

Points of downsizing the chip multilayer ceramic capacitors -Notice for board design-version.4

Feb. 24, 2022

Murata Manufacturing Co., Ltd



For the purpose of products downsizing, the plan to displace smaller parts is under discussion. Consider that crack risk of board bending stress may be occurred, when a chip multilayer ceramic capacitors (MLCC as follows) is only changed its land size to 1005mm (0402 inch) or 0603mm (0201 inch), from existing 1608mm (0603 inch). Here are some points need to pay attention.

This material is to summarize the mechanism of the crack risk and the recommendation to improve safety on operating. As to use the MLCCs safely, we recommend you to read the material.

If you want to know more details about board bending stress, please refer to “Application Manual – Board bending stress –”in our website, my Murata.

Attention: The contents shown after 3.FEM simulation is just to show the analysis result of deflection test which was generated by using analysis software. This result does not guarantee any analysis result.

2. Comparison the deflection of the MLCC

2-1. Test condition

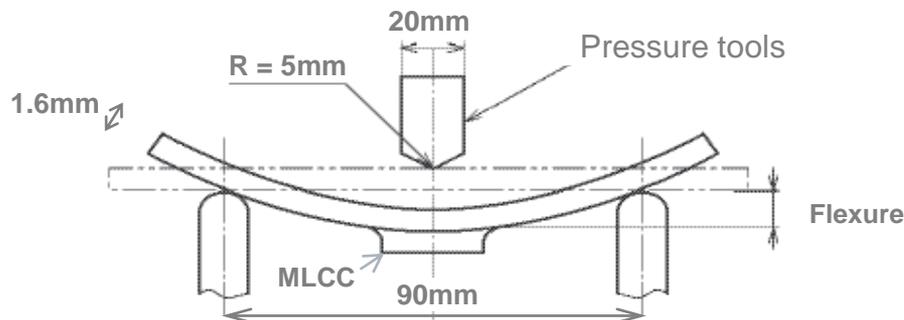
Comparison of deflection by using deflection test

Test Method:

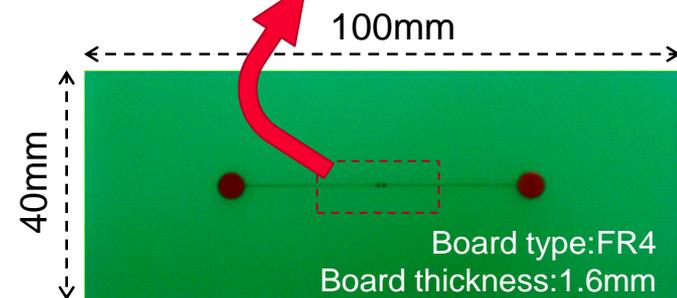
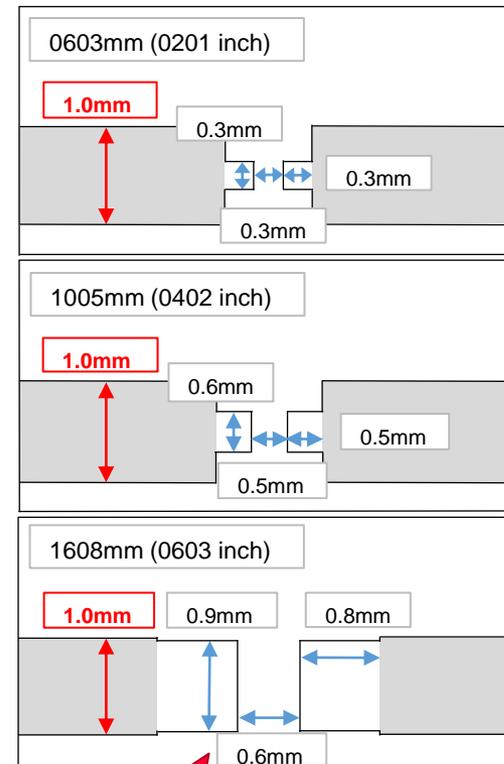
We only change land size according to MLCC size. We do not change any other factors. Wiring width is 1mm and copper foil thickness with plating is 35μm.

Test items:

0603mm (0201 inch), 1005mm (0402 inch), 1608mm (0603 inch)



Test method of deflection

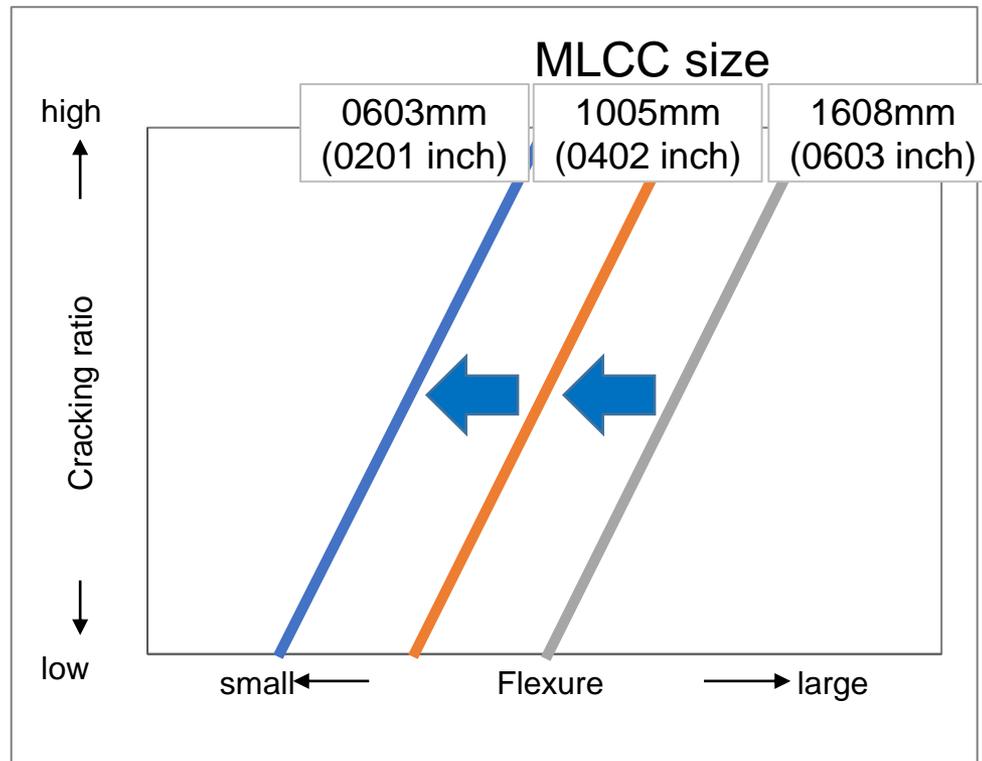


Substrate – Test board –

2. Comparison the deflection of the MLCC 2-2. Test result

This section shows the comparison of crack occurrence ratio against degree of flexure according to MLCC chip size.

When the wiring width is 1 mm and the copper foil thickness with plating is 35 μ m, the smaller the chip size is, the lower the deflection result is.

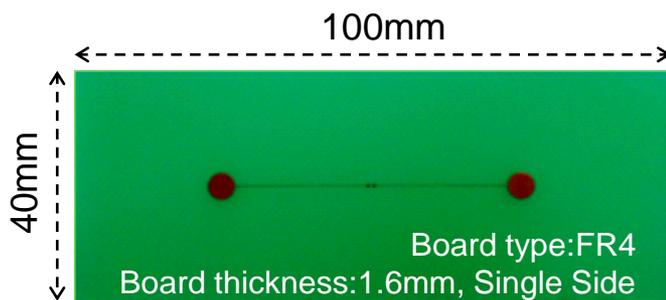


MLCC chip size and substrate bending test result graph

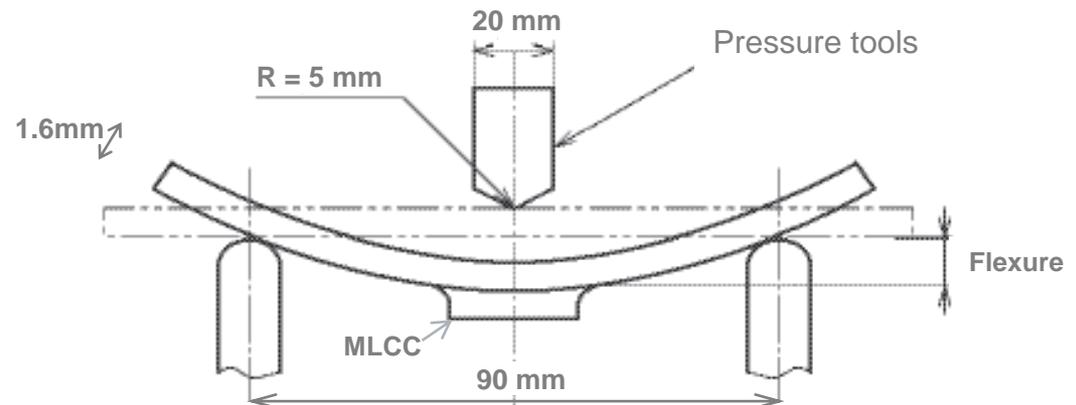
3 . FEM simulation

The board design can affect the mechanical stress generated in the capacitor. Please refer to “Application Manual – Board bending stress –”.

This material is to clarify how the board design influences the deflection test results. By using FEM analysis, we compare the stress that occurred in the edge of termination of MLCC.



Substrate – Test board –

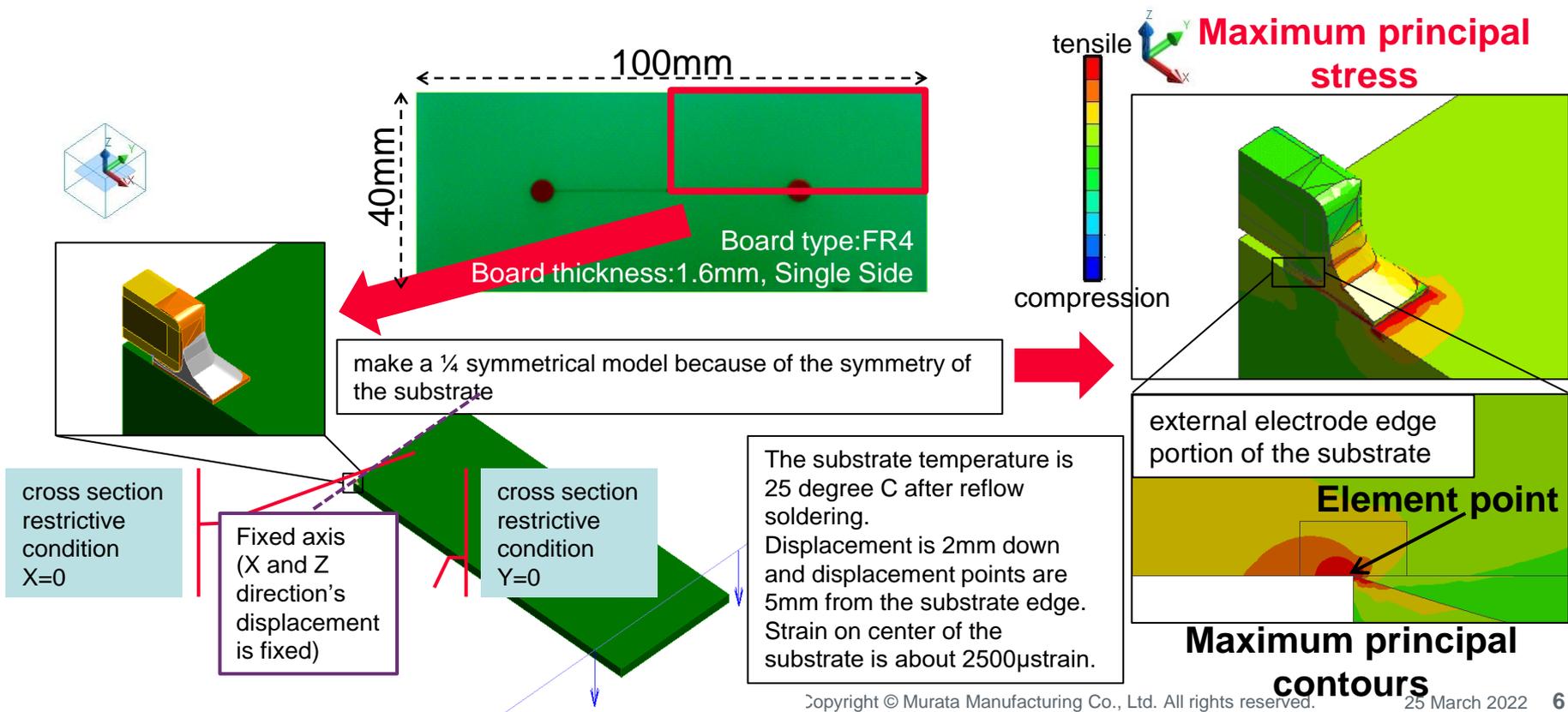


Test method of deflection

3 . FEM simulation

3-1. Analysis condition

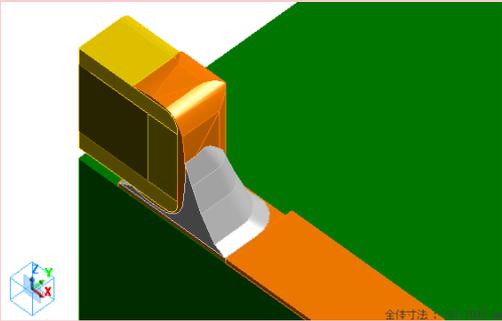
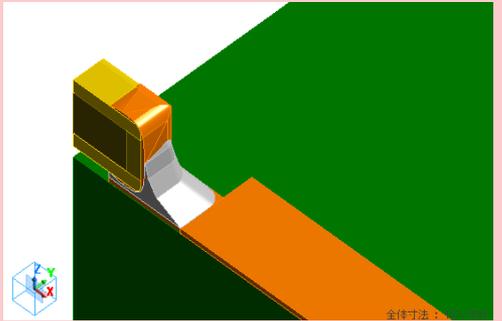
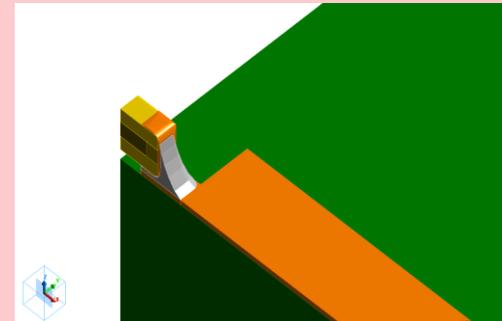
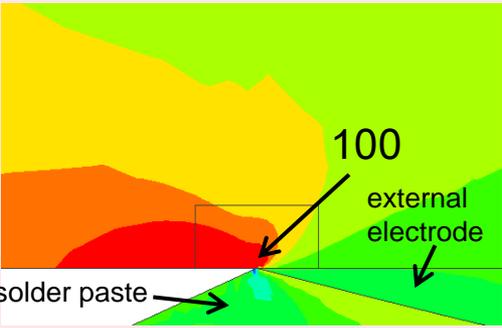
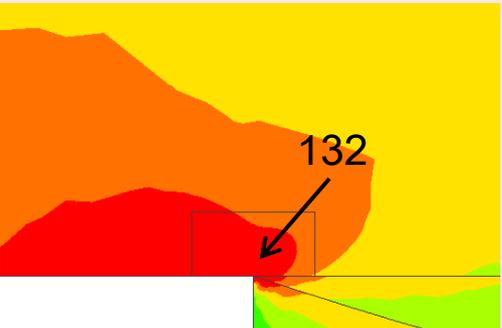
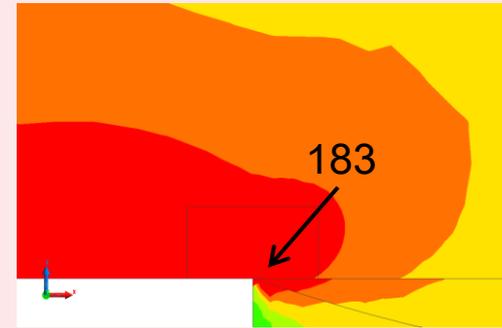
Analysis software	:Femtet®
Model	:Mechanical stress analysis, 3D ¼ or 3D ½ symmetrical model
Analysis type	:Elastic, 0MPa at 25 degree C before reflow soldering
Element	:Maximum principal stress
MLCC	:1608mm (0603 inch), 1005mm (0402 inch), 0603mm (0201 inch)
Wiring length of the substrate	:25mm



3 . FEM simulation

3-2.Comparison of MLCC size

Simulation model for deflection

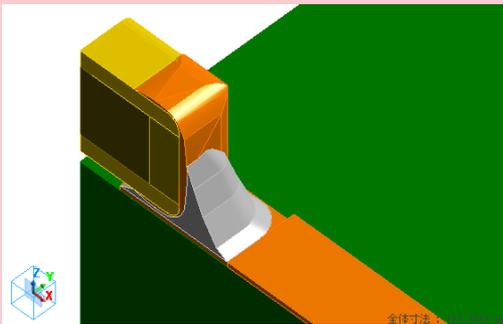
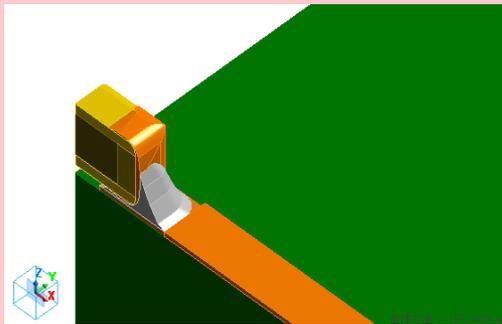
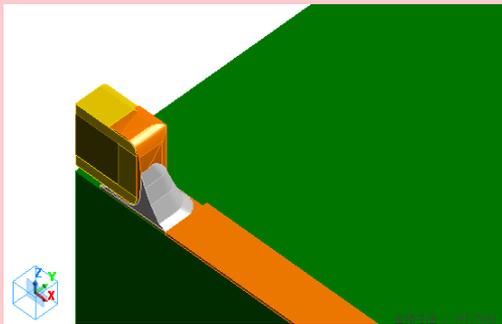
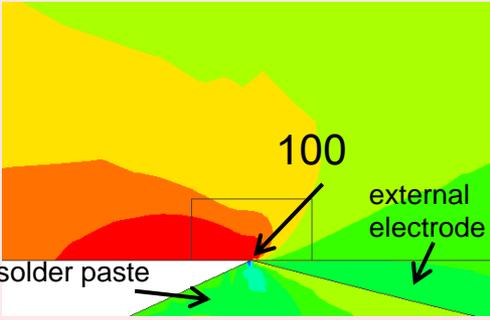
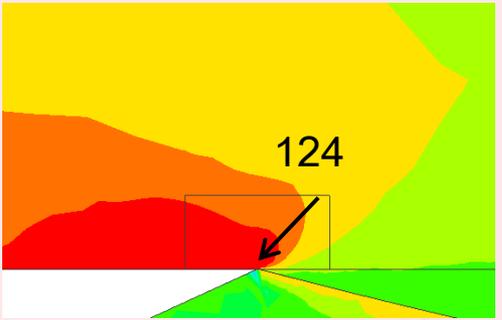
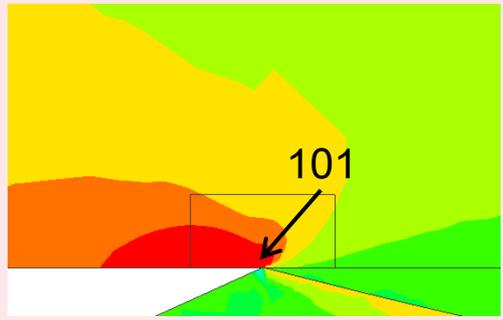
Size	1608mm (0603 inch)	1005mm (0402 inch)	0603mm (0201 inch)
Wiring width	1mm	1mm	1mm
Copper foil	35 μ m	35 μ m	35 μ m
Analysis model ($\frac{1}{4}$ symmetrical model)			
Analysis result (Maximum principal contours)			
	the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100		

When MLCC size is smaller under the same wiring width, the stress applied on the MLCC is higher.

3 . FEM simulation

3-2.Comparison of MLCC size

Verification by similarity contraction(1005mm (0402 inch))

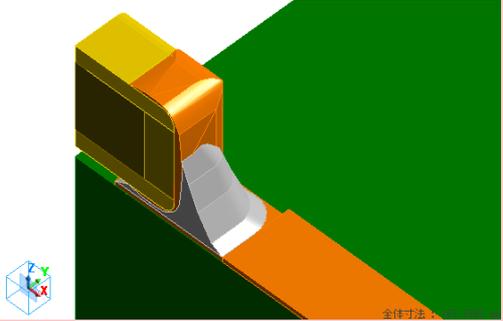
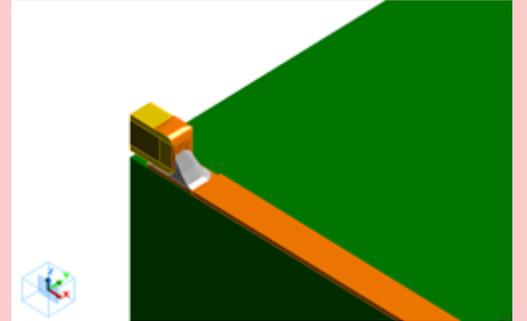
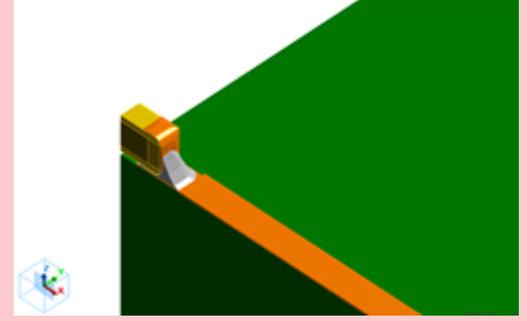
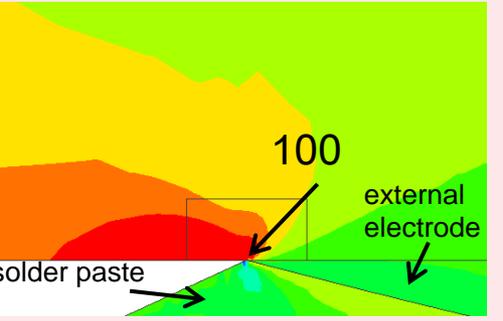
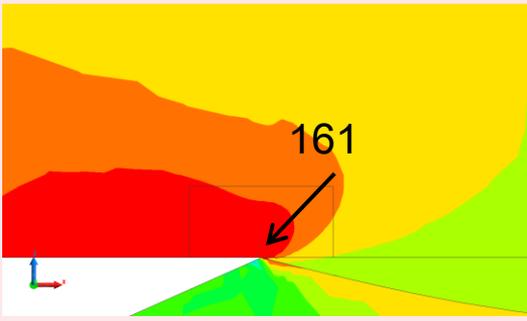
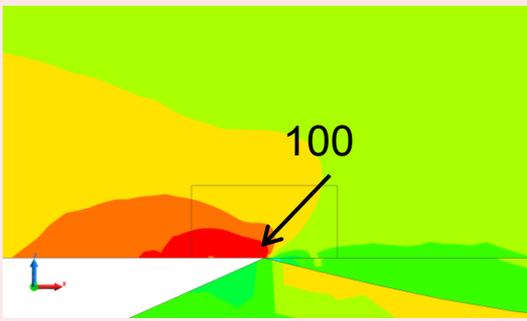
Size Wiring width Copper foil	1608mm (0603 inch) 1mm 35μm	1005mm (0402 inch) (similarity contraction) 0.625mm(similarity contraction) 35μm	1005mm (0402 inch) (similarity contraction) 0.625mm(similarity contraction) 22μm(similarity contraction)
Analysis model (¼ symmetrical model)			
Analysis result (Maximum principal contours) tensile  compression			
	<p>Solder paste and land size are also contracted similarly. There is no change in substrate resin.</p> <p>the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100</p>		

When wiring width and copper foil is changed, based on MLCC downsizing, the stress applied on the MLCC is approximately same level.

3 . FEM simulation

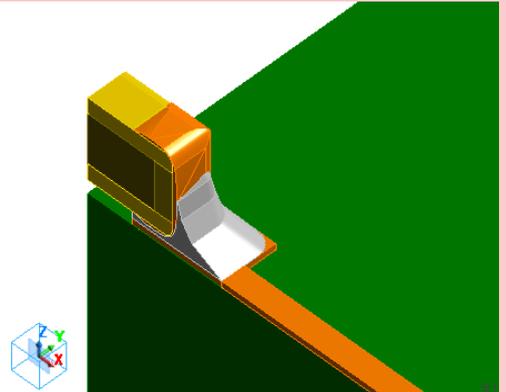
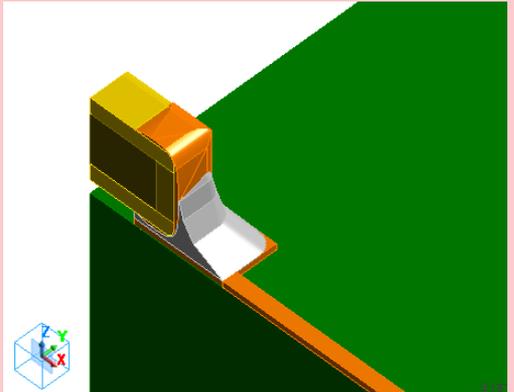
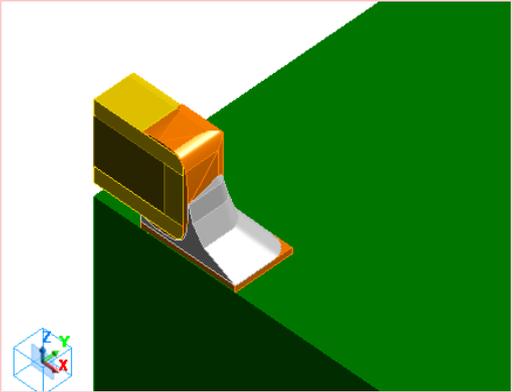
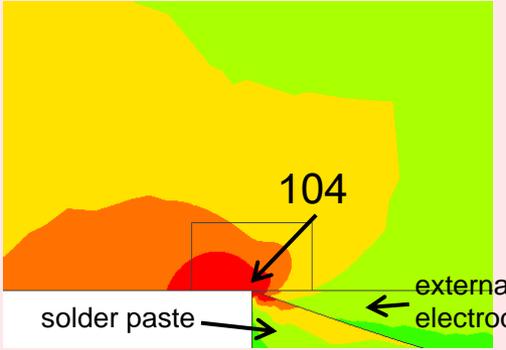
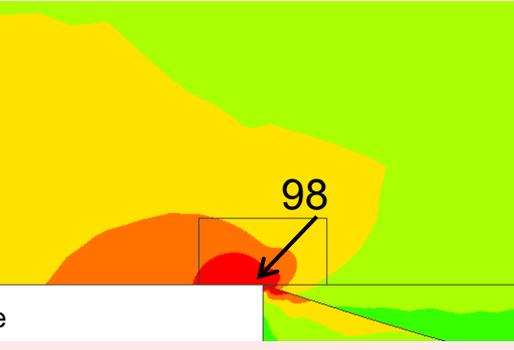
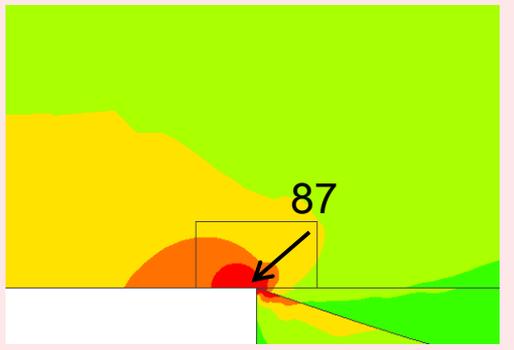
3-2.Comparison of MLCC size

Verification by similarity contraction(0603mm (0201 inch))

Size Wiring width Copper foil	1608mm (0603 inch) 1mm 35μm	0603mm (0201 inch) (similarity contraction) 0.375mm(similarity contraction) 35μm	0603mm (0201 inch) (similarity contraction) 0.375mm(similarity contraction) 13μm(similarity contraction)
Analysis model (¼ symmetrical model)			
Analysis result (Maximum principal contours) tensile  compression	 <p>external electrode</p> <p>solder paste</p>		
	<p>the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100</p>		

When wiring width and copper foil is changed, based on MLCC downsizing, the stress applied on the MLCC is approximately same level.

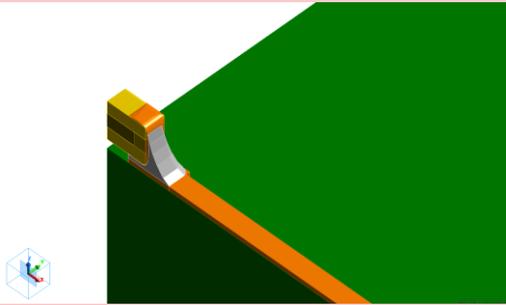
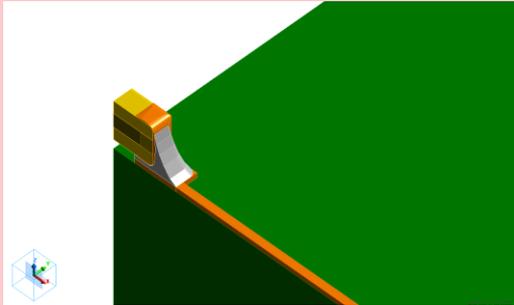
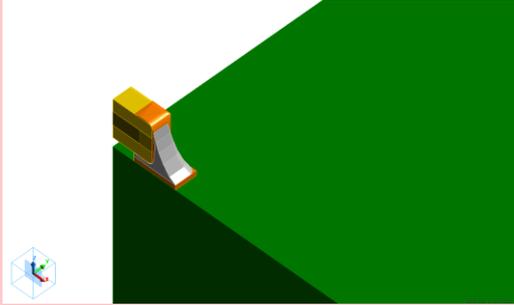
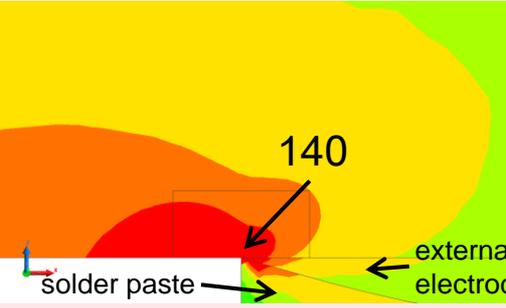
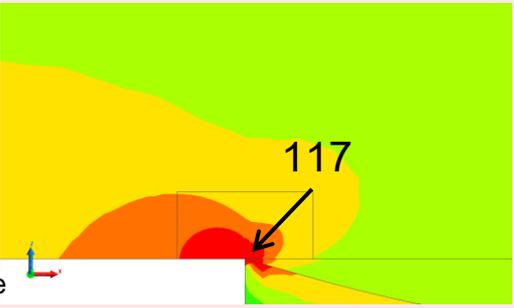
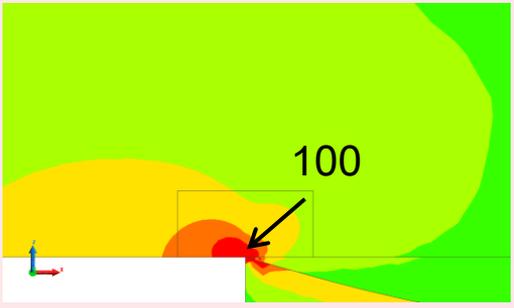
4 .Countermeasure of wiring width 4-1.1005mm (0402 inch)

Size Wiring width Copper foil	1005mm (0402 inch) 0.25mm 35μm	1005mm (0402 inch) 0.15mm 35μm	1005mm (0402 inch) Non(or Via) 35μm
Analysis model (¼ symmetrical model)			
Analysis result (Maximum principal contours)			

the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100

When wiring width is thinner, the stress applied on the MLCC is reduced.
It is effective to have thinner wiring width based on MLCC downsizing.

4 .Countermeasure of wiring width 4-2.0603mm (0201 inch)

Size Wiring width Copper foil	0603mm (0201 inch) 0.25mm 35μm	0603mm (0201 inch) 0.1mm 35μm	0603mm (0201 inch) Non(or Via) 35μm
Analysis model (¼ symmetrical model)			
Analysis result (Maximum principal contours)			
<p>the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100</p>			

When wiring width is thinner, the stress applied on the MLCC is reduced.

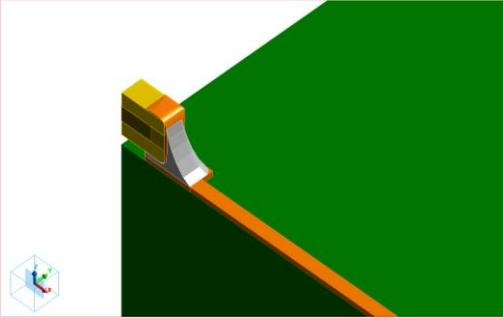
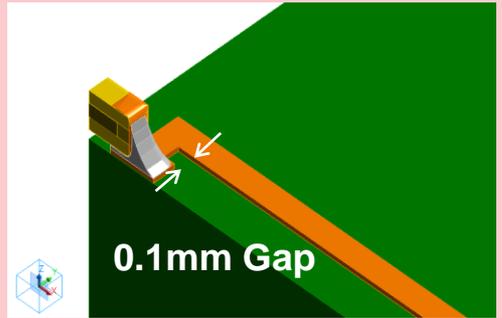
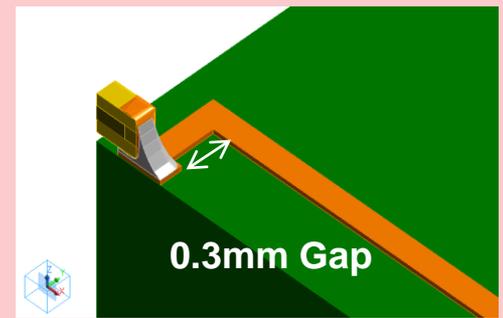
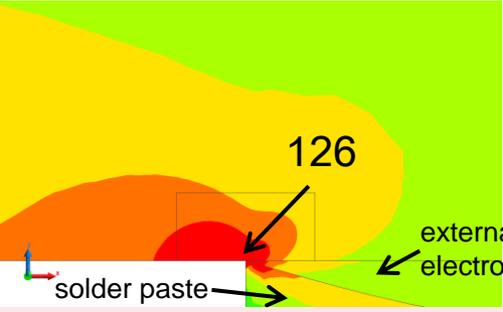
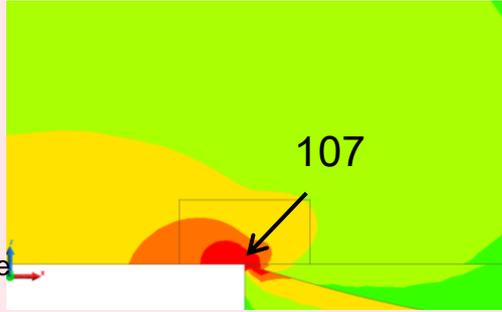
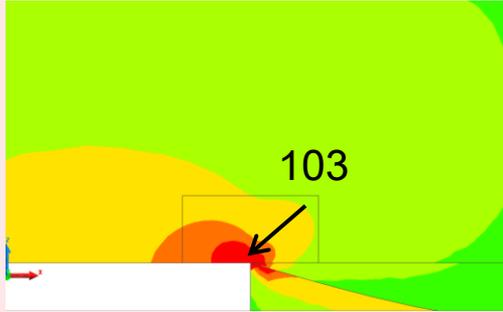
It is effective to have thinner wiring width based on MLCC downsizing.

5 .Countermeasure of wiring draws direction 5-1.1005mm (0402 inch)

Size Wiring width Copper foil	1005mm (0402 inch) 0.25mm 35μm	1005mm (0402 inch) 0.25mm(0.2mm Gap) 35μm
Analysis model (¼ symmetrical model)		
Analysis result (Maximum principal contours)		
<p>the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100</p>		

When wiring is drawn in the MLCC width direction(MLCC short direction), the stress applied on the MLCC is reduced.

5 .Countermeasure of wiring draws direction 5-2.0603mm (0201 inch)

Size Wiring width Copper foil	0603mm (0201 inch) 0.15mm 35μm	0603mm (0201 inch) 0.15mm(0.1mm Gap) 35μm	0603mm (0201 inch) 0.15mm(0.3mm Gap) 35μm
Analysis model ($\frac{1}{4}$ symmetrical model)		 <p>0.1mm Gap</p>	 <p>0.3mm Gap</p>
Analysis result (Maximum principal contours)	 <p>126</p> <p>tensile</p> <p>solder paste</p> <p>external electrode</p> <p>$\frac{1}{4}$ symmetrical model</p>	 <p>107</p> <p>$\frac{1}{2}$ symmetrical model</p>	 <p>103</p>
<p>compression</p> <p>the basis of relative comparison with the 1608mm (0603 inch), wiring width 1mm is 100</p>			

When wiring is drawn in the MLCC width direction(MLCC short direction), the stress applied on the MLCC is reduced. When distance between wiring and MLCC is enlarged, the stress is more reduced.

6 .Summary of FEM analysis

- The tensile stress applied to MLCC caused by deflection can be minimized to the approximately same level by downsizing wiring design (including wiring width and copper foil).
- When downsizing MLCC without changing wire width and copper foil, the stress applied to the MLCC gets higher.
- In order to reduce the stress applied to MLCC,
 1. Wiring width should be thinner according to MLCC size/downsizing.
 2. The direction of wiring extraction should be W(width) direction (MLCC short direction).

7 .Comparison the deflection of the 0603mm (0201 inch) MLCC related to copper foil 7-1.Test condition



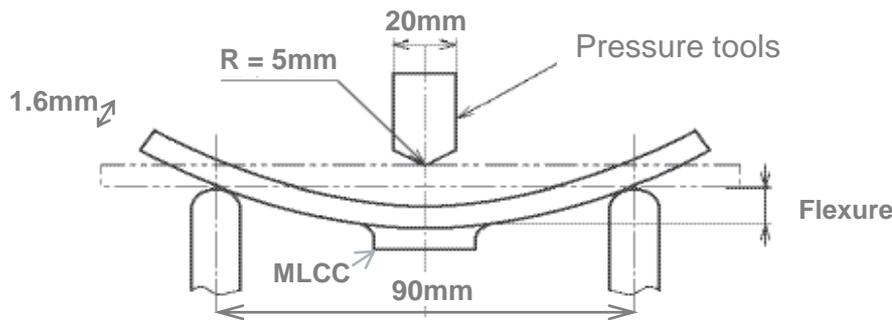
Comparison of deflection by using deflection test

Substrate – Test board –:

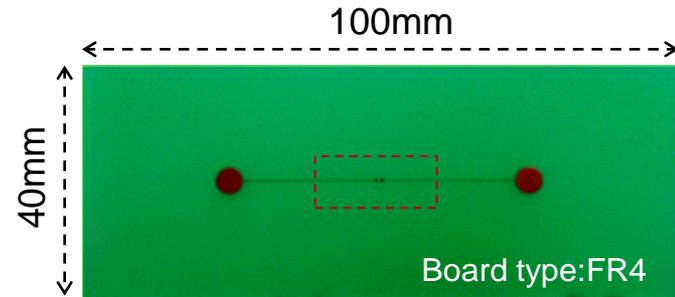
Board thickness	1.6mm
Wiring width	0.15mm
Copper foil thickness with plating	35 μ m, 70 μ m, 105 μ m

Test items:

0603mm (0201 inch)



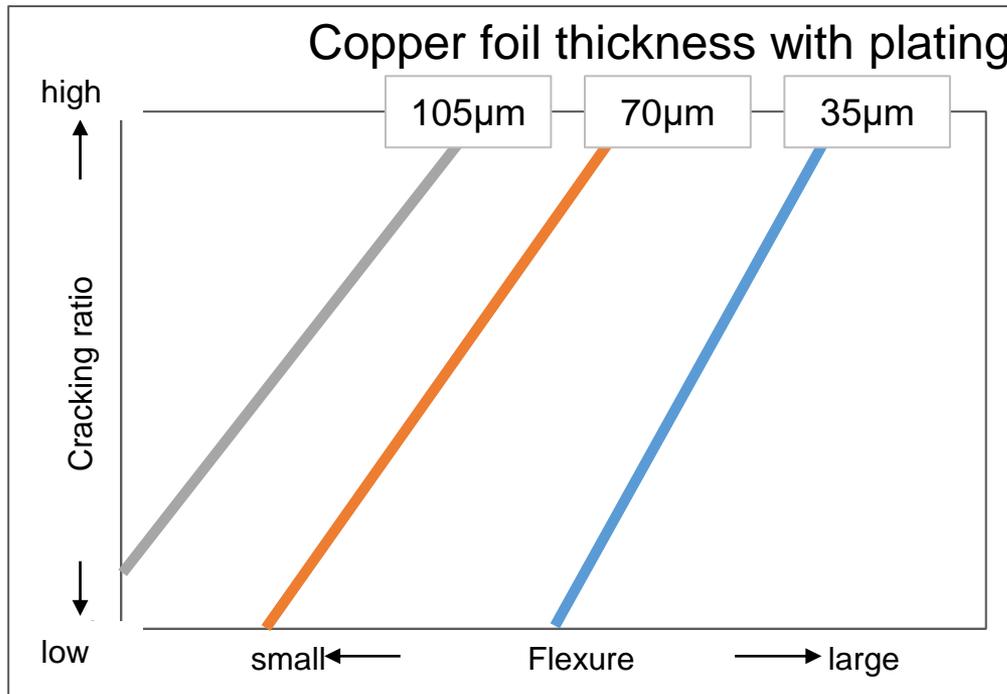
Test method of deflection



Substrate – Test board –

7. Comparison the deflection of the 0603mm (0201 inch) MLCC related to copper foil 7-2. Test result

This section shows the comparison of crack occurrence ratio against degree of flexure according to copper foil thickness with plating. The thicker the copper foil thickness is, the lower the deflection result is. Please take these points into consideration when downsizing MLCC to 0603mm (0201 inch).



7. Comparison the deflection of the 0603mm (0201 inch) MLCC related to copper foil 7-3.FEM simulation result

Size Wiring width Copper foil	0603mm (0201 inch) 0.15mm 35 μ m	0603mm (0201 inch) 0.15mm 70 μ m	0603mm (0201 inch) 0.15mm 105 μ m
Analysis model ($\frac{1}{4}$ symmetrical model)			
Analysis result (Maximum principal contours) tensile compression	<p>126 external electrode solder paste</p>	<p>162</p>	<p>194</p>
<p>the basis of relative comparison with the 0603mm (0201 inch), wiring width 1mm is 100</p>			

When copper foil is thicker, the stress applied on the MLCC is higher.

End

<http://www.murata.com>

