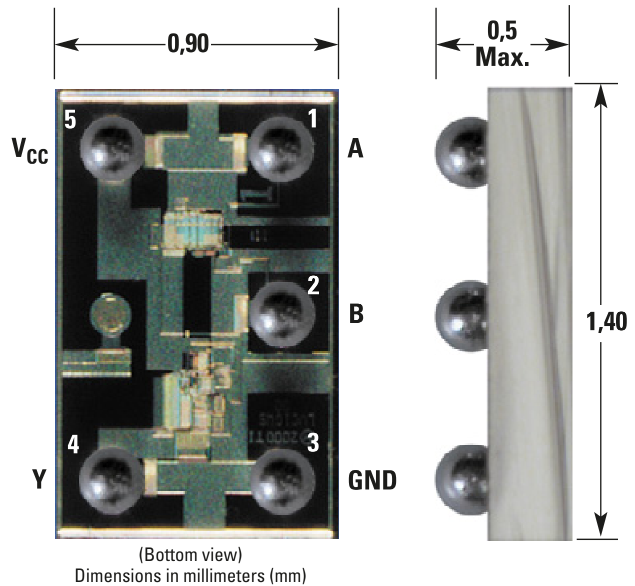
Design Summary for WCSP Little Logic

www.ti.com/nanostar

Introduction to NanoStar and NanoFree

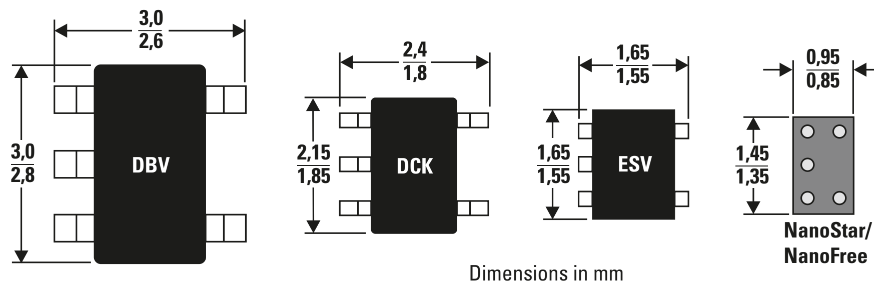
As the marketplace continues to demand size reductions in various consumer electronic products such as cell phones, PDAs, MP3/CD players and other portable devices, the need for smaller logic packaging becomes paramount. The major challenge of today's digital processing industry is the overall system cost reduction as complexity and functionality increase. These marketplace forces have resulted in circuit integration and board miniaturization becoming a necessary trend for successful competition. To address these rapidly evolving customer requirements, TI has defined the latest innovation in logic packaging: NanoStar™ and NanoFree™. This is a wafer-chip-scale package (WCSP) and, to date, is the world's smallest 5-, 6- and 8-pin logic solution for Little Logic functions. NanoStar and NanoFree are registered under JEDEC MO-211, and are the only wafer-level logic solutions available to date. NanoStar uses an eutectic SnPb ball, and NanoFree uses a Pb-free (SnAgCu) ball. Other than ball metallurgy, there is no difference between NanoStar (YEP) and NanoFree (YZP). TI offers both a small ball and a large ball version of the WCSP.



(Bottom view)
Dimensions in millimeters (mm)

Package Designators
YEP = SnPb Large Ball
YZP = Pb-Free Large Ball

Package Data



Dimensions in mm

Package Comparison

Package Data	SOT-23 (5-pin) TI – DBV	SC-70 (5-pin) TI – DCK	ESV	WCSP (5-/6-pin) TI – YEP/YZP
Length (mm)	2,90 ± 0,10	2,00 ± 0,15	1,60 ± 0,05	1,40 ± 0,05
Width (mm)	2,80 ± 0,20	2,10 ± 0,30	1,60 ± 0,05	0,90 ± 0,05
Height Max (mm)	1,45	1,10	0,60	0,50
Footprint Area (mm²)	8,12	4,20	2,56	1,26
Approx. Weight (g)	0,0135	0,006	0,003	≤0,000998

Package Data (Continued)

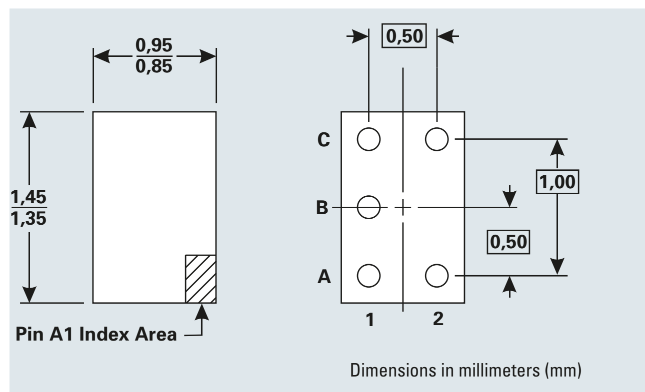
Dual-/Triple-Gate Comparison

Package Data	SOT-23 (6-pin) TI – DBV	SC-70 (6-pin) TI – DCK	SSOP (8-pin) TI – DCT	VSOP (8-pin) TI – DCU	WCSP (8-pin) TI – YEP/YZP
Length (mm)	2,90 ± 0,10	2,00 ± 0,15	2,95 ± 0,20	2,0 ± 0,10	1,90 ± 0,05
Width (mm)	2,80 ± 0,20	2,10 ± 0,30	4,0 ± 0,25	3,10 ± 0,10	0,90 ± 0,05
Height (mm)	1,20 ± 0,25	0,95 ± 0,15	1,30 max	0,90 max	0,50 max
Footprint Area (mm^2)	8,12	4,20	11,80	6,20	1,71
Weight (g)	0,0135	0,006	0,0206	0,0095	0,0013

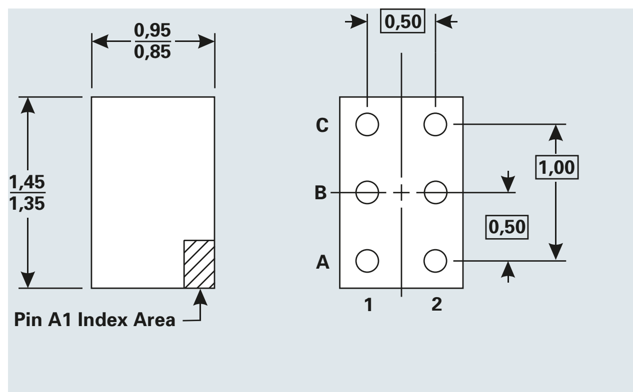
Package Attributes

Attribute	5-Ball	6-Ball	8-Ball
Ball Pitch (mm)	0,5	0,5	0,5
Ball Diameter (mm)	Small Ball = 0,17 Large Ball = 0,23	Small Ball = 0,17 Large Ball = 0,23	Small Ball = 0,17 Large Ball = 0,23
Package Length (mm)	1,4	1,4	1,9
Package Width (mm)	0,9	0,9	0,9
Package Height (mm)	0,5 max	0,5 max	0,5 max
Ball Matrix (rows, columns)	3 x 2, depopulate 1	3 x 2	4 x 2
Weight (mg)	Small Ball = 0,995 Large Ball = 1,07	Small Ball = 0,998 Large Ball = 1,13	Small Ball = 1,30 Large Ball = 1,53
Ball Metallurgy	SnPb or Pb-Free	SnPb or Pb-Free	SnPb or Pb-Free
Moisture Level	Level 1 @ 260°C	Level 1 @ 260°C	Level 1 @ 260°C

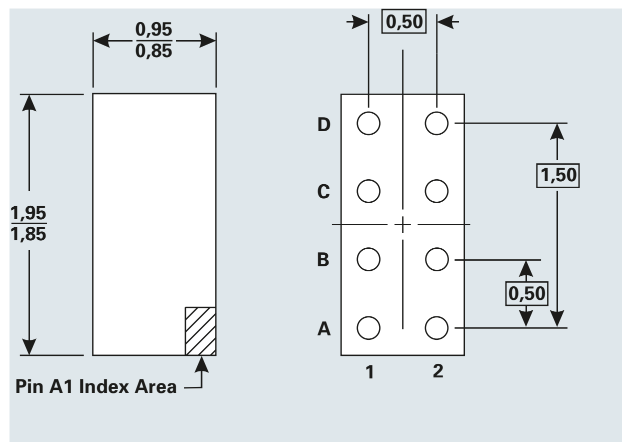
5-Ball Package



6-Ball Package

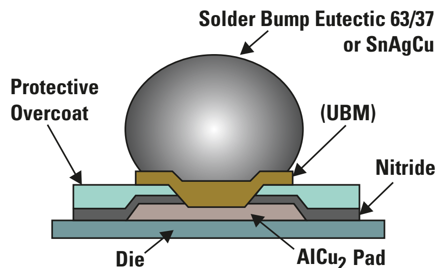


8-Ball Package

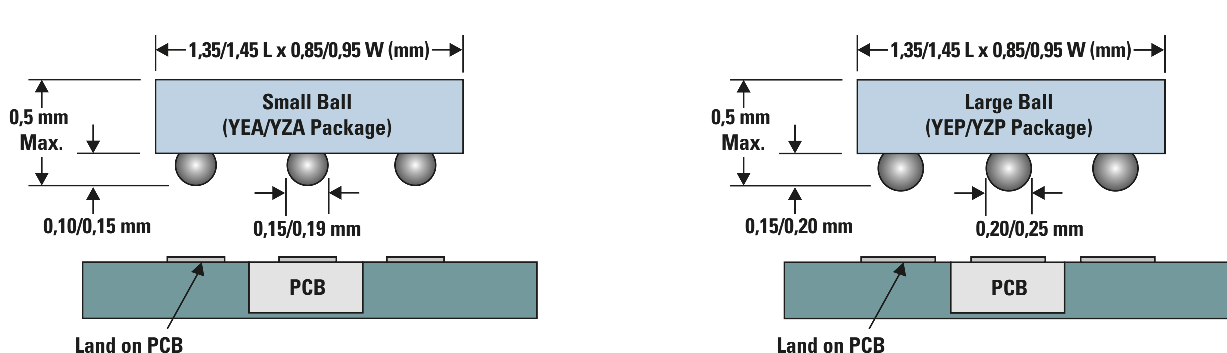


PCB Design Guidelines

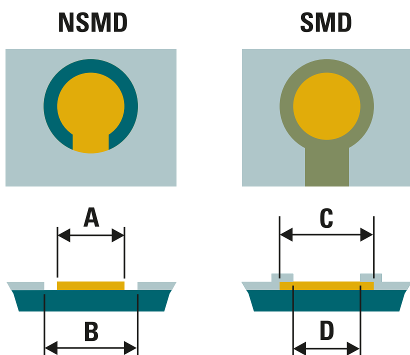
Solder Ball Composition



Package Area Configuration (0,5-mm Ball Pitch)

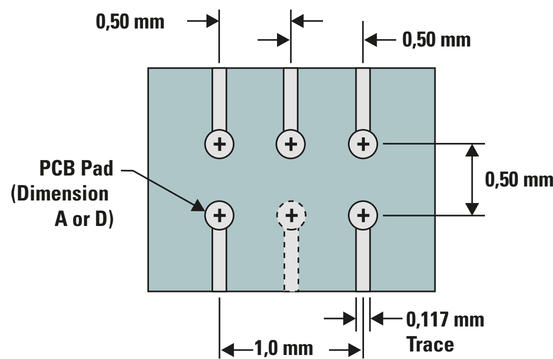


PCB Design

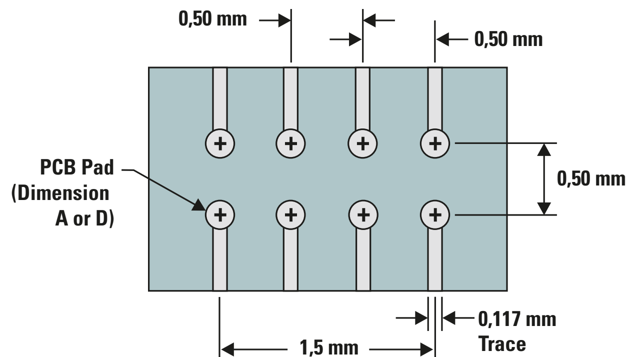


Non-Solder Mask Defined (NSMD) Preferred Method		Solder Mask Defined (SMD)	
Copper Pad	Solder Mask Opening	Copper Pad	Solder Mask Opening
"A"	"B"	"C"	"D"
Small Ball (YEA, YZA)			
0,175 mm + 0,0/–0,025 mm	0,350 mm ± 0,025 mm	0,350 mm ± 0,025 mm	0,175 mm + 0,0/–0,025 mm
Large Ball (YEP, YZP)			
0,225 mm ± 0,025 mm	0,350 mm ± 0,025 mm	0,350 mm ± 0,025 mm	0,225 mm ± 0,025 mm

5-/6-Ball PCB Pattern



8-Ball PCB Pattern



Note: Trace width shall be ≤ ⅔ pad diameter.

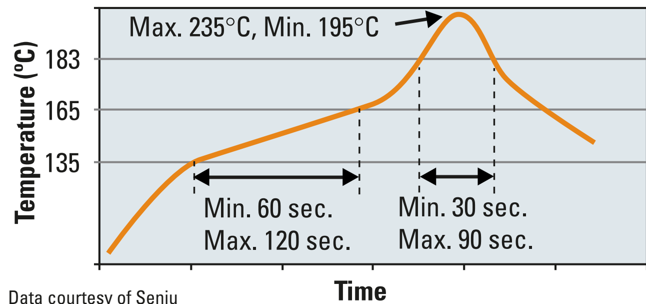
IR Reflow Profile

Reflow Parameters

	Pb Assy	Pb Free
Ramp Rate:	3°C/sec. Max.	3°C/sec. Max.
Preheat	135 to 165°C	150 to 180°C
	60 to 120 sec.	60 to 120 sec.
Time Above Liquidus:	183°C 30 to 90 sec.	220°C 30 to 90 sec.
Peak Temp.	235°C ±5°C	255°C ±5°C
Time Within 5°C Peak Temp.	20 to 40 sec.	20 to 40 sec.
Ramp Down Rate	6°C/sec. Max.	6°C/sec. Max.

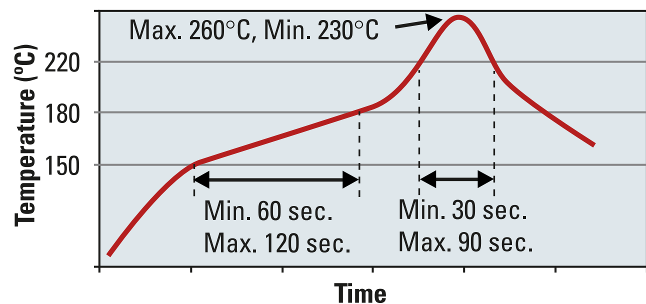
Note: These are ideal profiles, and actual conditions obtained in any specified reflow oven will vary. The profiles are based on convection or RF plus forced convection heating.

SnPb Eutectic (AT-Alloy and S2062) Recommended Temperature Profile



Data courtesy of Senju

Pb-Free Ball NanoFree Recommended Temperature Profile



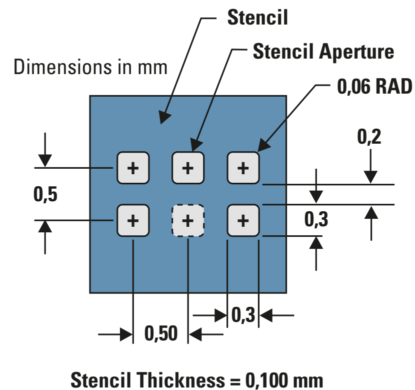
Stencil Vitals

Solder Paste

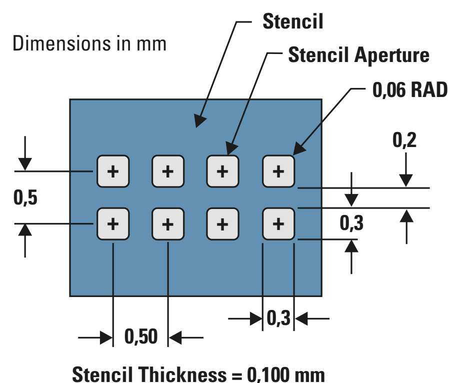
TI recommends the use of type 3 or finer solder paste when mounting the WCSP package. The use of paste offers the following advantages:

- Paste aids wetting of the solder ball to the PCB land.
- The adhesive properties of the paste will hold the component in place during reflow.
- Paste contributes to the final volume of solder in the joint, and thus allows this volume to be varied to give an optimum joint.
- Paste selection is normally driven by overall system assembly requirements. In general, the "no clean" compositions are preferred due to the difficulty in cleaning under the mounted components.

5-/6-Ball Solder Stencil (Small/Large Ball)



8-Ball Solder Stencil (Small/Large Ball)



Thermal Characteristics

Thermal Impedance Values at Various Airflow Rates (Model data per JESD 51-7 and JESD 51-3)

Package		Thermal Impedance	Airflow (linear ft/minute)			
			0	150	250	500
Small Ball						
5-Ball	1S0P	$R_{\theta JA}$ (°C/W)	251.66	233.62	224.28	211.12
		$R_{\theta JC}$ (°C/W)	21.4	—	—	—
	1S2P	$R_{\theta JA}$ (°C/W)	154.32	152.05	150.73	148.72
		$R_{\theta JC}$ (°C/W)	18.75	—	—	—
6-Ball	1S0P	$R_{\theta JA}$ (°C/W)	236.83	219.01	210.02	197.39
		$R_{\theta JC}$ (°C/W)	21.03	—	—	—
	1S2P	$R_{\theta JA}$ (°C/W)	143.47	141.14	139.87	137.93
		$R_{\theta JC}$ (°C/W)	18.48	—	—	—
8-Ball	1S0P	$R_{\theta JA}$ (°C/W)	236.59	218.76	209.46	196.32
		$R_{\theta JC}$ (°C/W)	16.45	—	—	—
	1S2P	$R_{\theta JA}$ (°C/W)	139.87	137.69	136.34	134.34
		$R_{\theta JC}$ (°C/W)	14.80	—	—	—
Large Ball						
5-Ball	1S2P	$R_{\theta JA}$ (°C/W)	131.56	129.26	128	126.08
		$R_{\theta JC}$ (°C/W)	18.0	—	—	—
6-Ball	1S2P	$R_{\theta JA}$ (°C/W)	123.36	121.03	119.8	119.3
		$R_{\theta JC}$ (°C/W)	17.6	—	—	—
8-Ball	1S2P	$R_{\theta JA}$ (°C/W)	101.92	99.69	98.5	96.75
		$R_{\theta JC}$ (°C/W)	13.79	—	—	—

Board-Level Reliability Data

	Board-Level Reliability N_1 (cycles to first failure)
NanoStar/NanoFree (YEA/YZA)	>1000 cycles

No underfill or adhesive was used, nor is required for these packages.

Test Parameters:
- 2 cycles/hr: –40 to +125°C
- 0.8-mm thick FR4 epoxy board
- per IPC-9701, TC3, NTC-C

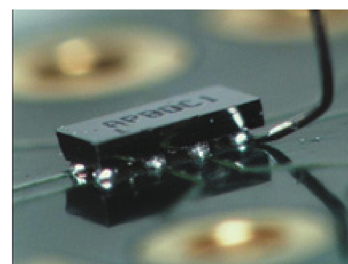
Board Mounting Pick-up Tools

Due to the package size and configuration, a rectangular or circular shaped pick-up tool is recommended. It also is recommended that the tool have an outside diameter smaller than the package body, with a compliant tip. Recommended placement force is 200 gF.

WCSP Testability

Solder Balls Provide Easy Access

Due to the ideal placement of the solder balls along the outside of the package along with sufficient ball height, probe tips can easily create a dedicated contact to the individual pins.



Electrical Characteristics

WCSP Package (YEA/YZA)

	R (Ω)	L (nH)	C (pF)		
			5-Ball	6-Ball	8-Ball
Mean	0.001	0.021	0.046	0.046	0.043

Note: Electrical package parasitic was achieved through electrical modeling and is based on a 3D model. Actual electrical data may differ slightly from simulated results.

Little Logic Product Portfolio Electrical Performance

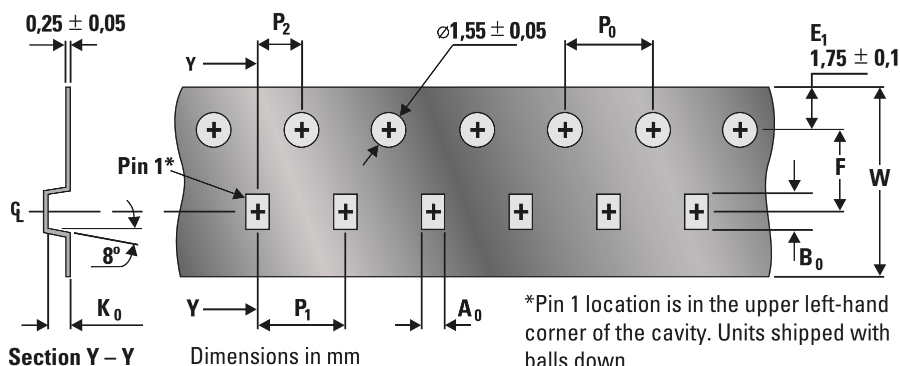
Family	Operating Voltage Range (V)	Optimized Voltage (V)	Propagation Delay (typ) (ns)	Output Drive (mA)	Input Tolerance (V)	I_{OFF} Protection
AUP	0.8 to 3.6	3.3	3.5	4	3.6	Yes
AUC	0.8 to 2.7	1.8	2.0	8	3.6	Yes
LVC	1.65 to 5.5	3.3	3.5	24	5.5	Yes
AHC	2.0 to 5.5	5	5.0	8	5.5	No
AHCT	4.5 to 5.5	5	5.0	8	5.5	No
CBT	4.5 to 5.5	5	0.25*	—**	5.5	Yes
CBTD	4.5 to 5.5	5	0.25*	—**	5.5	Yes
CBTLV	2.3 to 3.6	3.3	0.25*	—**	3.6	Yes

*The propagation delay is the calculated RC time constant of the typical on-state resistance of the switch and the specified load capacitance when driven by an ideal voltage source (zero output impedance). The value listed is a maximum.

**The FET switch has no output drive. The drive current at the output terminal is determined by the drive current of the device connected at the input terminal of the FET switch.

Packaging Tape and Reel

Reel Tape Configuration (Small/Large Ball)



Dimensions	5- and 6-Ball	8-Ball
Pocket Width, A_0 (mm)	1,10 ± 0,05	1,10 ± 0,05
Pocket Length, B_0 (mm)	1,60 ± 0,05	2,10 ± 0,05
Pocket Depth, K_0 (mm)	0,56 ± 0,05	0,56 ± 0,05
Pocket Pitch, P_1 (mm)	4,0 ± 0,1	4,0 ± 0,1
Sprocket Hole-to-Pocket Centerline, F (mm)	3,50 ± 0,05	3,50 ± 0,05
Sprocket Hole-to-Pocket Offset, P_2 (mm)	2,0 ± 0,05	2,0 ± 0,05
Sprocket Hole Pitch, P_0 (mm)	4.,00 ± 0,1	4,00 ± 0,1
Tape Width, W (mm)	8,00 ± 0,3	8,00 ± 0,3
Reel Diameter (mm) Max.	178	178

Rework Procedure

There are several rework equipment vendors in the market offering well designed equipment and established processes. Air-Vac Engineering (www.air-vac-eng.com) has established NanoStar reflow profiles for both convection and contact heat (conduction) rework processes. A typical process for the convection using DRS-24NC equipment for a 0.056-inch thick FR4 board can be:

Eutectic Balls

1) Apply flux to component using Auto Flux feature of DRS24
2) Align device over pads
3) Place device on board
4) Raise nozzle .050"
5) Preheat board to 90°C, nozzle warming up 20% air flow, 100°C
6) Soak Stage—20% air flow, 200°C, 90 seconds
7) Ramp Stage—20% air flow, 300°C, 30 seconds
8) Reflow Stage—25% air flow, 325°C, 55 seconds
9) Cooldown Stage—40% air flow, 25°C, 30 seconds

Pb-Free Balls
Apply flux to component using Auto Flux feature of DRS24

1) Align device over pads
2) Place device on board
3) Raise nozzle .050"
4) Preheat board to 90°C, nozzle warming up 20% air flow, 125°C
5) Soak Stage—20% air flow, 225°C, 90 seconds
6) Ramp Stage—20% air flow, 335°C, 30 seconds
7) Reflow Stage—25% air flow, 370°C, 65 seconds
8) Cooldown Stage—40% air flow, 25°C, 50 seconds

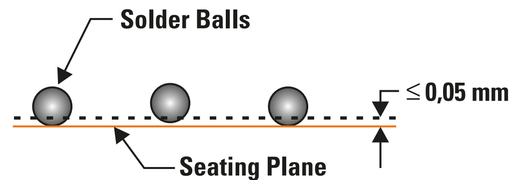
The recommended tooling for both the convection and conduction processes is:

Process	Nozzle Description	Nozzle Part Number	Tray
Hot Gas	NanoStar .0365" x .0560" x .0155" 5-ball	N09DVG-7	A04DVG06
Contact	NanoStar .0365" x .0560" x .0155" 5-ball	CE037-056TI	A0201X8-OX

Geometric Dimensional Tolerances

Coplanarity

This package meets a coplanarity of 0,05 mm as shown. Coplanarity is defined as a unilateral tolerance zone measured upward from the seating plane.
(Reference ASME Y14.5M - 1994)



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