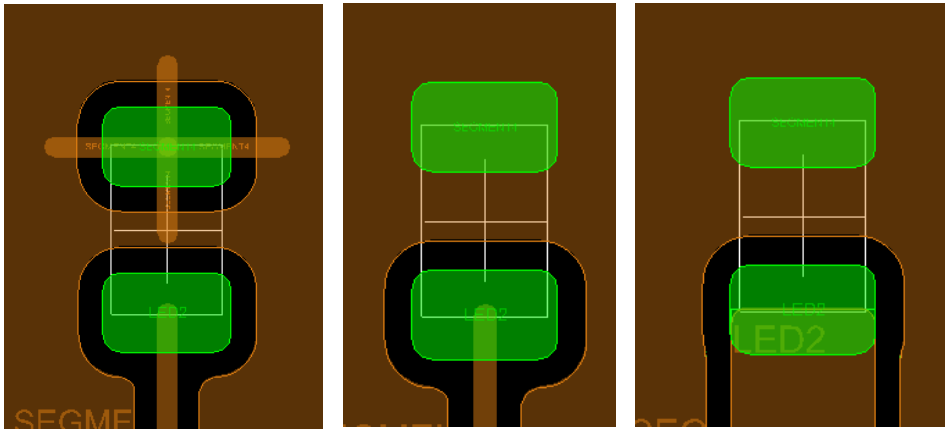


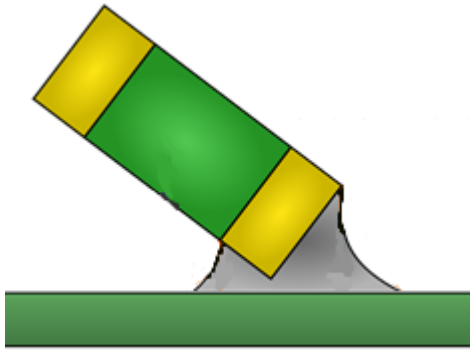




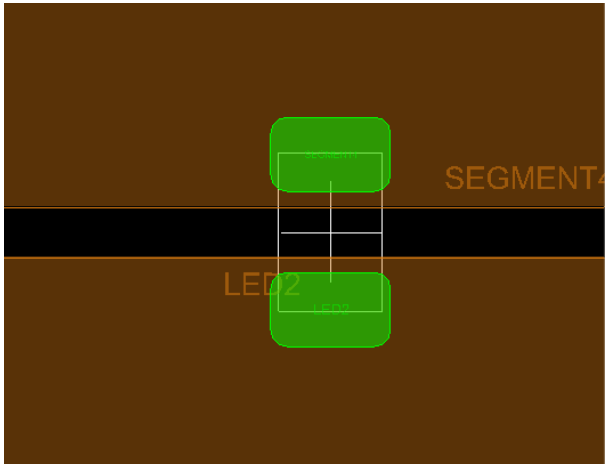
0805



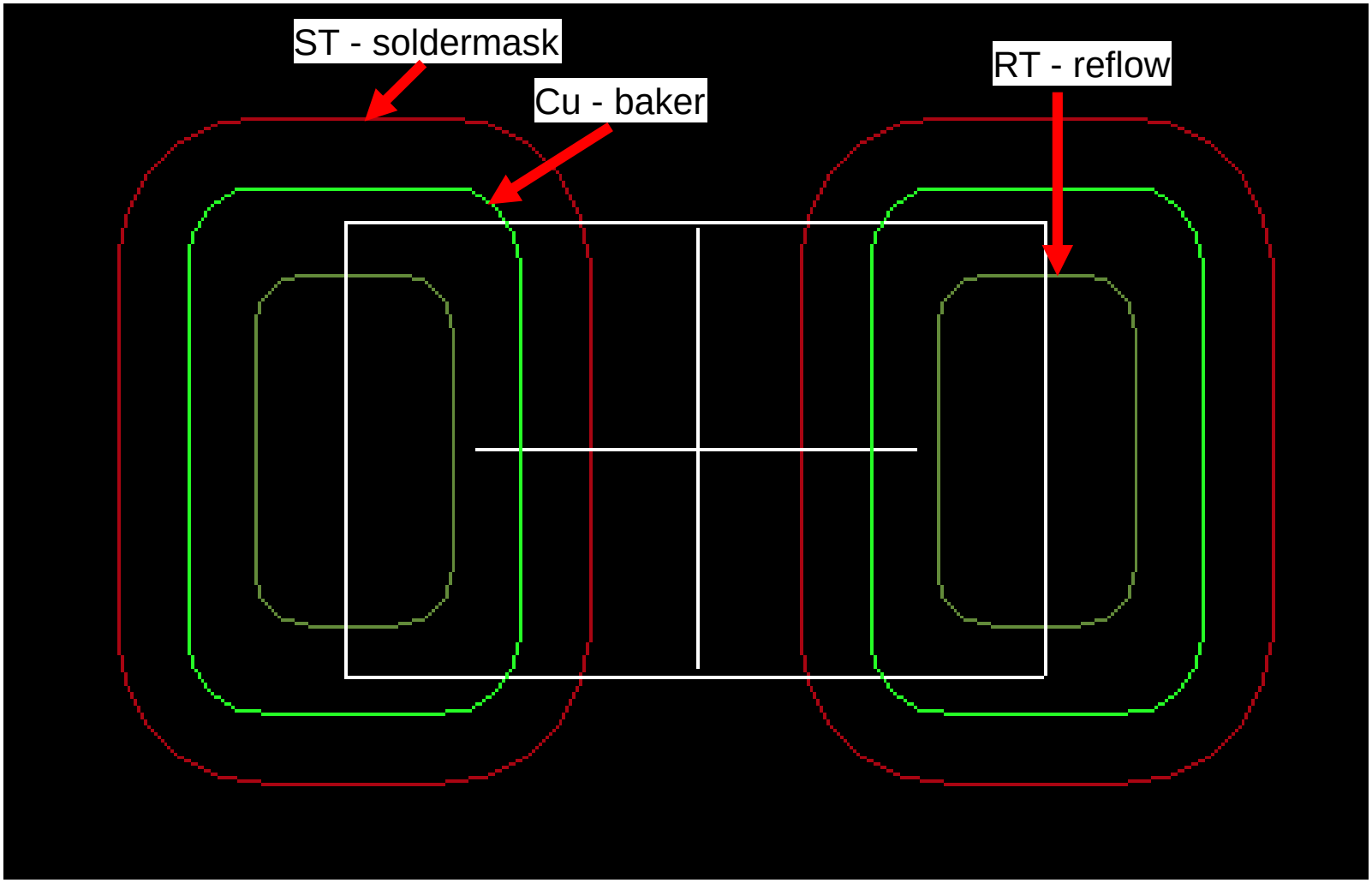


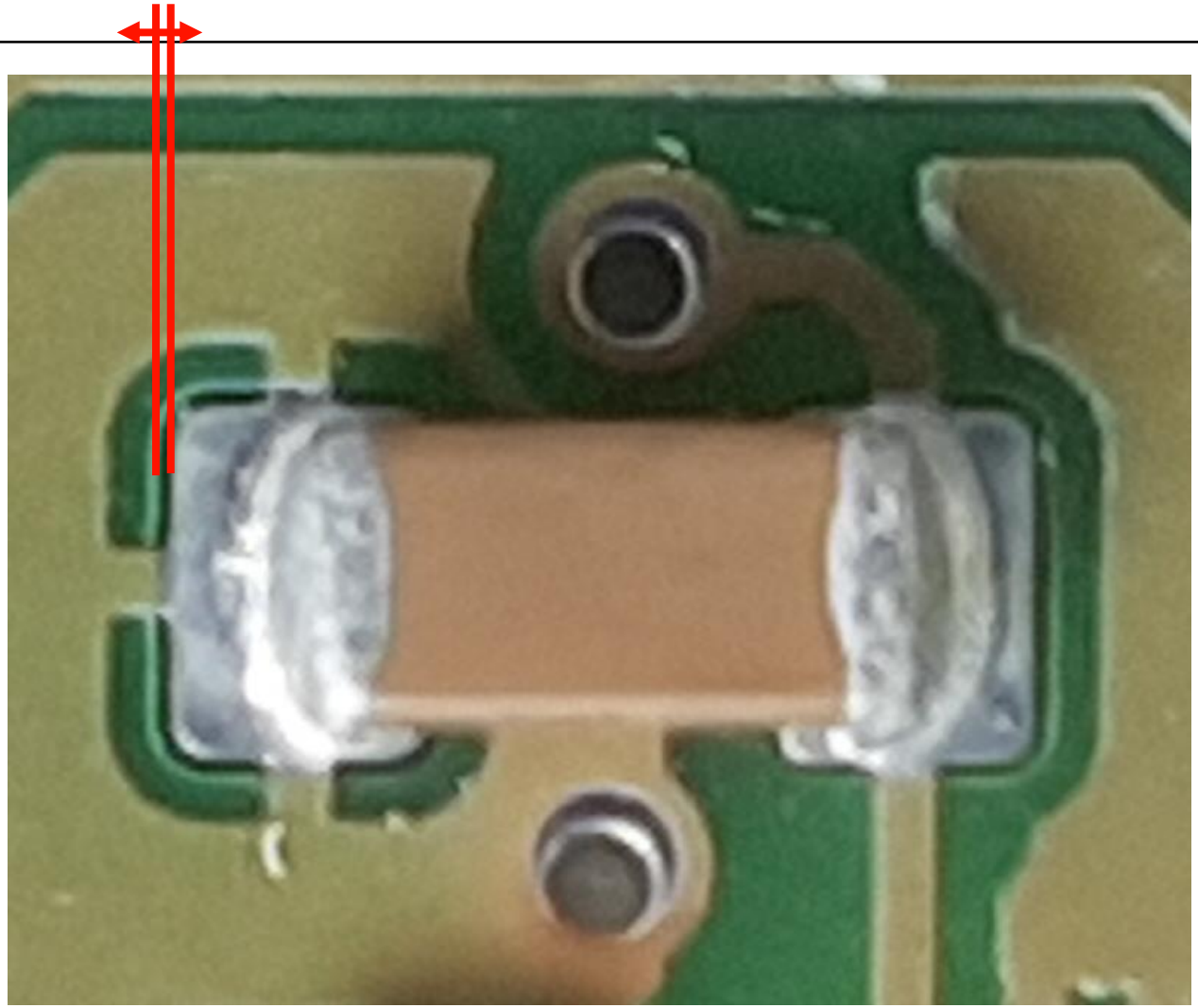


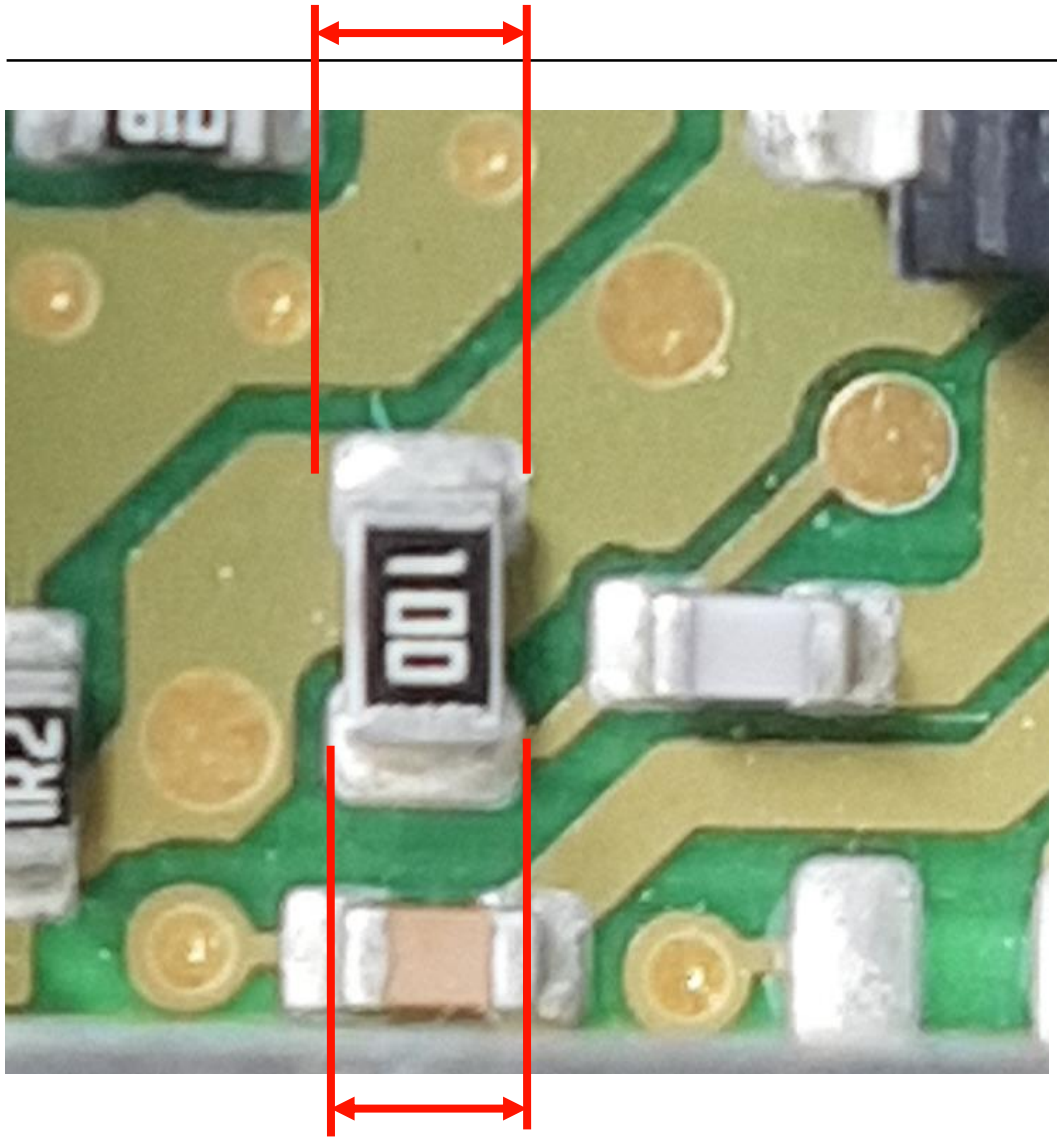
Tombstone Effect

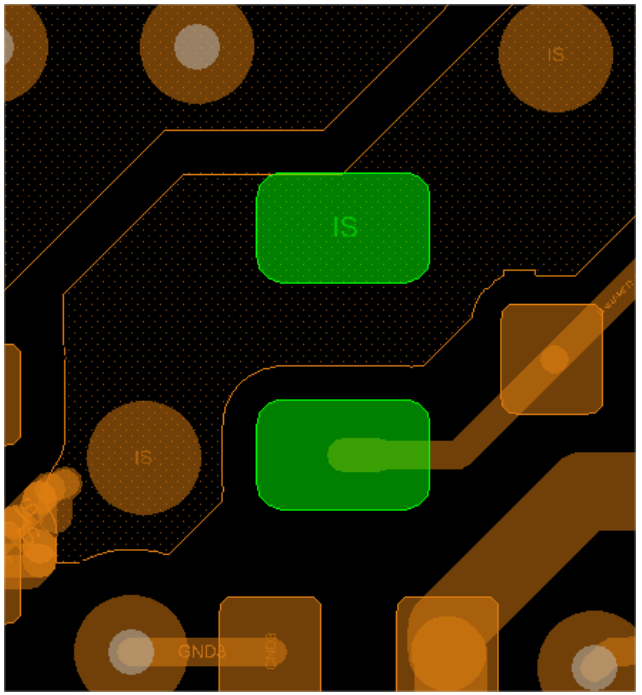


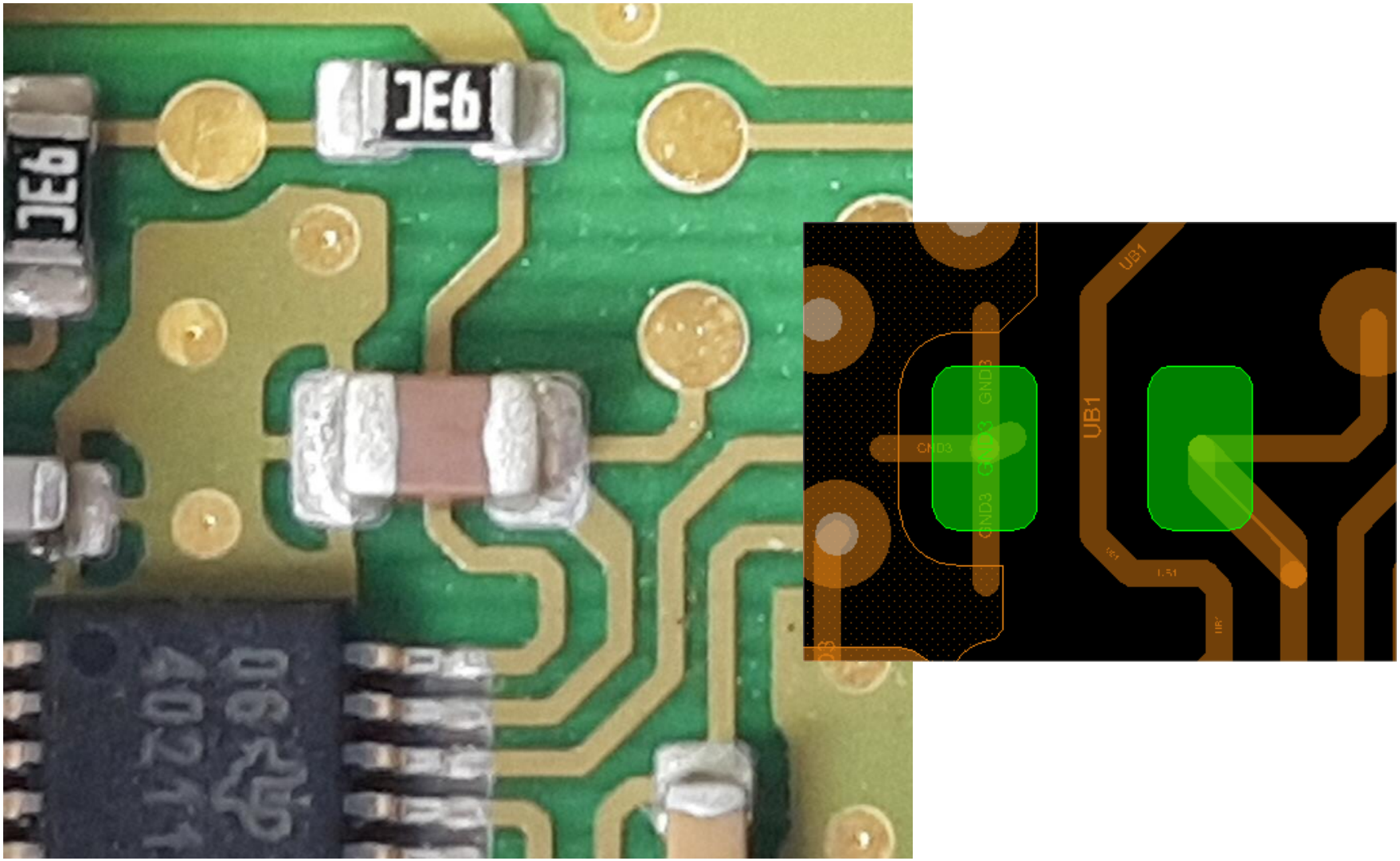
Povečanje pada (Cu, ST)

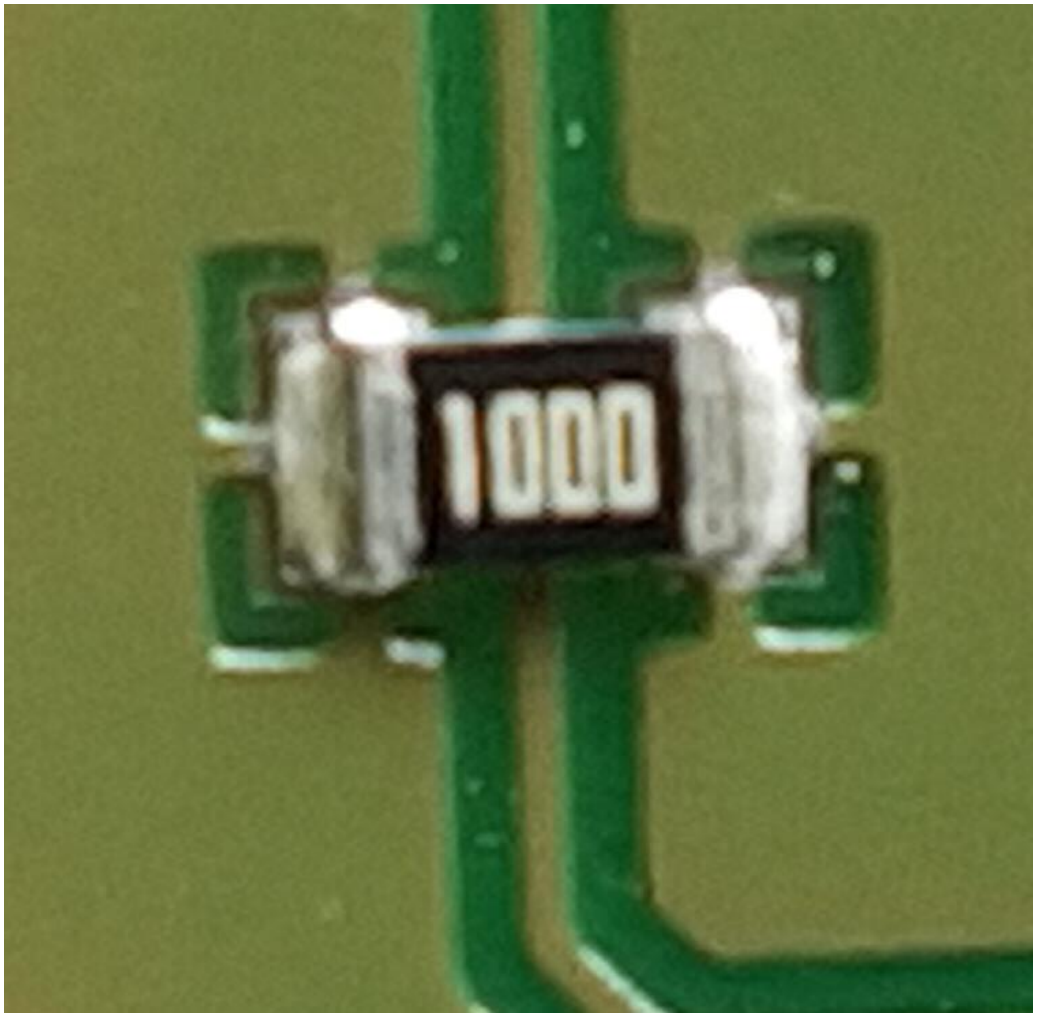


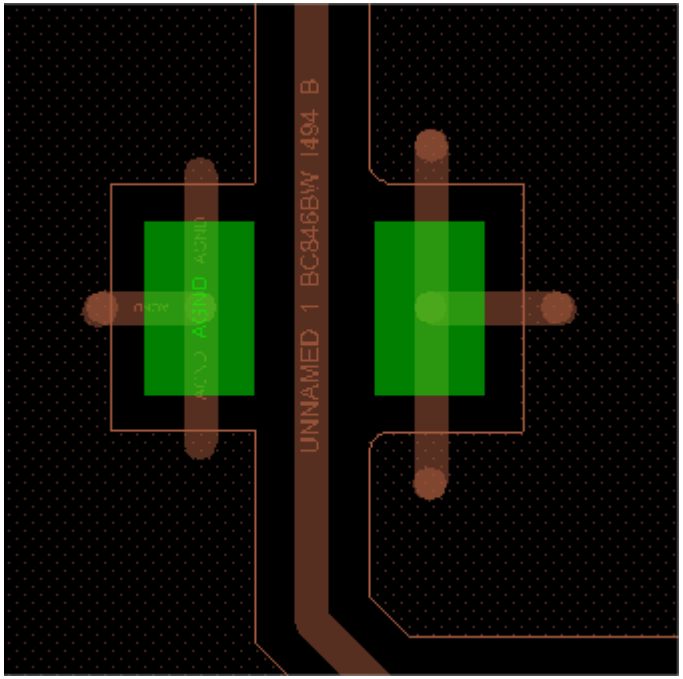



100
2R1

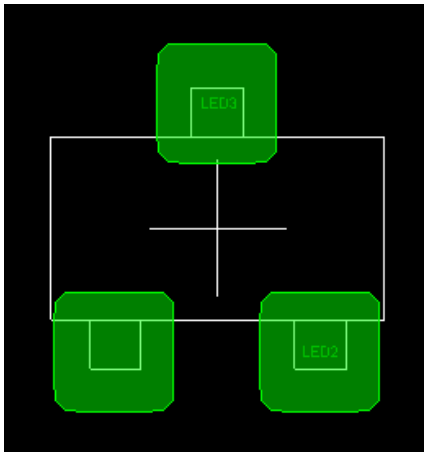

IS
IS
GND

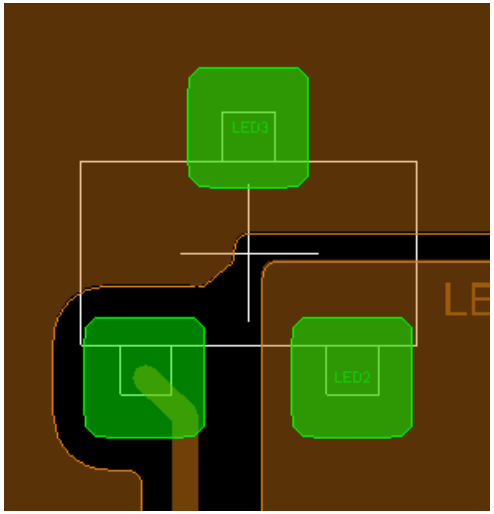

JE6
JE6
UB1
UB1
GND3
GND3
GND3
GND3

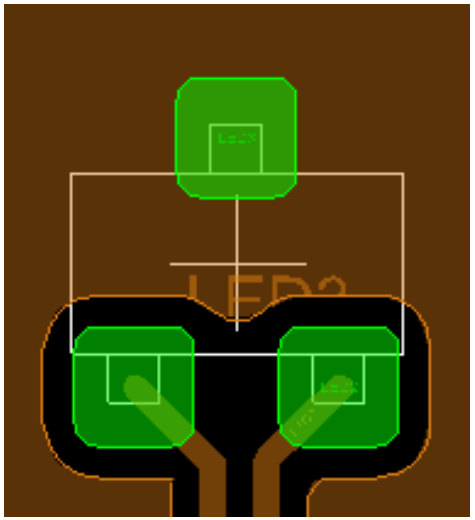

1000

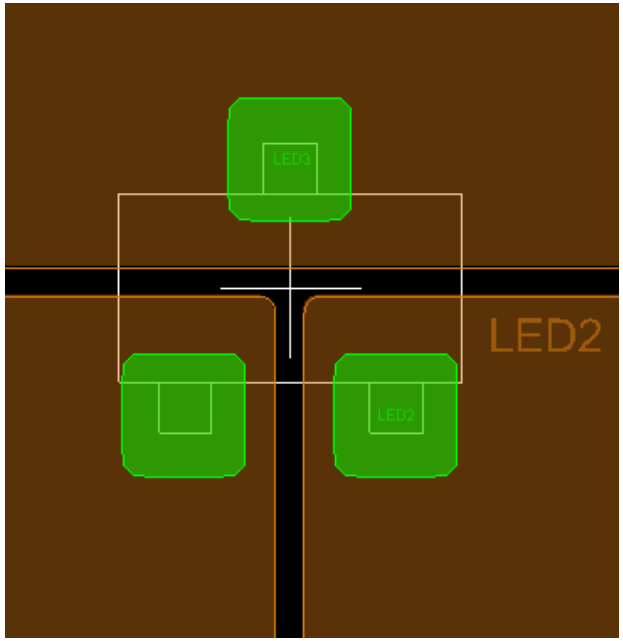

UNNAMED 1 BC846BW 494 B

SOT23

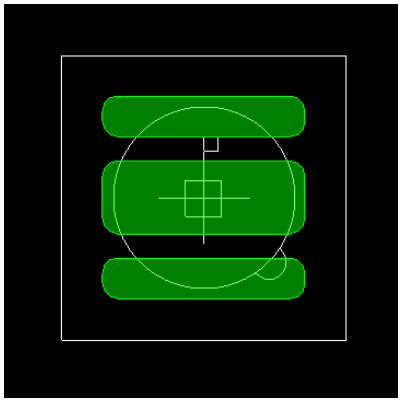


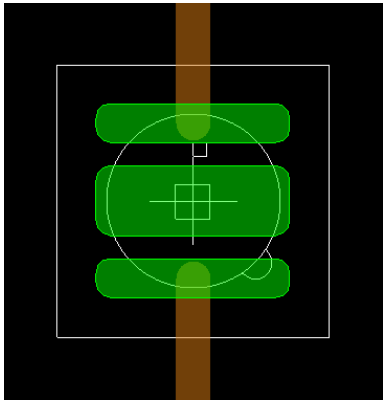


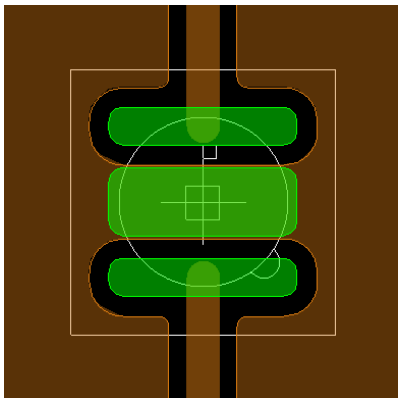


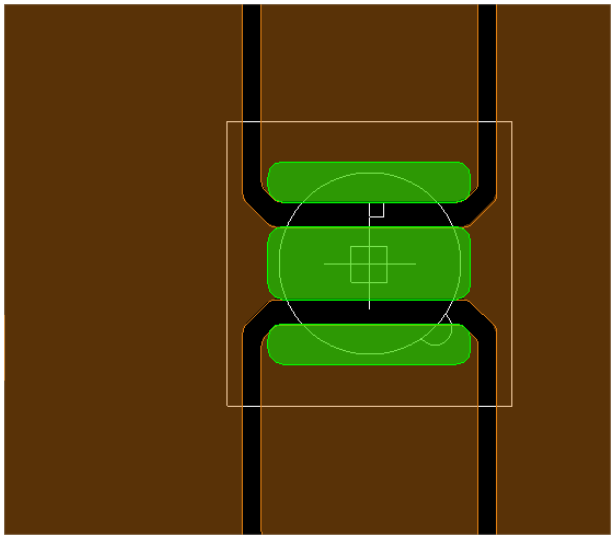


Oslon Black (3 pin)



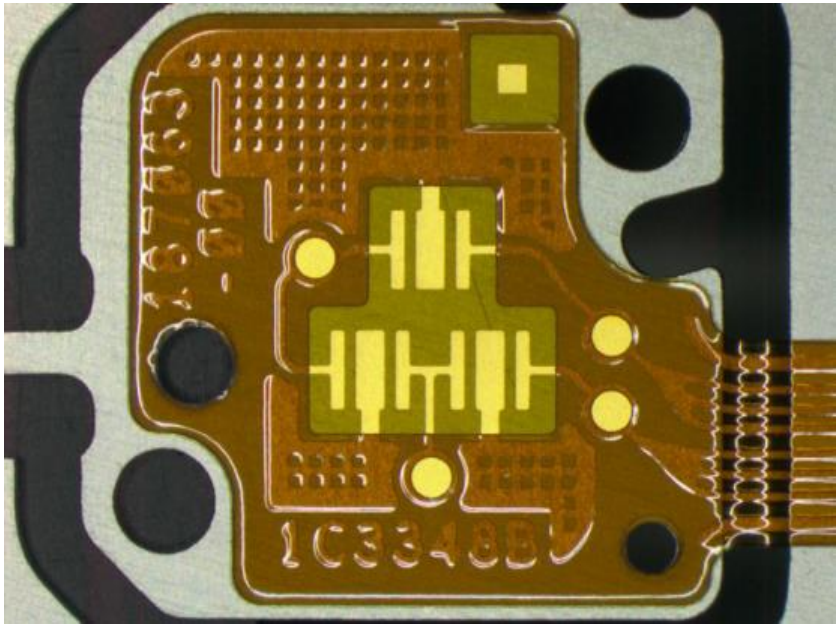




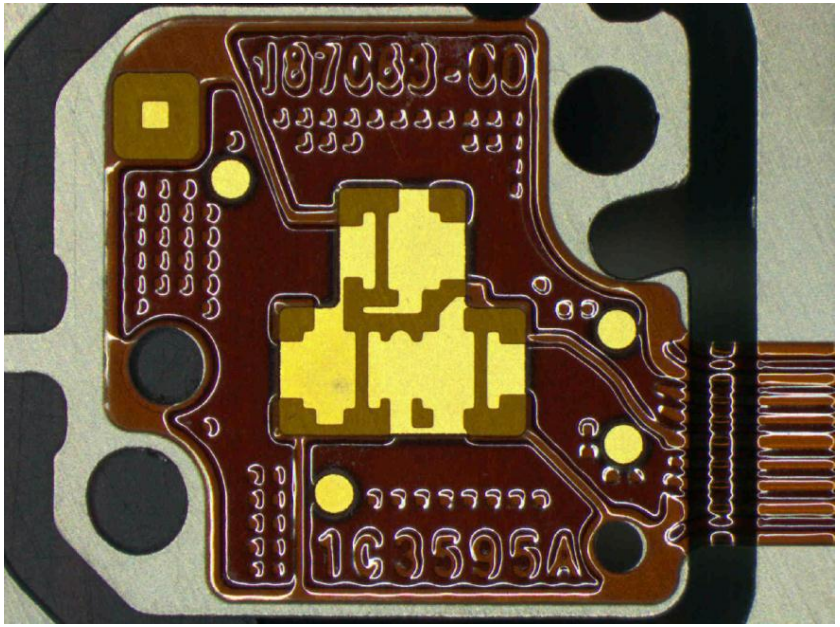


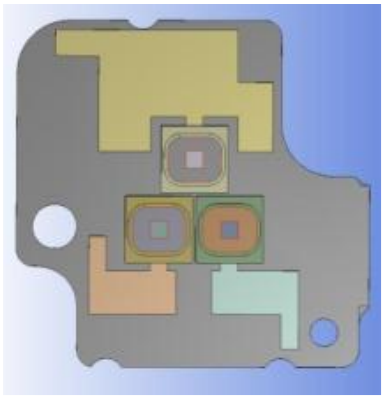
Optimizacija PCBja po površini

PCB s premajhno toplotno disipacijo:

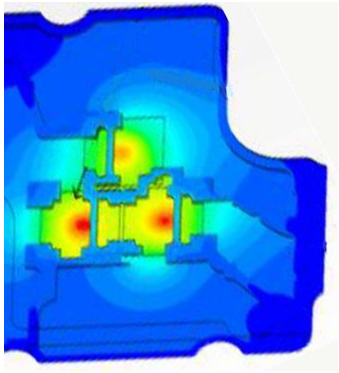


Optimiziran PCB:

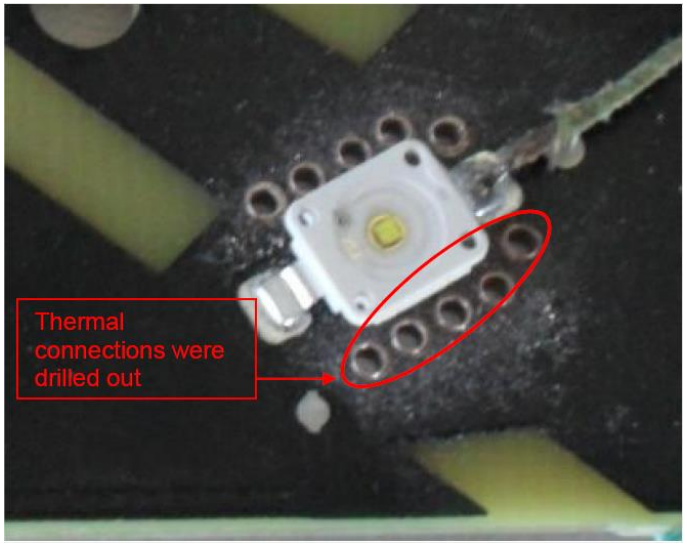


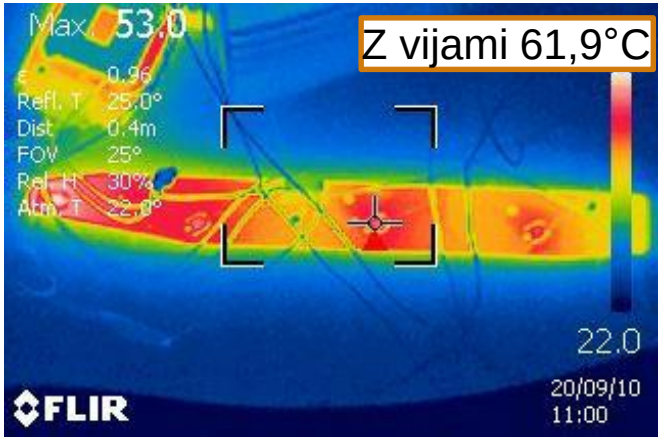


- Majhna sprememba bakrene površine veliko spremeni odvajanje toplote



Optimizacija PCBja s termalnimi vijami



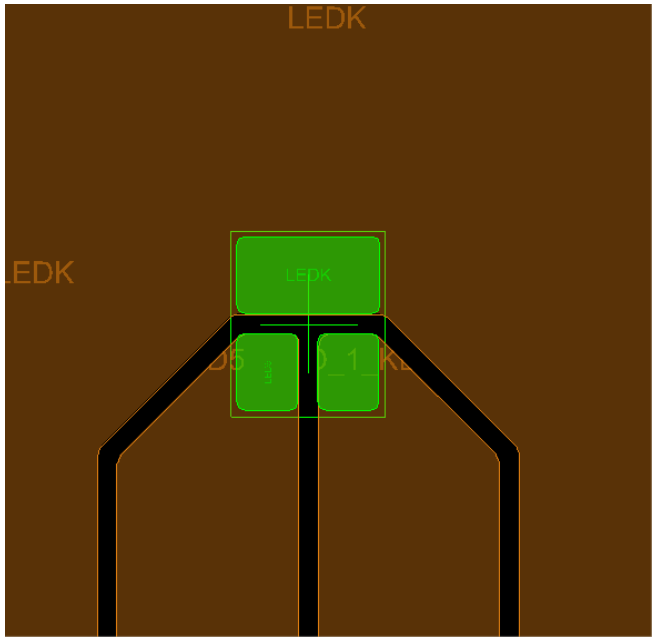


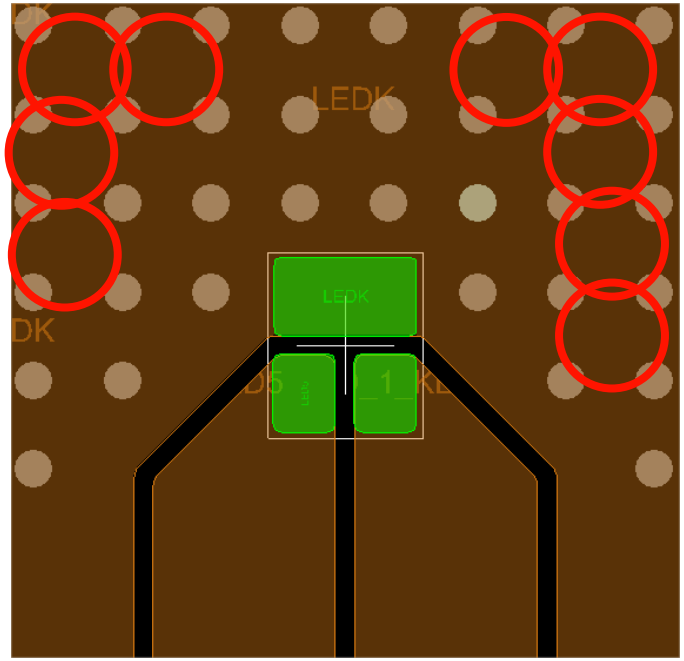
Z vijami 61,9°C

Brez vij 68,3°C

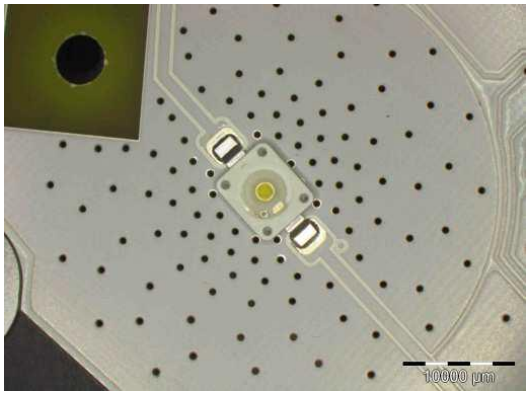
- 400mA

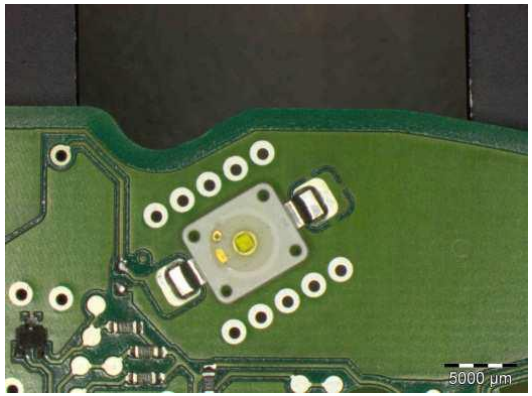
Postavitev vij v okolici komponente



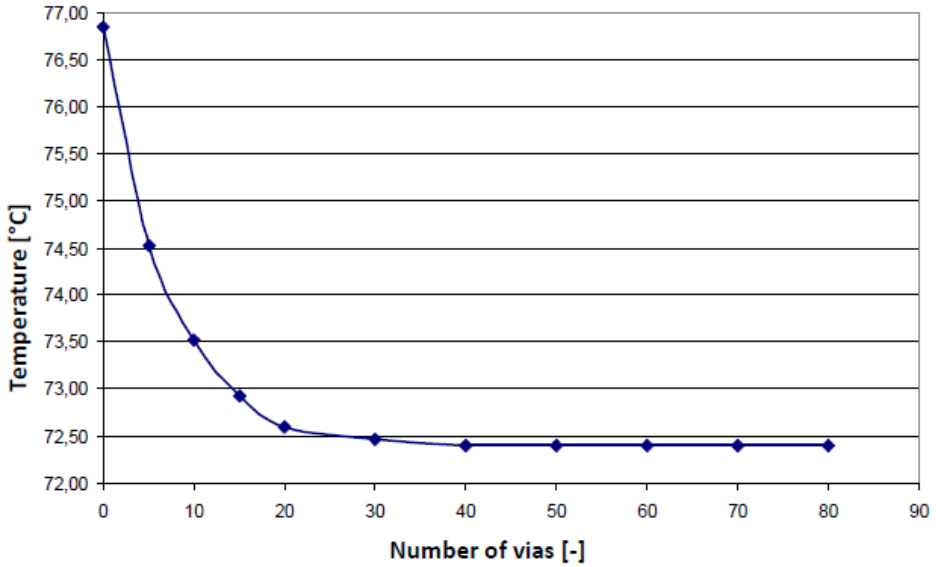


Številčnost vij



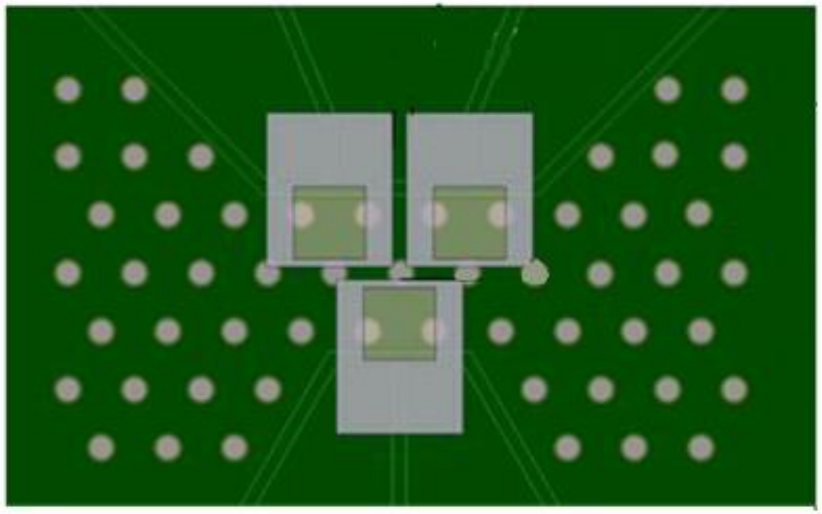


- Število vij ne pomeni boljše toplotne disipacije
- Število termalnih vij z dobro učinkovitostjo je od 8 do 15
  - Več kot toliko vij ne poveča učinkovitosti

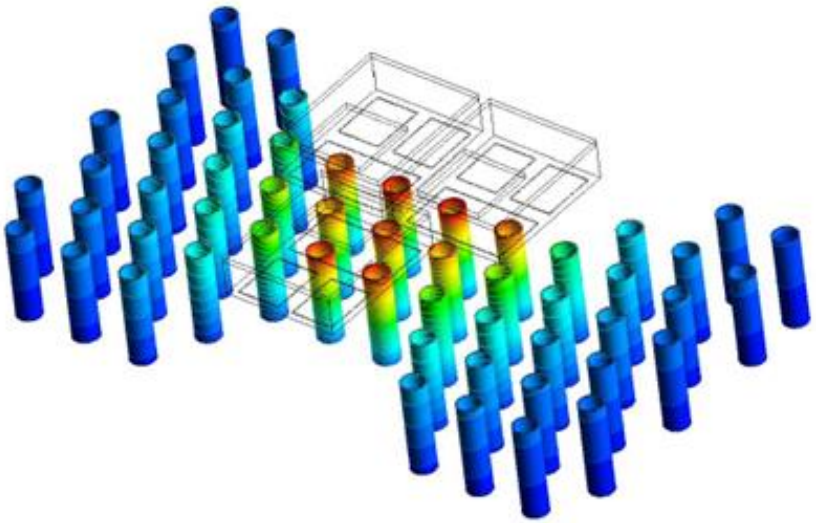


Številčnost vij

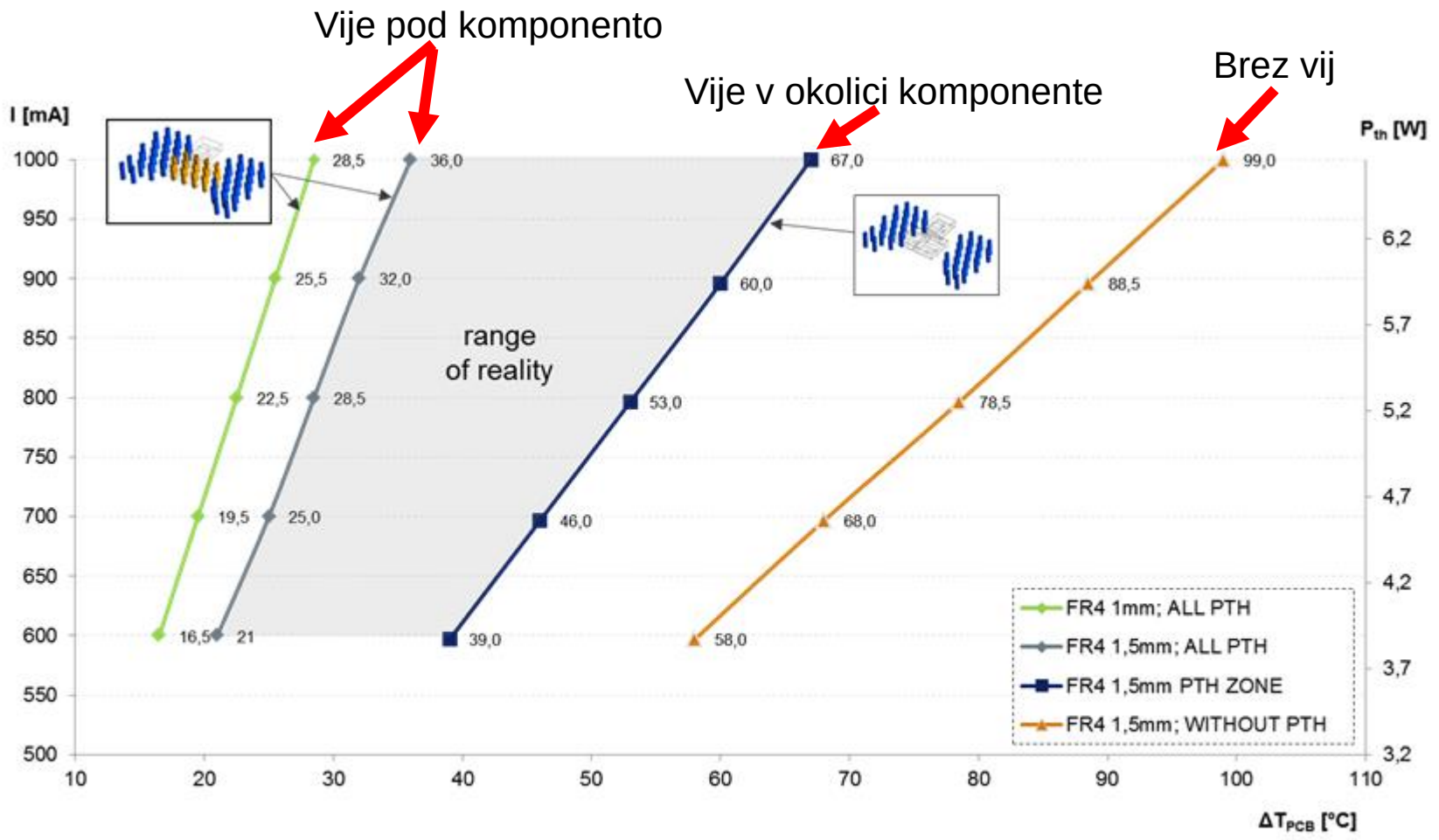
PTH configuration



PTH temperatures

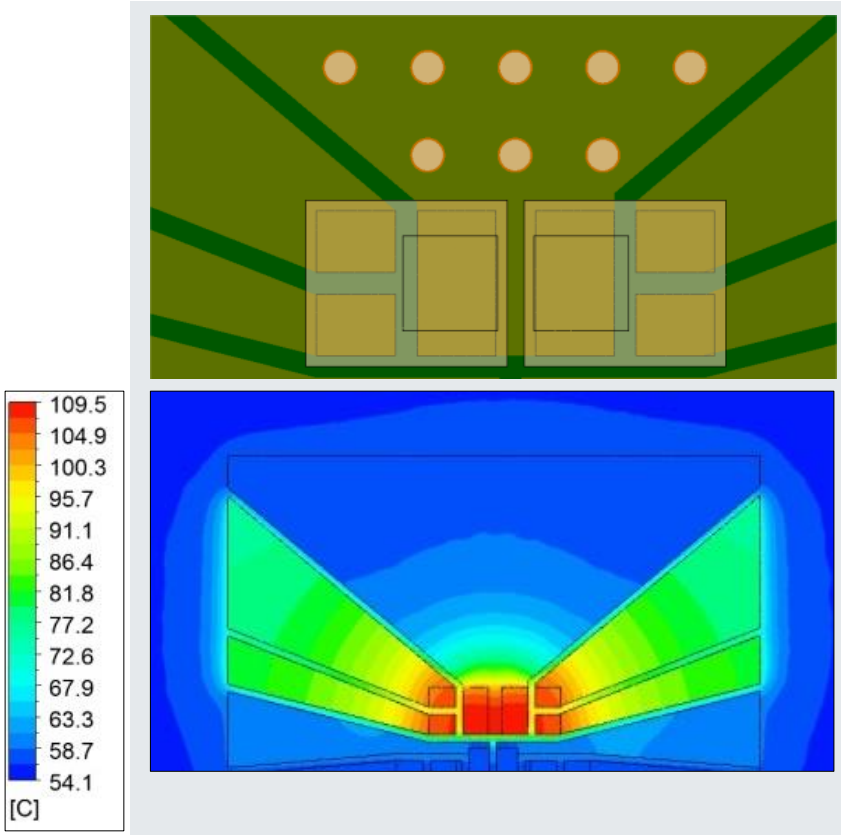


Primerjava vij
pod komponento in ob komponenti

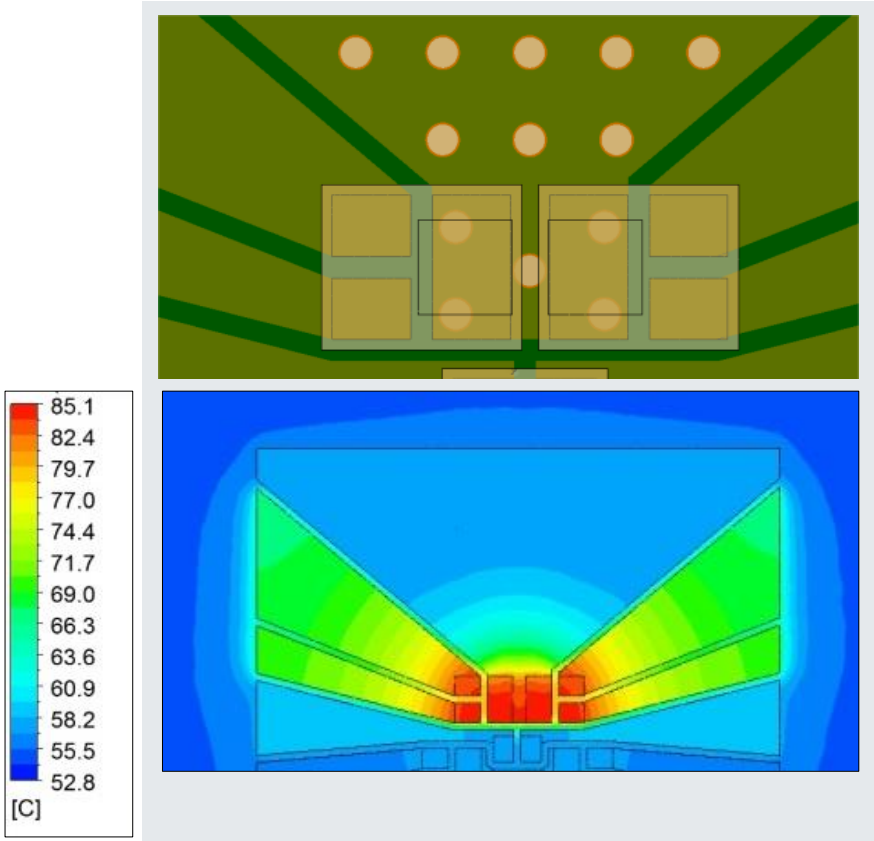


Primerjava vij

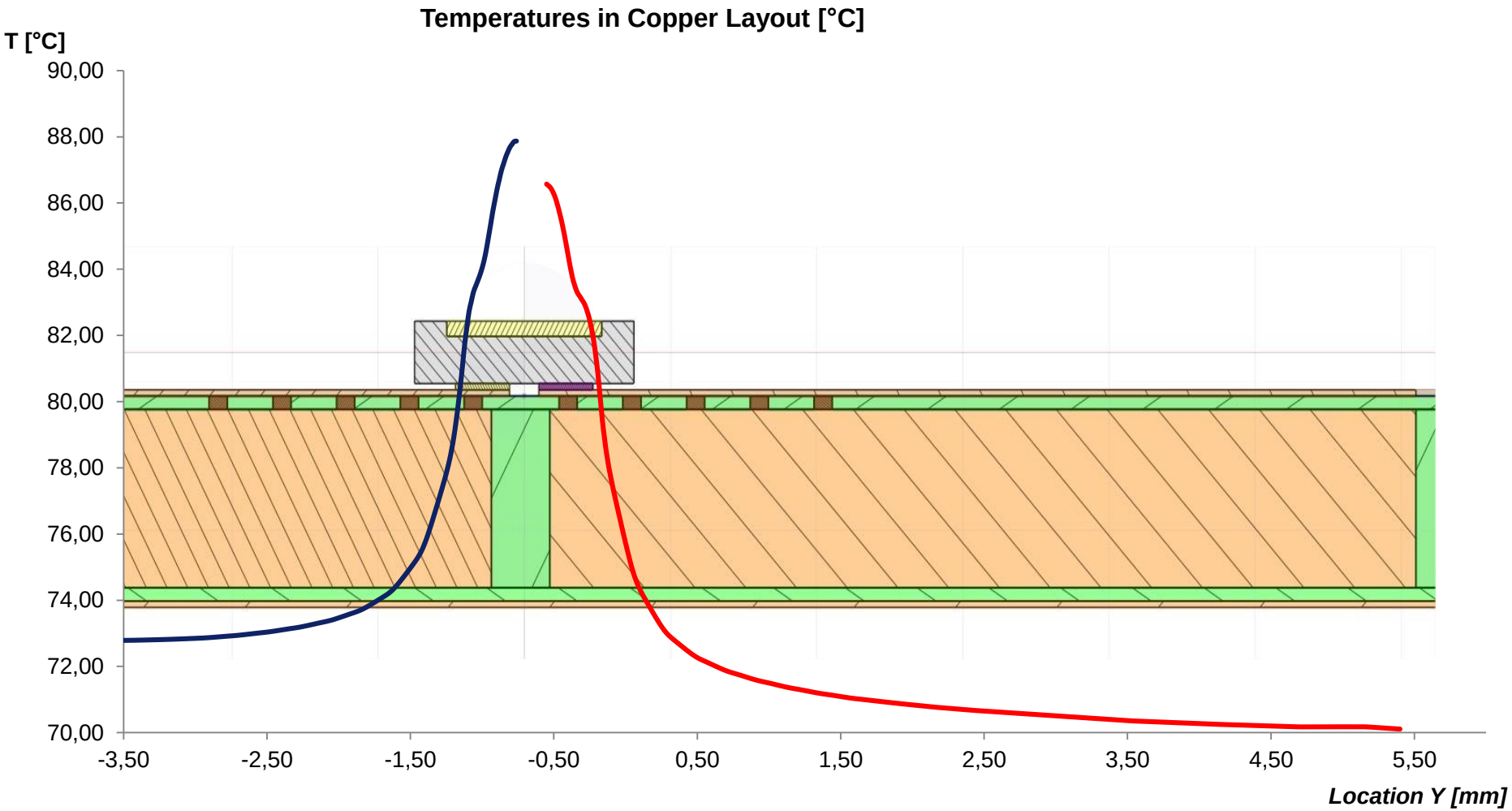
PTH vias



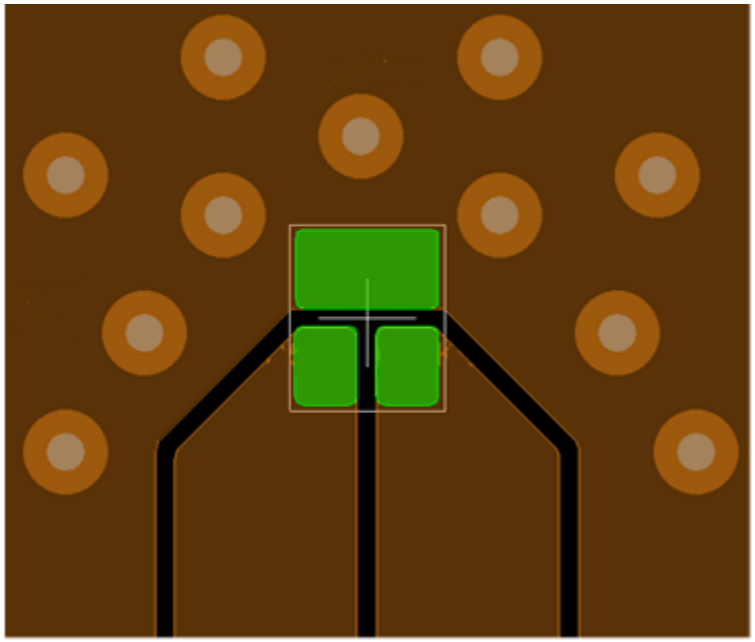
Plugged PTH vias with metal cap



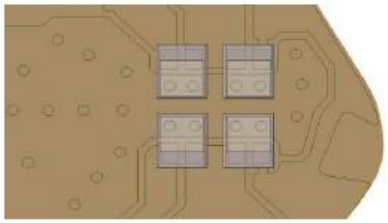
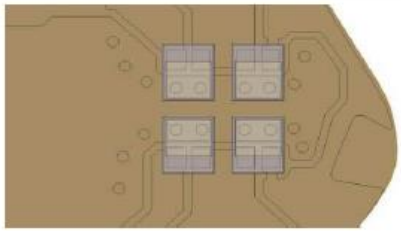
Distanca - toplota

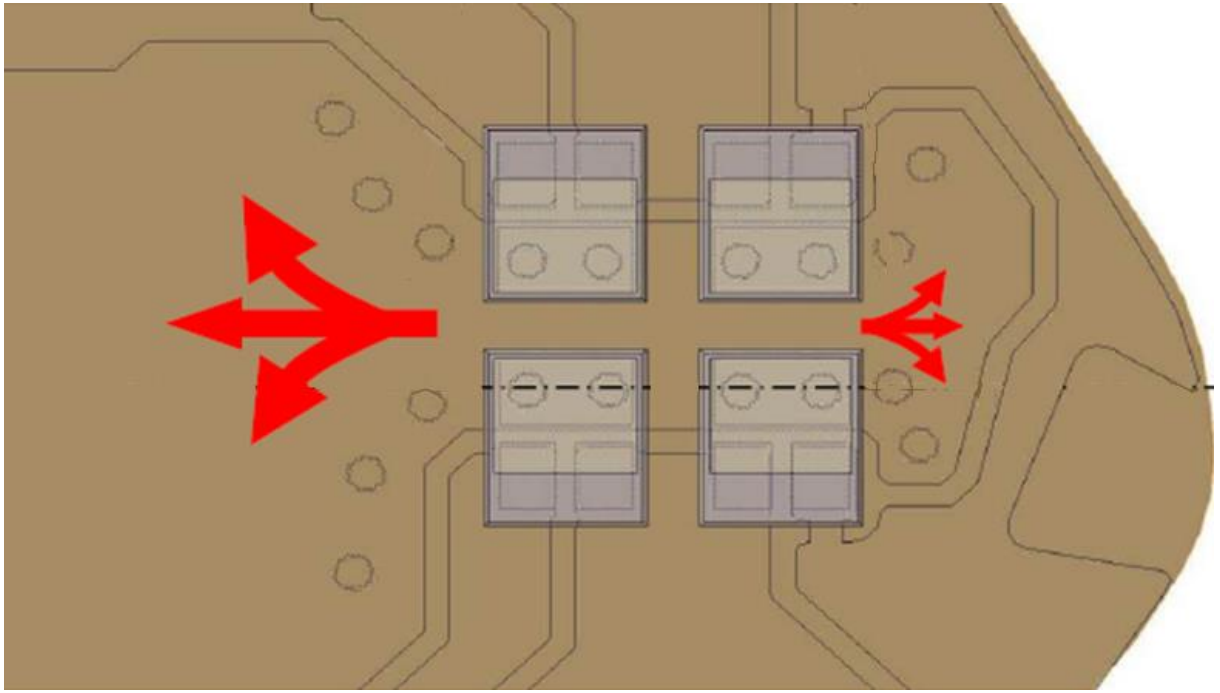


Optimalna postavitev vij v okolici komponente



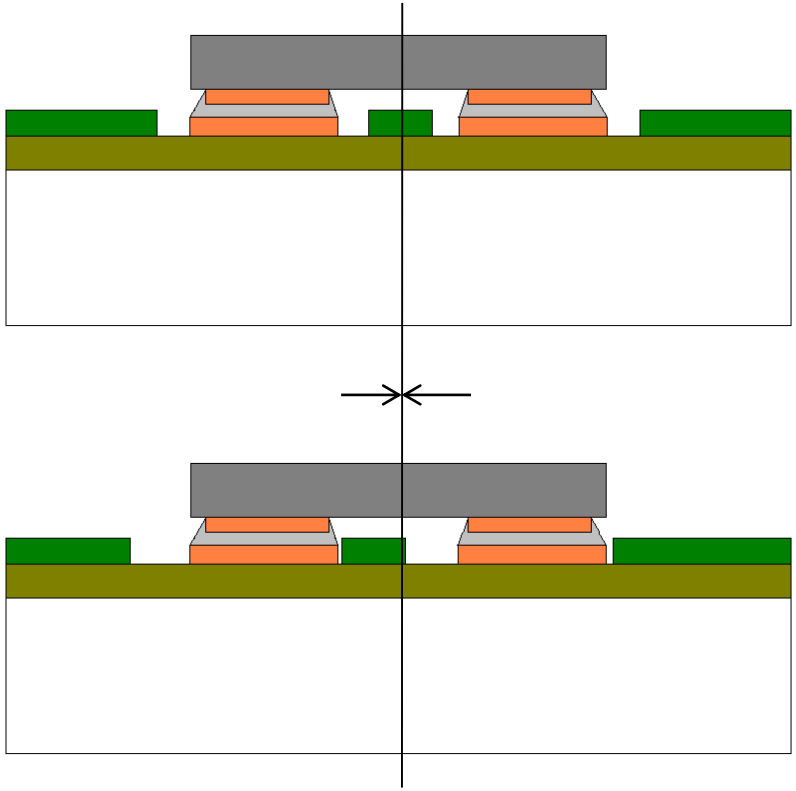
Boljši PCB

Acceptable design →		Better design →	



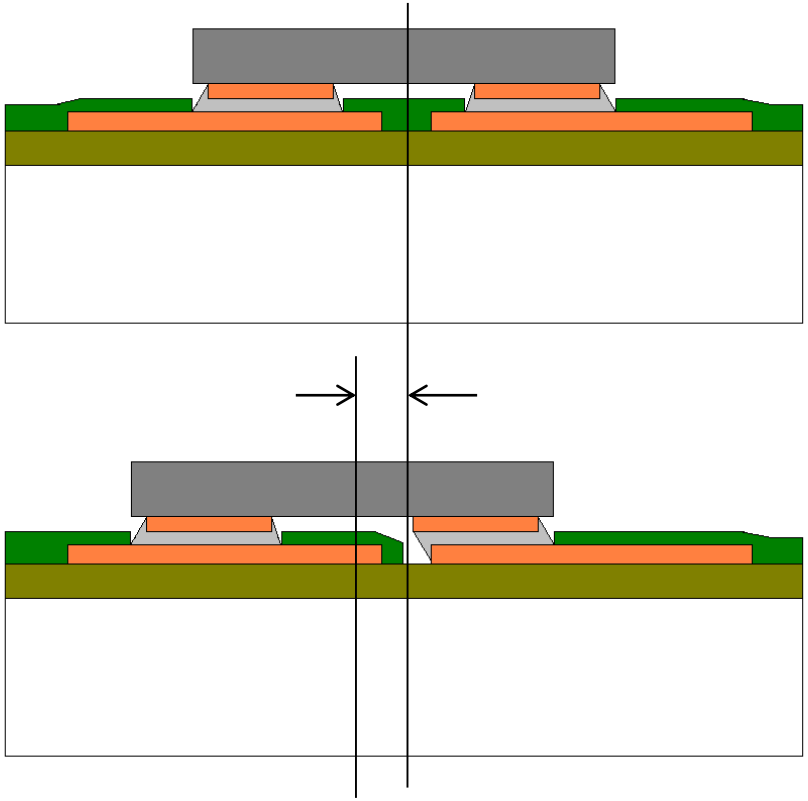
Termalno optimiziran footprint

Standardni podnožje



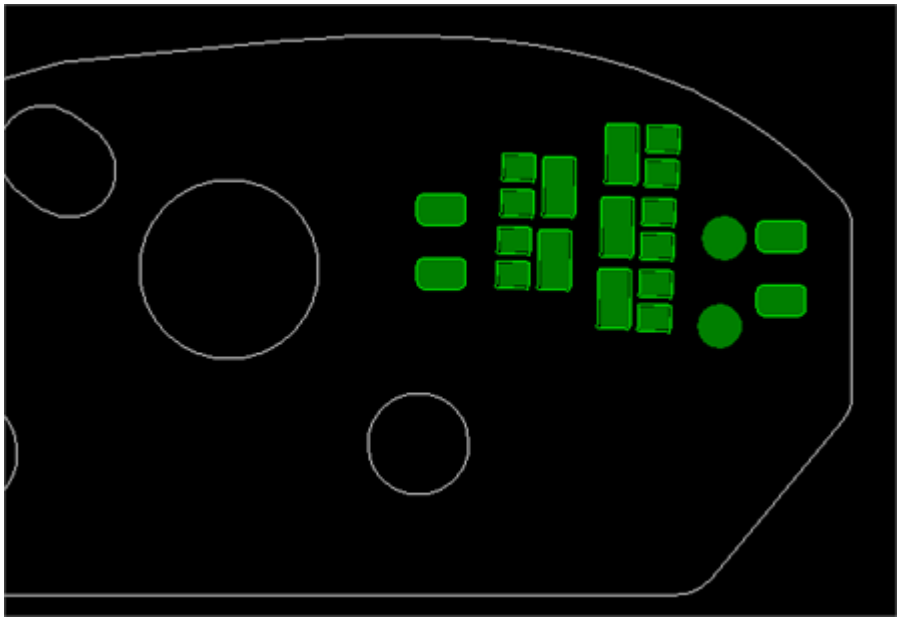
Extensive Independent of Solder Resist.

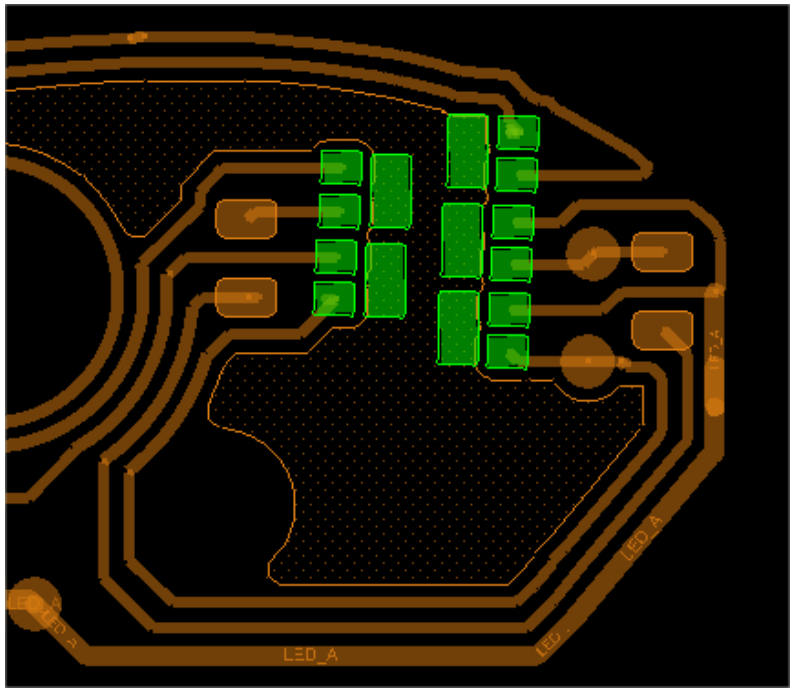
Termalno optimiziran podnožje



Soldering influenced by Solder Resist

Primer





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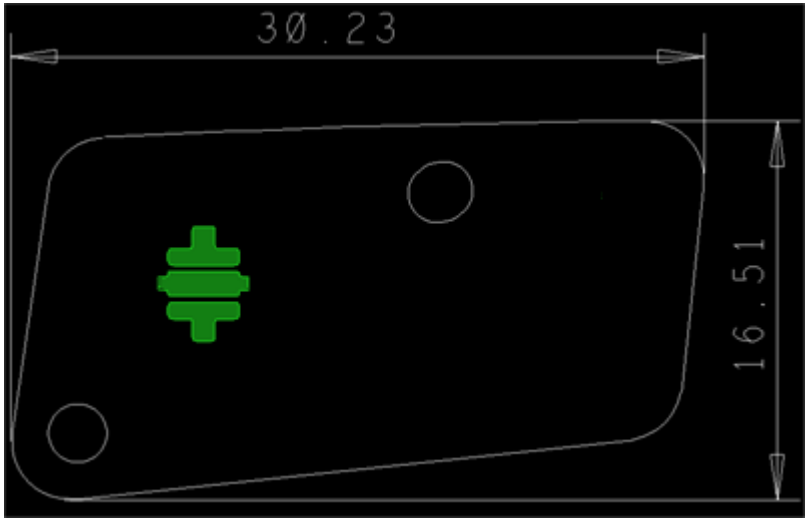

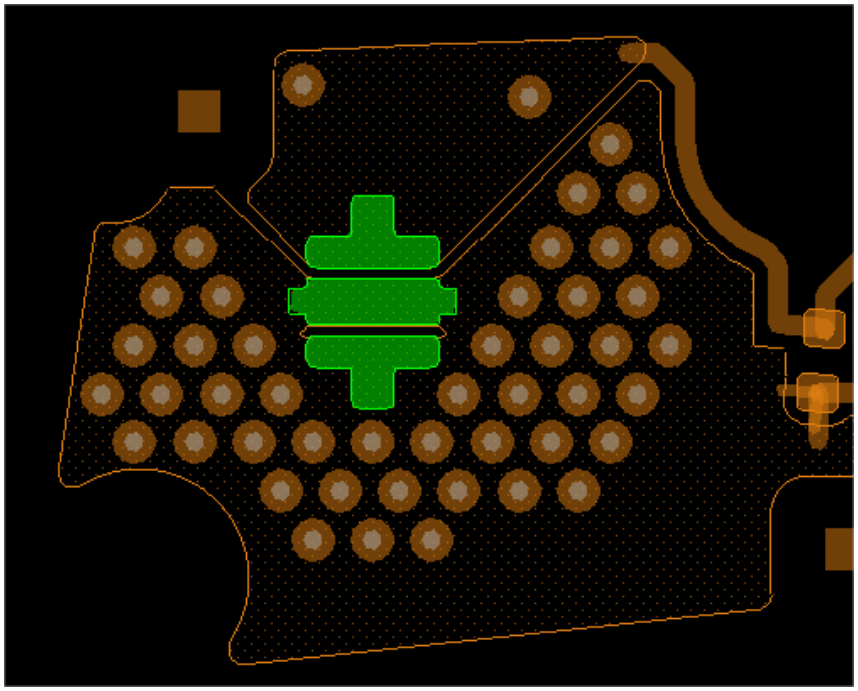

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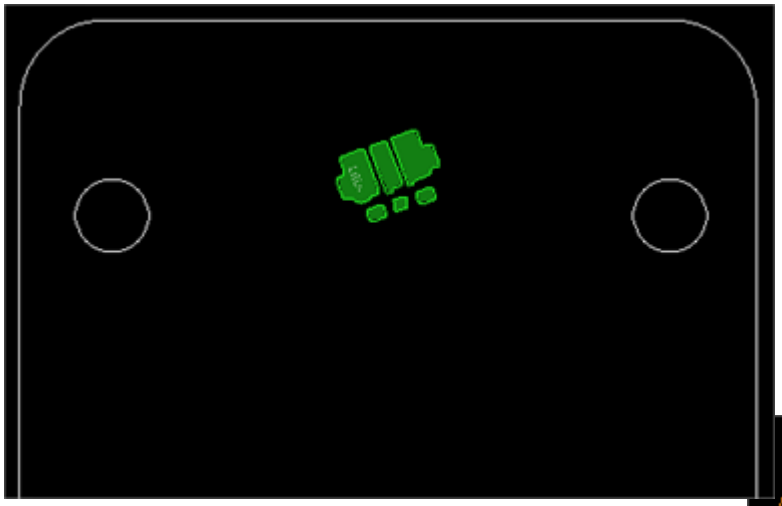

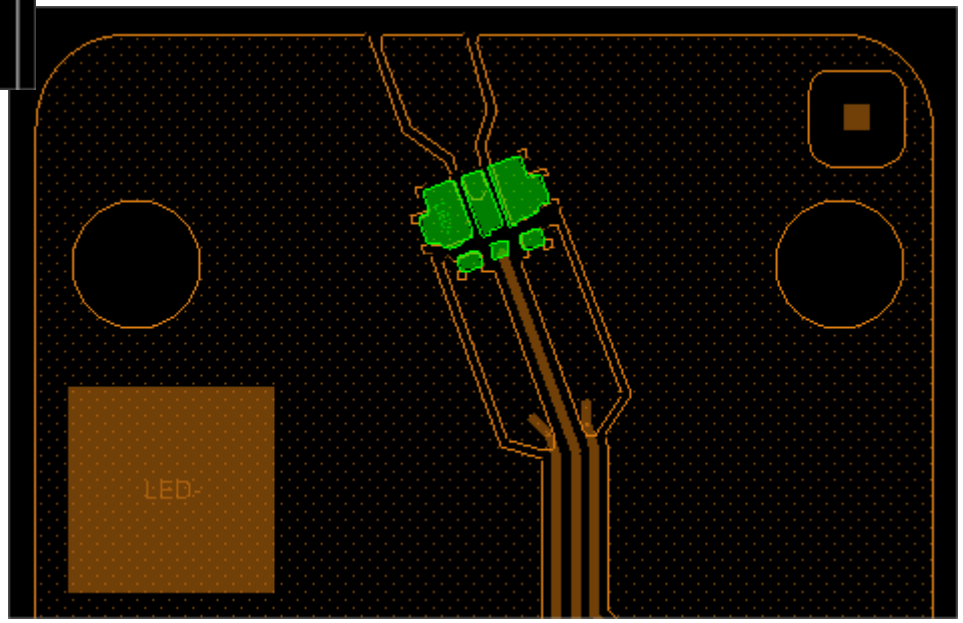

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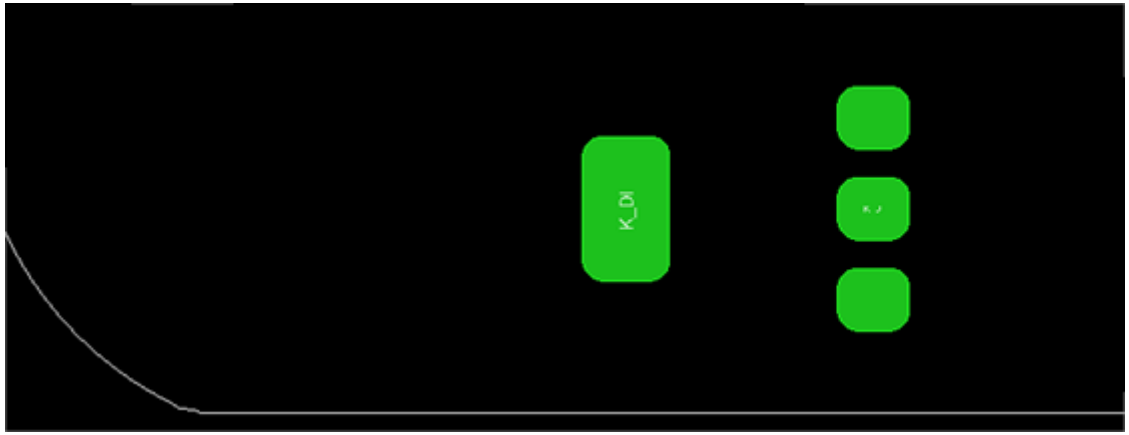

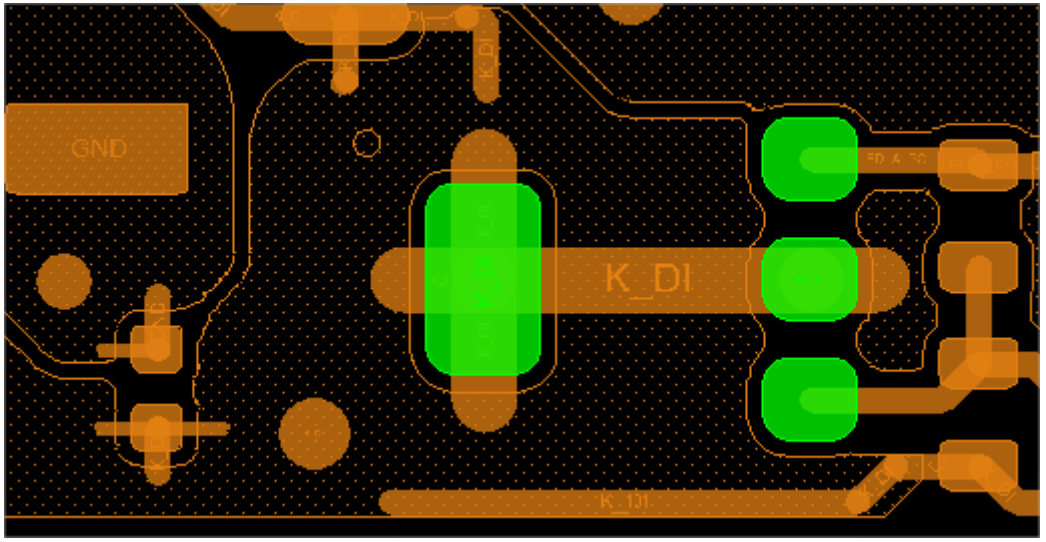

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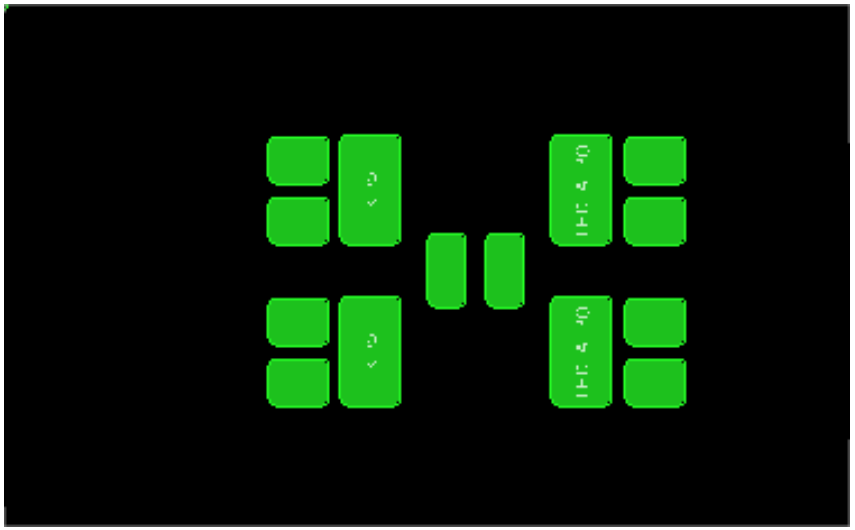

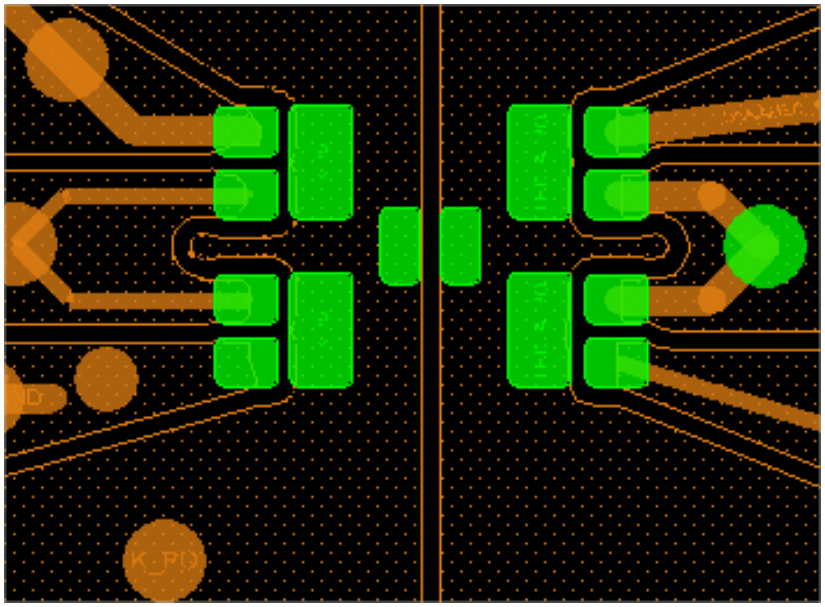

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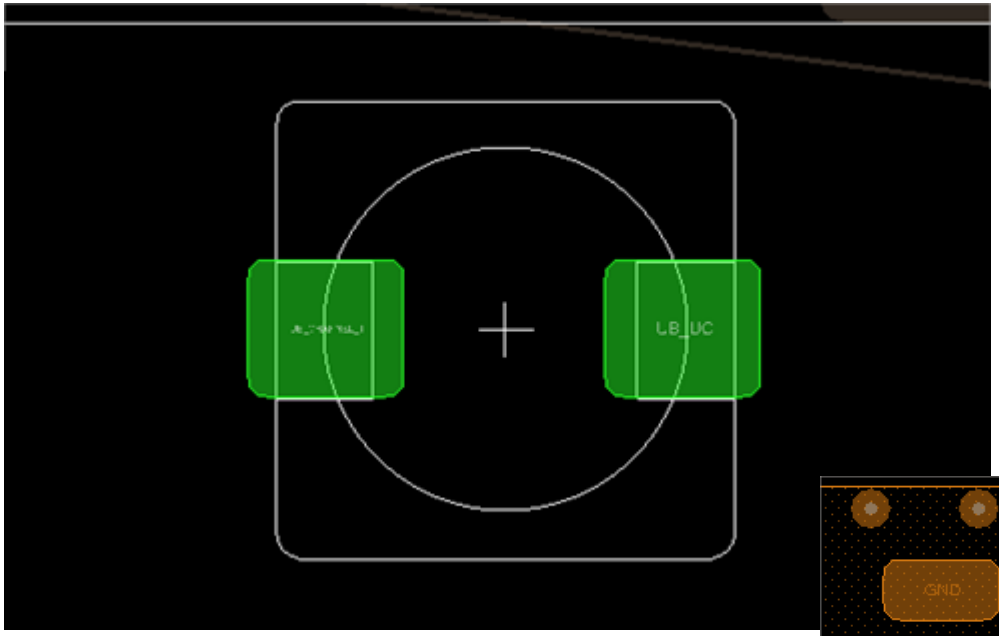

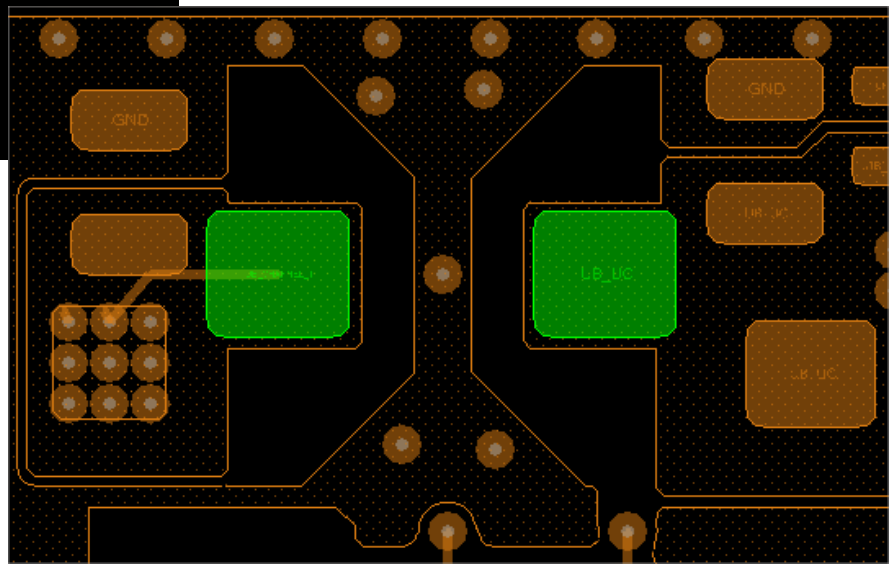

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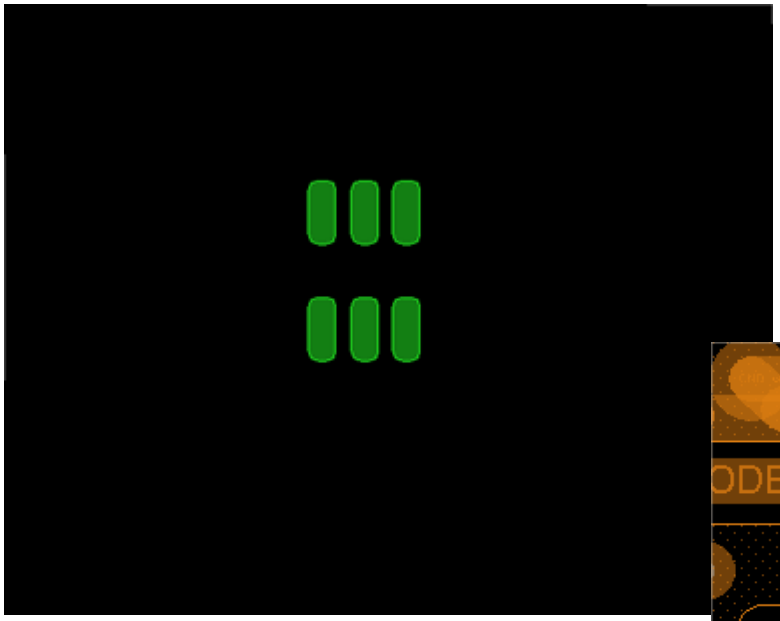

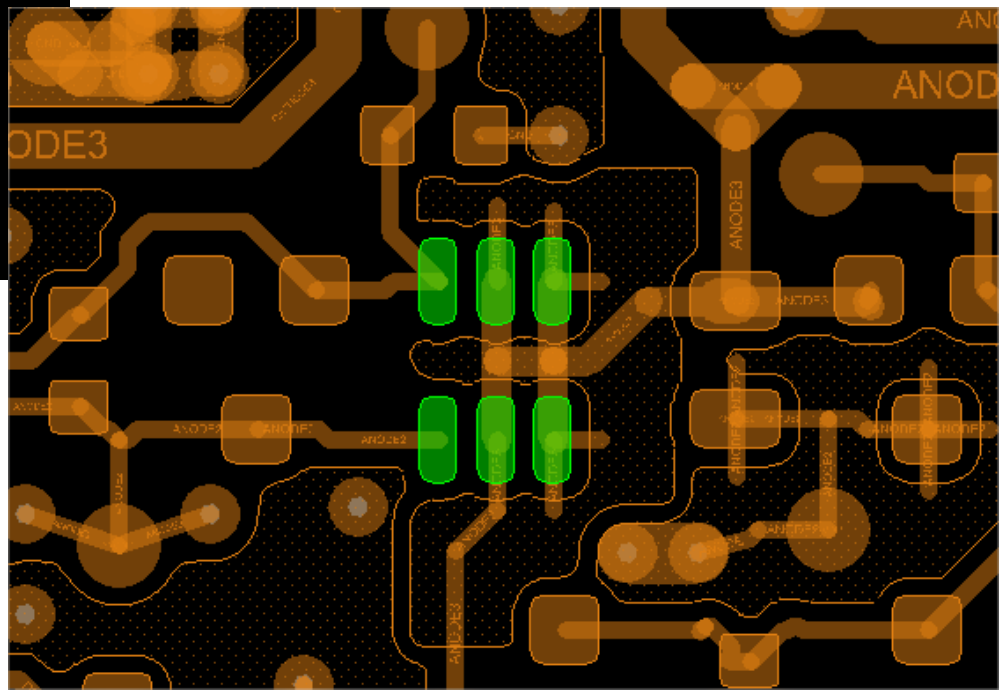

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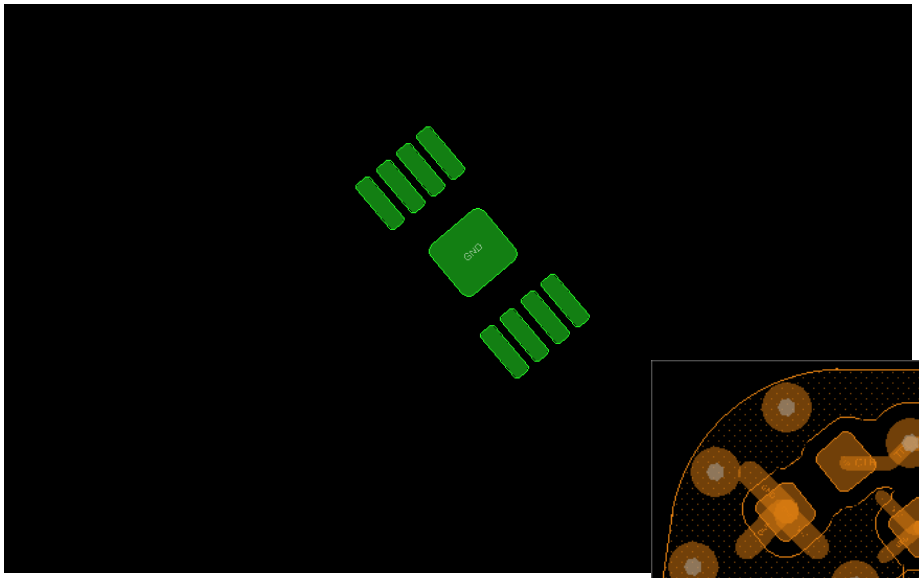

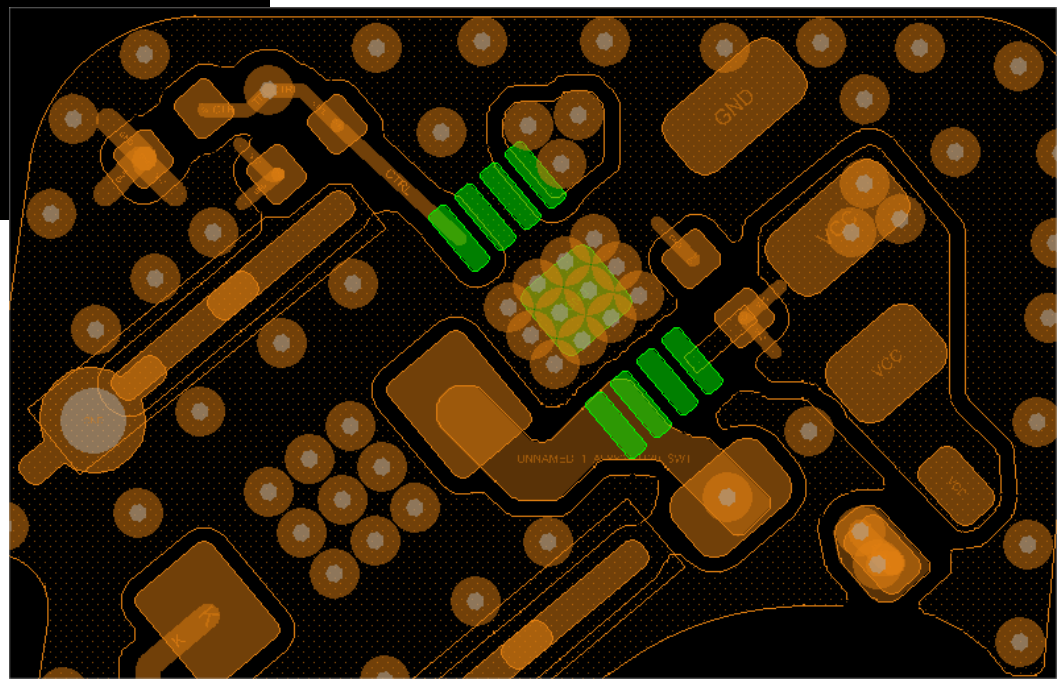

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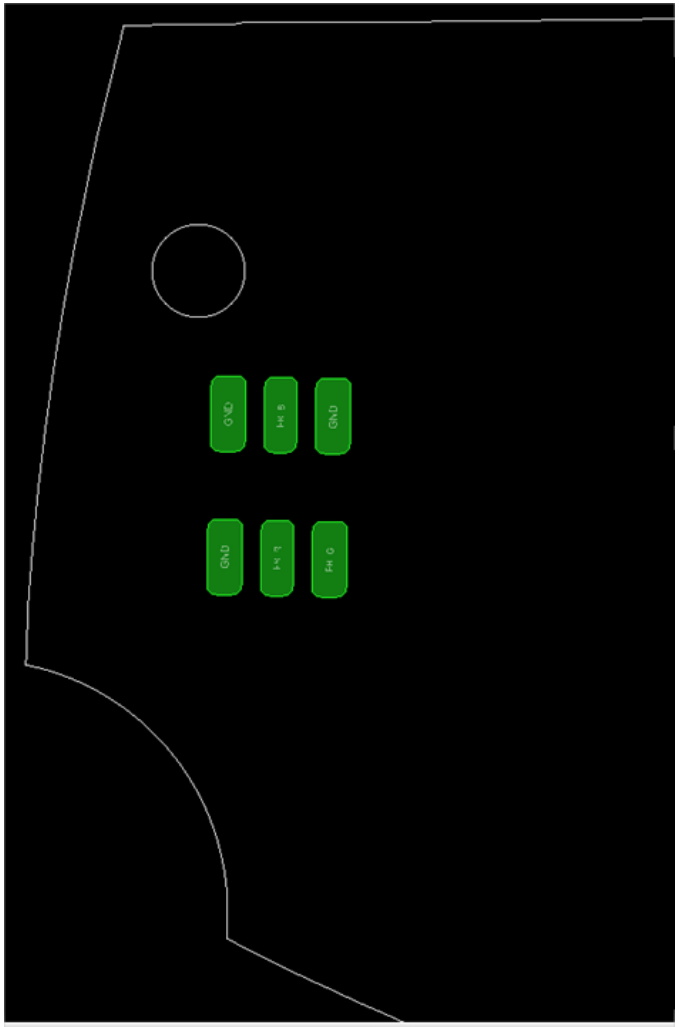
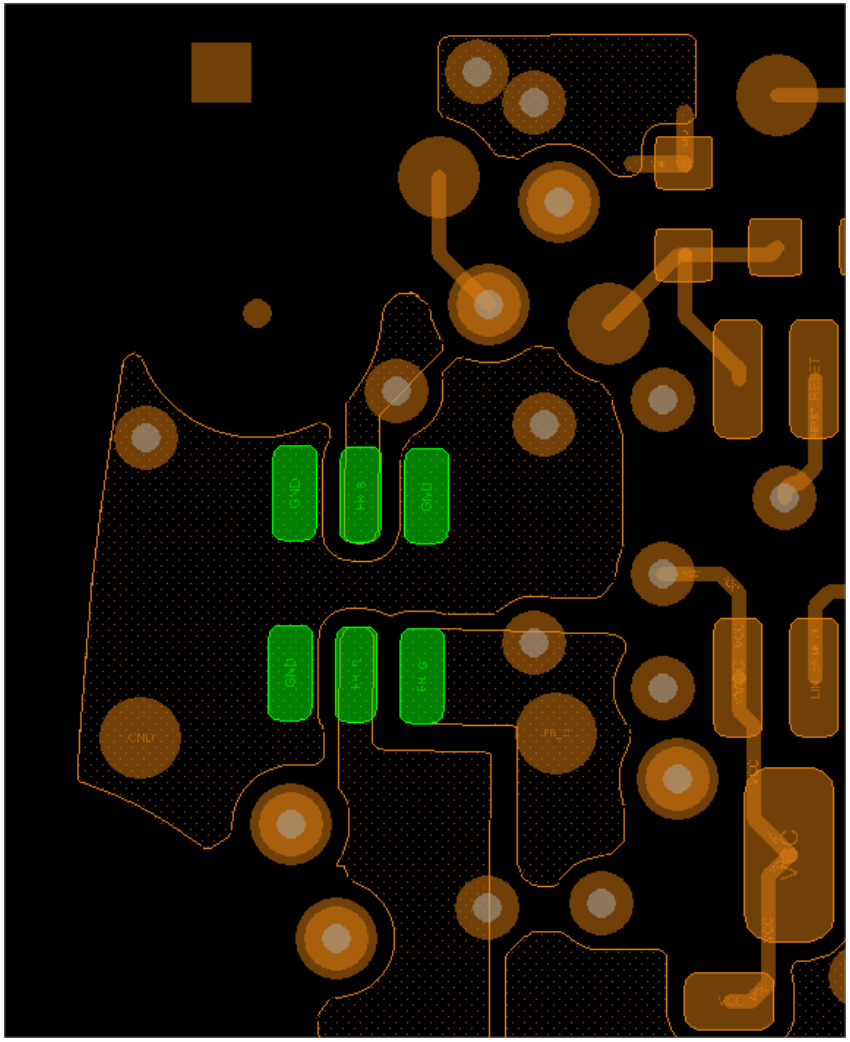
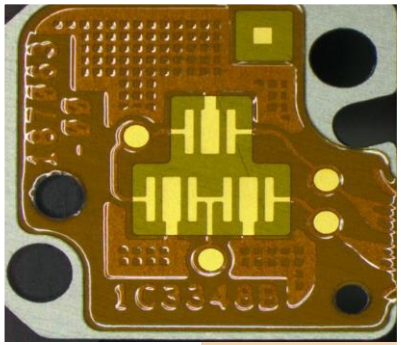


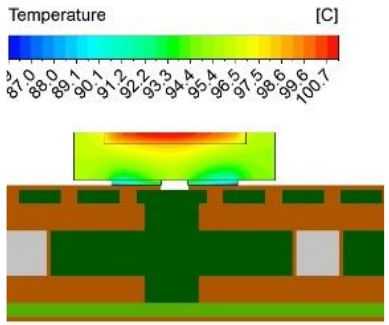


Termična optimizacija pri načrtovanju vezij



Površina Cu

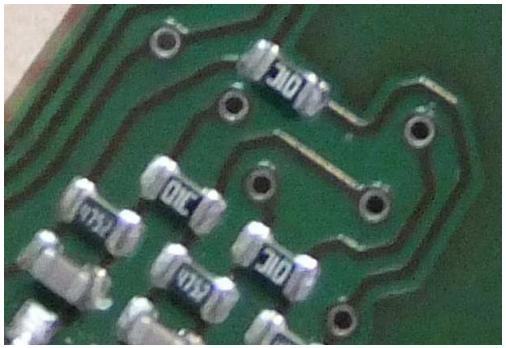
- Horizontalna disipacija



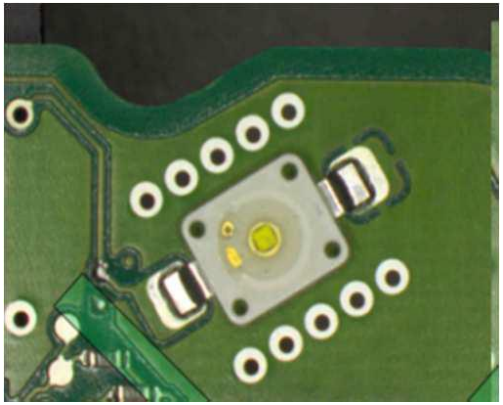
PCB material

- Vertikalna disipacija

PTH vije

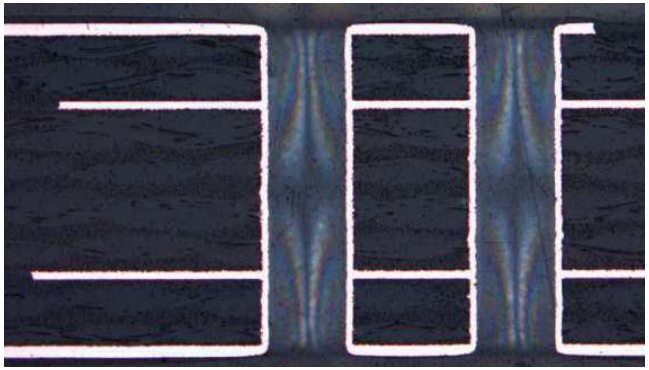


- Signalne vije



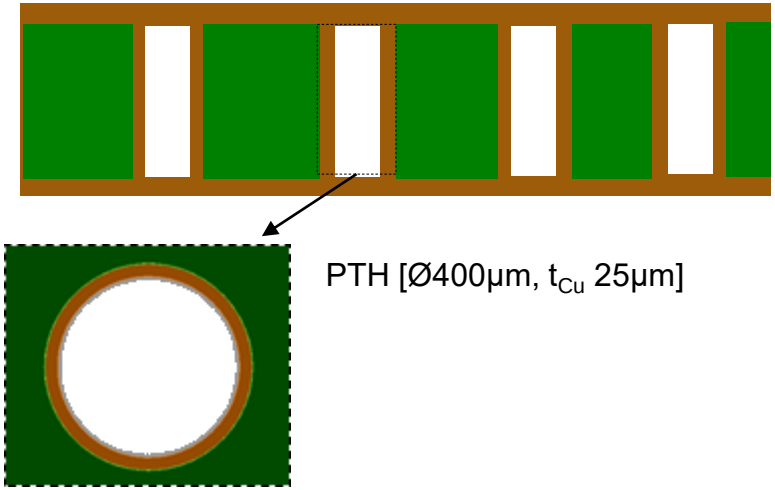
- Termalne vije

- Platane luknja, ki vzpostavi električno povezavo med bakrom na različnih lajerjih
- Najmanjša debelina metalizacije = 25µm pri debelini PCB-ja 1.5mm
- Uporabljamo jih lahko za pritrjevanje komponent, montažo ali toplotno disipacijo
- PTH > Plated Through Hole

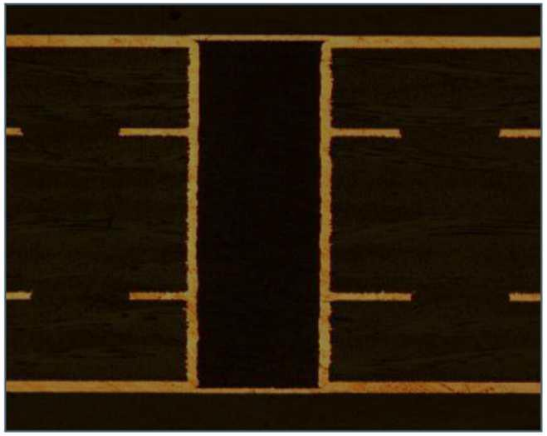


Plugged PTH vias

- Prerez PCBja

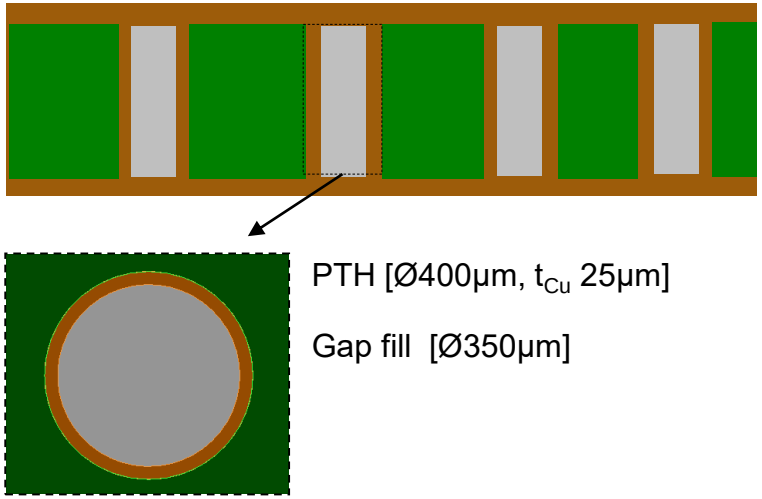


Part	Material	Thermal conductivity [W/mK]
Copper layers	Copper	380
FR4	Dielectric	0,37
PTH	Copper	380
Air	Air	0,026



Plugged PTH vias with metal cap

- Prerez PCBja



Cu-layer [t_{Cu} 50µm]

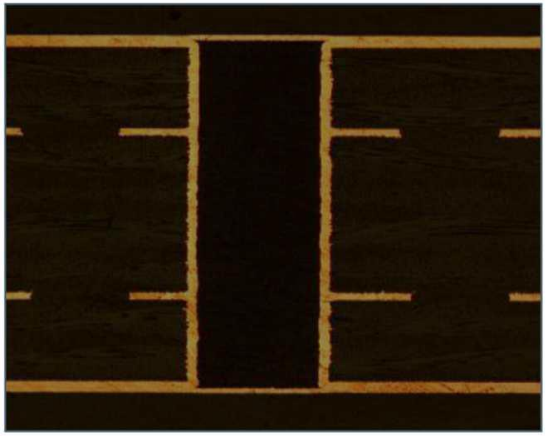
FR4 [t_{FR4} 1500µm/1000µm]

Cu-layer [t_{Cu} 50µm]

PTH [Ø400µm, t_{Cu} 25µm]

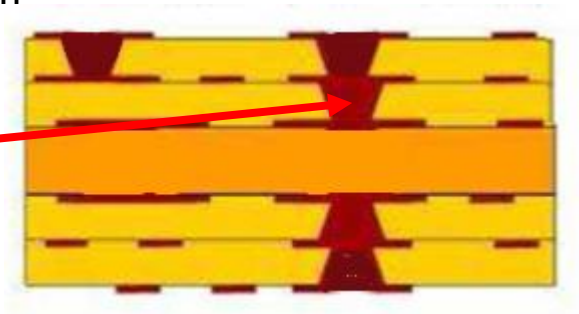
Gap fill [Ø350µm]

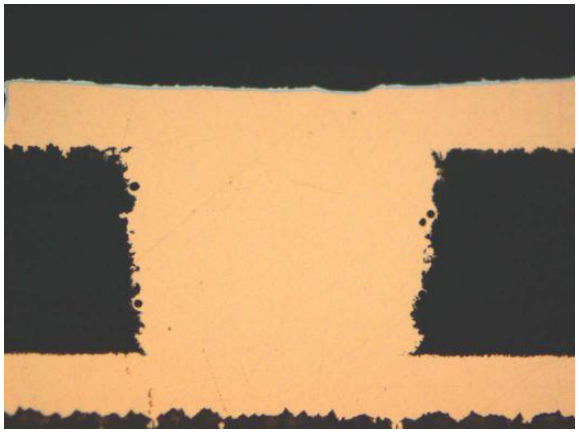
Part	Material	Thermal conductivity [W/mK]
Copper layers	Copper	380
FR4	Dielectric	0,37
PTH	Copper	380
Gap fill	Plastic	0,2

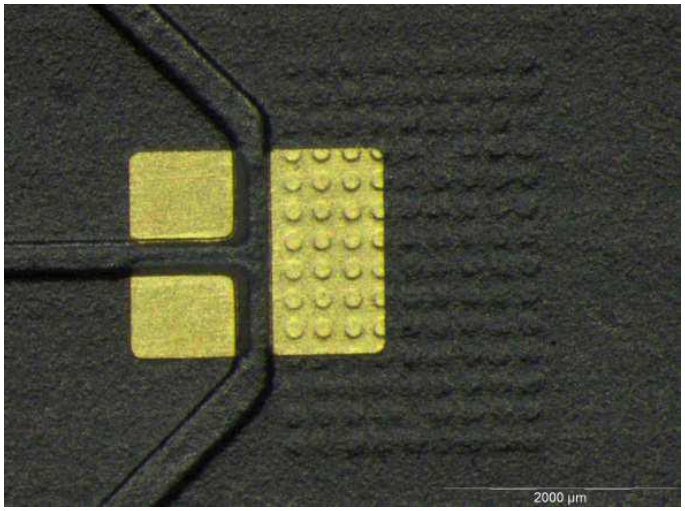


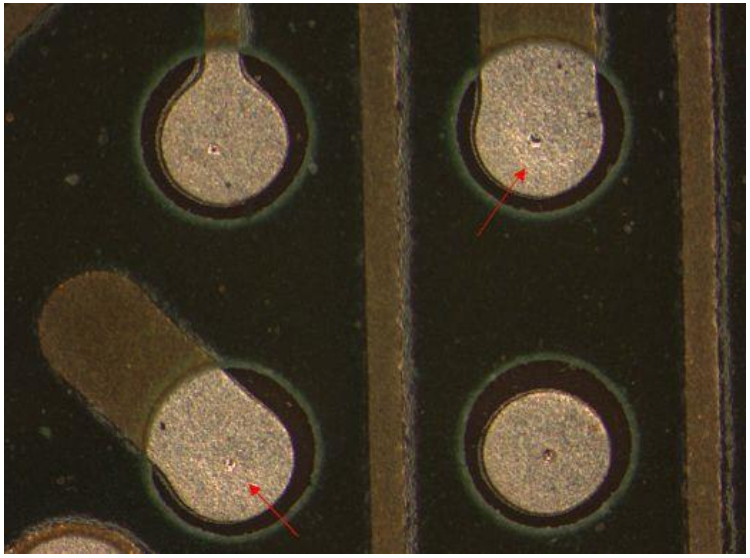
Copper filled Microvia

- Zelo majhna (premer 0.125 - 0.15mm)
  - Dielektrik le do 106µm
- Lasersko vrtanje



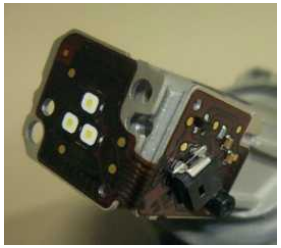






Toplotno optimizirani PCB materiali

FPC with Al-stiffener

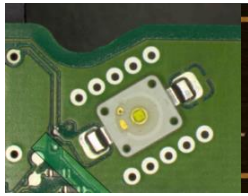


IMS (insulated metal substrate)

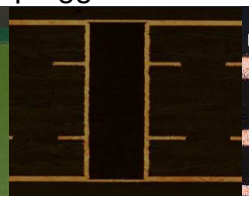
Heatsink-PCB

PCB tehnologije

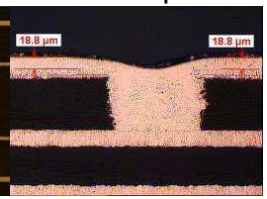
Thermo-Vias



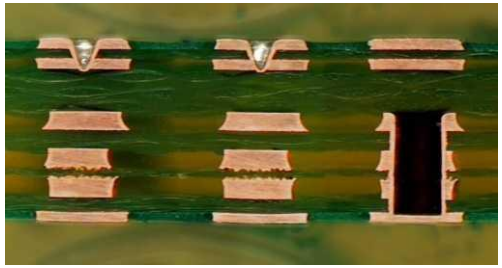
plugged Th.-vias



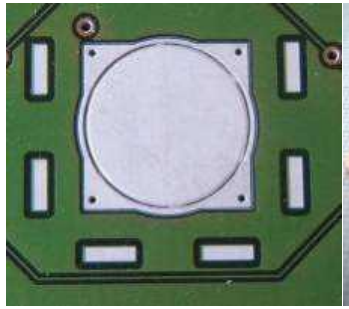
Cu-filled µ Vias



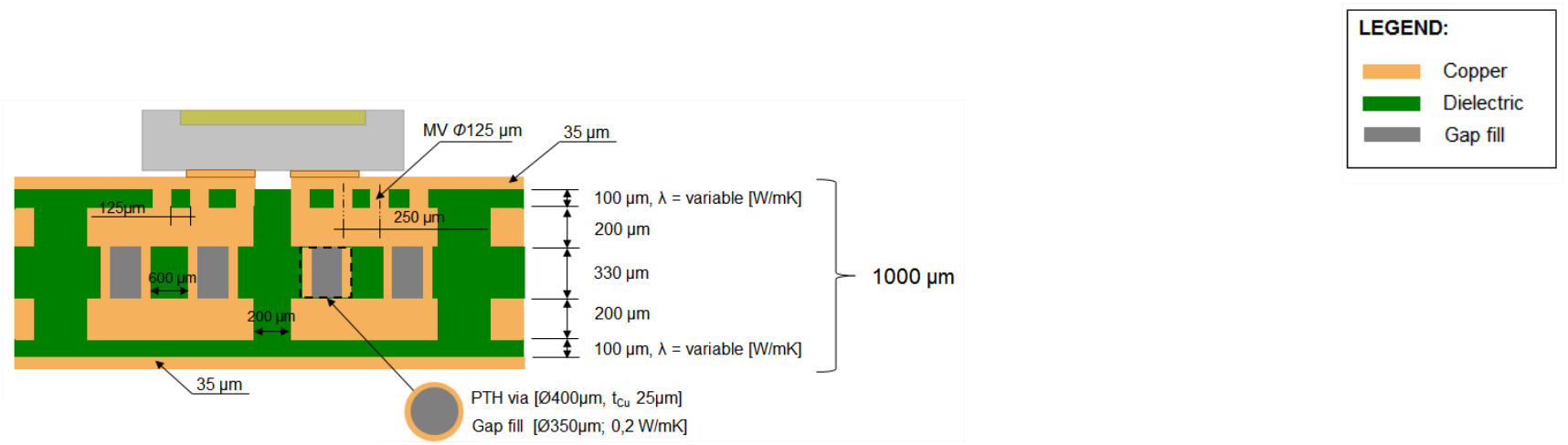
Multilayer-PCB

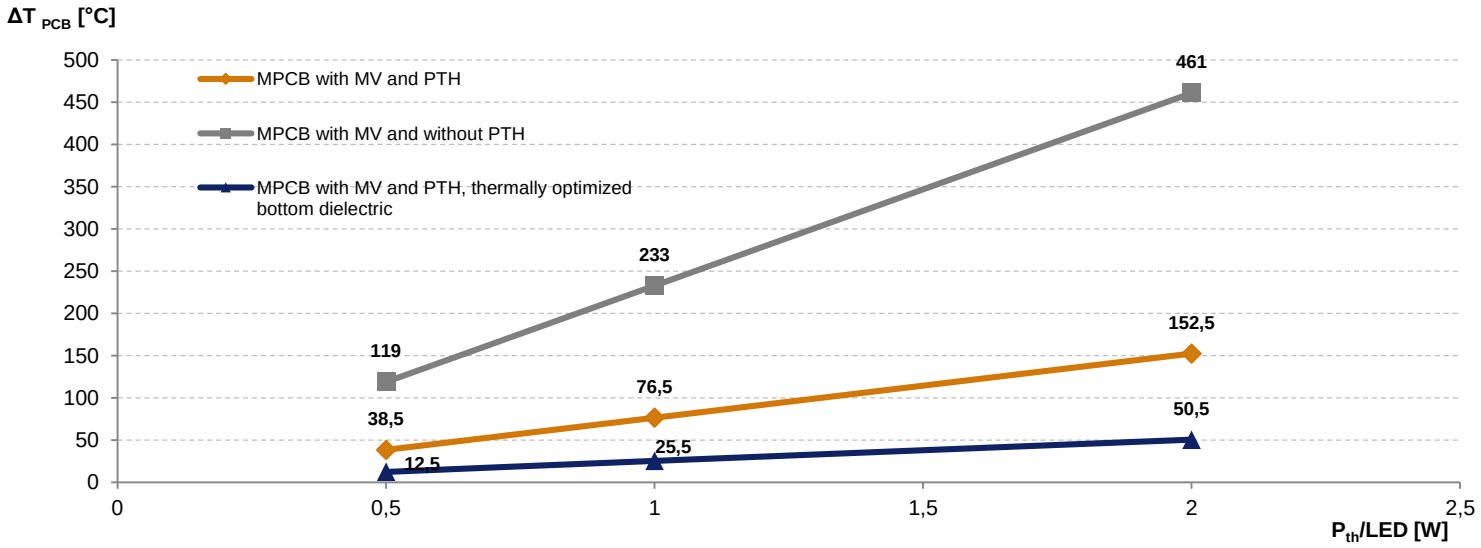


Cu-Inlays



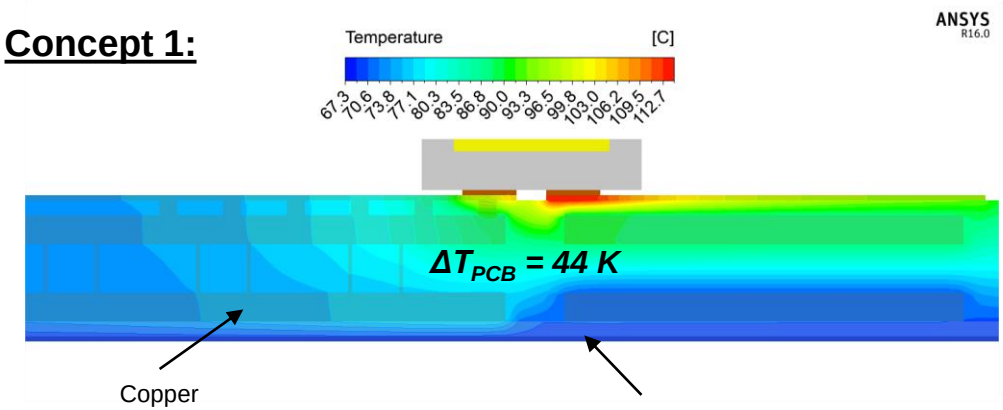
Multilayer Fr4 PCB

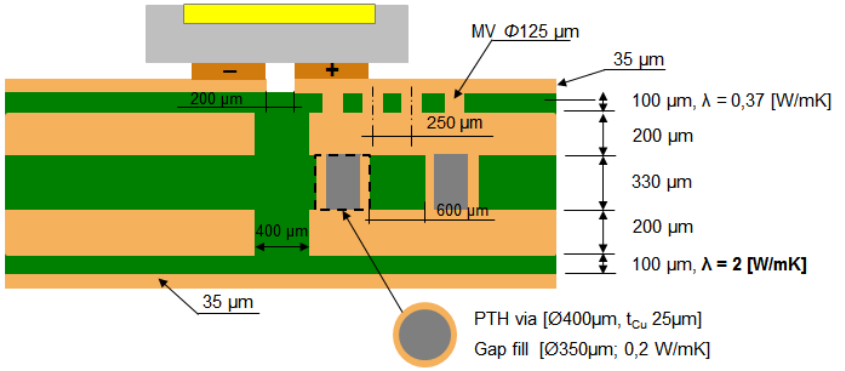




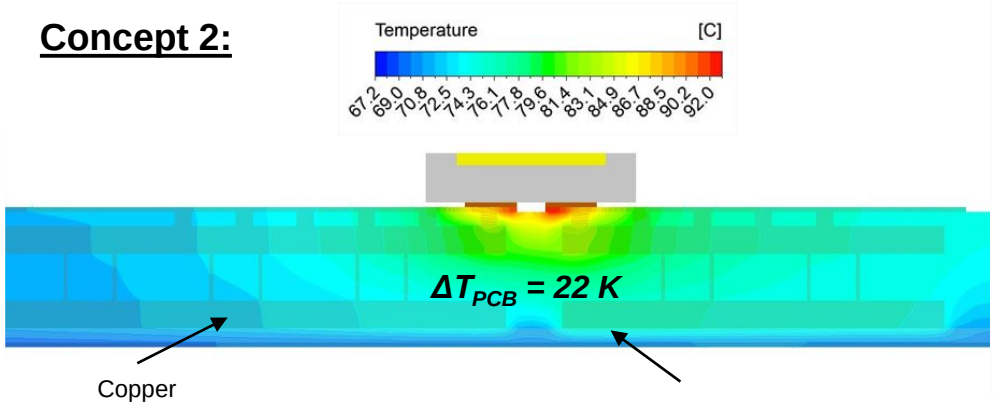
Multilayer FR4 PCB

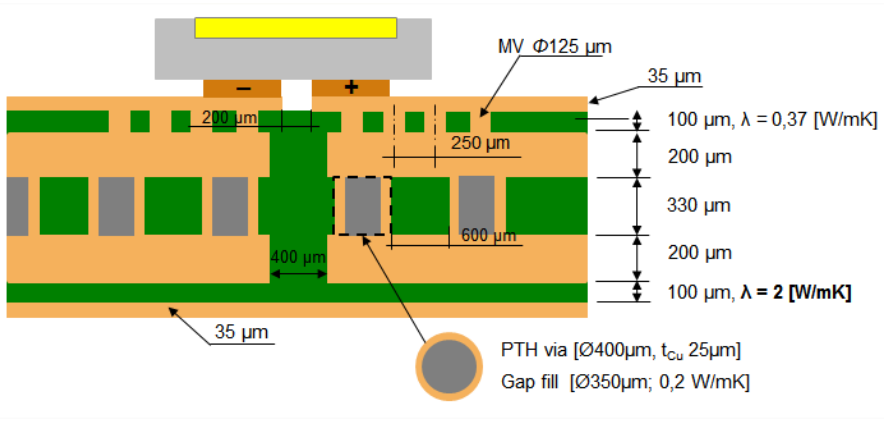
Concept 1:



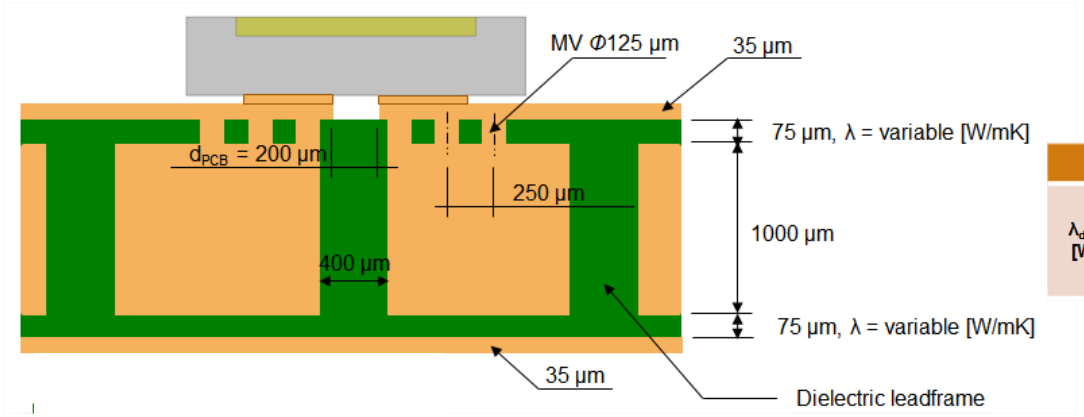


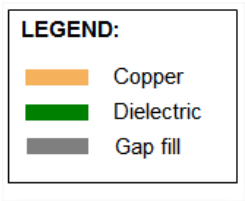
Concept 2:



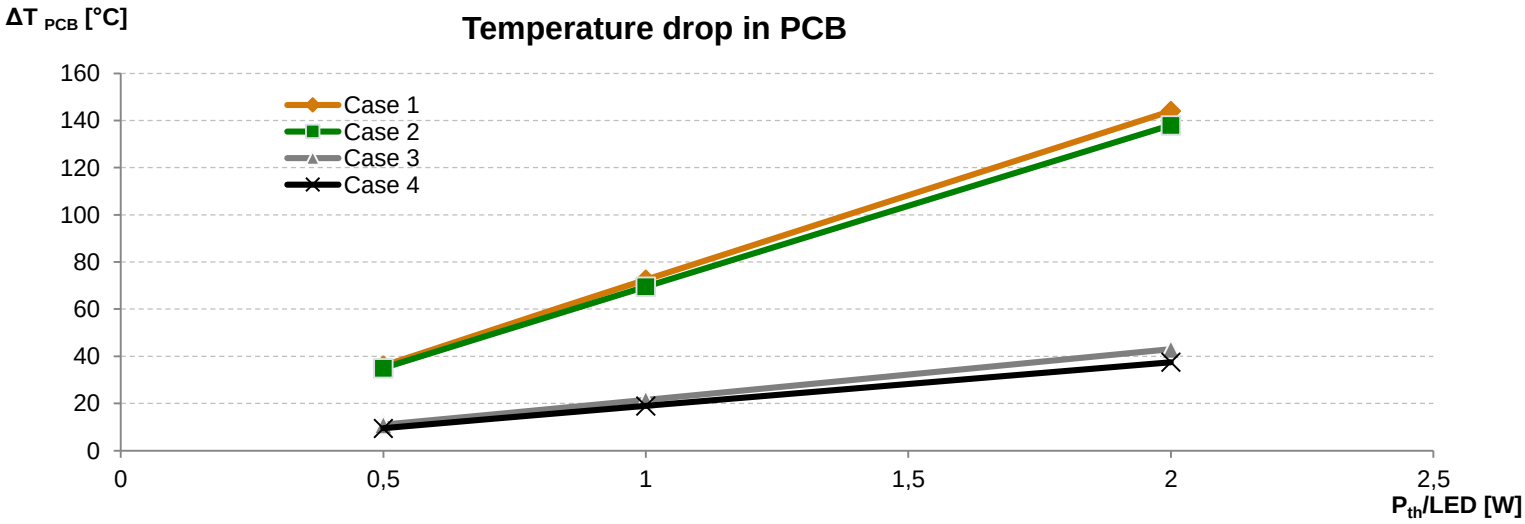


FR4 + Cu Inlay PCB

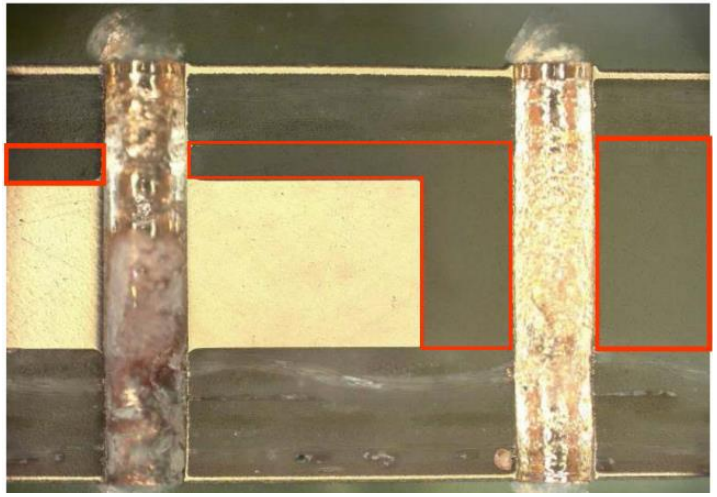


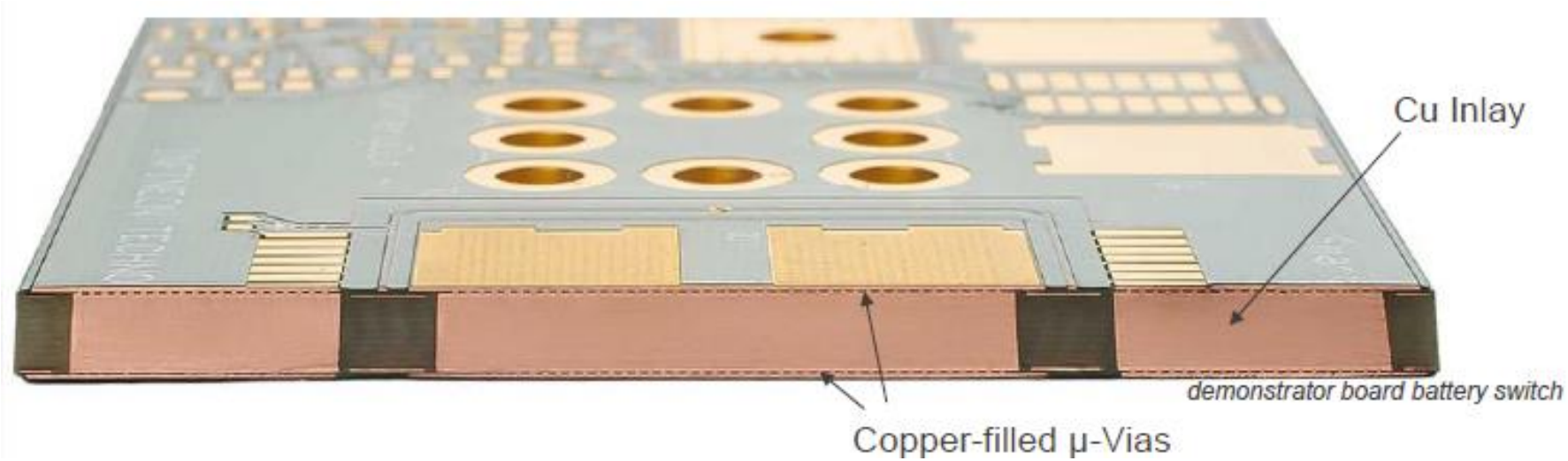


		Case 1	Case 2	Case 3	Case 4
$\lambda_{dielectric}$ [W/mK]	Top	0,37	2	2	2
	Leadframe	0,37	0,37	0,37	2
	Bottom	0,37	0,37	2	2



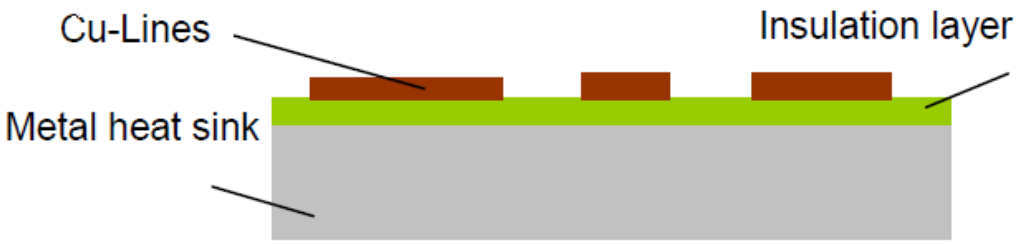
Specialne tehnologije za boljšo termalno disipacijo
Copper Inlay (FR4)

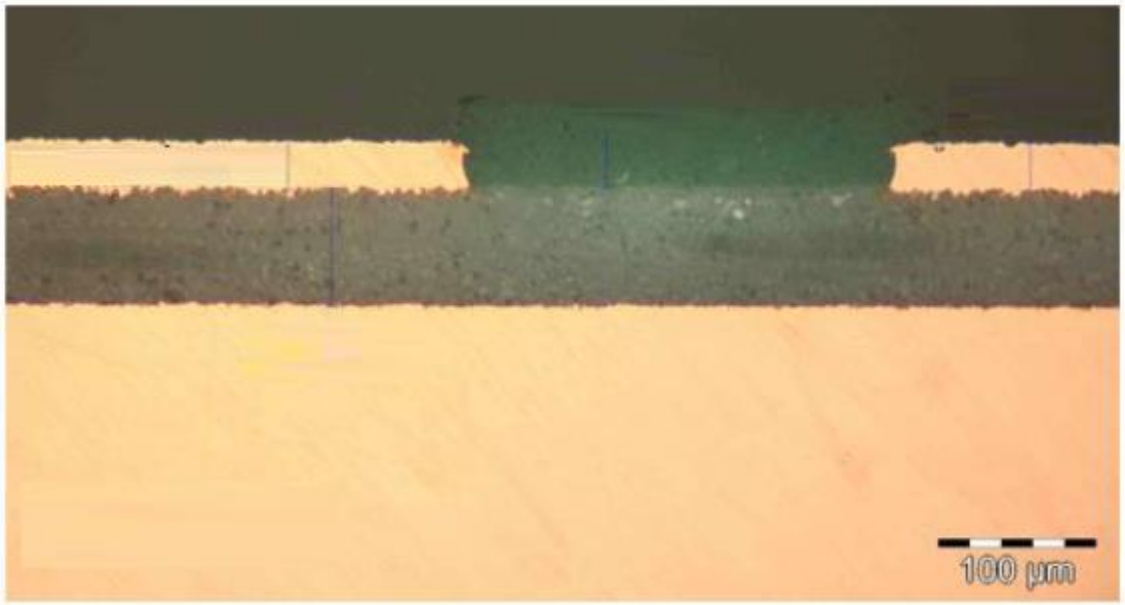




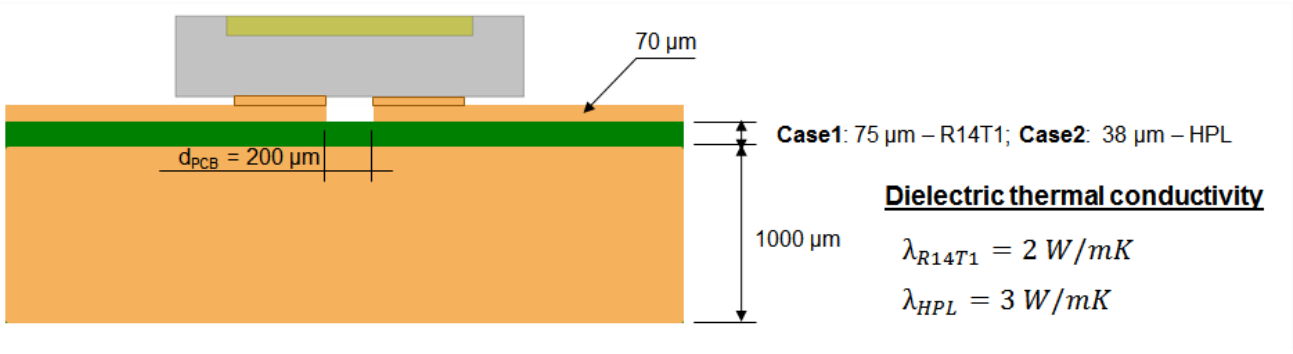
IMS
insulated metal substrate

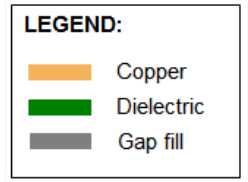
- Boljša toplotna disipacija
- Poznamo dva substrata
  - Aluminij IMS (250 W/mK)
  - Bakren IMS

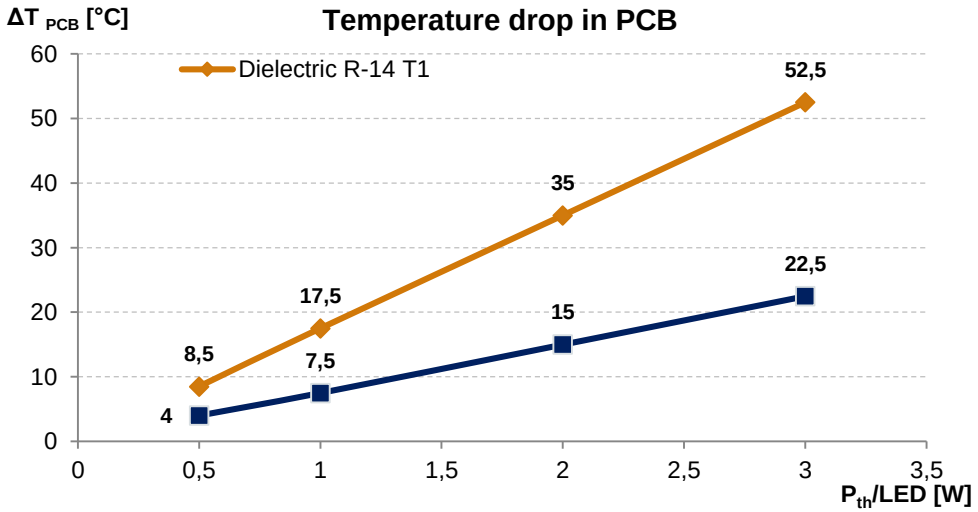




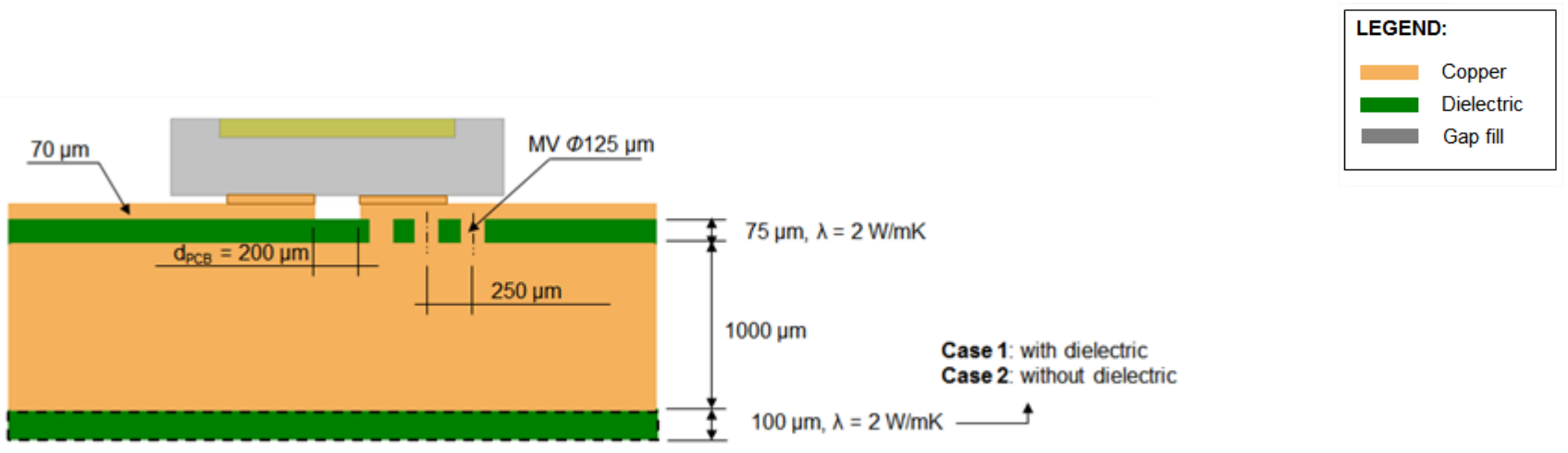
Copper IMS with λ - optimized

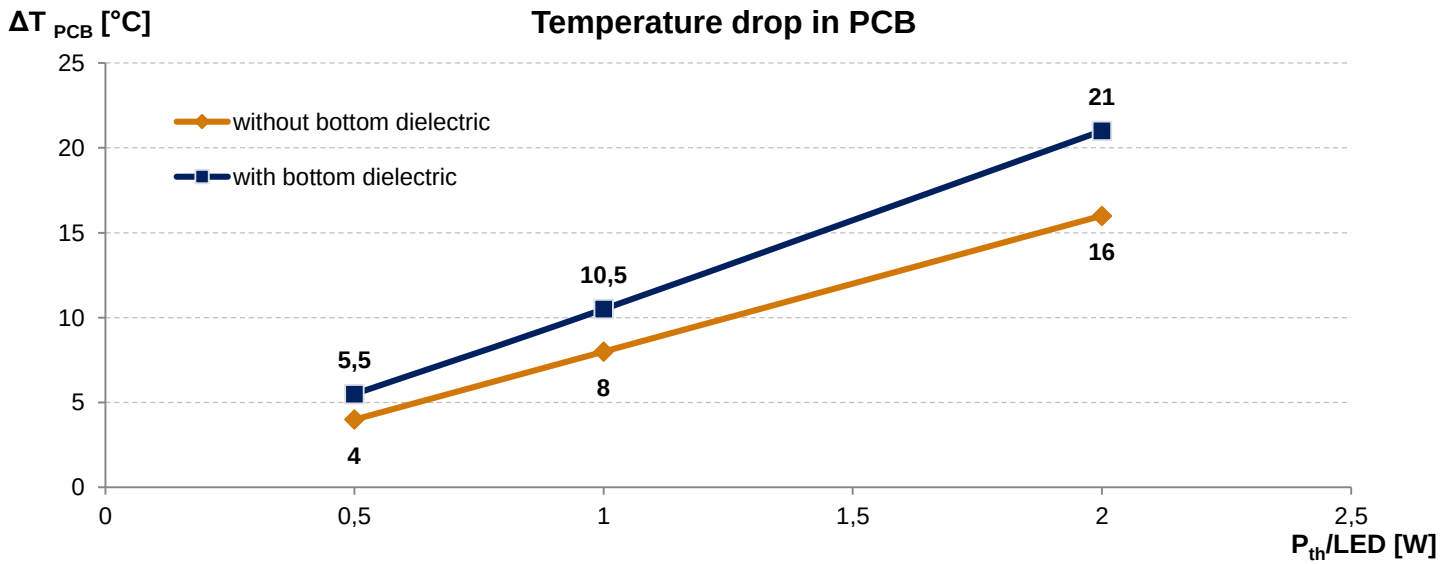




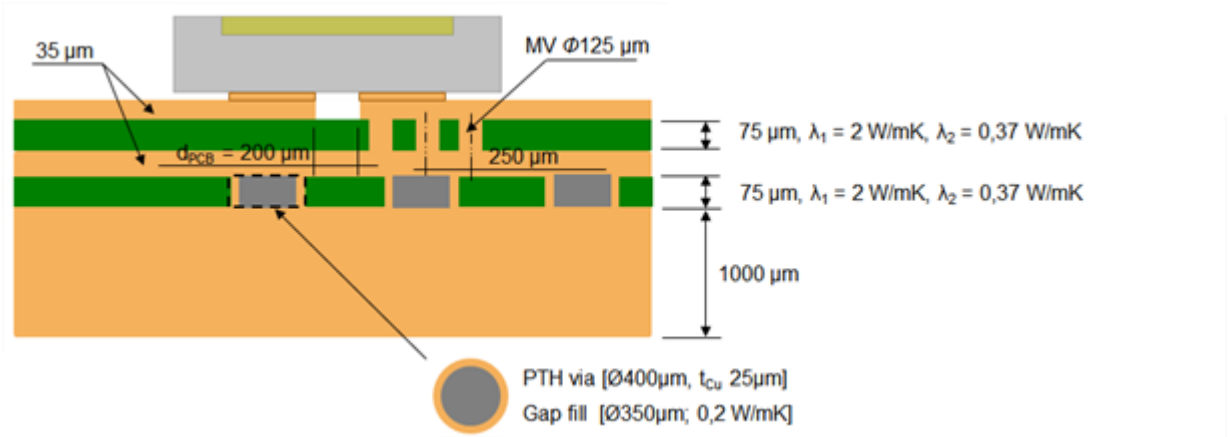


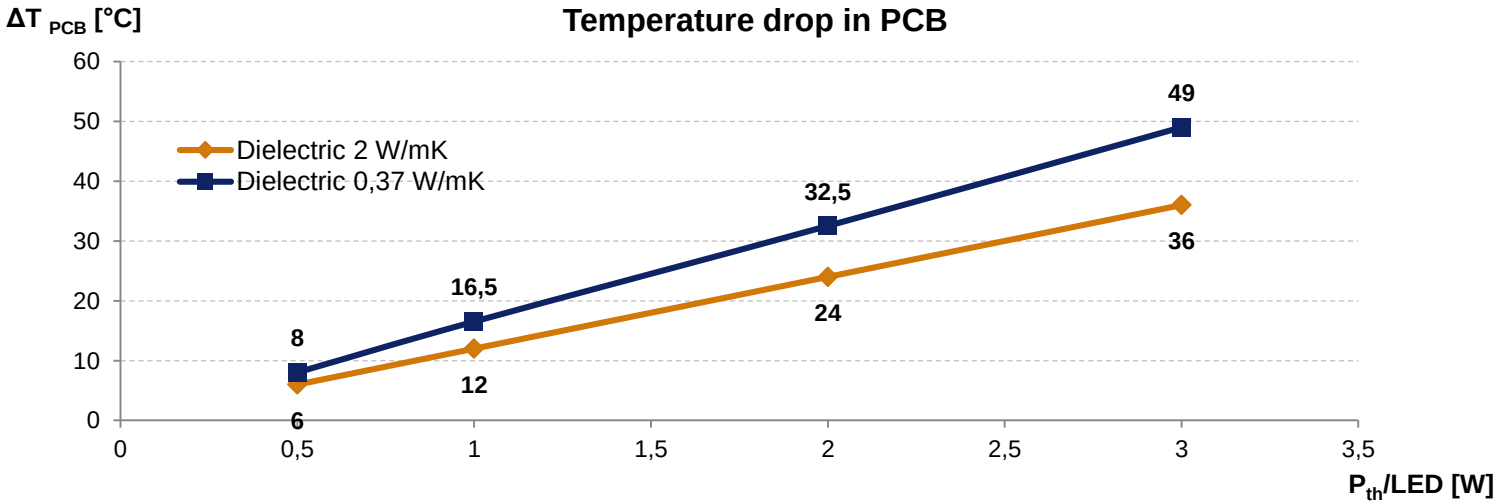
Copper IMS with microvias



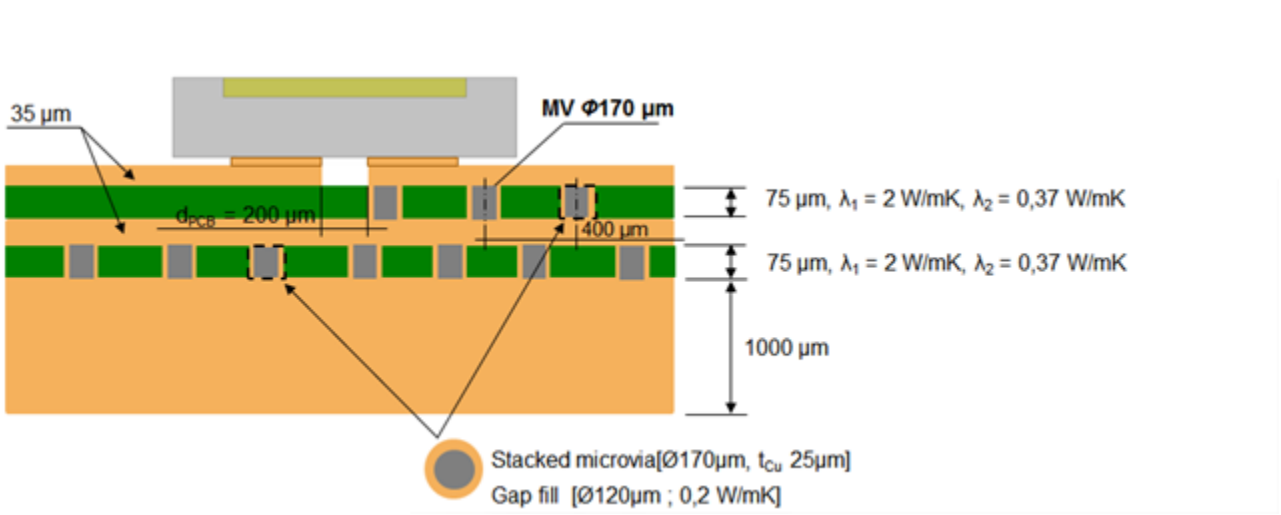


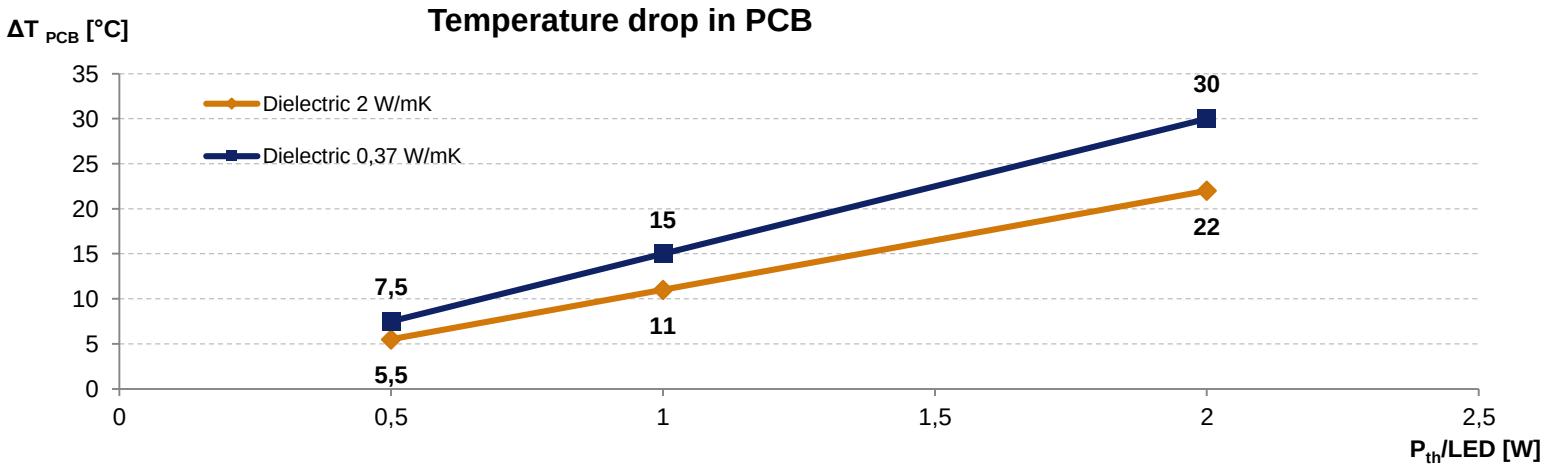
2 layer IMS with microvias + capped PTH vias



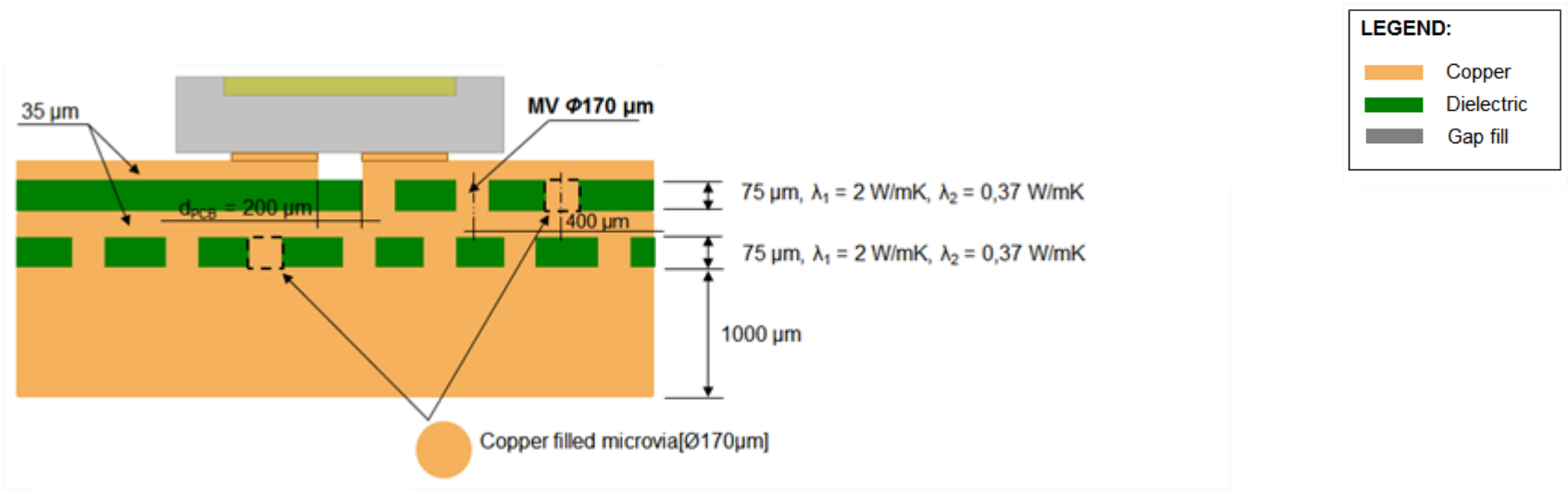


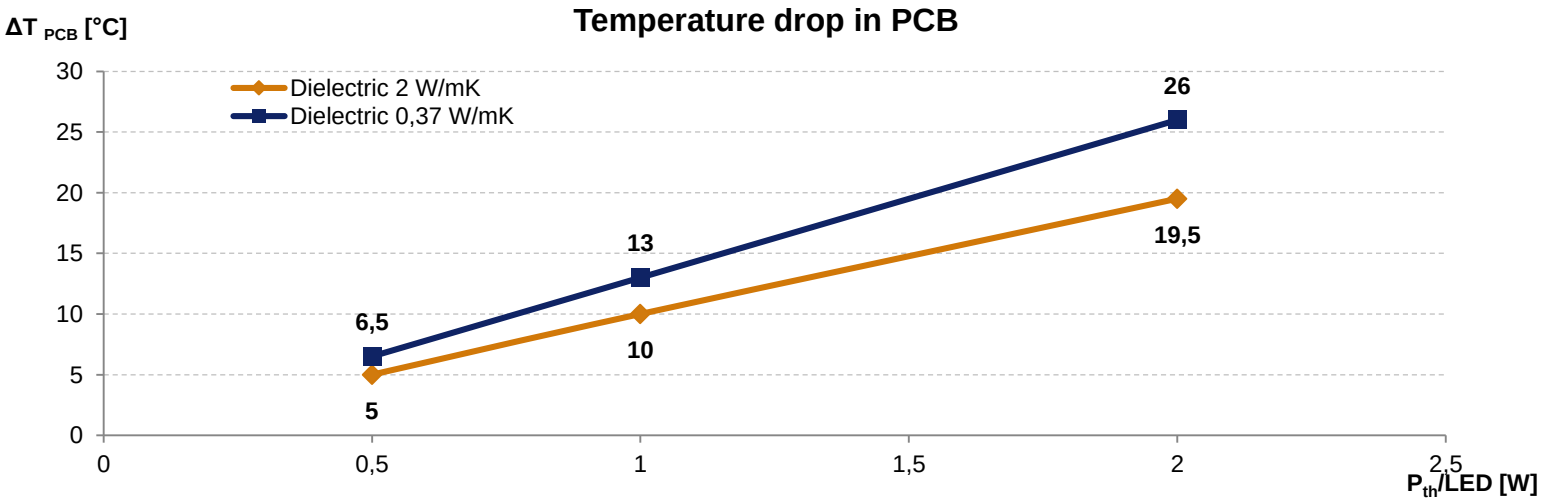
2 layer IMS with Stacked microvias



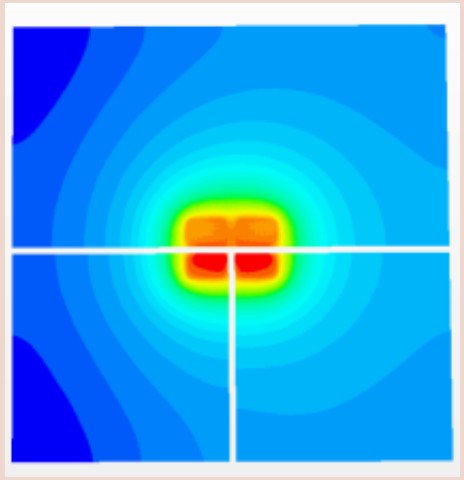
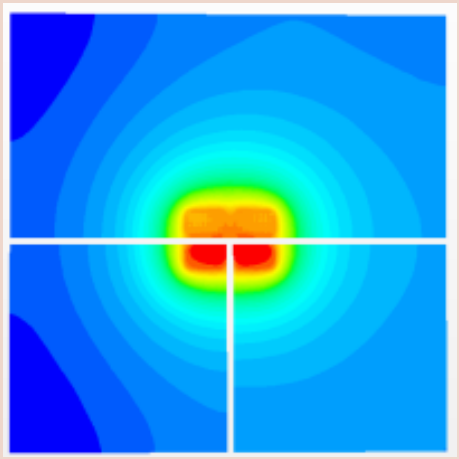
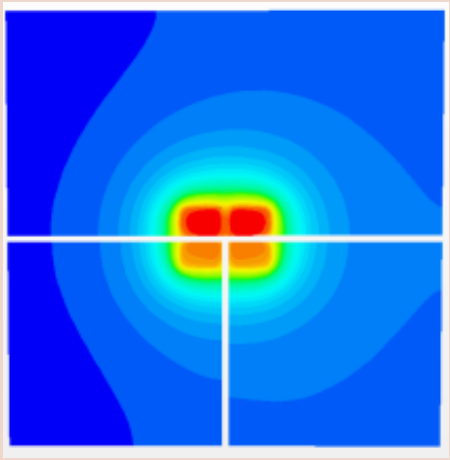
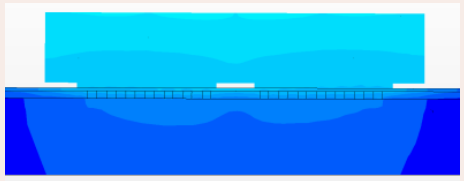
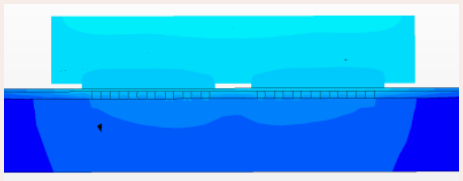
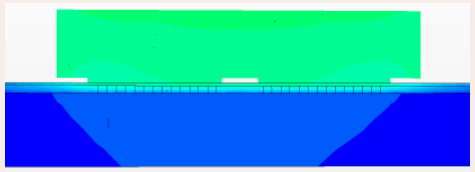


2 layer IMS with Copper filled microvias



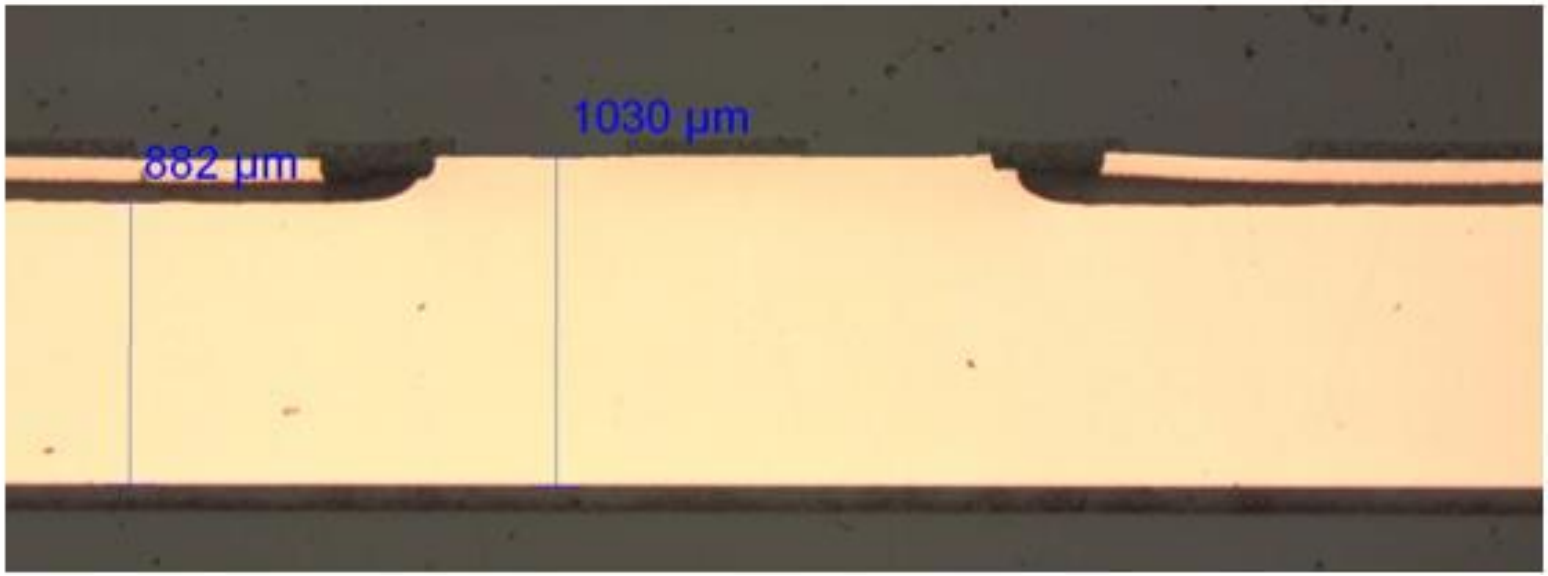


Primerjava različnih Dielektrikov

Dielectric layer **2 W/mK**	Dielectric layer **1 W/mK**	Dielectric layer **0,37 W/mK**
		
		
0°C	+10°C	+15°C

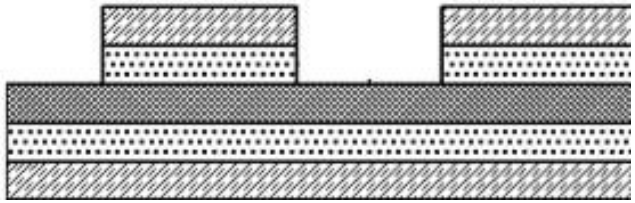
Specialne tehnologije za boljšo termalno disipacijo
Pedestal

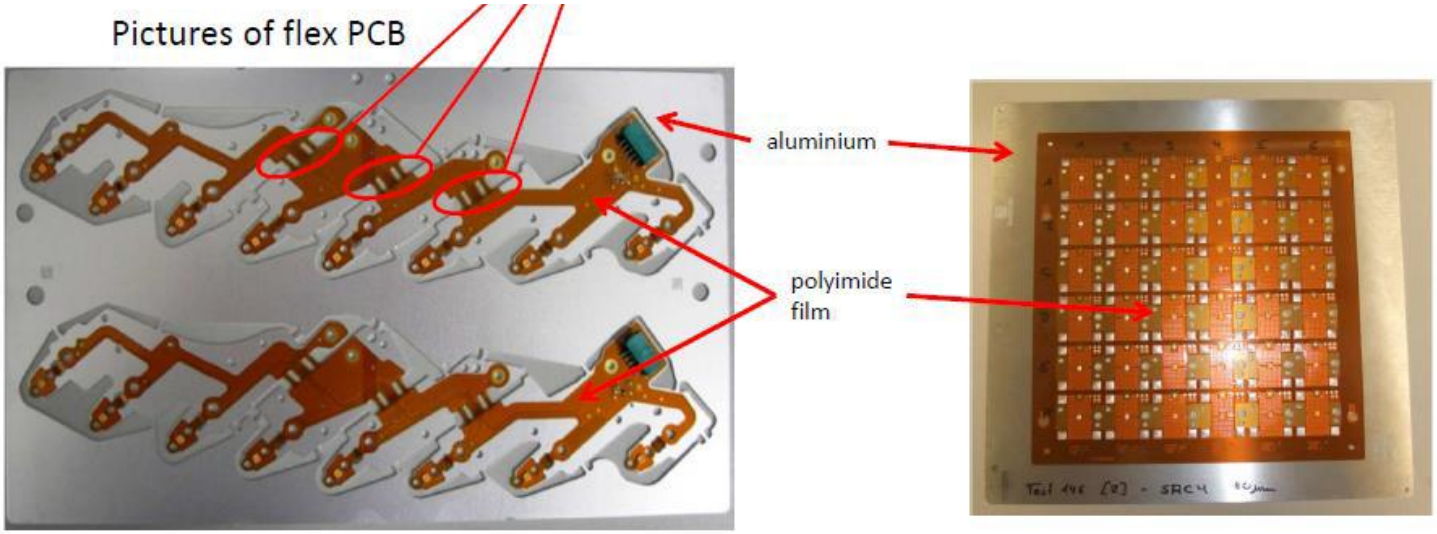
- Uporaba Cu-IMS



Flexible Printed Board (FPC) z Al-stiffener

- Bakrena folija je z lepilom fiksirana na substratu
- Zaščita je nameščena z lepilom na bakreno folijo.
- Odprtine za komponente so izrezane
- Za zaščito se lahko uporabi solder masko ali sitotisk
- Poznamo tudi SemiFlex in Rigid-Flex

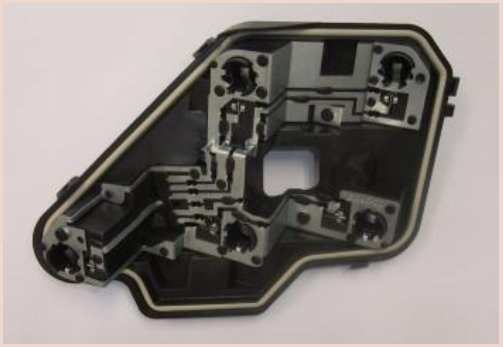
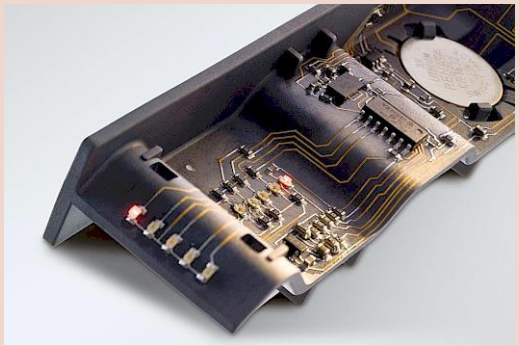
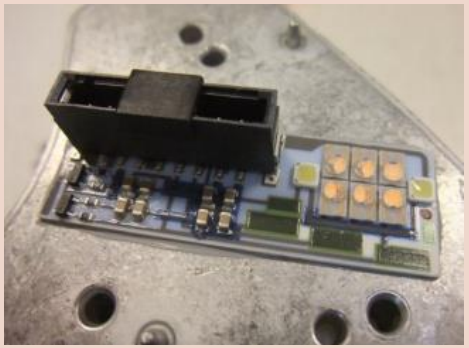




Primerjava različnih materialov

	FR4 PCB	Cu-IMS	Al-IMS	Flex-PCB
+	Poceni Zaneslivost spajkanja	Dobra termalna disipacija Zaneslivost spajkanja	Cenejši kot Cu-IMS Zaneslivost spajkanja	Možnost fleksibilne fiksacije
-	Za dobro termalno disipacijo potrebujemo dodatne tehnologije (vije, inlay)	Visoki stroški	Slabo spajkanje	Visoki stroški Slaba termalna disipacija, oziroma potrebujemo dodatne tehnologije (Al stiffener) Visoke tolerance

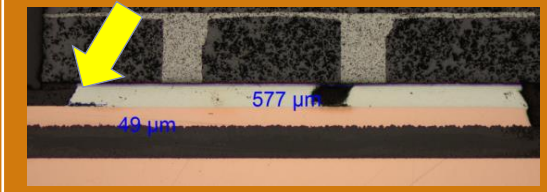
Drugi materiali

Lead frame	3D-MID	Ceramic
		
Prednosti: • Poceni • 3D design • Robustnost	**Prednosti:** • 3D design	**Prednosti:** • Visoka termalna disipacija • Možnost integracije component v PCB (upori, tuljave)
Slabosti: • Omejeno fino strukturiranje	**Slabosti:** • Omejena termalna disipacija • Visoki stroški proizvodnje (orodje)	**Slabosti:** • Visoki stroški proizvodnje • Ni možnosti vijačenja zaradi pokanja keramike • Omejen dizajn

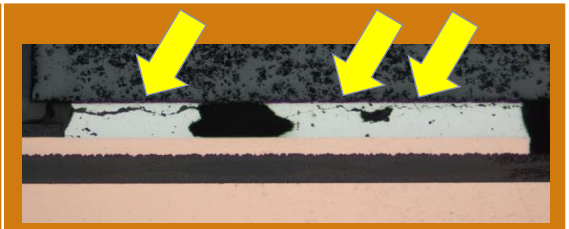
Kaj še vpliva na termalno disipacijo termalno-mehanski stres

- Glavni vzrok za nastanek razpok znotraj spajke je neusklajenost koeficientov toplotnega raztezanja med komponentami in substratum

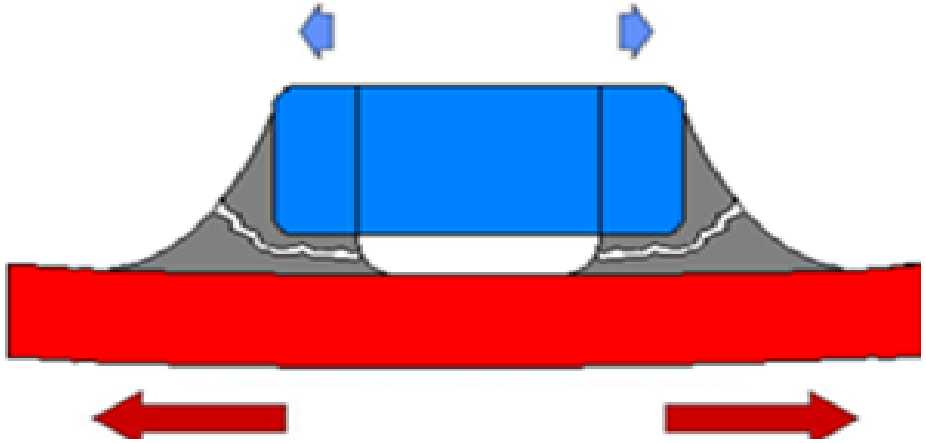
500 šokov: nič razpok



750 šokov: še dovoljene razpoke

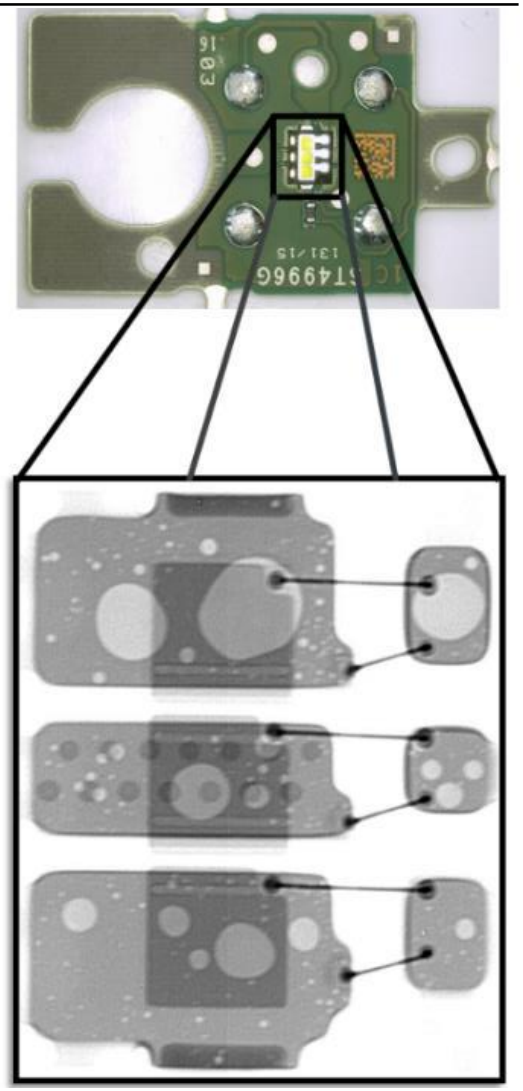


1000 šokov: popolna razpoka



Kaj še vpliva na termalno disipacijo
Solder voids

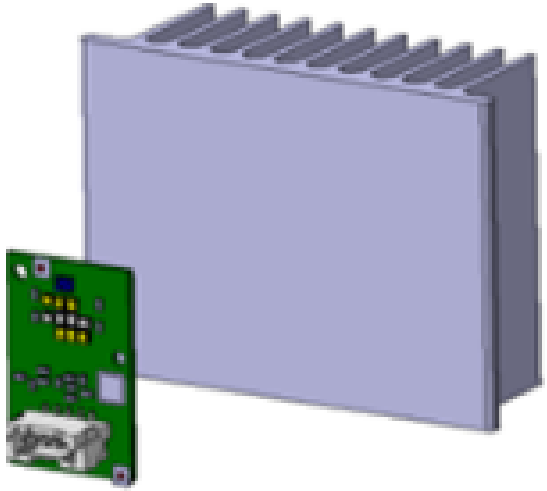
- Uporaba komponente s skritim padom, detekcijo lahko vidimo le z uporabo X-Ray analize
- Ne moremo jih preprečiti
- Zračni mehurčki > nastanejo zaradi izpusta ostankov fluxa in reakcijskih produktov metalurških interakcij
- Lahko zelo zmanjšajo termalno disipacijo
- Ena možnost ki zmanjšuje % voidov je “vacuum soldering”



Specialne tehnologije za boljšo termalno disipacijo
Heatsink

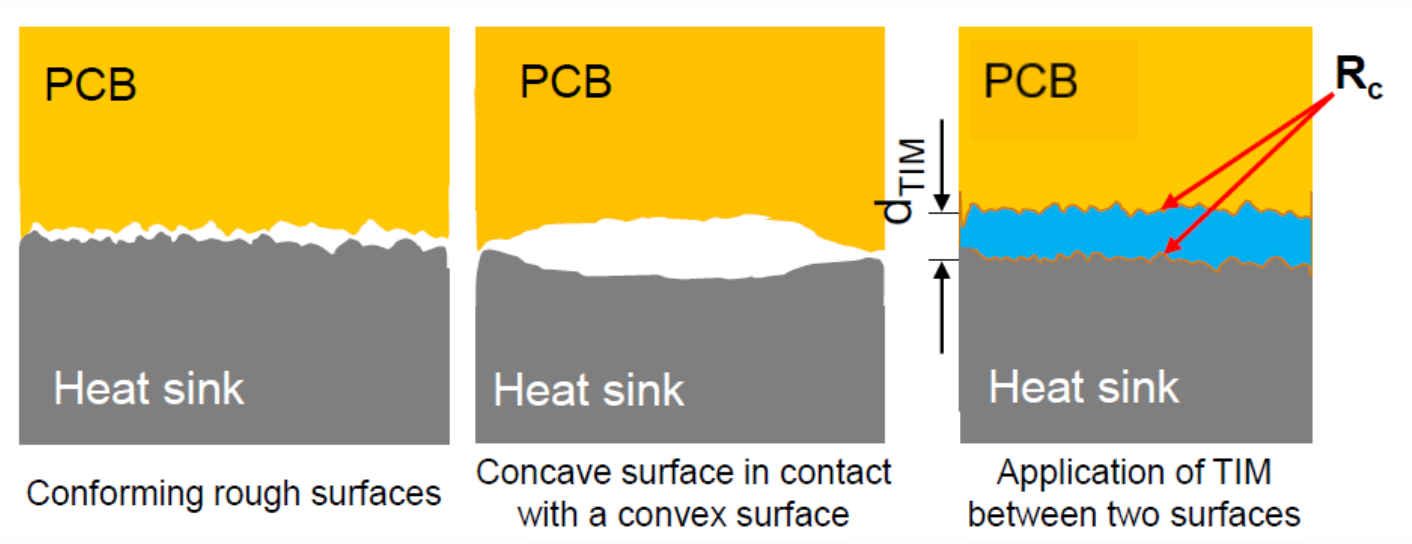
- Aluminijaski hladilnik
  - Izstiskanje hladilnika (Strangpress)
  - Visokotlačno vlitje (Druckguss)
  - Toplotna pločevina s kovičastimi rebri

- Hladilnik iz Magnezija
  - Možnost uporabe tanjšega materiala
  - Thixomolding
  - Kombinacija ohišja in hladilnika



Specialne tehnologije za boljšo termalno disipacijo
TIM (thermal interface material) or TCA (thermal conductive adhesive)

- Optimizacija termalnega prehoda



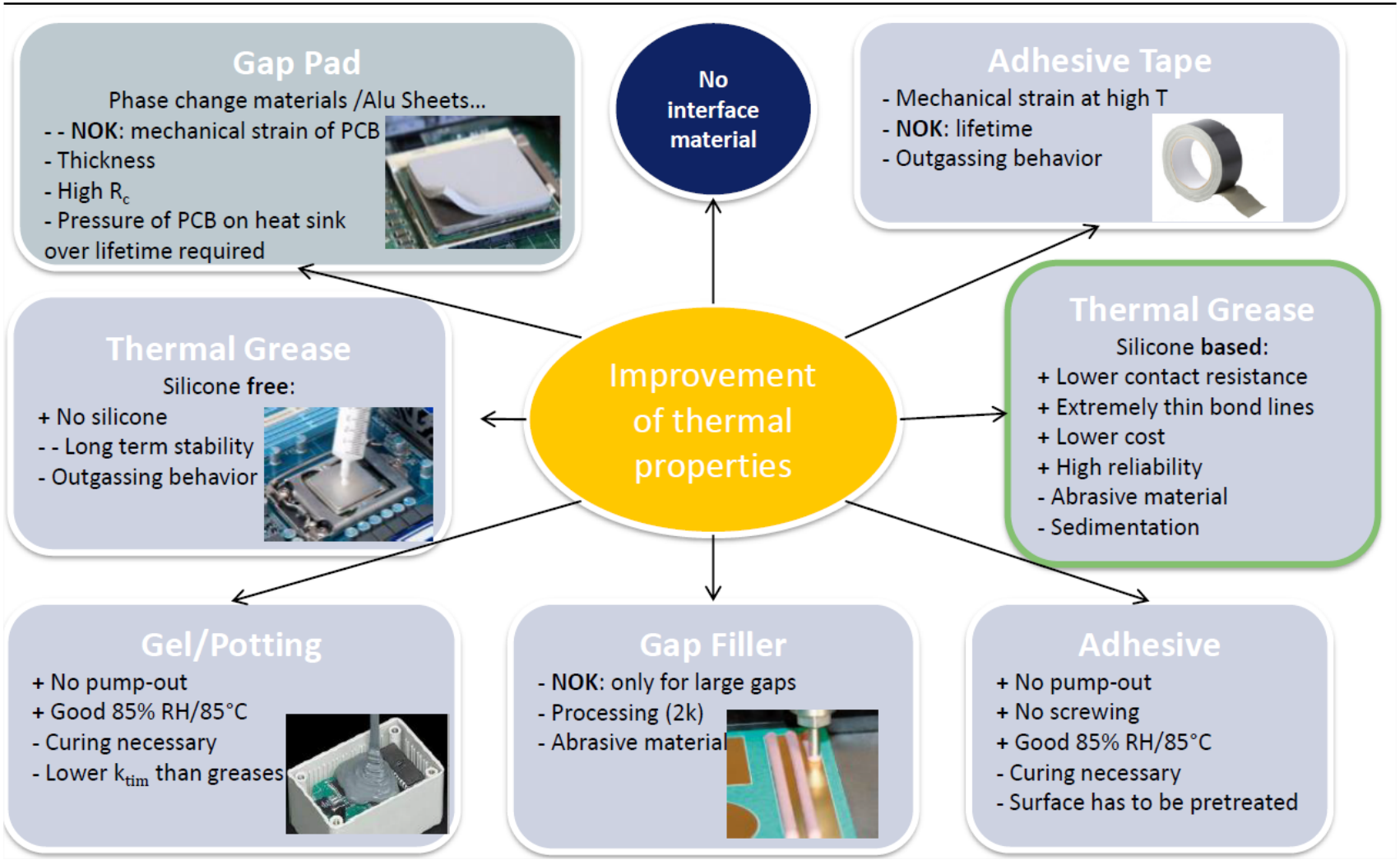
Conforming rough surfaces

Concave surface in contact with a convex surface

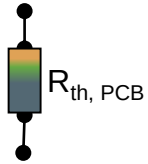
Application of TIM between two surfaces

Material	Thermal conductivity λ [W/(m*K)]
Air	0.026
TIM	3
Copper	380
Aluminium	250

Specialne tehnologije za boljšo termalno disipacijo
TIM pregled materialov



Računanje toplotne prevodnosti

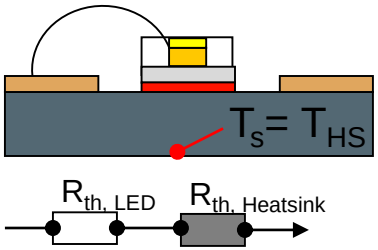


SMD-LED: $R_{th,typ}$ = 30-45 K/W
Multi-Chip-LED: $R_{th,typ}$ = 2-4 K/W
CSP-LED: $R_{th,typ}$ = 5-10 K/W

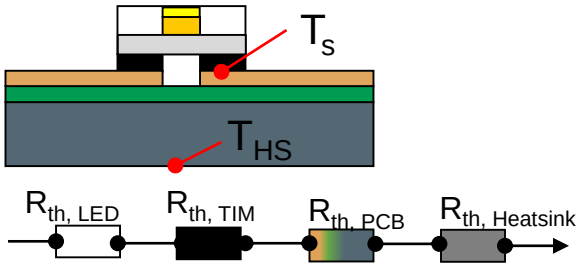
$$R_{th,tc} = \frac{\Delta T}{P_{th}} = \frac{d}{\lambda A}$$

	Material	Thermal Conductivity
	Phosphor	0,2 W/mK
	Chip	50 W/mK
	AlSi	170 W/mK
	Glue	>1 W/mK
	TIM	3W/mK
	Copper	400 W/mK
	Prepreg	**0,37 W/mK**
	Alu-IMS	120 W/mK

Multi-Chip-LED

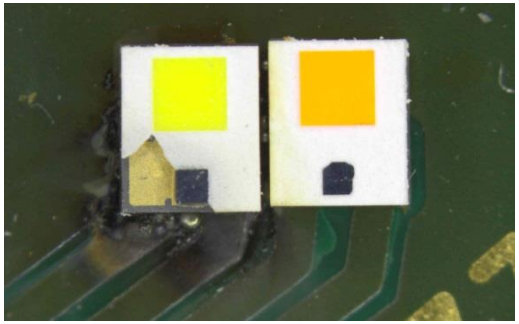


Sub-Mounted-Device



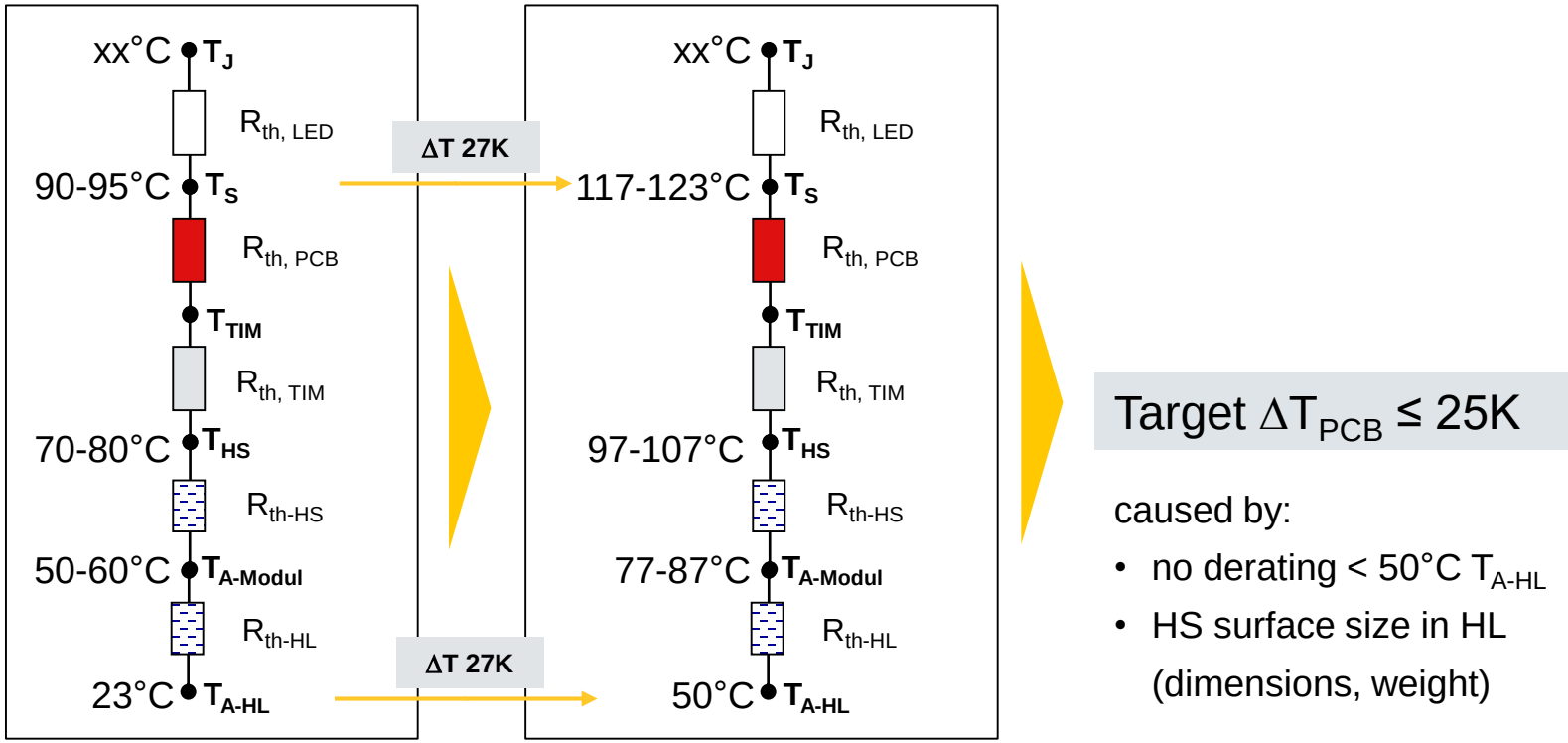
Focus:
- PCB-Layout
- PCB built up
- ➢ Decrease $R_{th\text{-}PCB}$

Toplotna poškodba SMD



Računanje toplotne prevodnosti

Thermal resistance:

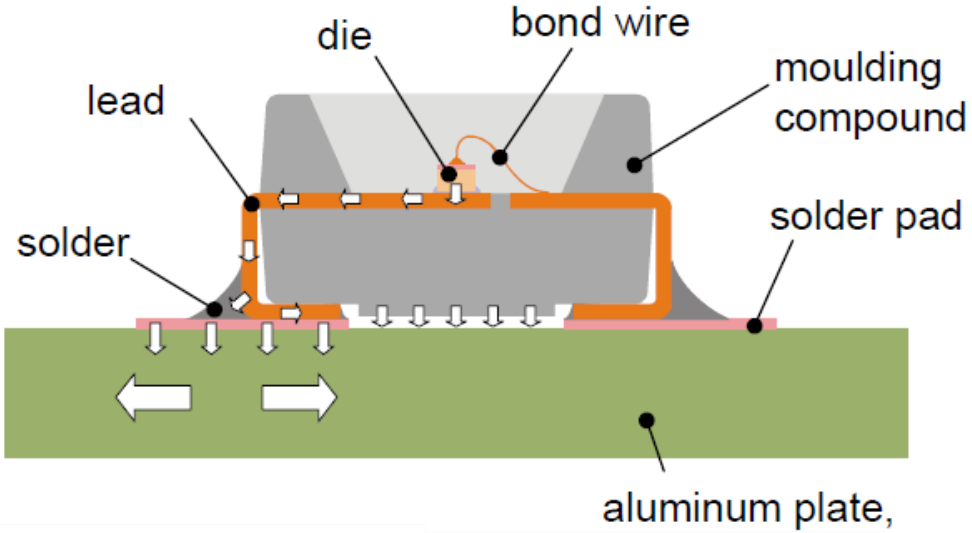


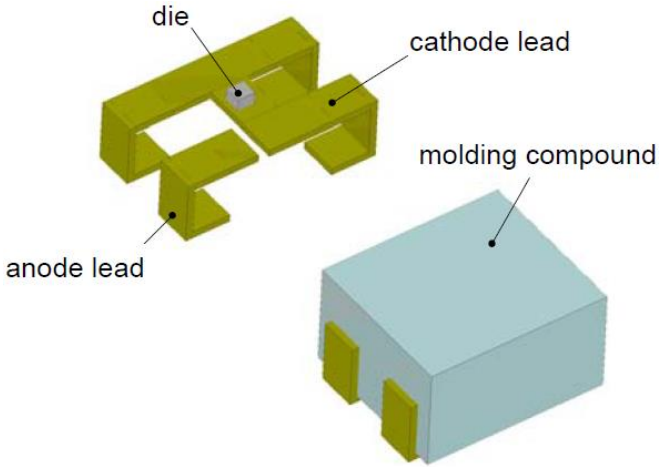
Target $\Delta T_{PCB} \leq 25K$

caused by:

- no derating < 50°C T_{A-HL}
- HS surface size in HL (dimensions, weight)

Kaj še vpliva na toploto struktura komponente





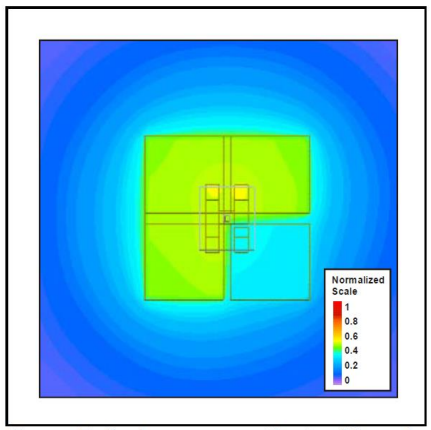


Figure 5: Pad area per cathode: 16 mm²

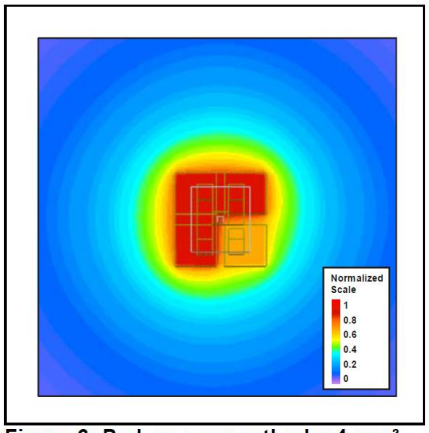


Figure 6: Pad area per cathode: 4 mm²

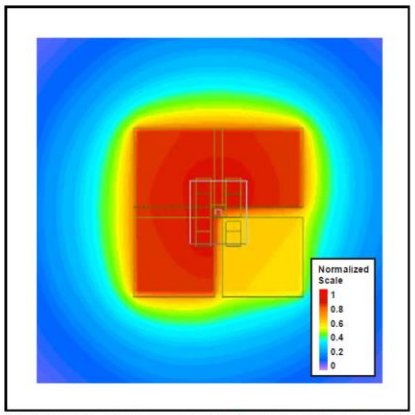


Figure 9: Substrate material with thermal conductivity of 0.2 W/(K m) (in the range of FR2)

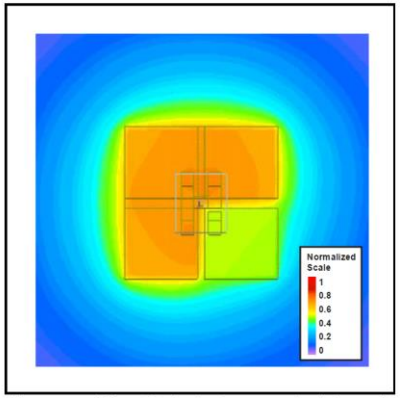


Figure 10: Substrate material with thermal conductivity of 0.35 W/(K m) (in the range of FR4)

Kako se testira distribuiranje toplote