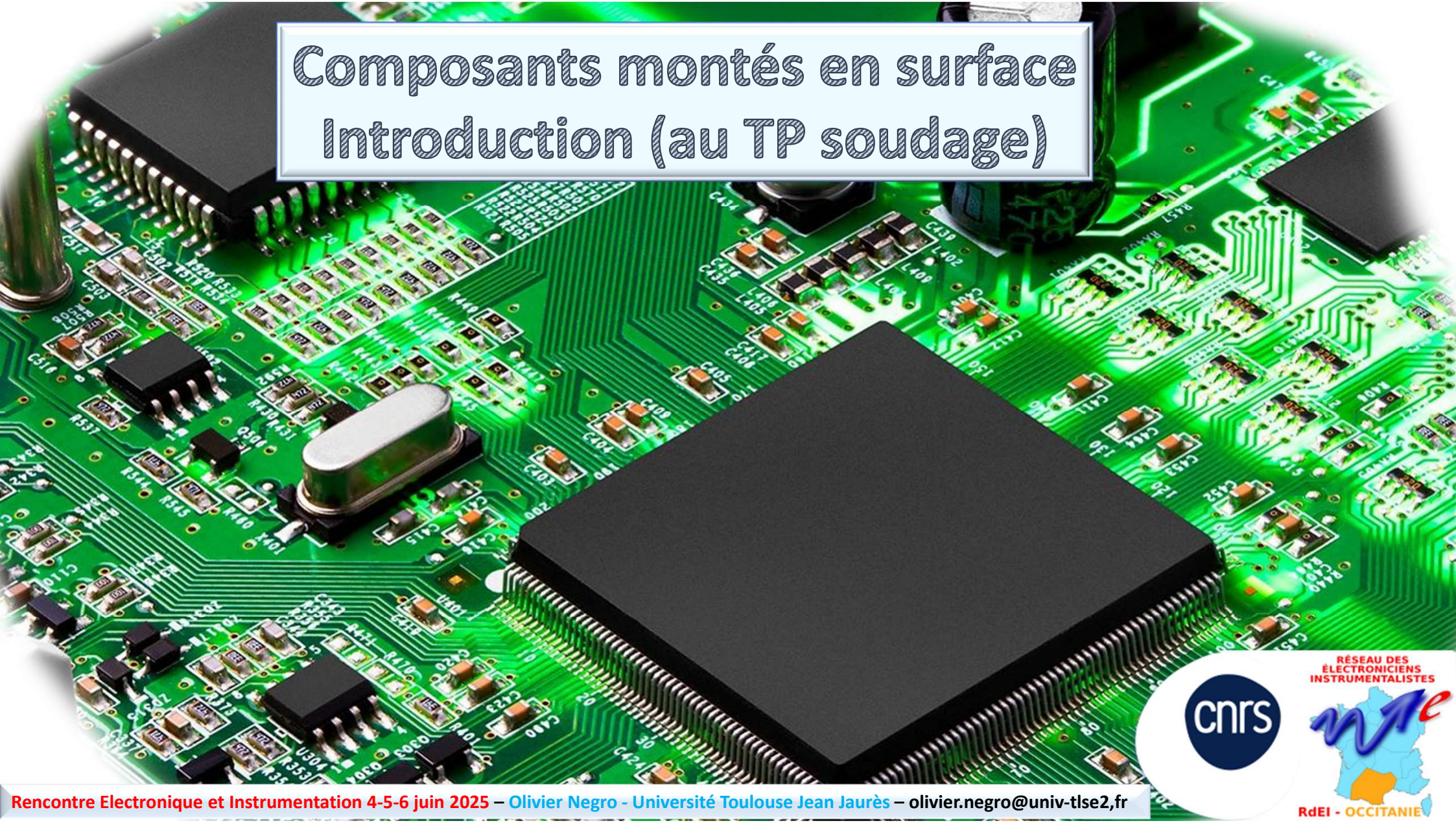
Composants montés en surface
Introduction (au TP soudage)

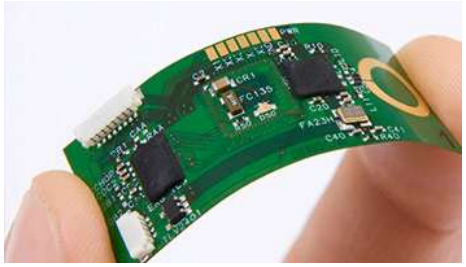


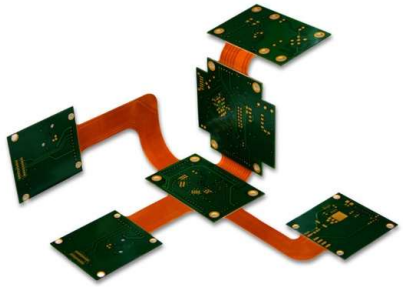
Rencontre Electronique et Instrumentation 4-5-6 juin 2025 – Olivier Negro - Université Toulouse Jean Jaurès – olivier.negro@univ-tlse2,fr

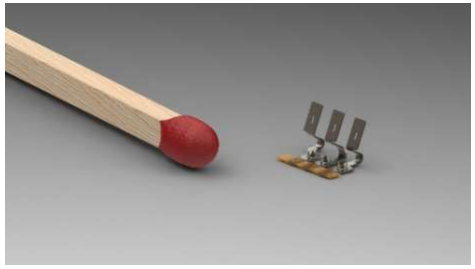
RÉSEAU DES ÉLECTRONICIENS INSTRUMENTALISTES
RdEI - OCCITANIE

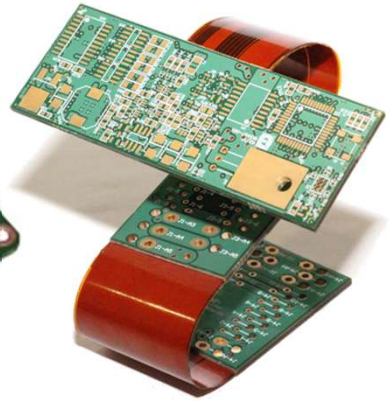
Circuit imprimé

Un **circuit imprimé** (ou **PCB** de l'anglais Printed Circuit Board) est un support, en général une plaque, permettant de maintenir et de relier électriquement un ensemble de composants électroniques entre eux, dans le but de réaliser un circuit électronique complexe. On le désigne aussi par le terme de carte électronique. Le PCB peut être rigide, souple ou mixte.







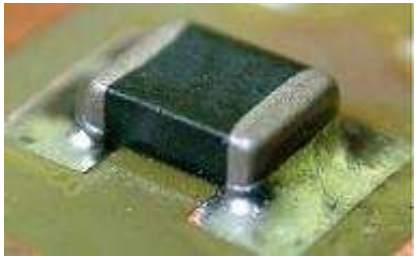


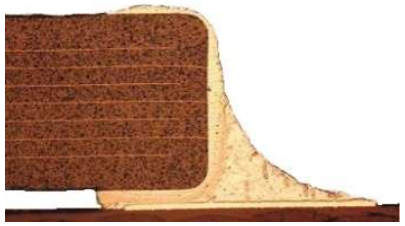
Technologie des composants montés en surface

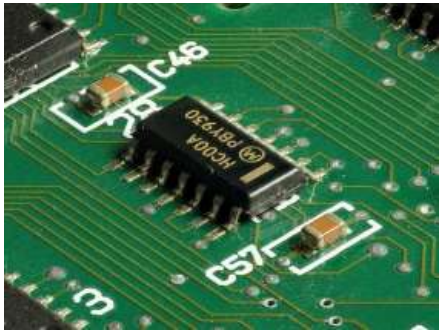
La technologie de montage en surface nommée également en anglais **Surface-Mount Technology (SMT)** est un procédé de production de circuits électroniques dans lesquels les composants sont montés ou placés directement sur la surface des cartes de circuits imprimés (PCB).

Un dispositif électronique ainsi faite est appelé un dispositif de montage en surface (**CMS**) nommée également en anglais **Surface Mount Device (SMD)**. Dans l'industrie, il a largement remplacé la technologie des composants traversant. Les deux technologies peuvent être utilisées sur la même carte. Un composant CMS est généralement plus petit que son homologue traversant.

Le composant monté en surface désigne une technique de fabrication des cartes électroniques et, par extension un type de composants utilisés par l'industrie électronique. Cette technique consiste à braser les composants d'une carte à sa surface, plutôt que d'en faire passer les broches au travers.







Avantages du CMS

- Les composants sont plus petits et plus légers.
- La densité (composants par unité de surface) de composant est plus élevée et beaucoup plus de connexions par composant.
- Les circuits imprimés n'ont plus à être percés pour souder les composants.
- L'assemblage peut être facilement automatisé.
- Assemblage simple et plus rapidement automatisé. Certaines machines de placement sont capables de placer plus de 136.000 composants par heure.
- Les tensions de surface centrent les composants automatiquement sur leur plage lors de l'étape de brasage, ce qui permet de corriger automatiquement de petites erreurs dans le placement des composants.
- Des composants peuvent être placés plus facilement sur les deux faces de la carte.
- Les résistances et inductances électriques sont diminuées, augmentant ainsi les performances en hautes fréquences.
- Les propriétés mécaniques en vibration sont meilleures.
- Temps de mise en place pour la production réduit.
- Le composant CMS coûte moins cher que leur équivalent traversant.

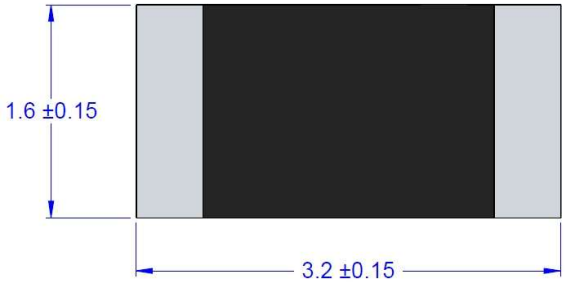
Inconvénients du CMS

- Un CMS ne peut pas être utilisé directement avec une plaque de prototypage rapide, ce qui nécessite soit un PCB personnalisé pour chaque prototype ou le montage du CMS sur un support traversant.
- La réparation manuel est plus difficile et exige des opérateurs qualifiés et des outils plus onéreux, en raison de la petite taille et des espacements.
- La fiabilité des joints de soudure devient de plus une préoccupation car la quantité de soudure est de plus en plus petite. La présence de vides peut éventuellement conduire à une défaillance du joint.
- Le CMS est inadapté à la haute puissance, ou à haute tension. Il est fréquent de combiner aux composants traversant comme des transformateurs, des semi-conducteurs de puissance, des gros condensateurs, des fusibles, des connecteurs, etc. monté sur un côté du PCB par des trous.
- Le CMS ne convient pas comme seule procédé de fixation pour les composants qui sont soumis à des contraintes mécaniques fréquents, tels que les connecteurs qui sont utilisés pour l'interface avec des périphériques externes qui sont souvent attachés et détachés.

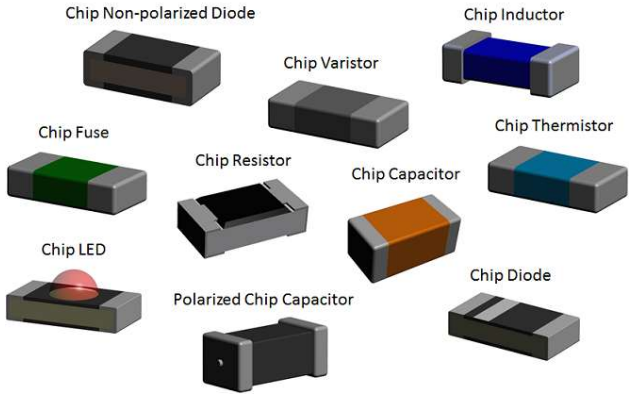
The basic components

(metric) – (inch)

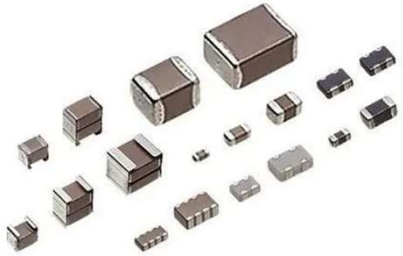
- ✓ 6332 - 2512
- ✓ 5025 – 2010
- ✓ 4532 – 1812
- ✓ 3225 – 1210
- ✓ 3216 – 1206
- ✓ 2012 – 0805
- ✓ 1608 – 0603
- ✓ 1005 – 0402
- ✓ - 03015
- ✓ 0603 - 0201
- ✓ 0402 – 01005
- ✓ 0201 - 008004



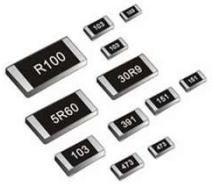
3216 - 1206



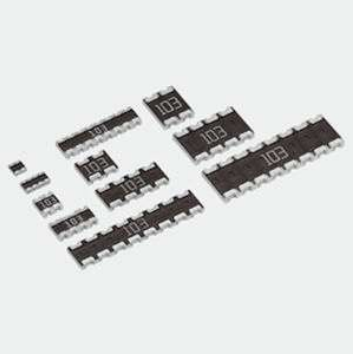
Chip capacitor



Chip resistor



Chip Array



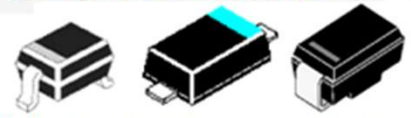
Inductors

Depends on many parameters and the manufacturer

Small-Outline Diode (SOD)

SOD-15	
SOD-80C	3.5 mm × ⌀ 1.5 mm
SOD-106	4.3mm x 2.5 mm x 2mm
SOD-110	1.2mm x 1,9mm x 1.5mm
SOD-123	2.65 mm × 1.6 mm × 1.35 mm
SOD-128	3.8 mm × 2.5 mm × 1.1 mm
SOD-323 (SC-76)	1.7 mm × 1.25 mm × 1.1 mm
SOD-523 (SC-79)	1.2 mm × 0.8 mm × 0.65 mm
SOD-723	1.0 mm × 0.6 mm × 0.65 mm
SOD-923	0.8 mm × 0.6 mm × 0.4 mm

Rectangular Case - Diode / Rectifier



Gull-Wing Leads Flat Leads J-Leads

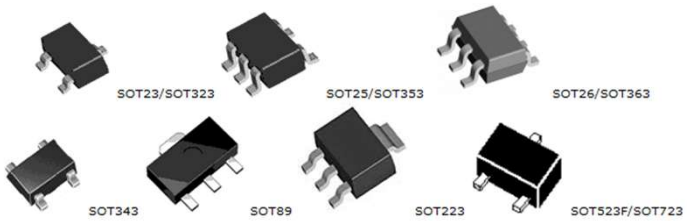
Case Code	Size & Description	Click Image Outline Drawing
SOD15	7.0L x 6.0W x 2.3H Plastic DO214AB-SMCJ	
SOD106	4.3L x 3.6W x 2.3H Plastic DO214AC	
SOD110	2.0L x 1.4W x 1.6H Ceramic	
SOD123G	2.7 x 1.5mm Gull Wing	
SOD123F DO-219AB	2.7 x 1.5mm Flat Leads	
SOD123FW DO-219AB	3.5 x 1.6mm Wide Flat Leads	
SOD323G SC76	1.7 x 1.3mm Gull Wing SC76	
SOD323FS DO-219AC	1.9 x 1.3mm Narrow Flat Lead	
SOD323FW	2.5 x 1.25mm Wide Flat Lead	
SOD523F SC79F	1.2 x 0.8mm Flat Leads	
SOD523FL SC79FL	1.2 x 0.8mm Flat Leads	
SOD723F	1.0 x 0.6mm Flat Leads	
SOD923F	0.8 x 0.6mm Flat Leads	
QFN2-0201	0.6 x 0.3mm Bottom Terminals	
SMAF SOD128	4.5 x 2.5mm Wide Flat Leads	
SMBF	5.2 x 3.5mm Wide Flat Leads	
SMCF	6.0 x 4.5mm Wide Flat Leads	

Small-Outline Transistor SOT

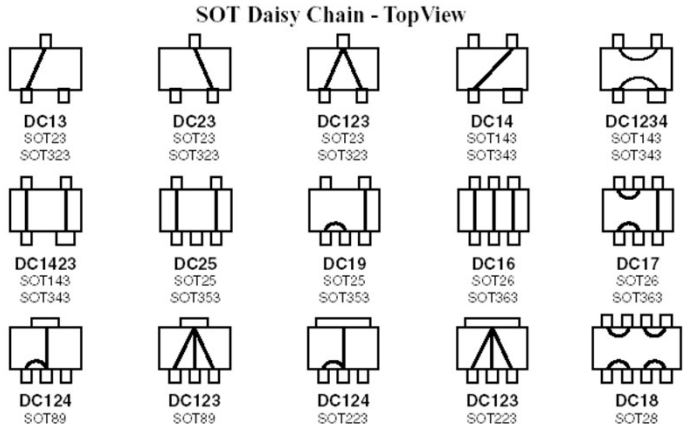
SOT23	TO-236AB
SOT25	SOT23-5 and SC74A
SOT26	SOT23-6 and SC74
SOT28	SOT23-8
SOT89	SC62 and TO-243AA
SOT143	TO-253AA
SOT223	SC73 and TO-261AA
SOT323	SC70
SOT343	SC82
SOT353	
SOD353	SC70-5 and SC88A
SOT363	SC70-6 and SC88
SOT523	Gull Wing
SOT523F	Flat Leads
SOT663	-
SOT723	VT3
SOT883	DFN3L, SC101 1.0x0.6mm
SOT923	0.8x0.6mm

Japanese Size

SC59	TO-236AA or SOT-346	
SC61A	4-Lead	
SC61B	Reverse Wide 4-Lead	
SC62	SOT89	
SC63	DPAK	
SC70	SOT323	
SC73	SOT223	
SC74	SOT26, SOT23-6, SOT457	
SC74A	SOT25 or SOT23-5	
SC75A	SC90 or SOT416	
SC76	SOD323	
SC79	SOD523F	
SC82	SOT343 - 4 Lead	
SC83A	D2PAK	
SC88	SOT363	
SC88A	SOT353	
SC89	SOT490 - SC75A with Flat Leads	
SC90	Micro-SOT	
SC101	SOT883, DFN3L 1.0x0.6mm	
EMT5	Wide body SC90	5-Ld Flat Lead
EMT6	Wide body SC90	6-Ld Flat Lead
VT3	SOT723	

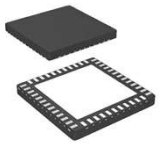


Diode in SOT package

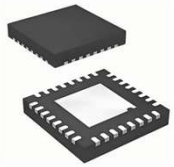


Flat packages

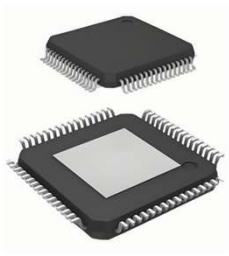
Flat-pack	Earliest version metal/ceramic packaging with flat leads
CFP	Ceramic flat-pack
CQFP	Ceramic quad flat-pack (Similar to PQFP)
BQFP	Bumpered quad flat-pack
DFN	Dual flat-pack
ETQFP	Exposed thin quad flat-package
LLP	Leadless Leadframe Package
PQFN	Power quad flat-pack (No-leads, with exposed die-pad for heatsinking)
PQFP	Plastic quad flat-package
LQFP	Low-profile quad flat-package



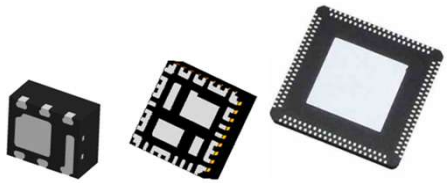
LLP



QFN



QFP



DFN - QFN

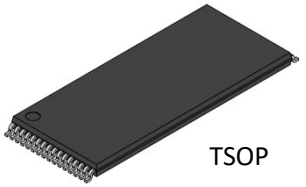
Flat Pack

QFN	Quad flat no-leads package (Also called as micro lead frame (MLF))
QFP	Quad flat package
MQFP	Metric quad flat-pack (QFP with metric pin distribution)
HVQFN	Heat-sink very-thin quad flat-pack, no-leads
TQFP	Thin quad flat-pack
VQFP	Very-thin quad flat-pack
TQFN	Thin quad flat, no-lead
VQFN	Very-thin quad flat, no-lead
WQFN	Very-very-thin quad flat, no-lead
UQFN	Ultra-thin quad flat-pack, no-lead
ODFN	Optical Dual-in-line Flat No-lead

Small Outline Packages

SOJ

SSOP



TSOP

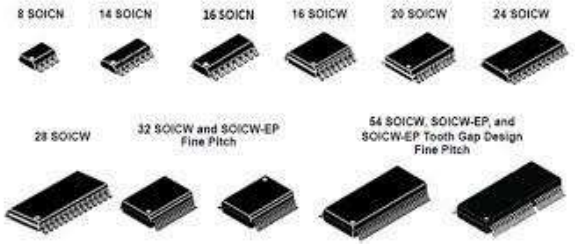
USON

SOP	Small-outline package
CSOP	Ceramic small-outline package
DSOP	Dual small-outline package
HSOP	Thermally-enhanced small-outline package
HSSOP	Thermally-enhanced shrink small-outline package
HTSSOP	Thermally-enhanced thin shrink small-outline package
mini-SOIC	Mini small-outline integrated circuit
MSOP	Mini small-outline package (Maxim uses the trademarked name µMAX for MSOP packages and MSE for Analog Devices/Linear Technologie)
PSOP	Plastic small-outline package
PSON	Plastic small-outline no-lead package

HTSSOP

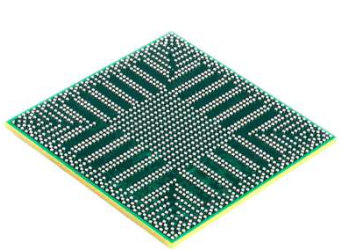
MSOP

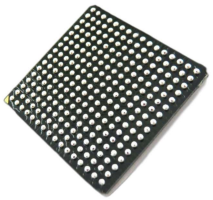
SOIC



QSOP	Quarter-size small-outline package (The terminal pitch is 0.635 mm)
SOIC	Small-outline integrated circuit (Also known as SOIC NARROW and SOIC WIDE)
SOJ	Small-outline J-leaded package
SON	Small-outline no-lead package
SSOP	Shrink small-outline package
TSOP	Thin small-outline package
TSSOP	Thin shrink small-outline package
TVSOP	Thin very-small-outline package
VSOP	Very-small-outline package
VSSOP	Very-thin shrink small-outline package (Also referred as MSOP = micro small-outline package)
WSON	Very-very-thin small-outline no-lead package
USON	Very-very-thin small-outline no-lead package (Slightly smaller than WSON)

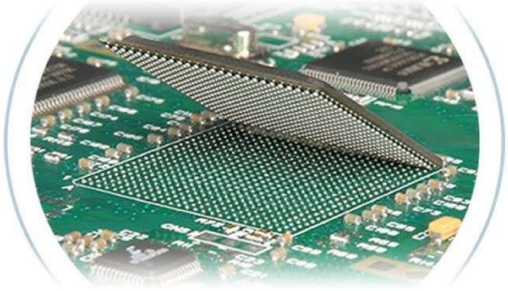
Ball Grid Array



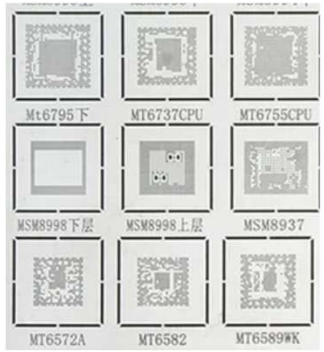


BGA

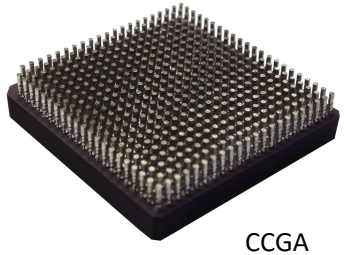
FBGA	Fine-pitch ball-grid array	A square or rectangular array of solder balls on one surface
LBGA	Low-profile ball-grid array	Also known as laminate ball-grid array
TEPBGA	Thermally-enhanced plastic ball-grid array	
CBGA	Ceramic ball-grid array	
OBGA	Organic ball-grid array	
TFBGA	Thin fine-pitch ball-grid array	
PBGA	Plastic ball-grid array	
MAP-BGA	Mold array process - ball-grid array	
UCSP	Micro (µ) chip-scale package	Similar to a BGA (A Maxim trademark example)
µBGA	Micro ball-grid array	Ball spacing less than 1 mm
LFBGA	Low-profile fine-pitch ball-grid array	
TBGA	Thin ball-grid array	
SBGA	Super ball-grid array	Above 500 balls
UFBGA	Ultra-fine ball-grid array	



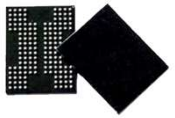
FBGA



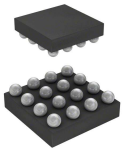
Stencil Reball



CCGA



TFBGA



UFBGA

Metal Electrode Leadless Face (MELF)

MicroMELF (MMU), 0102	2.2 mm × ⌀ 1.1 mm
MiniMELF (MMA), 0204	3.6 mm × ⌀ 1.4 mm
MELF (MMB), 0207	5.8 mm × ⌀ 2.2 mm

MELF Cylindrical Diode


Glass

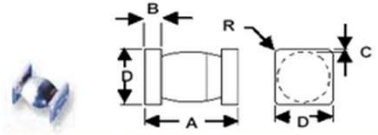

Plastic

Case Code	Size & Description	Click Image Outline Drawing
SM1-PLASTIC	MELF 2.5 x 5.0mm	
LL41-Glass	MELF DO-213AB, LL35, LL41 2.5 x 5.0mm	
SOD80	mini-MELF DO-213AA, LL34 1.6 x 3.5mm	
SOD87	mini-MELF 2.0 x 3.5mm	

MELF resitor/resistor

MELF diode

MELF SQUARE ENDS (Hermetic Mil-Type)



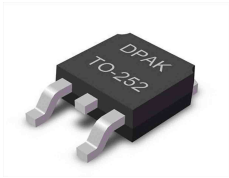
TopLine Part Number	Alternate Description	Length "A"	Flange End "D"	Flange Thick "B"	Gap "C"	Image
D-5B	E-CASE MELF-B 500W	0.200~0.225" 5.0~5.8mm	0.137"~0.148" 3.5~3.8mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
D-5C	G-CASE 1500W	0.205~0.245" 5.2~6.2mm	0.183"~0.202" 4.6~5.1mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
MELF-1	-	0.168~0.230" 4.2~5.9mm	0.091"~0.128" 3.4~3.8mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
D-5A	MELF-A	0.168~0.200" 4.27~5.08mm	0.091"~0.103" 2.3~2.6mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
MELF-C	-	0.168~0.300" 4.2~7.6mm	0.091"~0.128" 2.3~3.3mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
MELF-D	-	0.168~0.300" 4.2~7.6mm	0.137"~0.148" 3.5~3.8mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
MELF-E	-	0.168~0.300" 4.2~7.6mm	0.175"~0.195" 4.4~5.0mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
TBA	-	0.168~0.195" 4.2~5.0mm	0.070"~0.085" 1.8~2.2mm	0.019"~0.028" 0.48~0.72mm	0.003" 0.076mm	
MicroMELF	-	0.070~0.078" 1.8~2.0mm	0.047"~0.049" 1.2~1.25mm	- 0.012 0.3mm	0.003" 0.076mm	
QuadroMELF	-	0.130~0.145" 3.3~3.7mm	0.055"~0.063" 1.4~1.6mm	- 0.012 0.3mm	0.003" 0.076mm	

DPAK family

DPAK Decawatt Package (TO-252)
D2PAK ou DDPACK Double Decawatt Package TO-263)
D3PAK Decawat 3 Package (TO-268)

JEDEC Device	Nbr Leads	Pitch	Order Nbr RoHS Pb-Free	Device
Plastic Case - Surface				
TO-252AA Center Lead Trimmed SOT428	2L Center Lead Trimmed	4.6mm	DPAK-TIN TO252AA	
TO-263AB Center Lead Trimmed SOT404	2L Center Lead Trimmed	5.08mm	D2PAK-T TO263AB	
TO-252-3L Full 3 Leads	3L Untrimmed	2.30mm	DPAK3-T TO252-3L	
TO-263AA Full 3 Leads	3L Untrimmed	2.54mm	D2PAK3-T TO263AA	
TO-263-4 Center Lead Trimmed SOT426	4L Center Lead Trimmed	5.08mm	D4PAK-T TO263-4	
TO-252-5 Full 5 Leads	5L Untrimmed	1.27mm	DPAK5-T TO252-5	

JEDEC Device	Nbr Leads	Pitch	Order Nbr RoHS Pb-Free	Device
Plastic Case - Surface				
TO-263-5 Full 5 Leads	5L Untrimmed	1.27mm	D2PAK5-T TO263-5	
TO-263-7 Center Lead Trimmed SOT427	6L Center Lead Trimmed	0.85mm	D2PAK7-T TO263-7	
TO-252-7F Full 7 Leads	7L Untrimmed	0.88mm	DPAK7F-T TO252-7F	
TO-263-7F Full 7 Leads	7L Untrimmed	0.85mm	D2PAK7F-T TO263-7F	
TO-268	2L	10.9mm	D3PAK-T TO268	



Transistor Outline (TO)

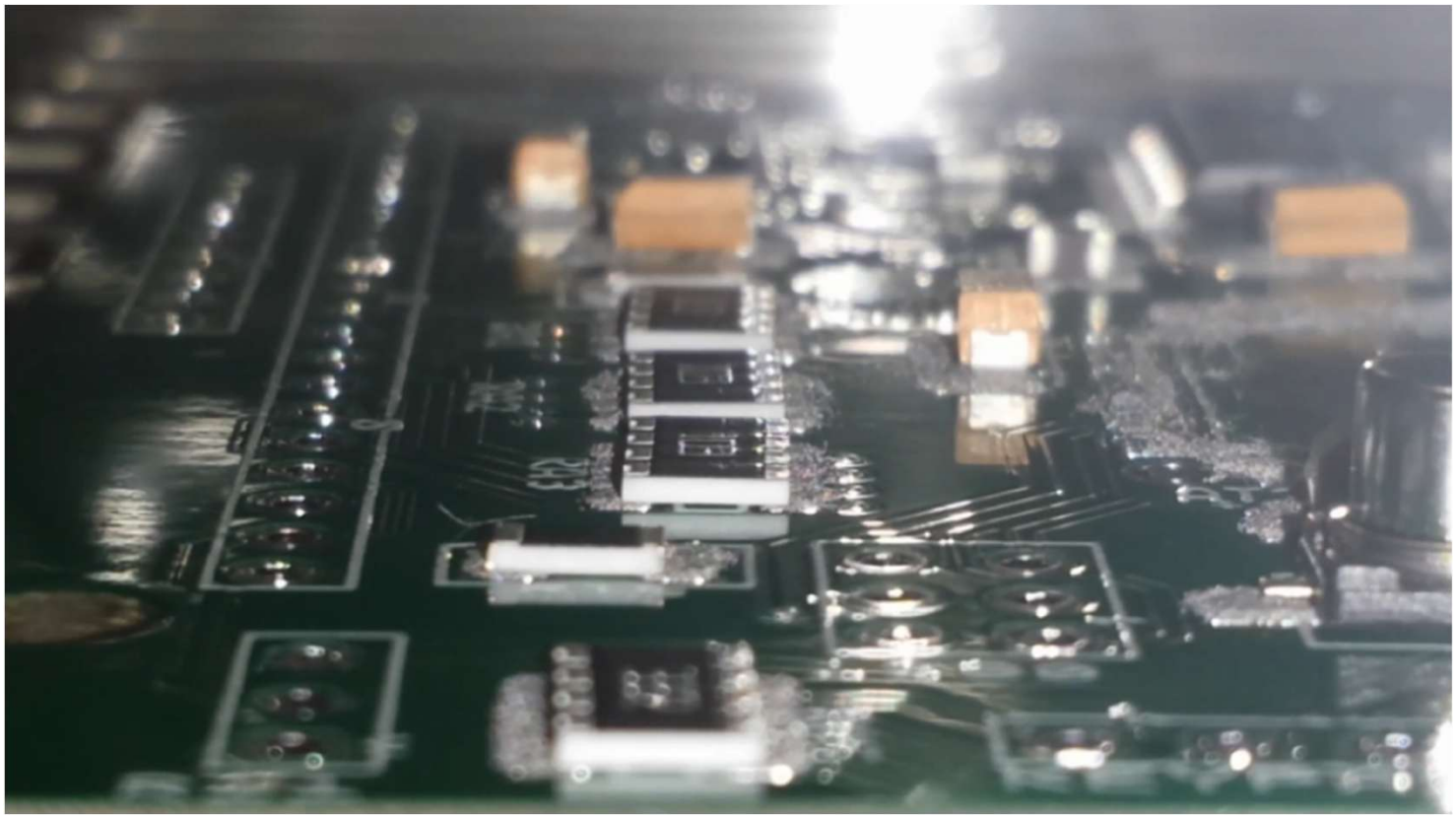
TO-XX: wide range of small pin count packages often used for discrete parts like transistors or diodes.

- TO-3: Panel-mount with leads
- TO-5: Metal can package with radial leads
- TO-18: Metal can package with radial leads
- TO-39: Metal can package with radial leads
- TO-46: Metal can package with radial leads
- TO-66: Similar shape to the TO-3 but smaller
- TO-92: Plastic-encapsulated package with three leads
- TO-99: Metal can package with eight radial leads
- TO-100: Metal can package with ten radial leads, similar to TO-99
- TO-126: Plastic-encapsulated package with three leads and a hole for mounting on a heat sink
- TO-220: Through-hole plastic package with a (usually) metal heat sink tab and three leads
- TO-226
- TO-247: Plastic-encapsulated package with three leads and a hole for mounting on a heat sink
- TO-251: Also called IPAK: SMT package similar to the DPAK but with longer leads for SMT or TH mounting
- TO-252: (also called SOT428, DPAK):[24]
- TO-262: Also called I2PAK: SMT package similar to the D2PAK but with longer leads for SMT or TH mounting
- TO-263: Also called D2PAK: SMT package similar to the TO-220 without the extended tab and mounting hole
- TO-274: Also called Super-247: SMT package similar to the TO-247 without the mounting hole

How to solder electronic components

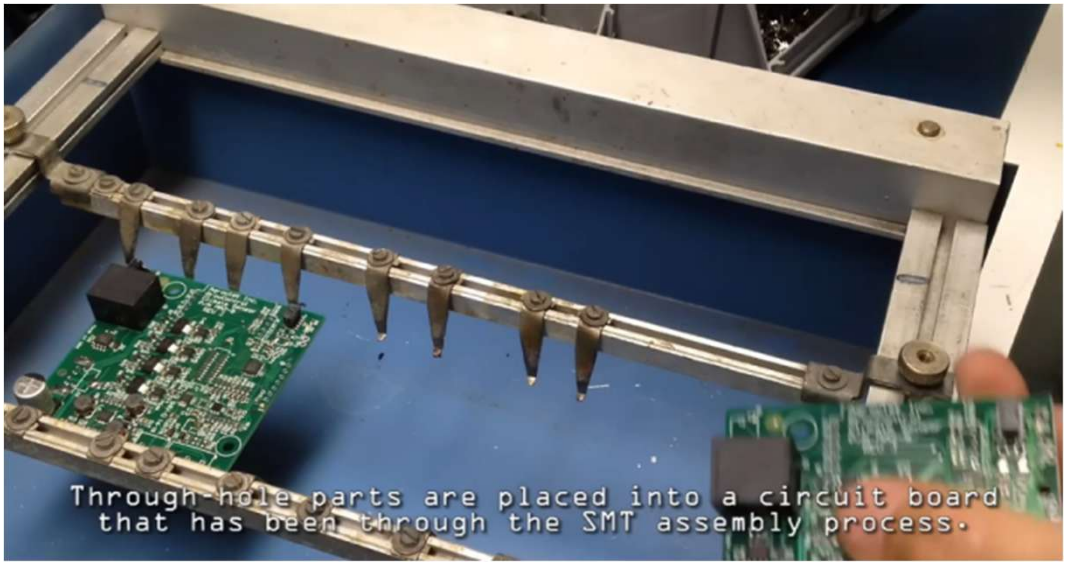
- Manual soldering (Soudage manuel)
- Reflow Soldering [Convection, Infrared] Soudage par refusion)
- Wave Soldering or Selective Wave Soldering (Soudage à la vague)
- Laser Soldering (Soudage par laser)
- Vapor Phase Soldering (+ vaccum) (Soudage par phase vapeur)

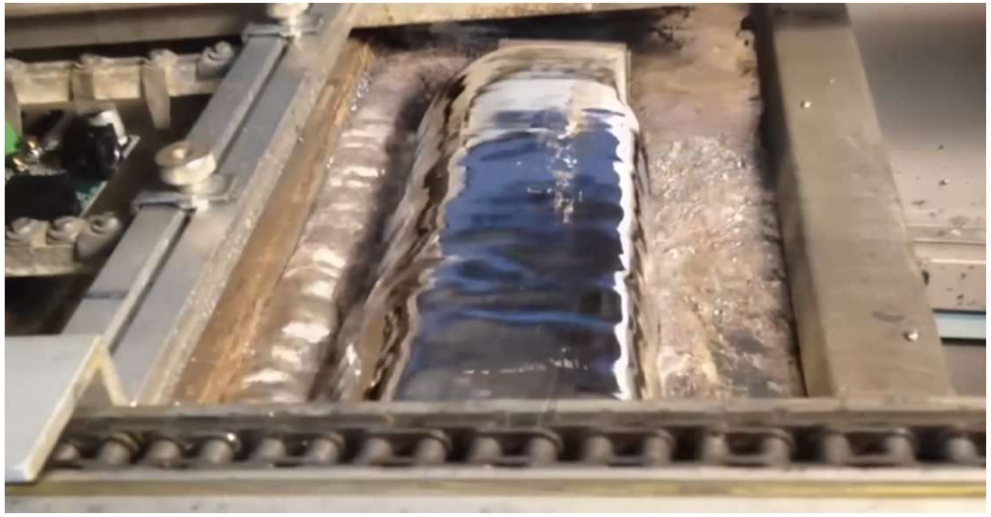
Reflow soldering



https://www.youtube.com/watch?v=LCmia0Wsmqg

Wave Soldering





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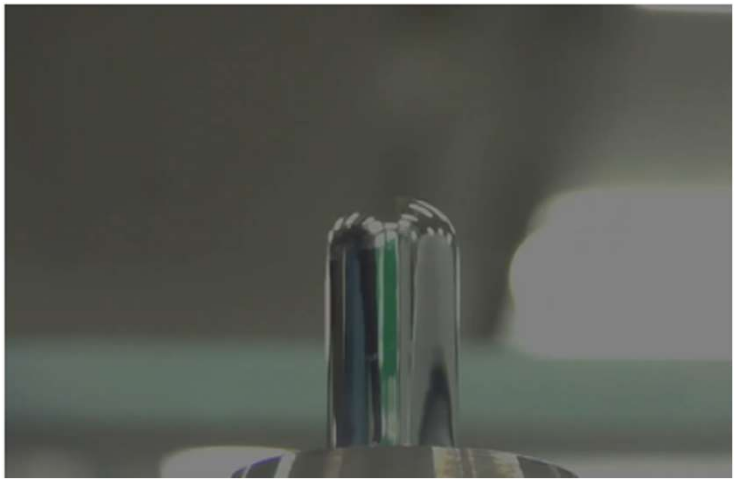
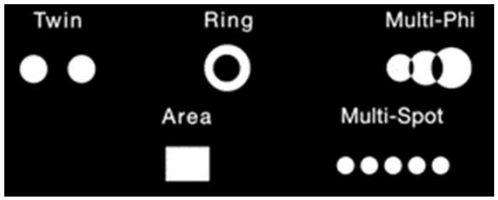
Selective Wave Soldering

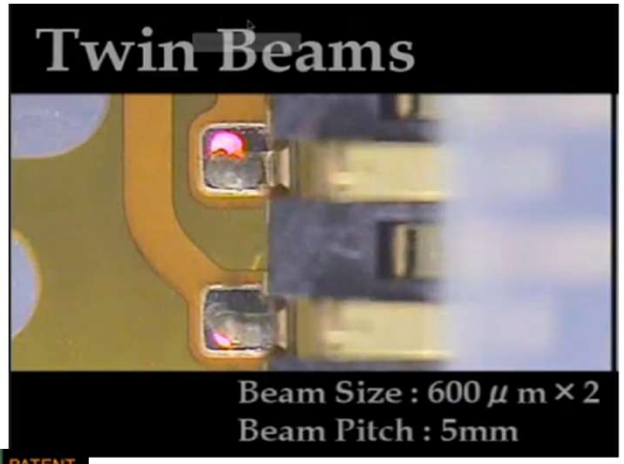


https://www.youtube.com/watch?v=vNuUe76-H4c

Laser Soldering

https://www.youtube.com/watch?v=KnyB9btlhS8#t=4s





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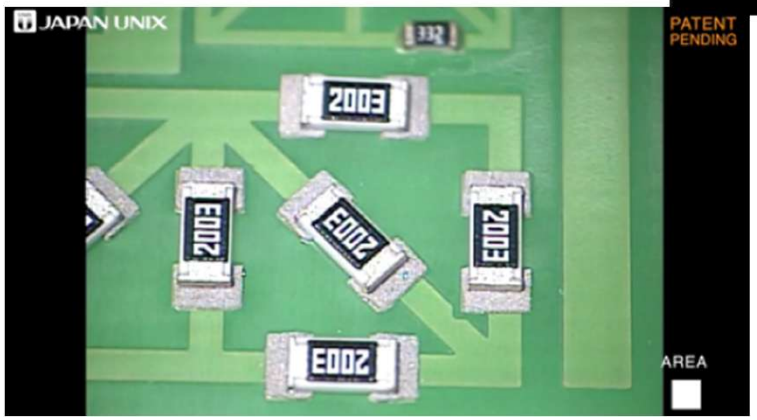

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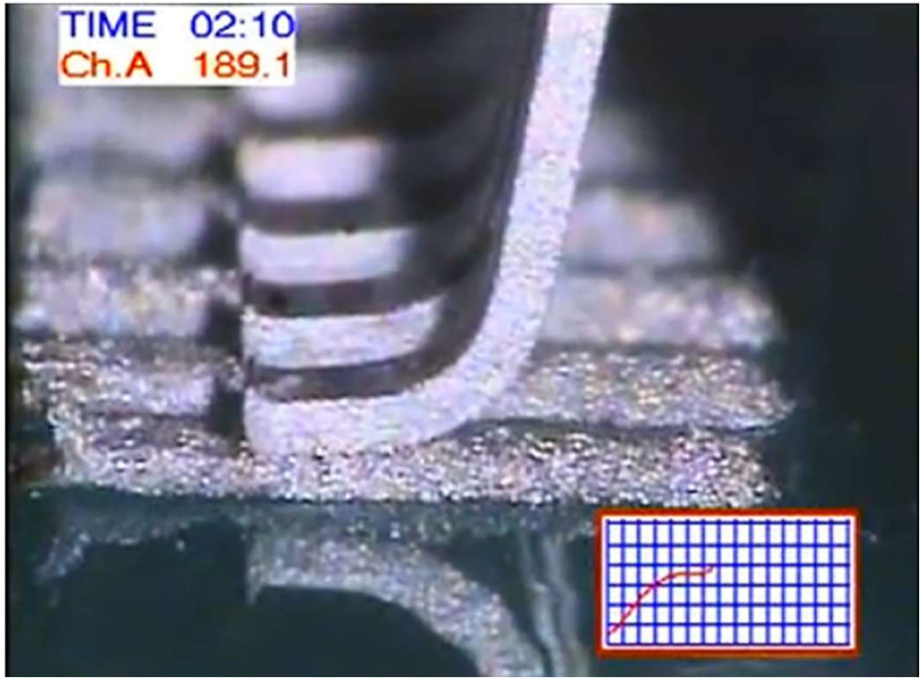
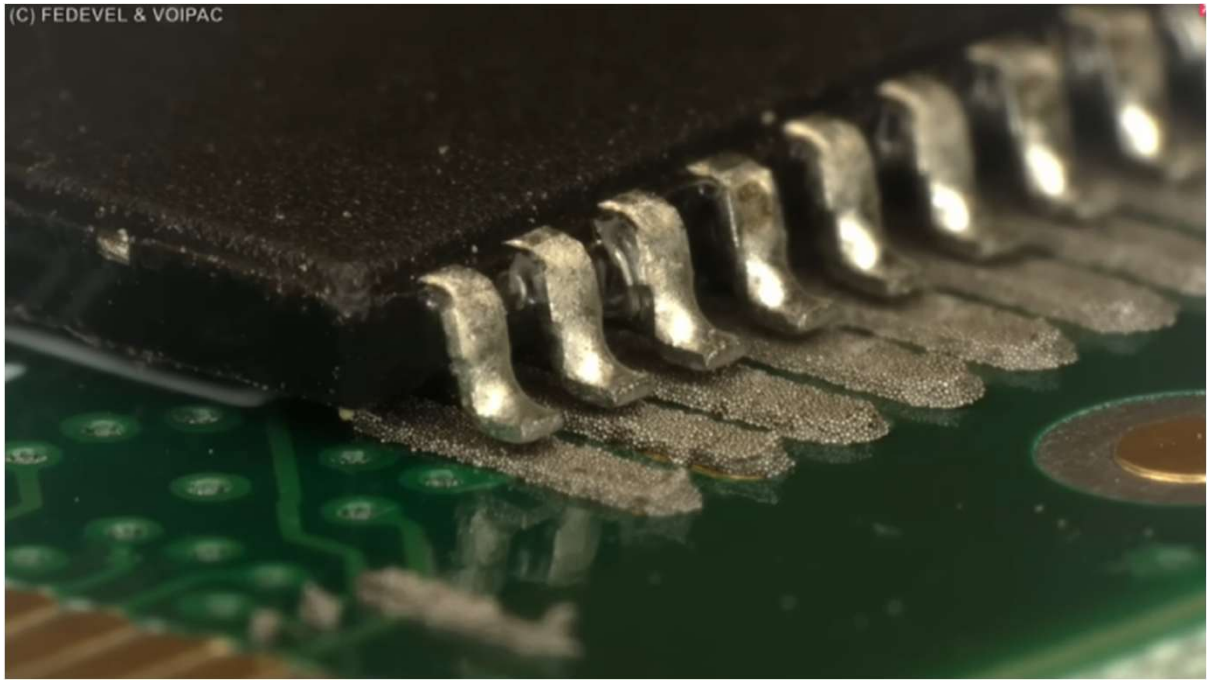
https://www.youtube.com/watch?v=BE70lkU2XMc#t=126s

SO Soldering

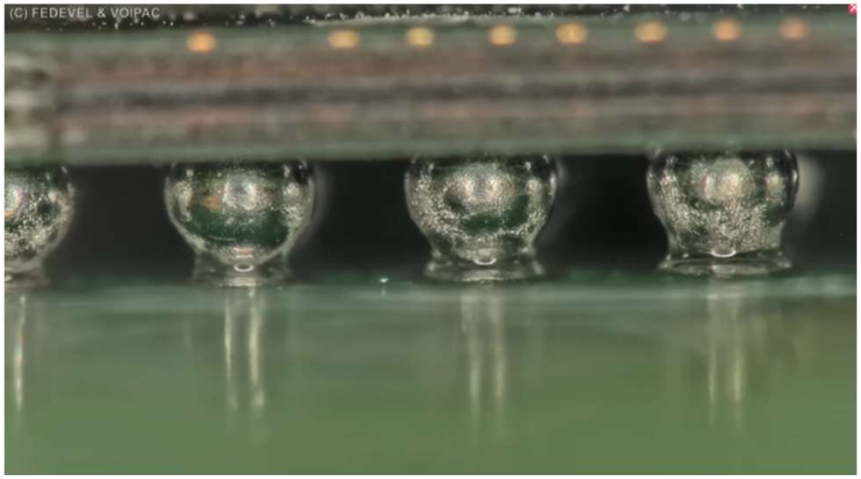




https://www.youtube.com/watch?v=2yQaLbQONXg

https://www.youtube.com/watch?v=m3Ny3j5nH0U&t=101s

BGA Soldering



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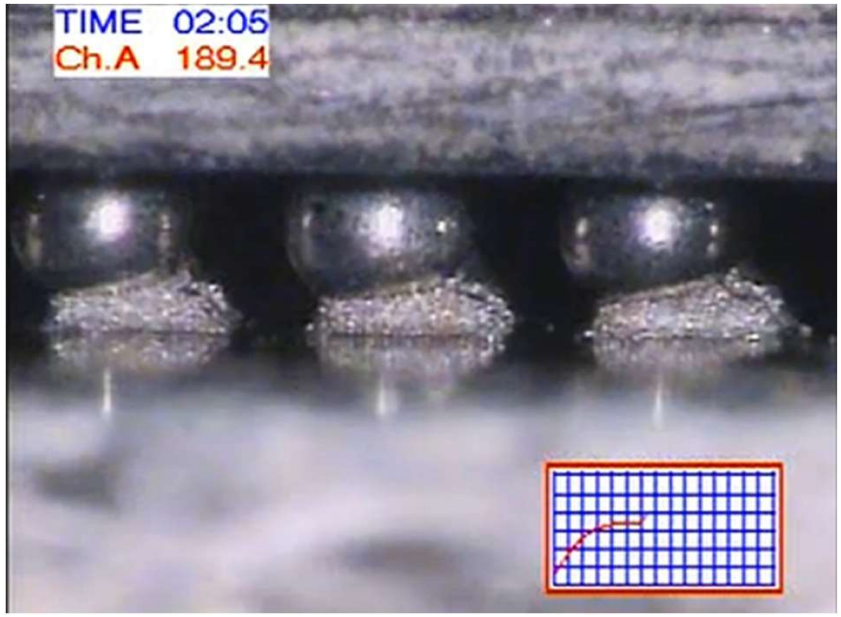

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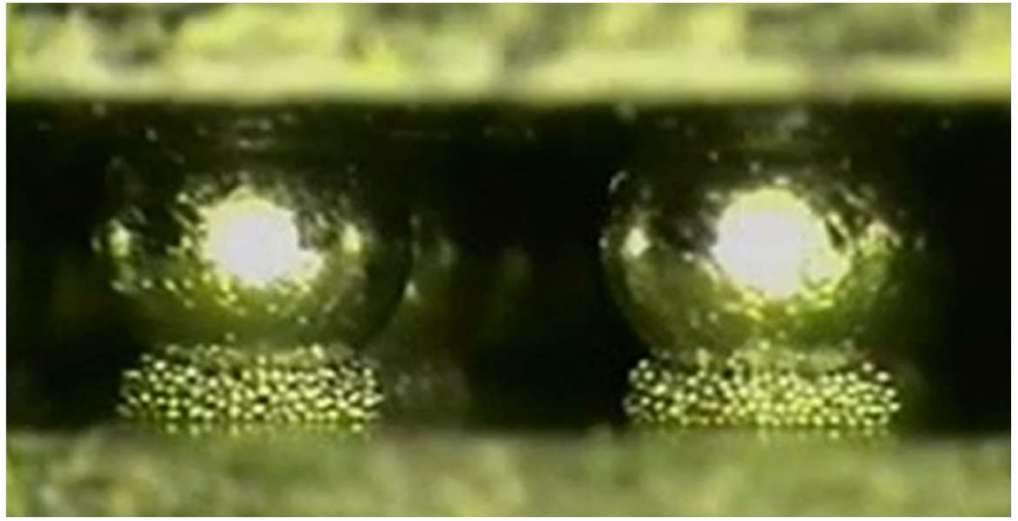

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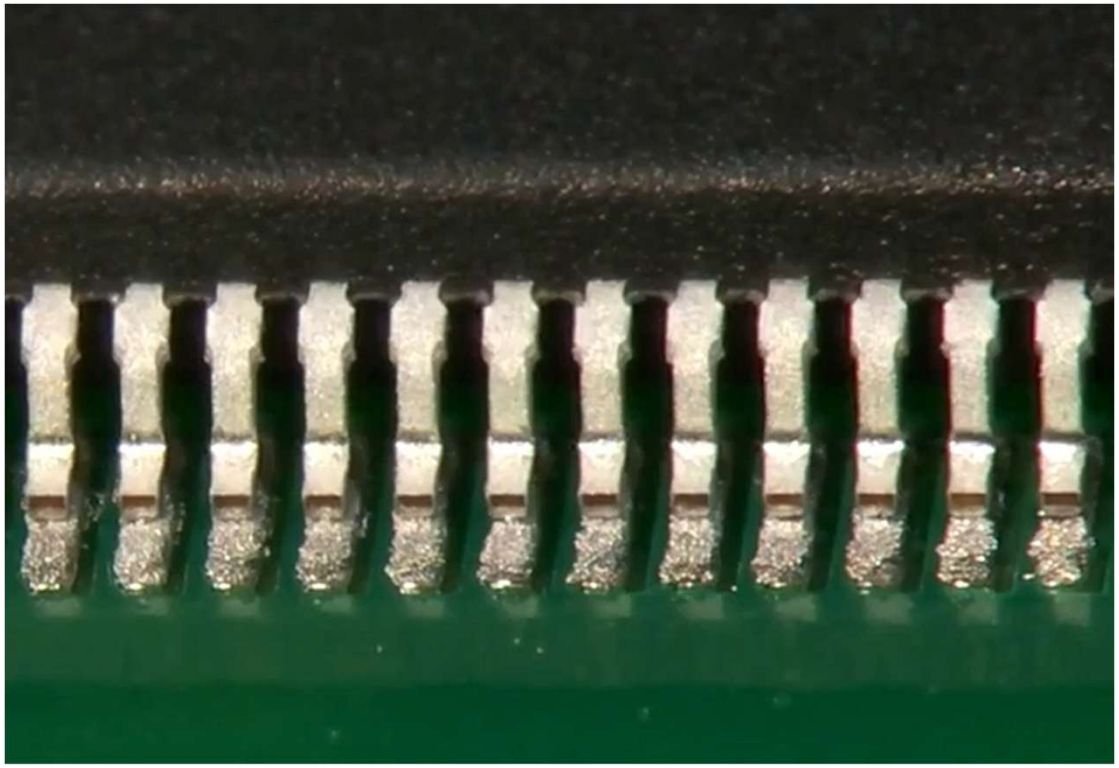
Coplanarity problems



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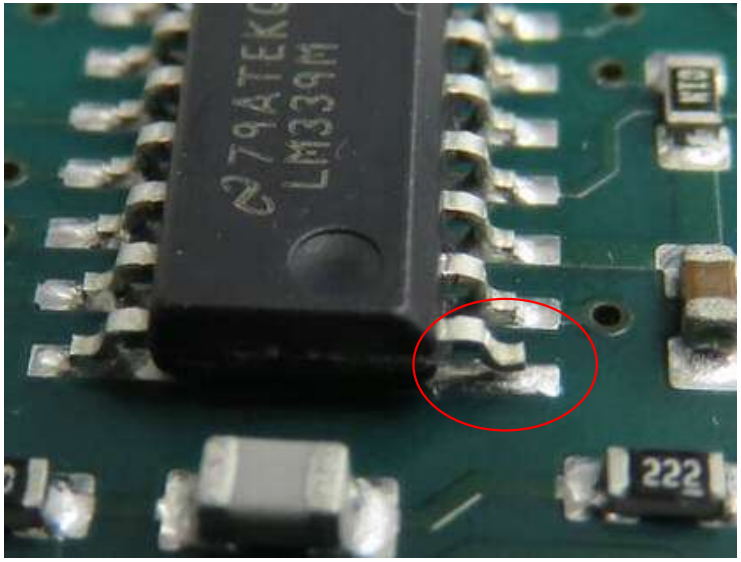
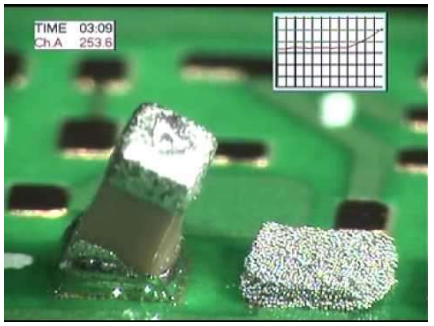
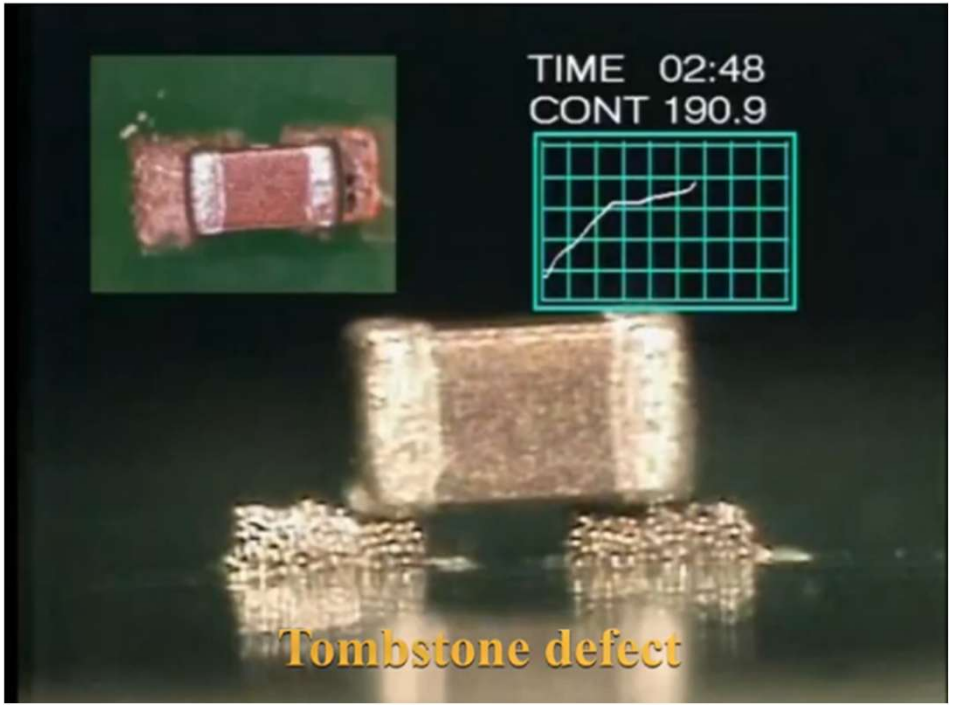


Tombstone problems





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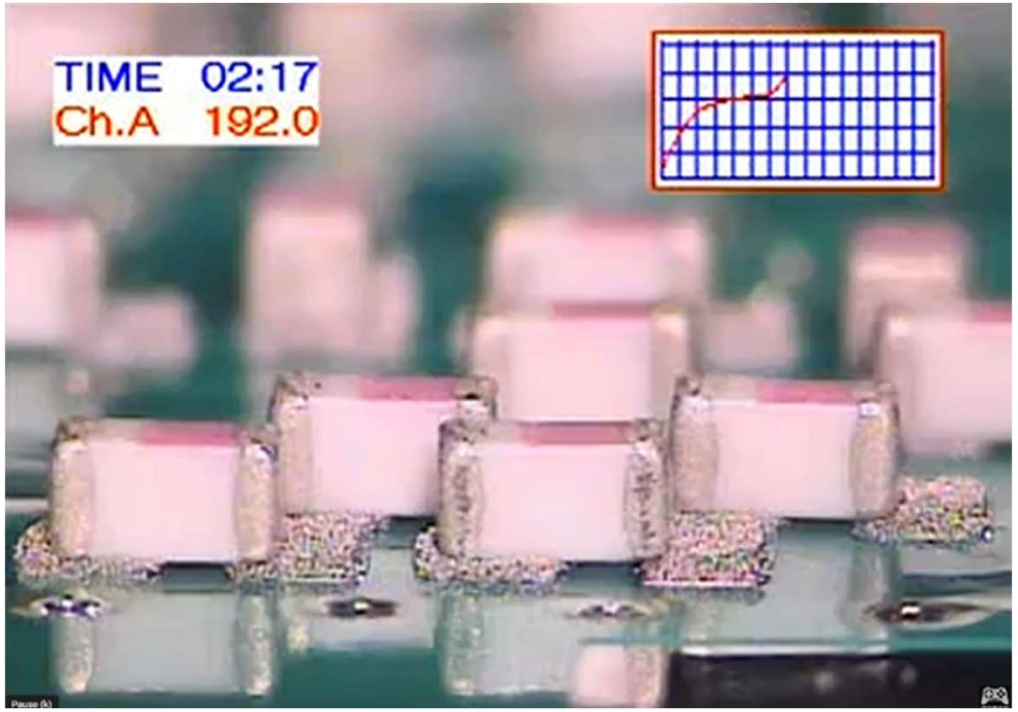

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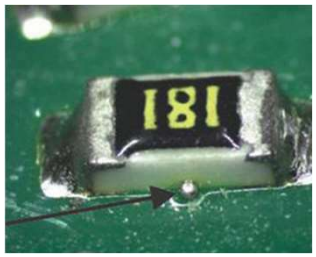
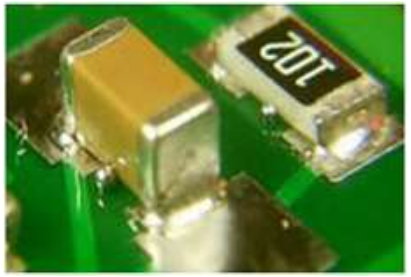
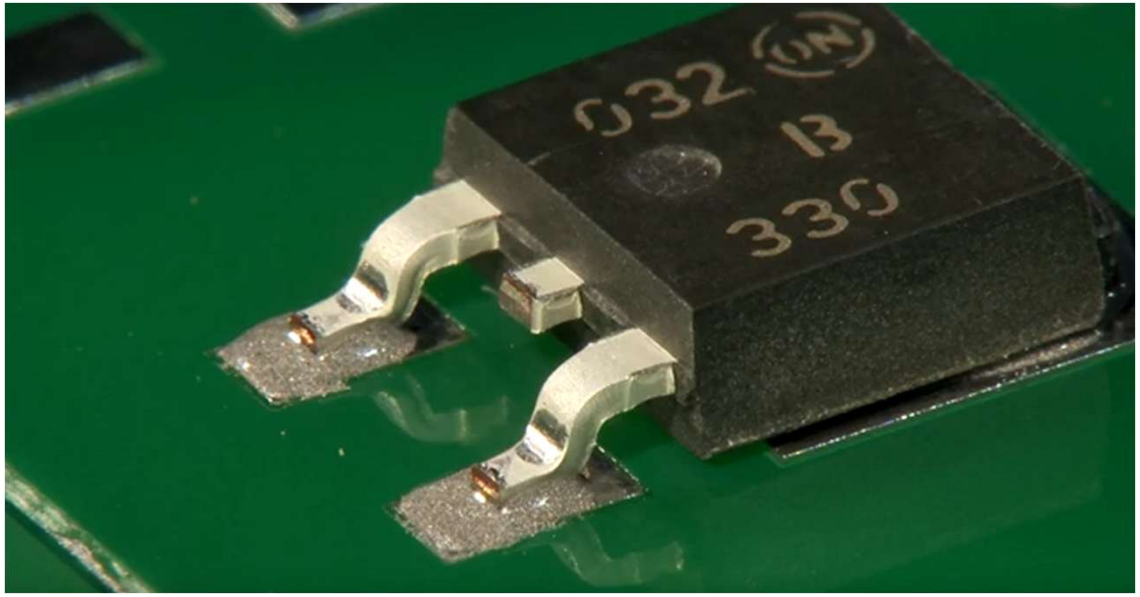
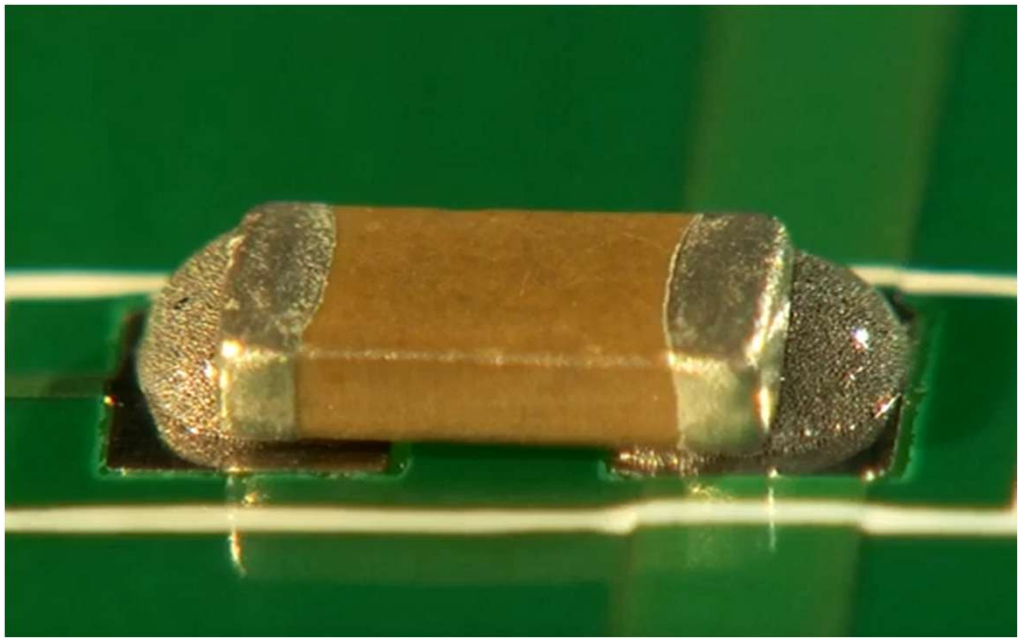
Solder Ball problems





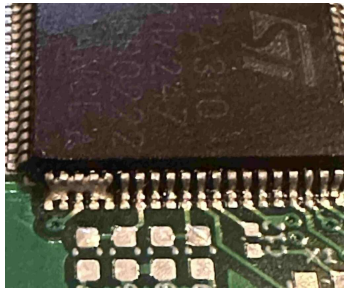


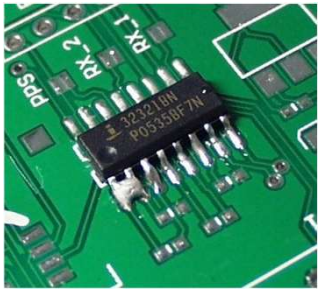


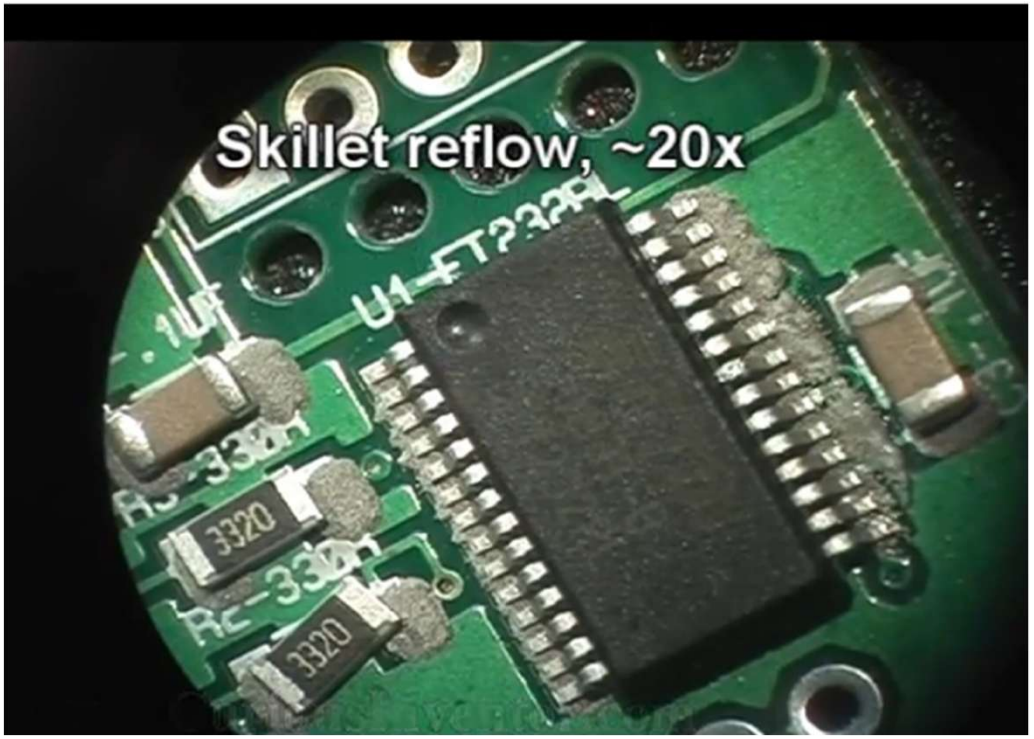
https://www.youtube.com/watch?v=u61Cde6Uh0I

https://www.youtube.com/watch?v=mLd-ZMXyzhM

Solder Bridge problems







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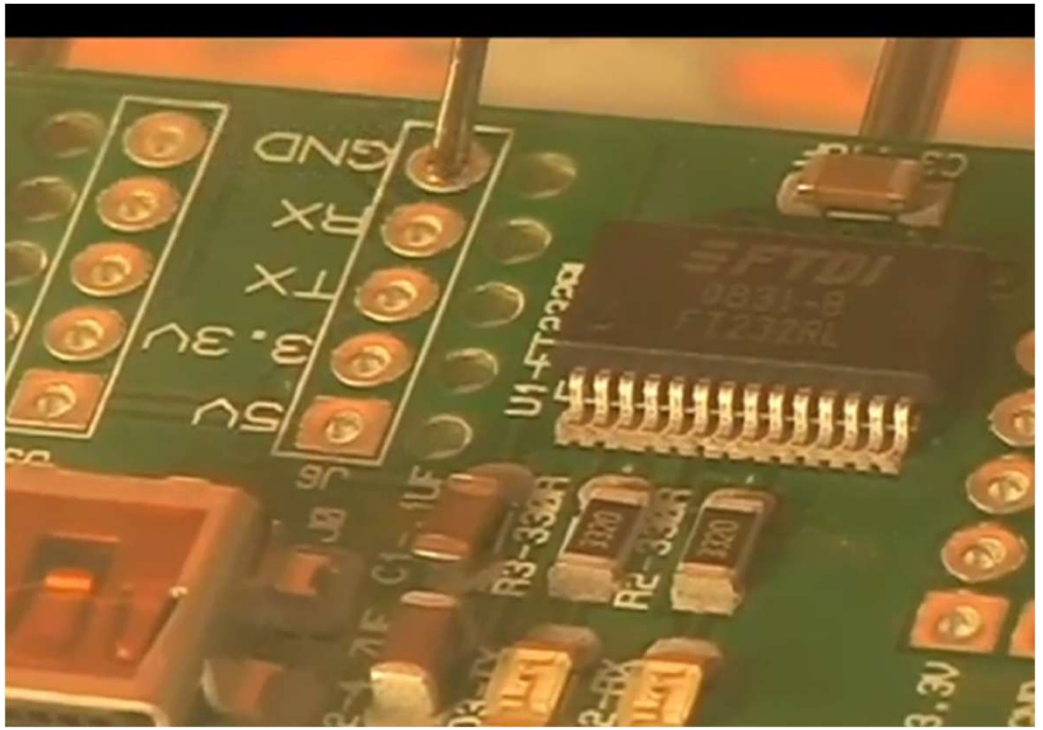

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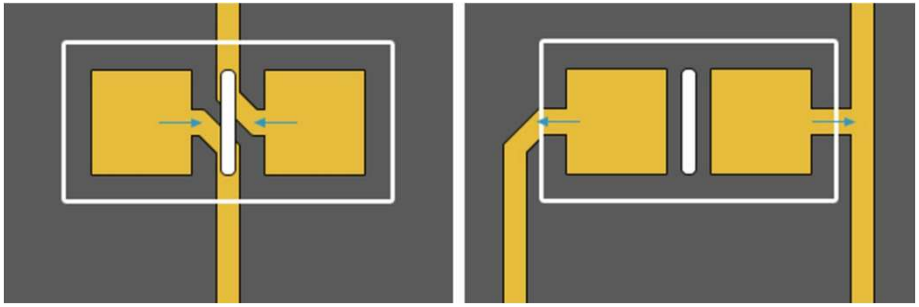
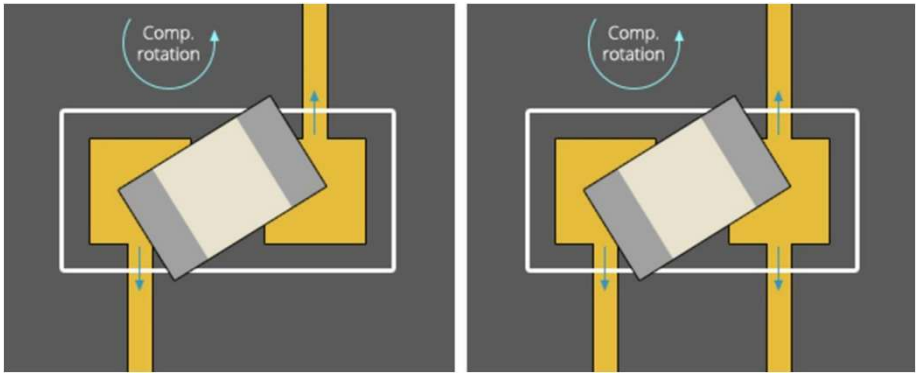
Why are there problems?

- Routing problems ?
- Solder Past problems ?
- Temperature problems ?
- Tools problemes ?

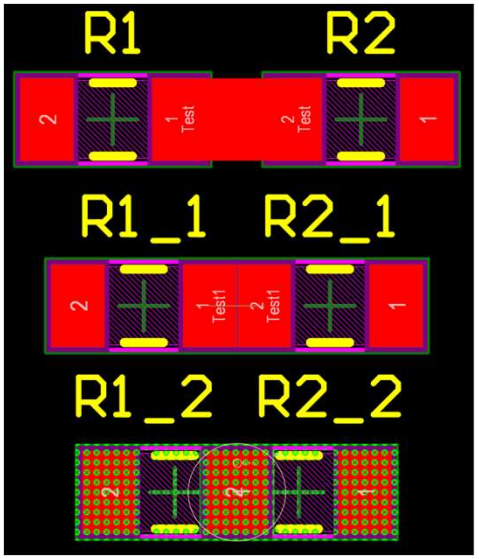
Considerations for Routing Two-Legged Components



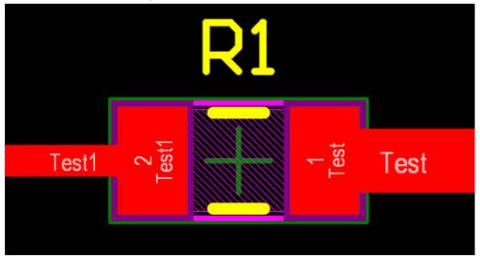
Recommended routing
(arrows indicate the direction of component movement)

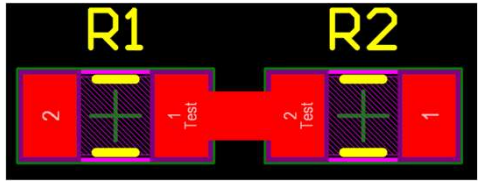


Routing not recommended
(arrows indicate the direction of component movement)



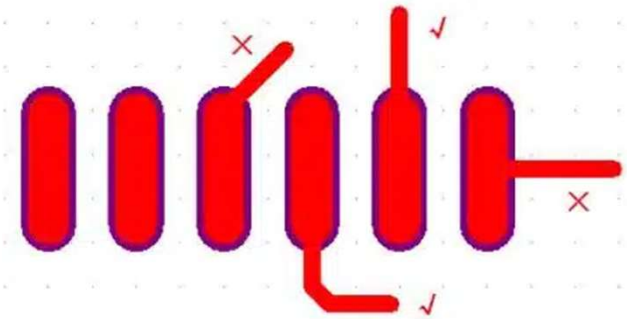
Routing not recommended



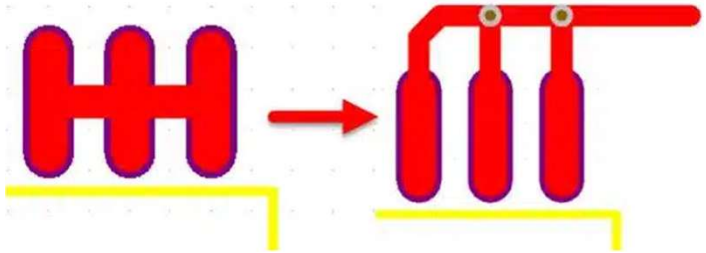


Recommended routing

Considerations for Routing Multi-Legged Components Inline

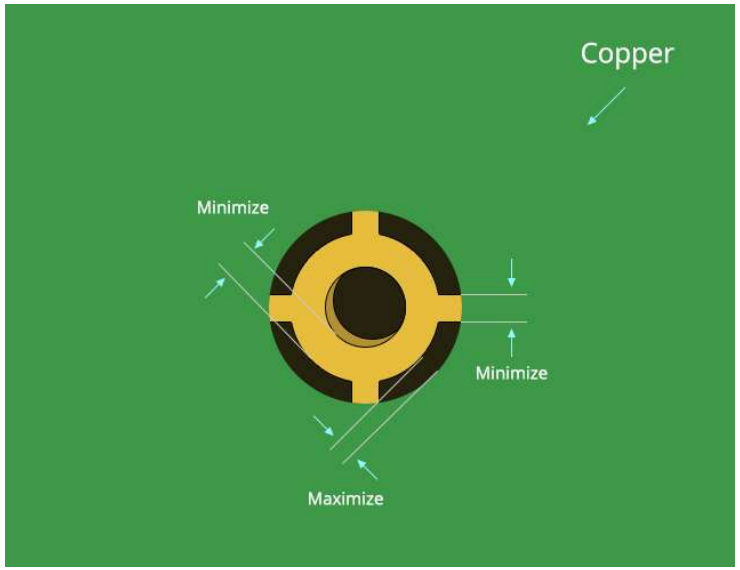


Correct routing of tracks from pads

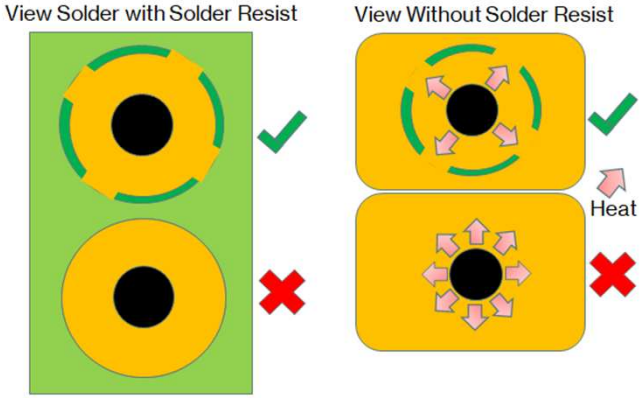


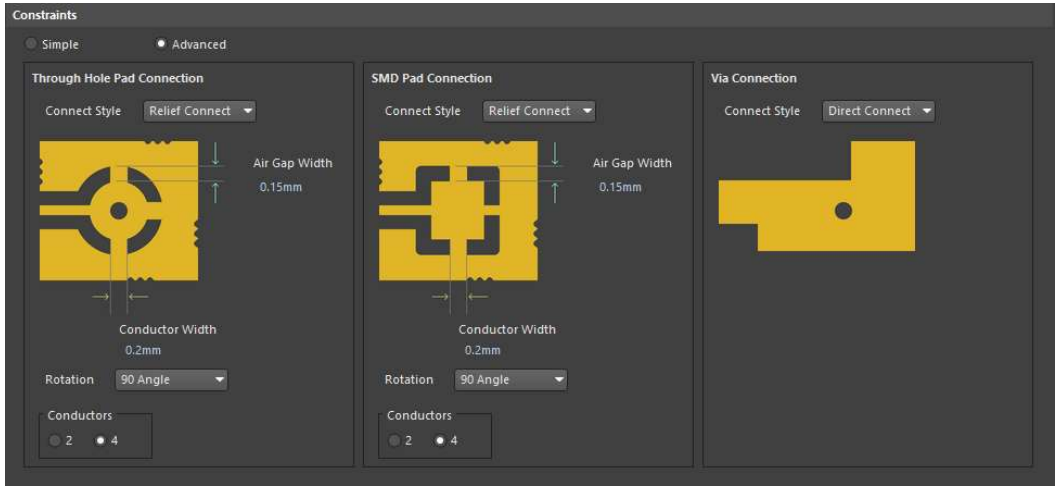
Connection strategy for adjacent solder pads

Considerations for routing components to copper planes

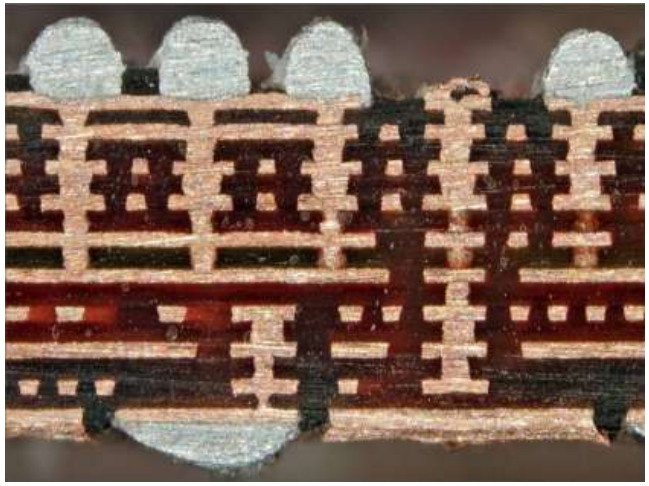


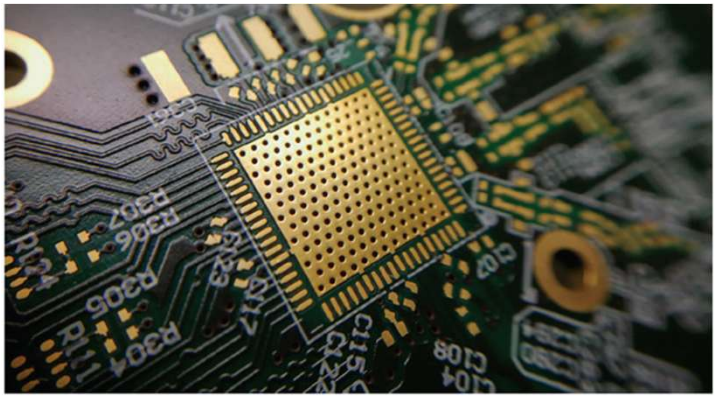
Typical diagram of a thermal brake



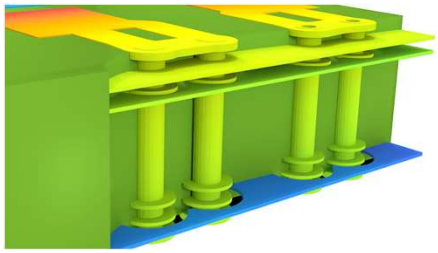


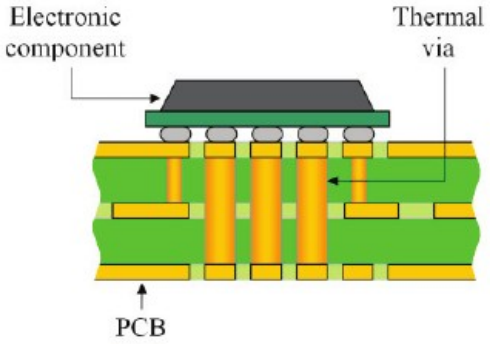
PCB problems

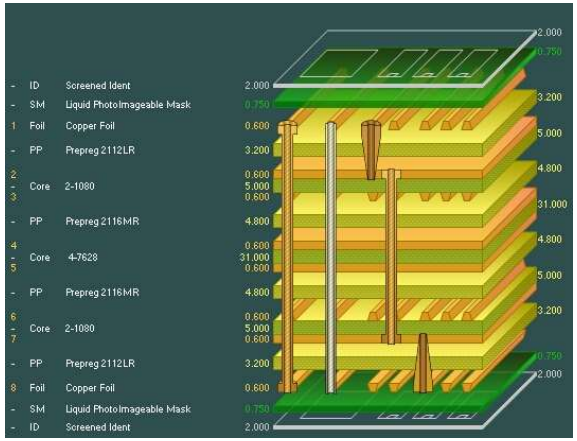


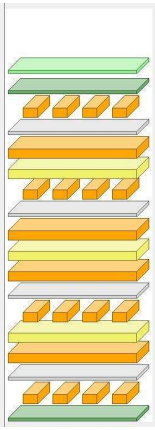


A QFN package with PCB thermal vias to assist with heat dissipation.







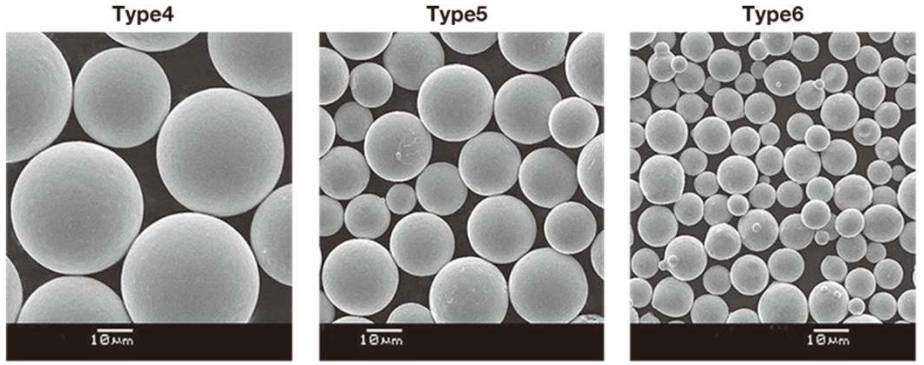


Layer Name	Type	Material	Thickness (mil)	Dielectric Material	Dielectric Constant
TOP SILK	Overlay				
TOP MASK	Solder Mask/Cover	Surface Material	0.04	Solder ...	3.5
Top	Signal	Copper	1.417		
Dielectric1	Dielectric	Prepreg	5	FR-4	4.2
Layer02	Internal Plane Gnd	Copper	0.7		
Dielectric 10	Dielectric	Core	10		4.2
Layer03	Signal	Copper	0.7		
Dielectric 5	Dielectric	Prepreg	10		4.2
Layer04	Internal Plane Gnd	Copper	0.7		
Dielectric 3	Dielectric	Core	4		4.2
Layer05	Internal Plane Pwr	Copper	0.7		
Dielectric 2	Dielectric	Prepreg	10		4.2
Layer06	Signal	Copper	0.7		
Dielectric 8	Dielectric	Core	10		4.2
Layer07	Internal Plane Gnd	Copper	0.7		
Dielectric 9	Dielectric	Prepreg	5		4.2
Bottom	Signal	Copper	1.417		
BOT MASK	Solder Mask/Cover	Surface Material	0.04	Solder ...	3.5

Solder Past Size, Flux, Alloy

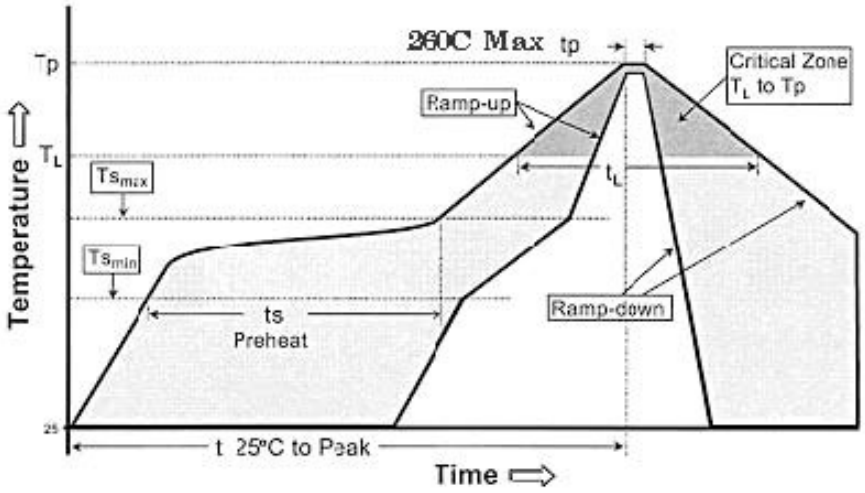
Type	Less than 0.5% larger than	10% Max. between	80% Min. Between	10% Max. Less than
1	160	150-160	75-150	75
2	80	75-80	45-75	45
3	60	45-60	25-45	25
4	50	38-50	20-38	20
5	40	25-40	15-25	15
6	25	15-25	5-15	5
7	15	11-15	2-11	2

Lead-Based, Lead-Free,
No-Clean, Water-Soluble, Rosin-based



Size Standard	0603	0402	03015	0201
Type 4				
Type 5				
Type 6				

Temperature problems

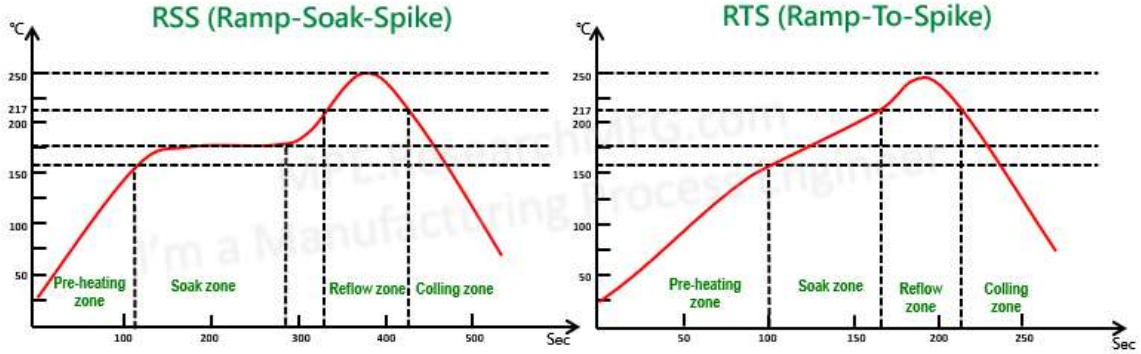


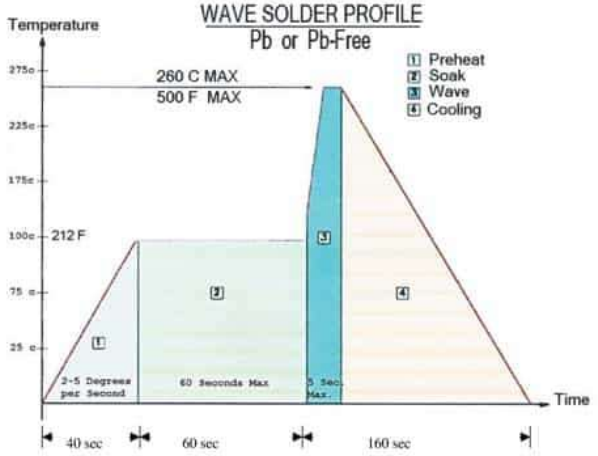
"TYPICAL" SMT REFLOW (Pb and Pb-Free)

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3 °C/second max.	3 °C/second max.
Preheat		
-Temperature Min (Ts_{min})	100 °C	150 °C
-Temperature Max (Ts_{max})	150 °C	200 °C
-Time (ts_{min} to ts_{max})	60-120 seconds	60-180 seconds
Time maintained above:		
-Temperature (T_L)	183 °C	217 °C
-Time (t_L)	60-150 seconds	60-150 seconds
Time within 5 °C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-Down Rate	6 °C/second max.	6 °C/second max.
Time 25 °C to Peak Temperature	6 minutes max.	8 minutes max.

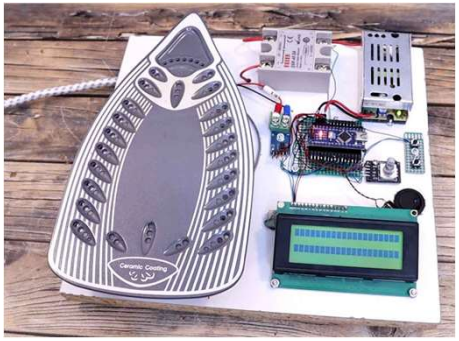
Note 1: *All temperatures refer to topside of the package, measured on the package body surface.*

Considerations for SMT Reflow Temperature Profiles

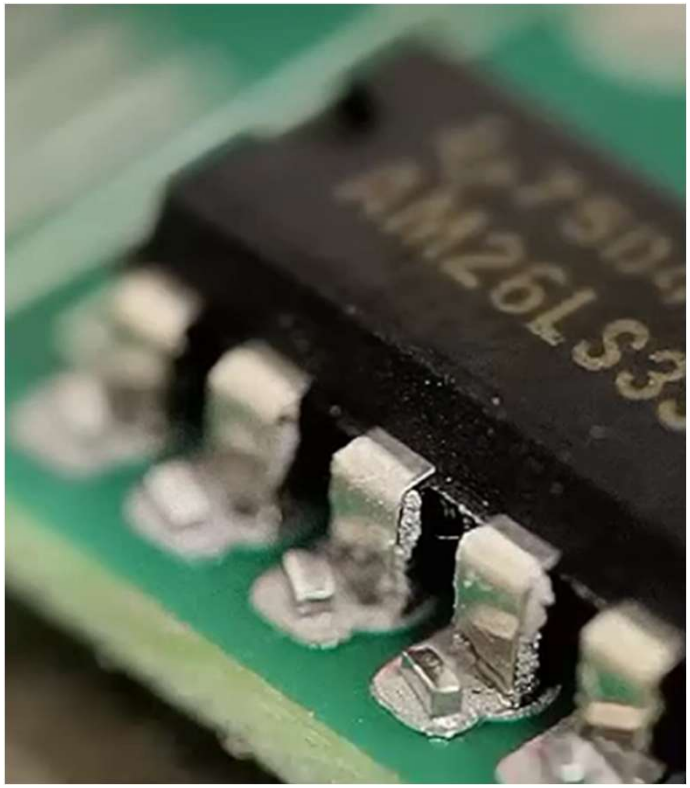




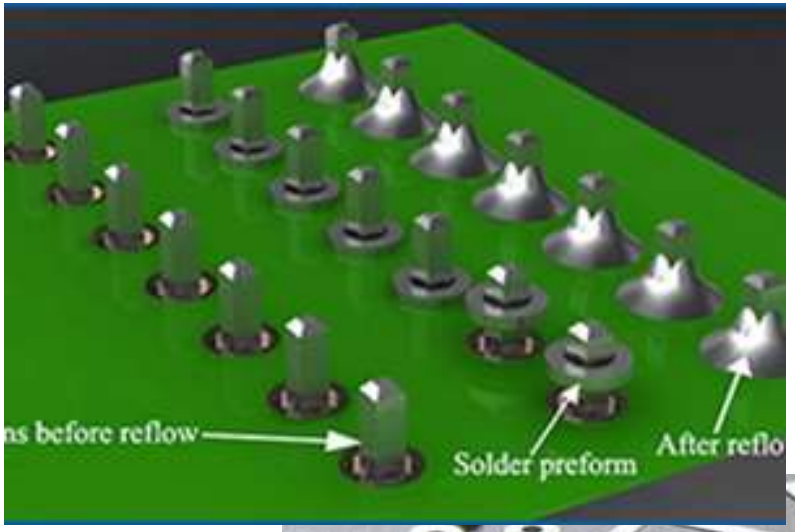
Tools problems



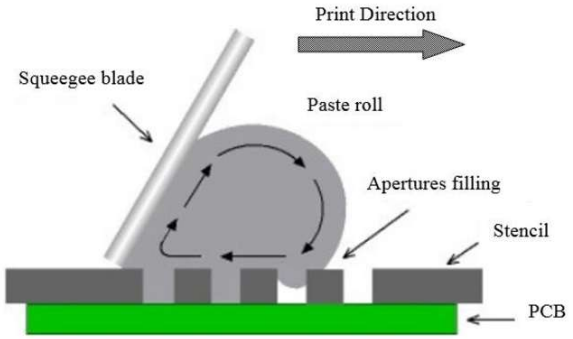
Preform (with or without solder past)

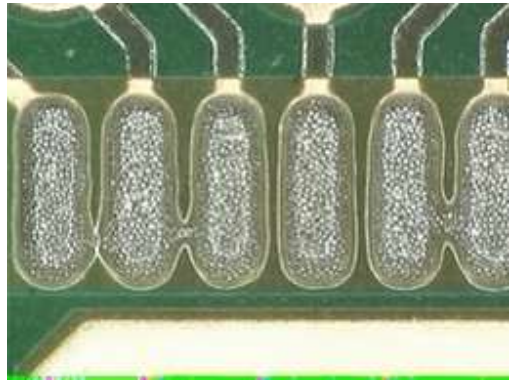


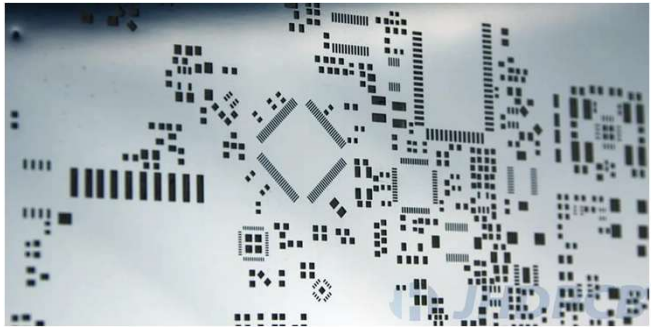
https://www.youtube.com/watch?v=-PtyE3vijSs

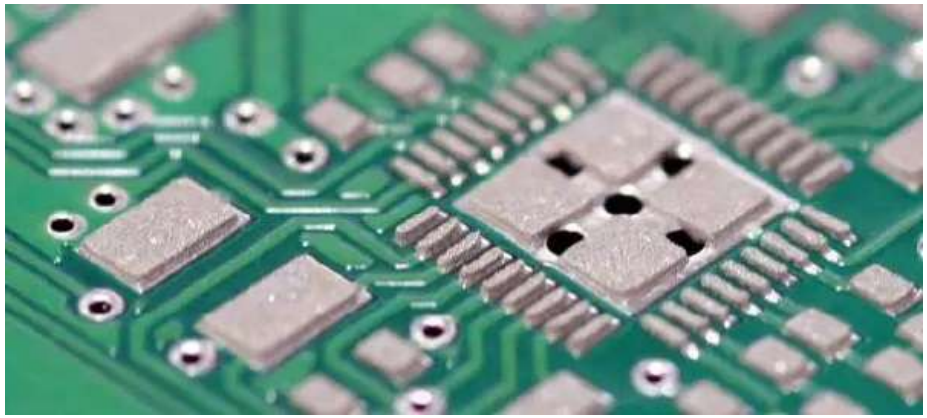


Solder Past (stencil or printing)

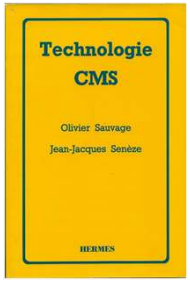








Recommandations de lecture



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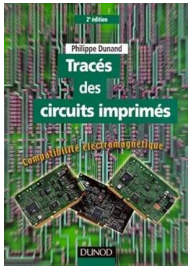

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