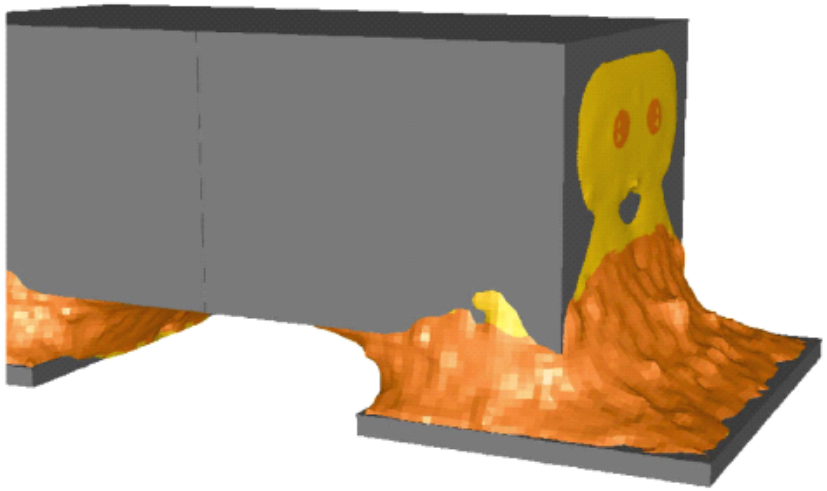


基于*FLOW-3D*自由表面追踪的钎焊数值模拟

Solder Simulation Application With Free Surface By FLOW-3D

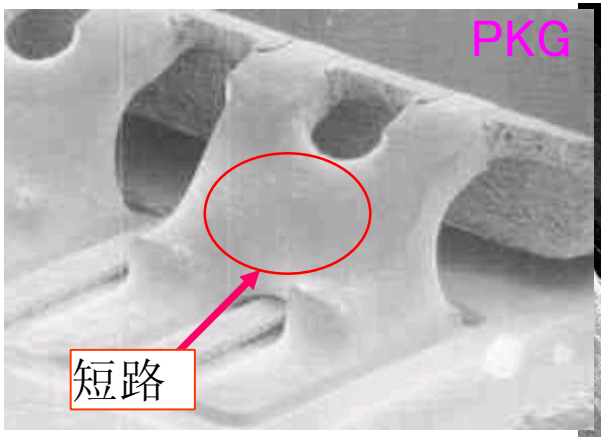
析模科技　虞伦

焊锡接合解析

☆ 有代表性的焊锡连接不良的例子

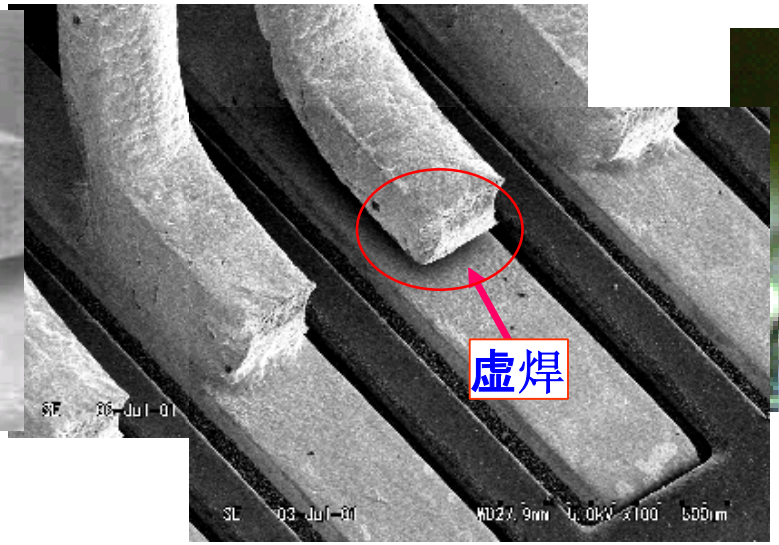
例举3个有代表性的电子元件焊接不良案例

1. 短路
2. 虚焊
3. 元件翘起

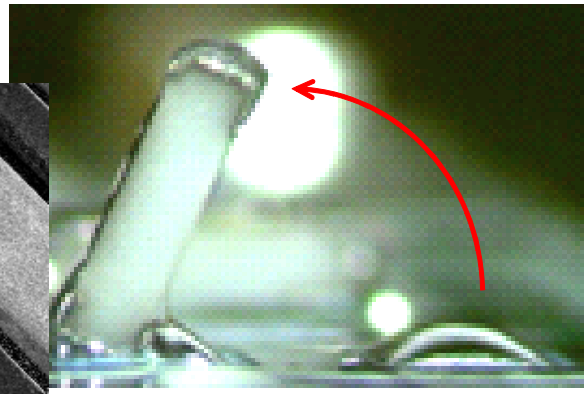


短路

因为焊锡跨过到焊脚间,零件无法正常运作



在焊脚和基板的间焊锡没连接



元件翘起

元件与基板电极没连接 .

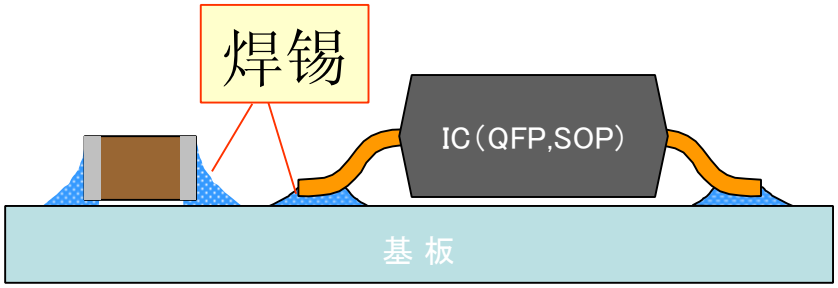
焊锡接合解析

☆ 焊锡接合解析

用CFD分析阐明电子元件和基板的连接时候发生的焊锡连接不良的情况，掌握发生问题的主要定性原因以消除问题.

使用软件：FLOW-3D

电子元件和基板一般以「焊锡」连接



电子元件的焊接

焊锡接合解析

- 用焊锡连接电子元件和基板
- 焊锡的加热溶融冷却凝固的经过的分析
- 焊锡的融熔扩展形状验证(单纯形状)

  -实地测量填角形状的比较验证
- 实际的焊脚形状验证(3维模型)

  -实地测量填角形状的比较验证
- 焊锡的连接不良的展示

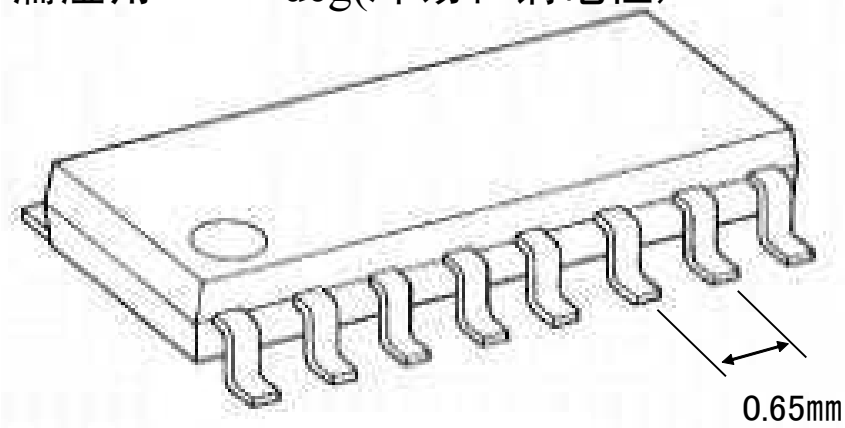
  -短路

☆ 解析的元件

零件尺寸　：2．5mm×5．0mm, t=0．8mm
焊脚间距間：0．65mm
焊脚数　　：14

◎ 焊锡材料特性

密度:　　8600 kg／m3
粘度:　　2．0×10-3Pa･s
表面張力: 550mN／m
濡湿角 ： 35deg(焊锡和铜電極)



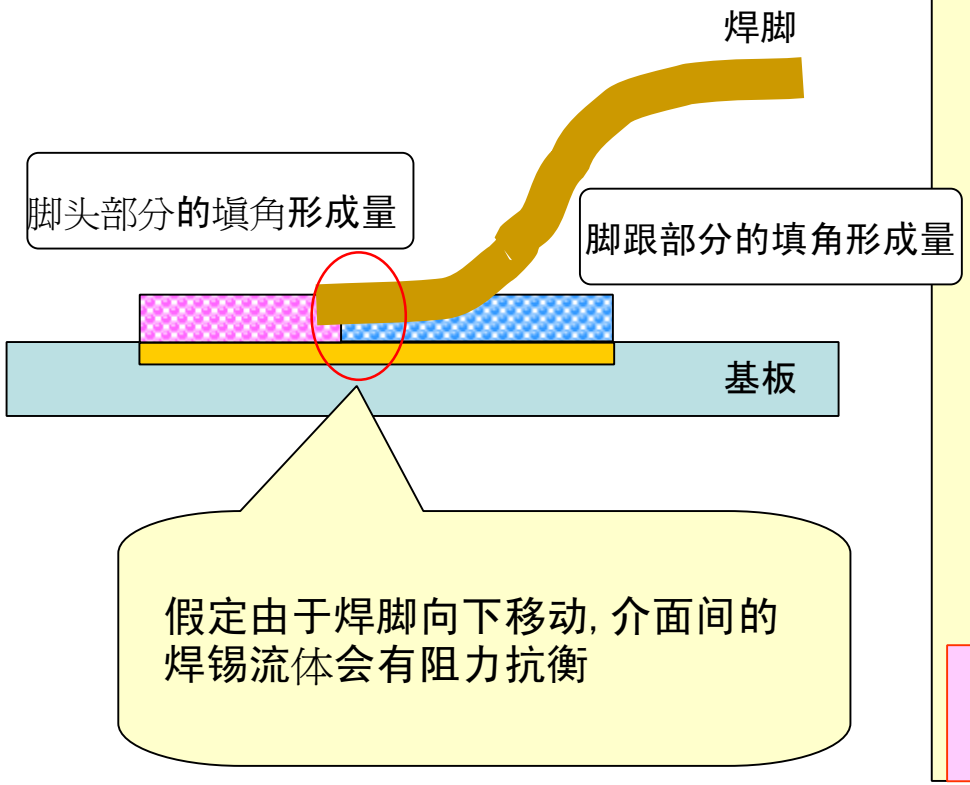
電子零件形状

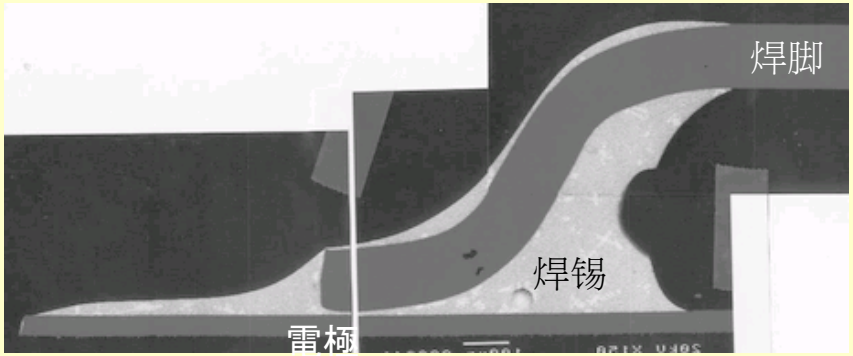
焊锡接合解析

解析例:2维模型

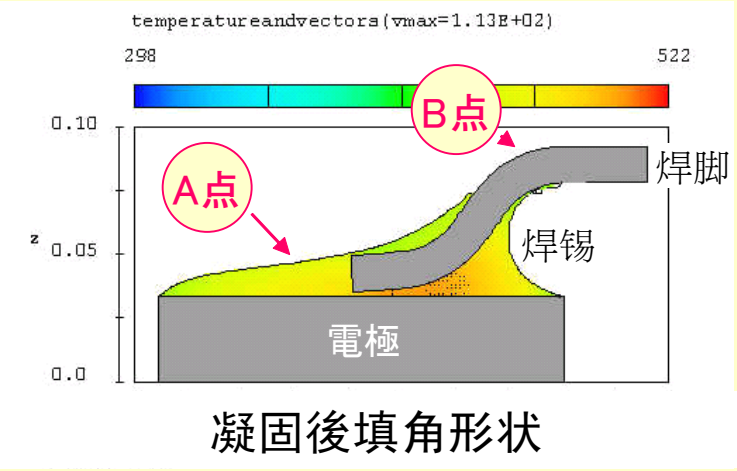
<u>実際現象</u>

焊锡溶融的时候零件因为重量,往下方掉下 .





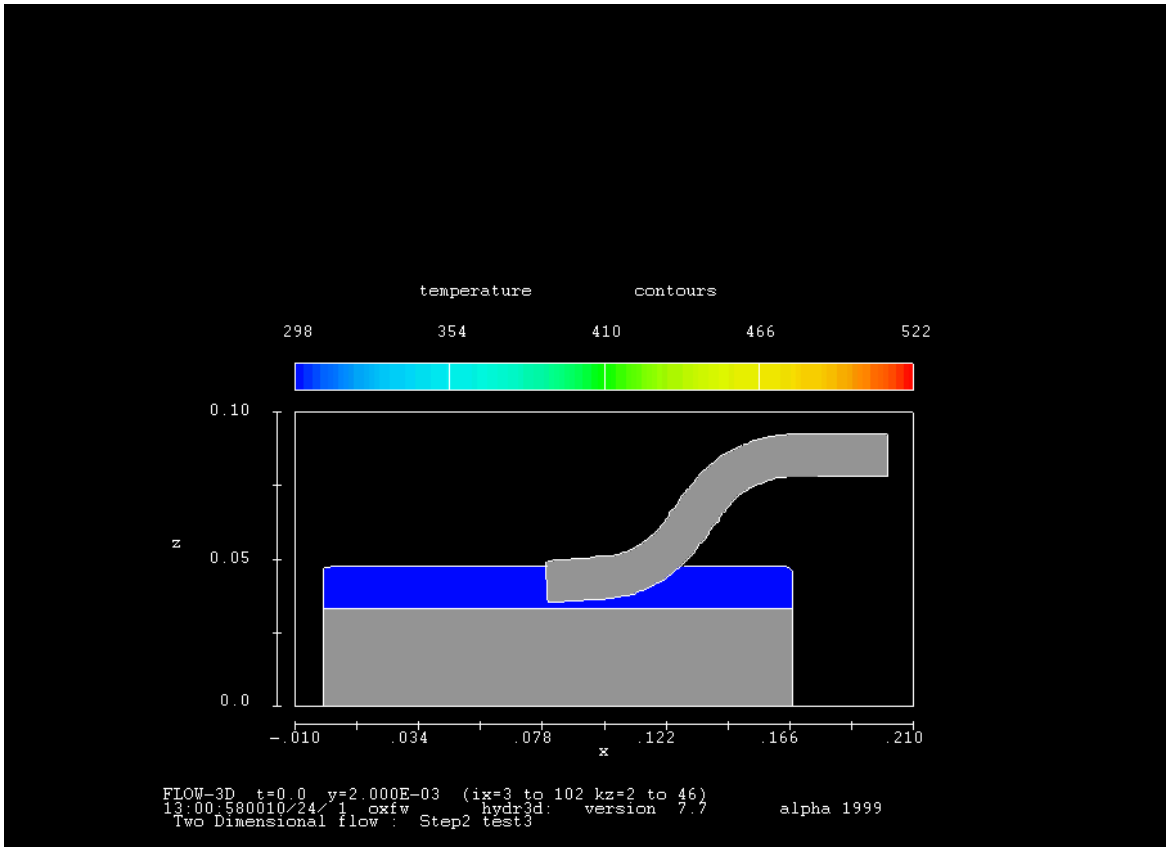
実際填角形状



凝固後填角形状

与实际的形状有差异,2维分析没考虑对宽度方向焊锡的流动是主要原因.

焊锡接合解析

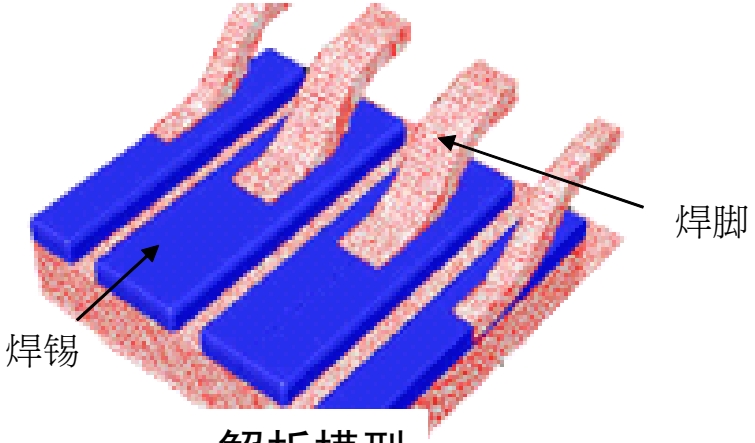


動画(2元解析)

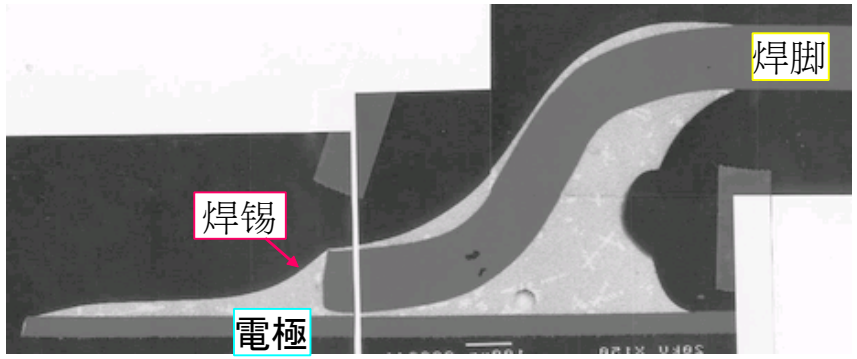
焊锡接合解析

解析例：三维模型

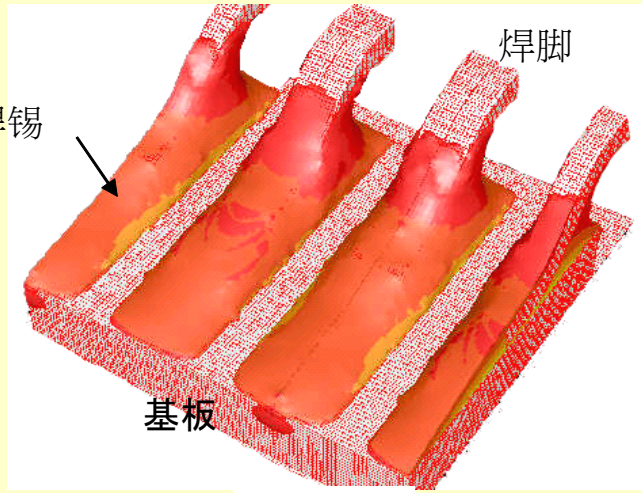
实际的焊脚形状以三维模型分析验证
焊锡的填角形状



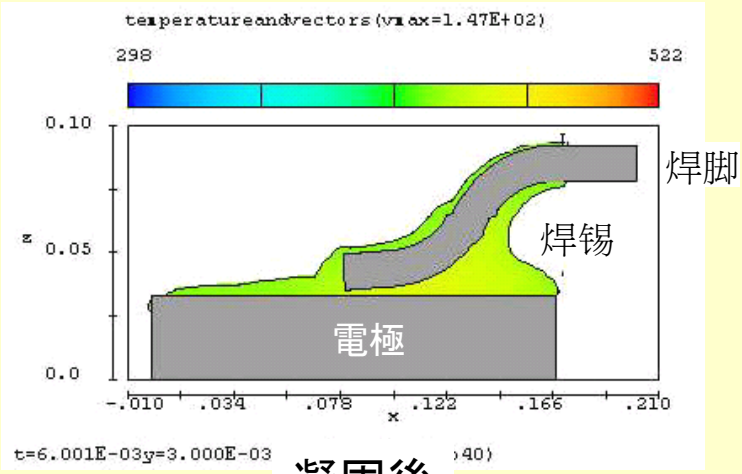
解析模型



实测焊角形状

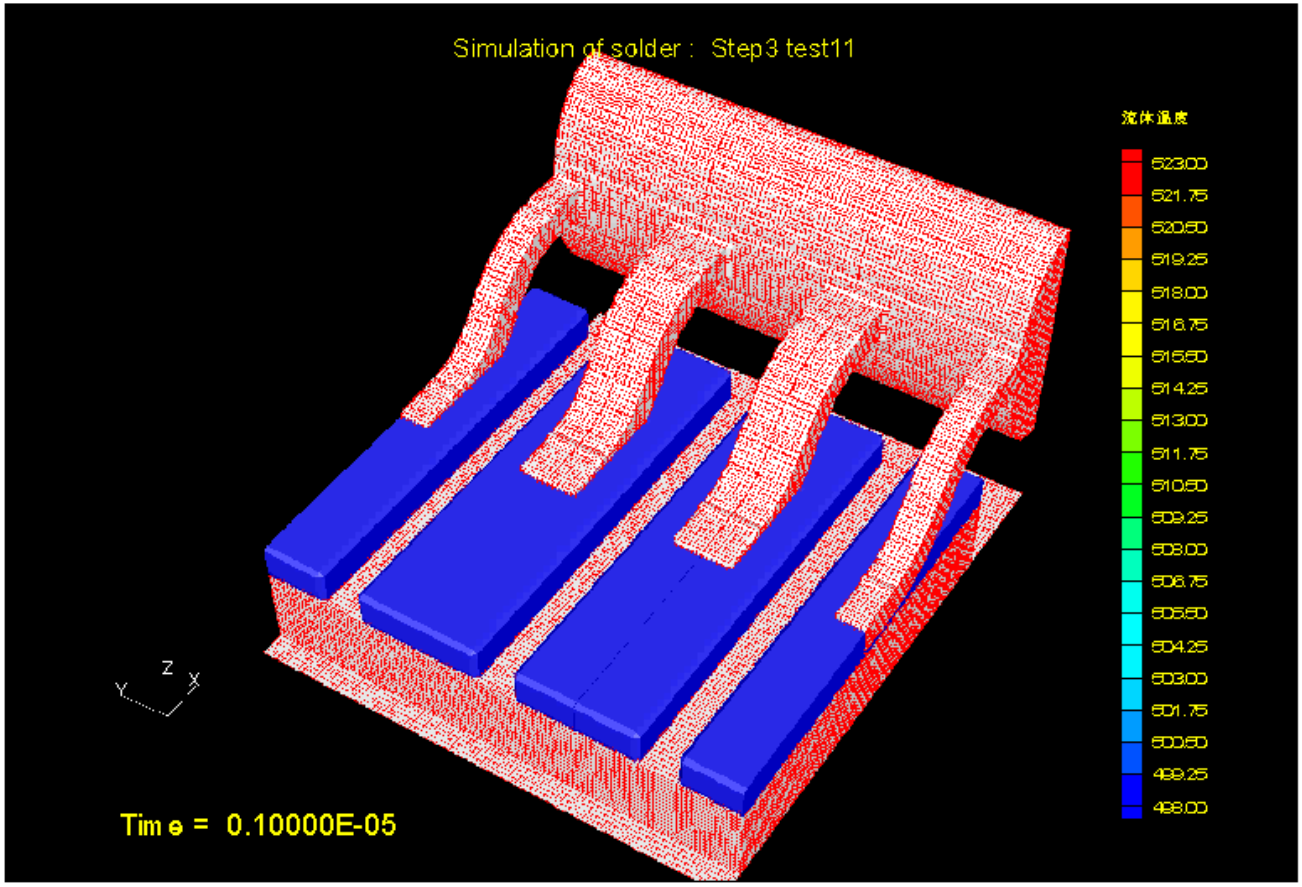


溶融時



凝固後

焊锡接合解析

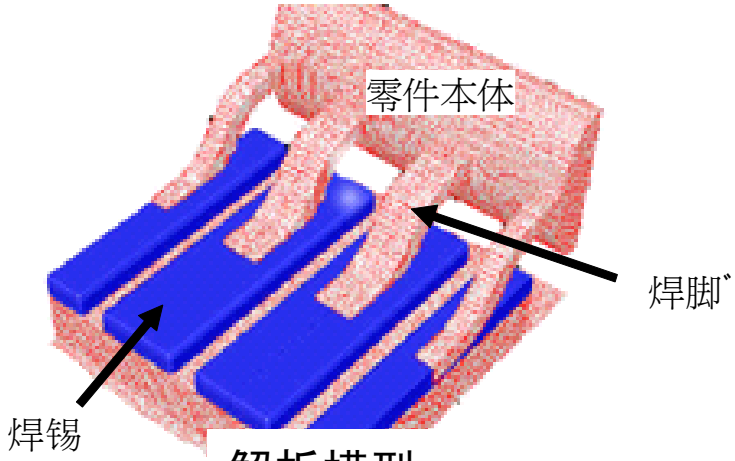


动画(3维分析:正常连接)

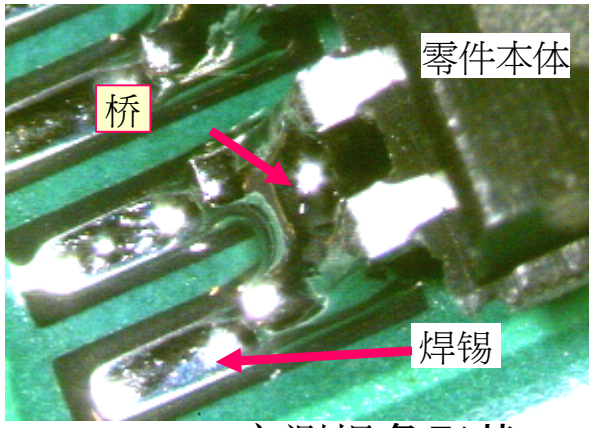
焊锡接合解析

解析例:焊锡连接不良

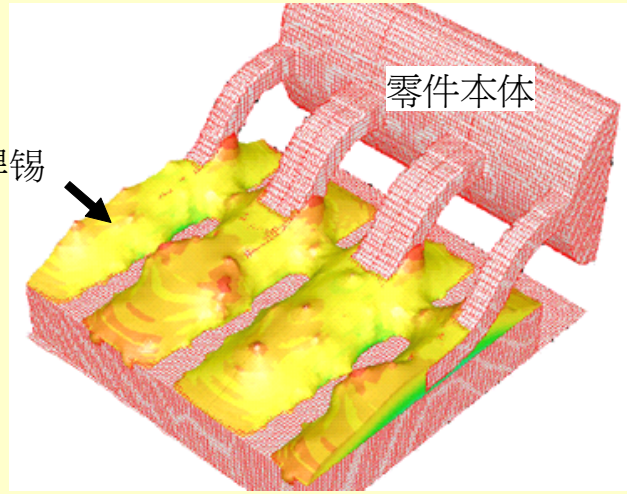
包含零件的热熔的3维模型及焊锡桥



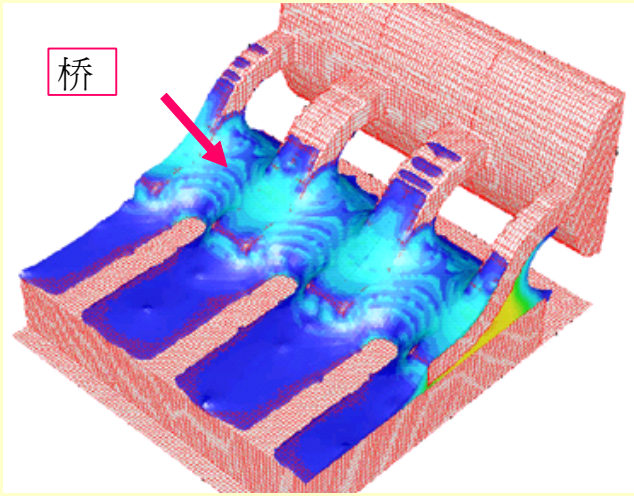
解析模型



实测焊角形状

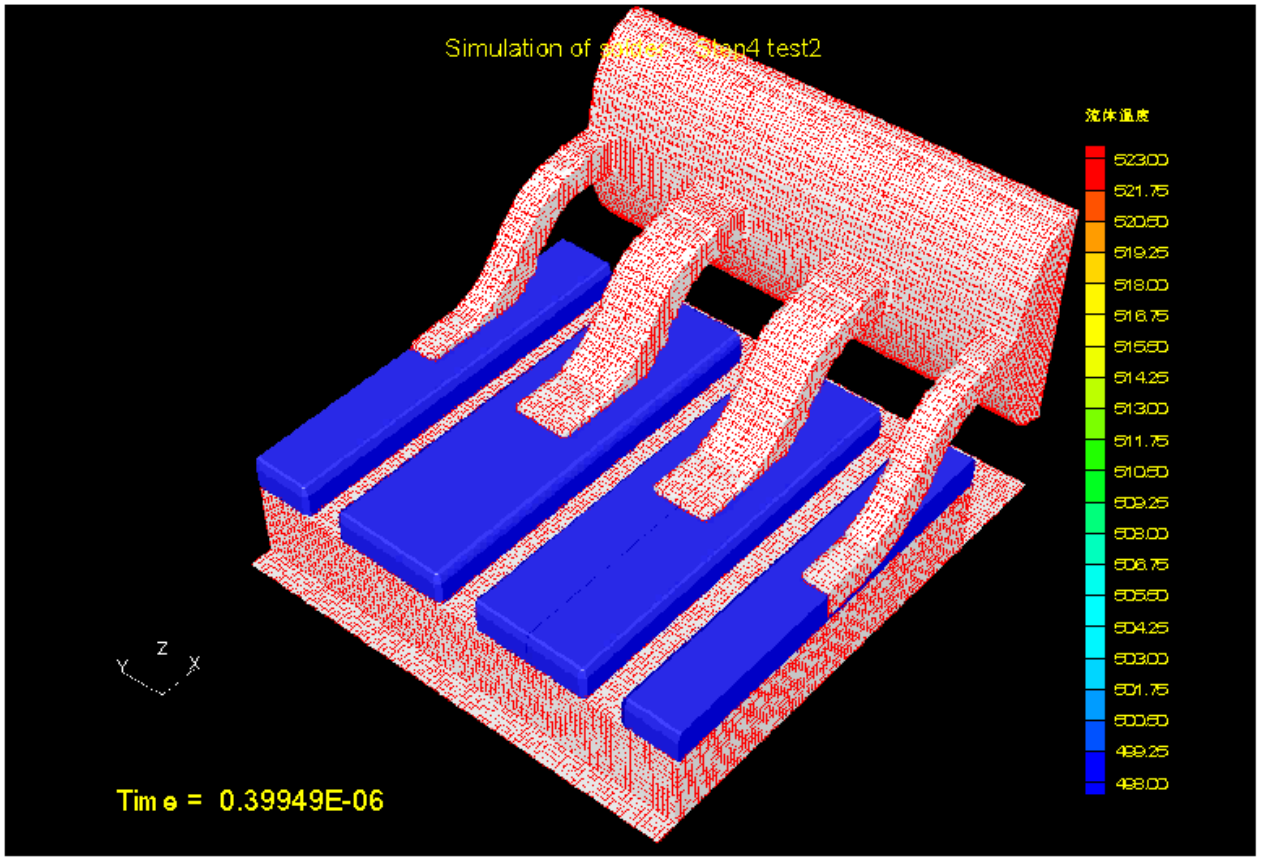


溶融時



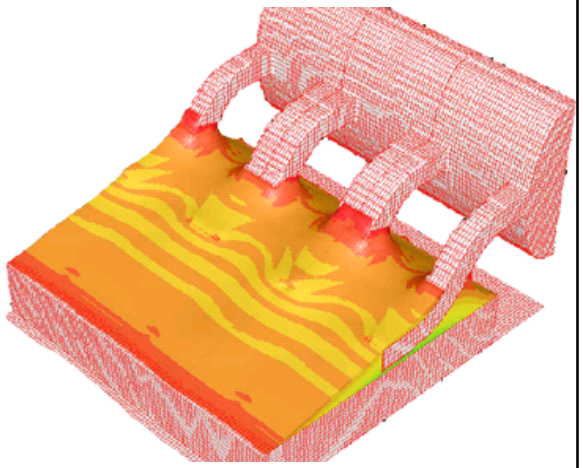
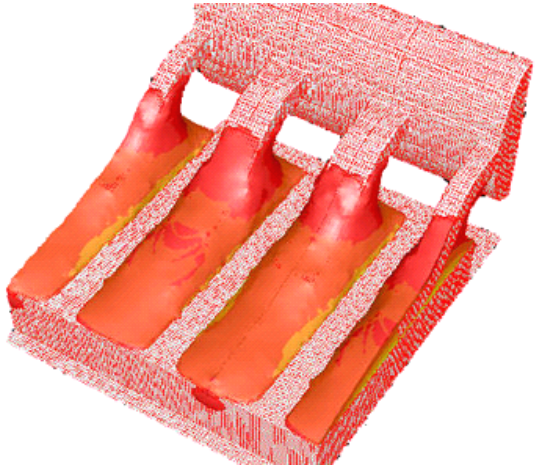
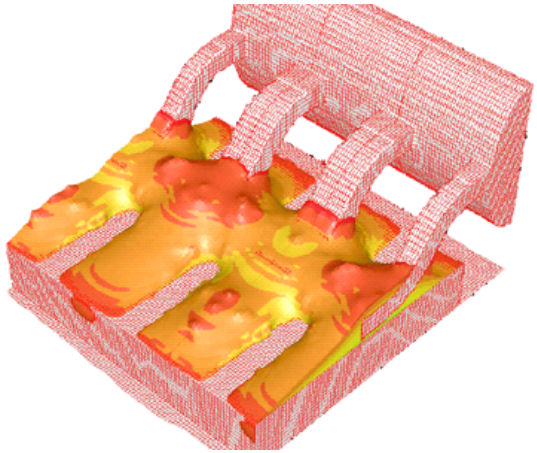
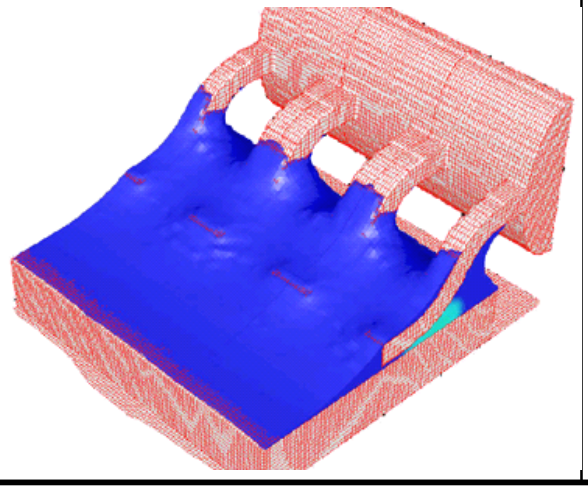
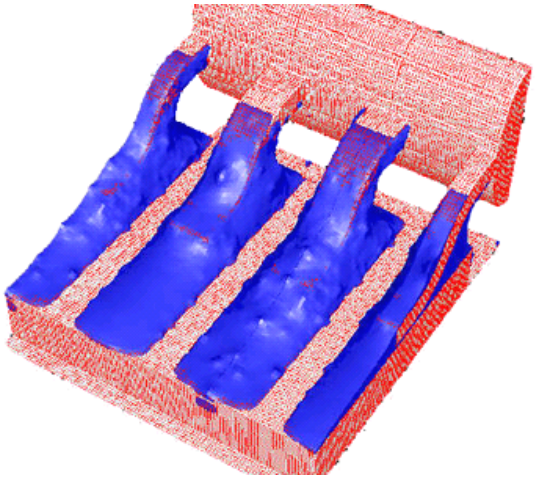
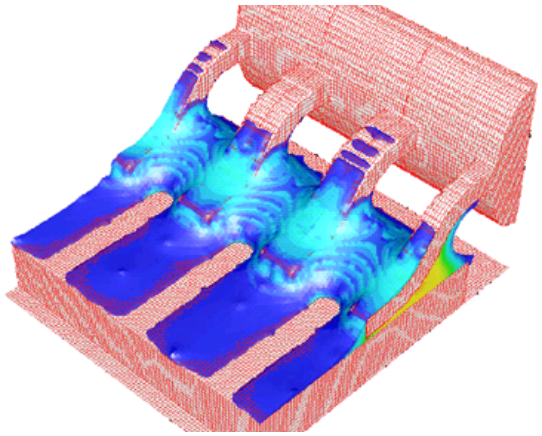
凝固後

焊锡接合解析

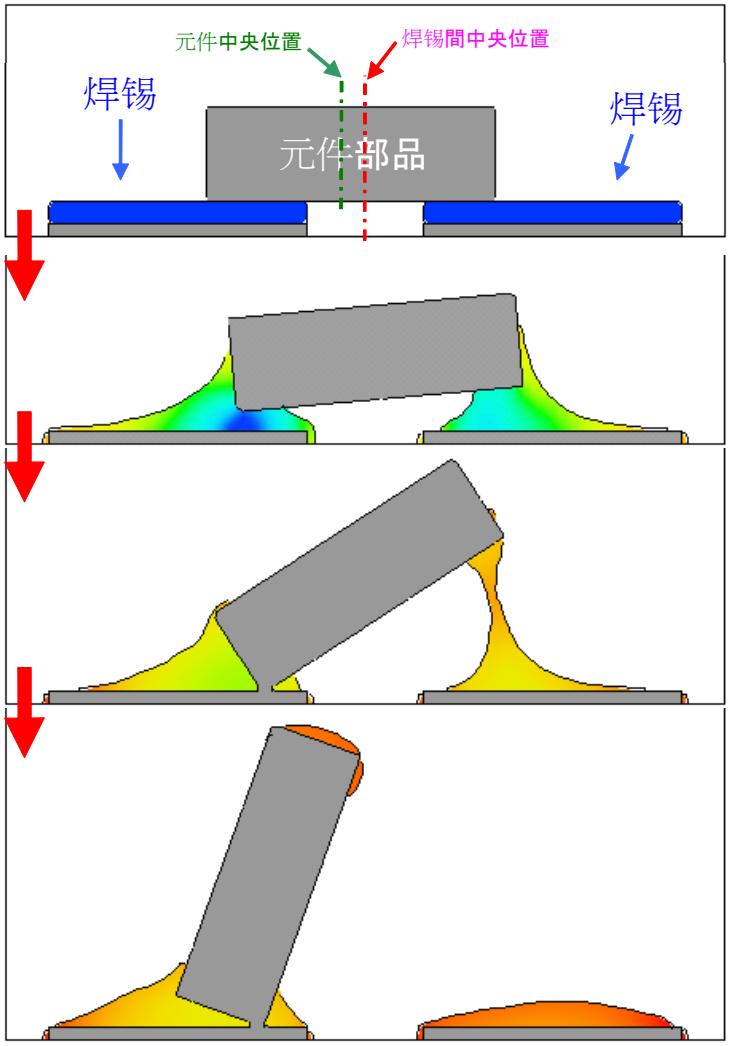


动画(3维解析:短路)

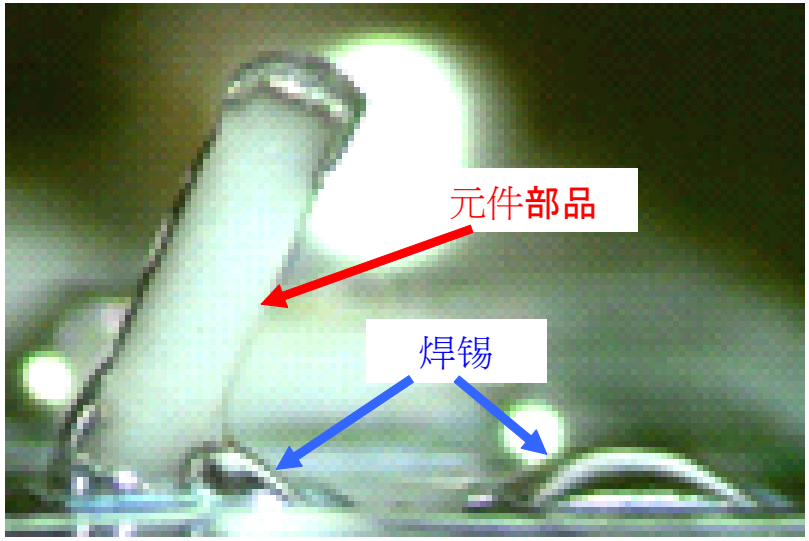
焊锡接合解析

	基板表面接触角：10 度	基板表面接触角：170 度	基板表面接触角：100 度
溶融時			
凝固後			

元件翘起

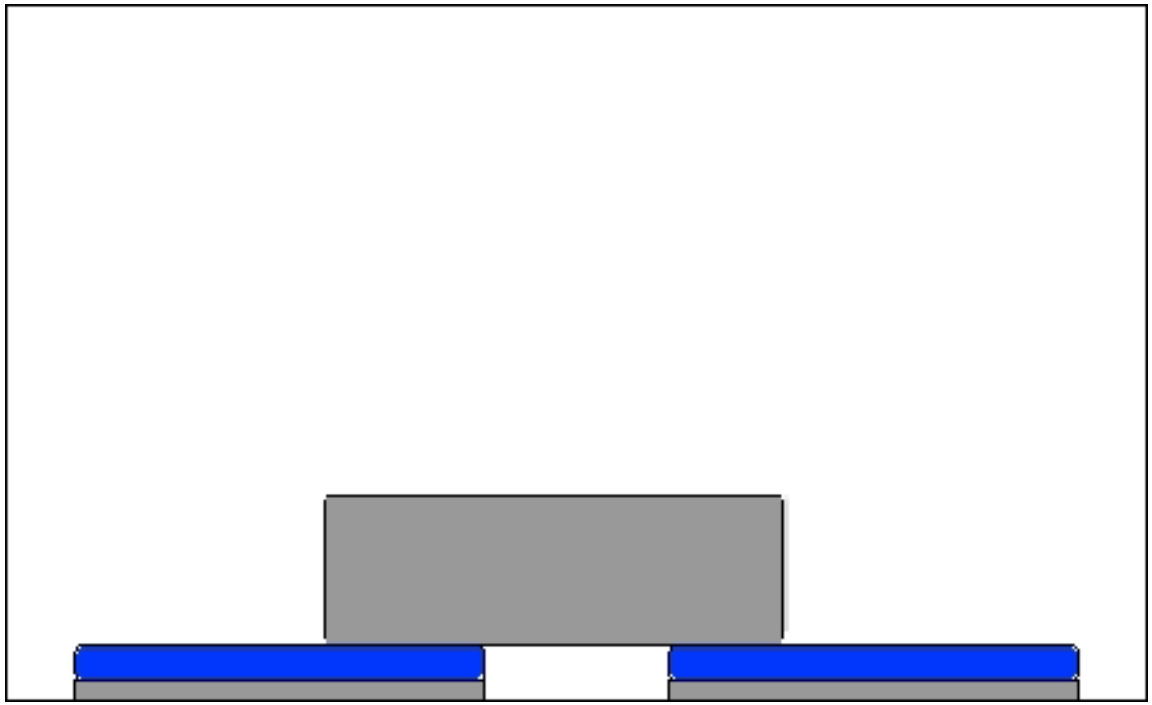


如果元件的初期配置偏离中线很多，表面张力左右失调且超过自我调适效果的界限会引起元件翘起



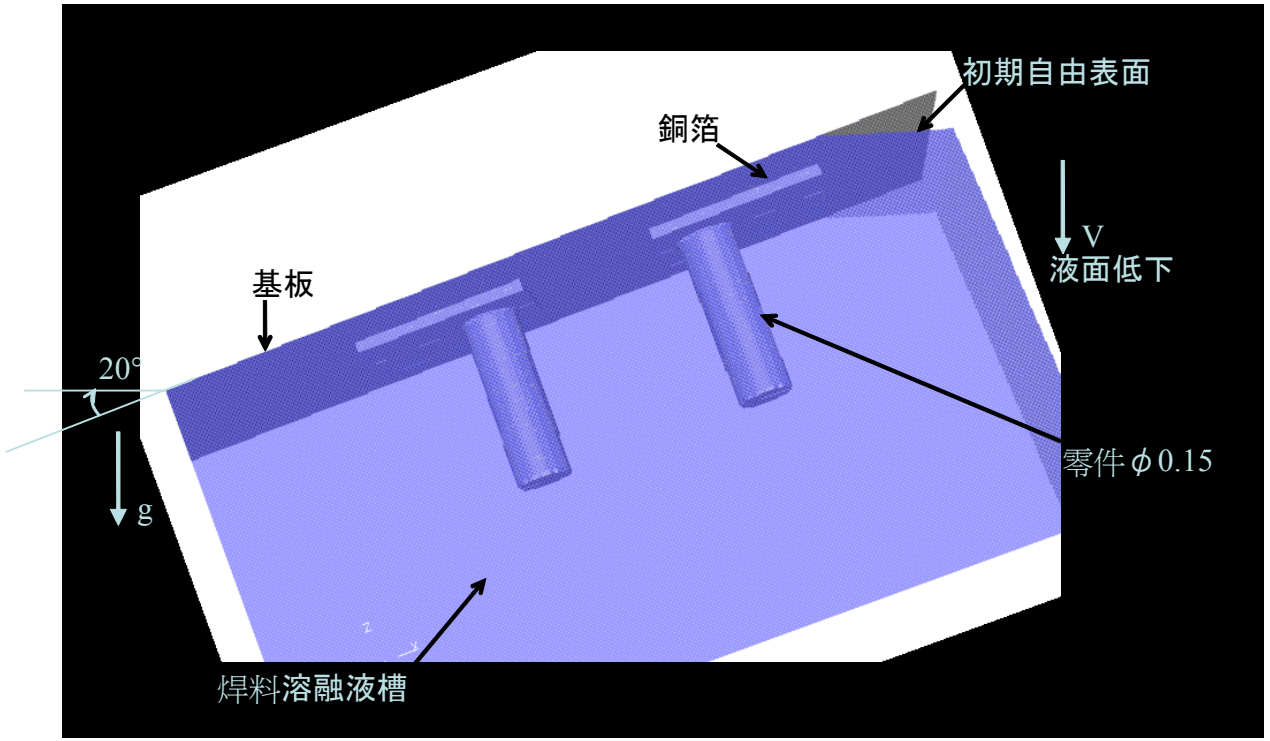
元件翘起的計算結果(左:凝固前)与实验结果(右:凝固后)

元件翘起



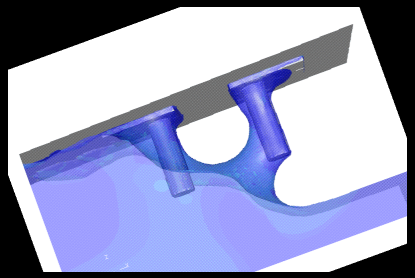
动画(2维分析:连接不良[元件翘起])

热浸焊料应用试验



- **焊料在槽中与基板接触及慢慢脱离的模型**
  - 基板于浸料槽中初期接触状态
  - 在浸料槽下放设出口,计算焊料液面下降时的瞬态流场
  - **基板**与水平呈20度角
  - **液面**下降**速度約**40cm/s

热浸焊料应用试验



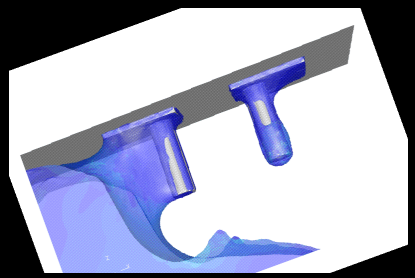
t=1.5ms ： 由于表面张力，焊料会附著在零件和铜箔上

浸料槽内焊料液面脱离零件时瞬间状态

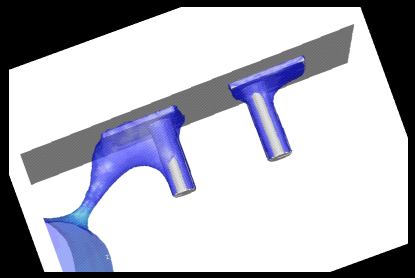
由于基板的低濡湿条件（大静态接触角）的缘故、

焊料液面脱离加速进行

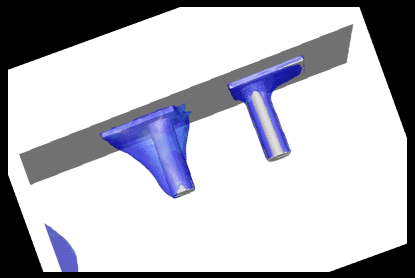
銅箔及零件的接触角为20°



t=2.5ms ： 上侧零件于焊料脱离后状態

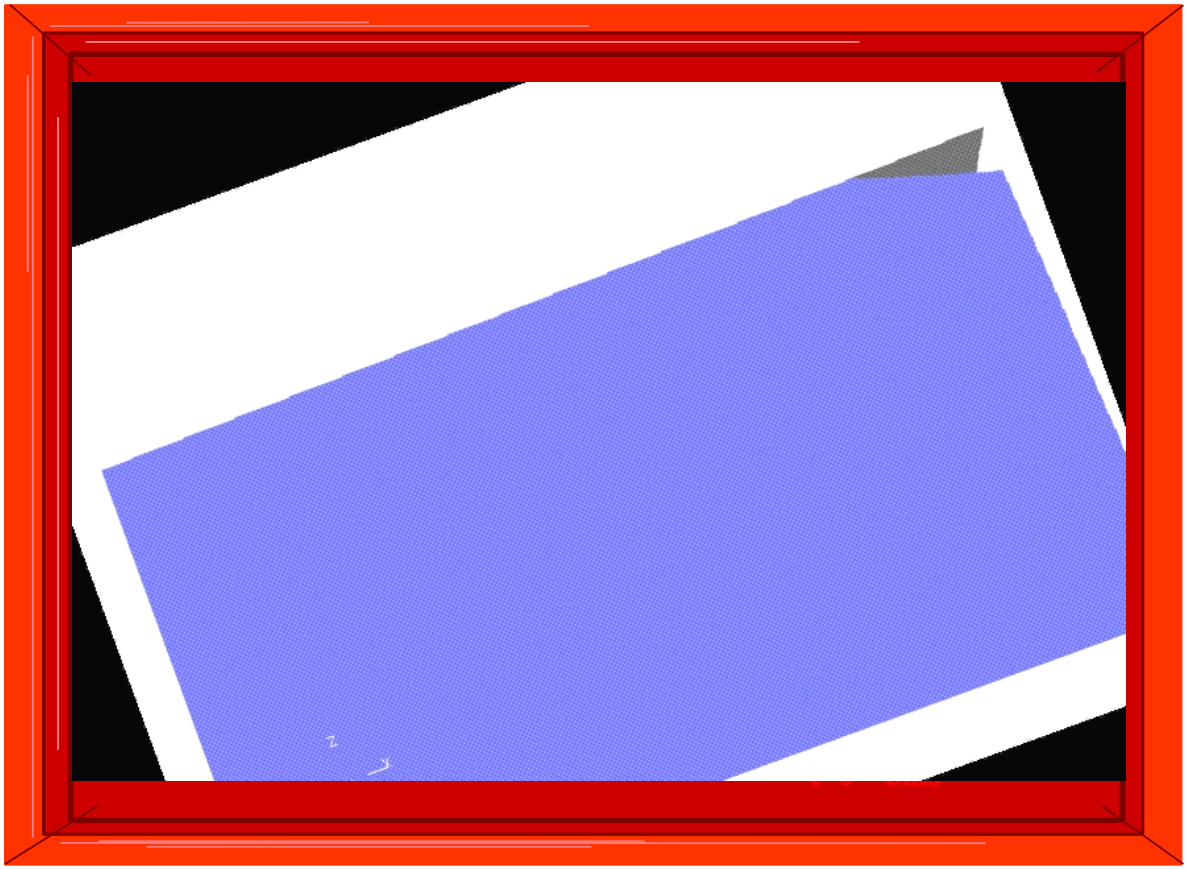


t=4ms ： 下侧零件于焊料面脱离时瞬间状態



t=5ms ： 下侧零件于焊料面脱离后状態

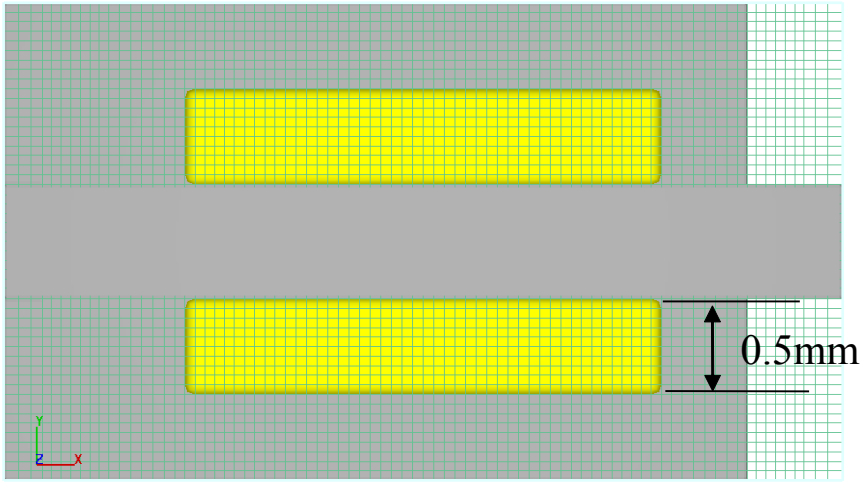
热浸焊料应用试验

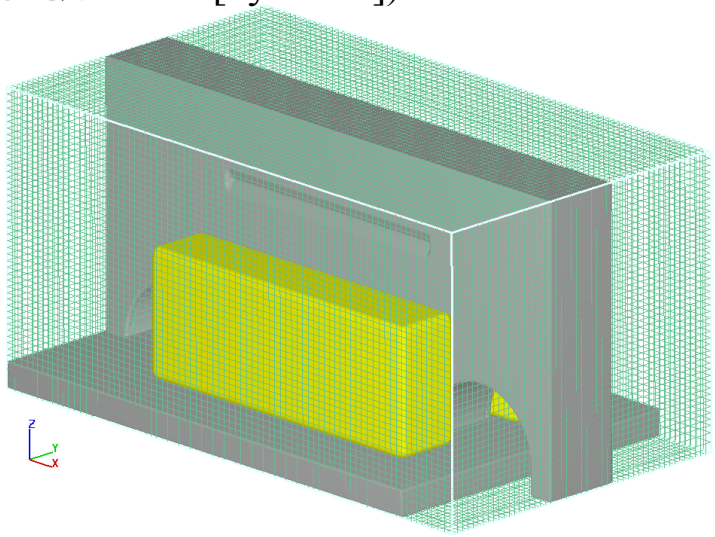


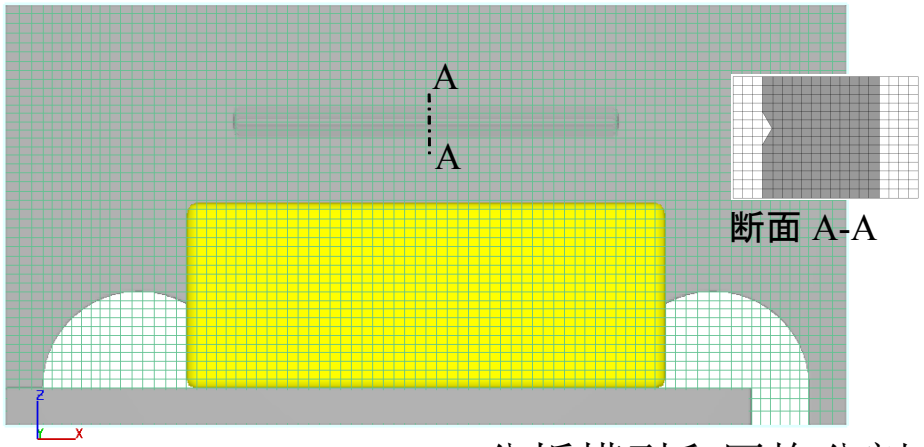
焊锡的融熔分布

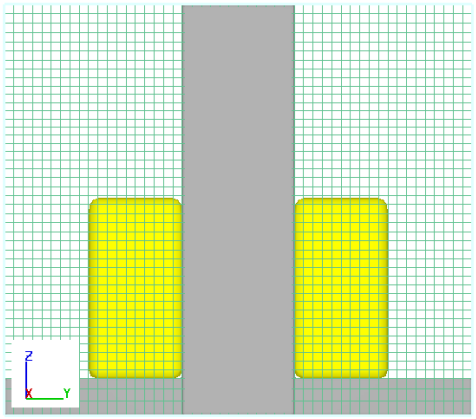
解析模型

- ●网格数　x:y:z ＝　80 :50 :46 ＝ 184000
- ●焊锡(**密度**:7.4 [g/cm3], **粘度**:0.0165[Poise], **表面張力**:440[dyne/cm])





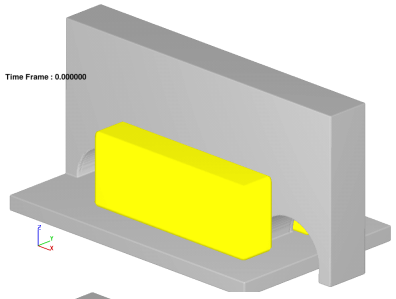




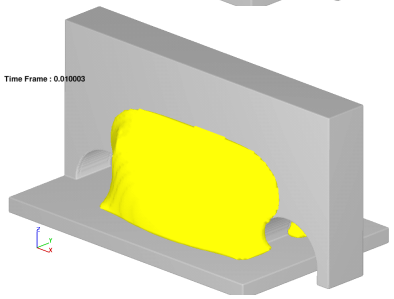
分析模型和网格分割

焊锡的融熔分布(没压边加工)

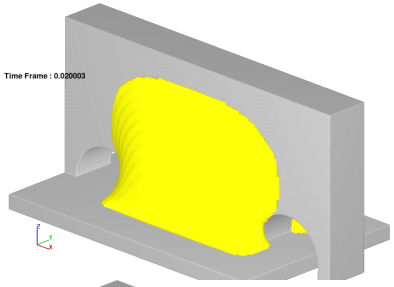
時刻：t_0



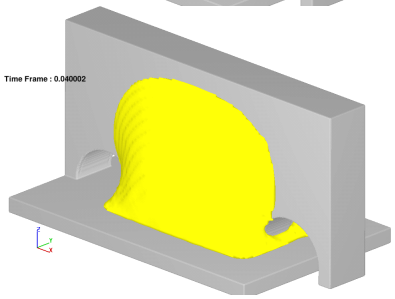
t_1



t_2



t_3



焊锡的融熔分布（没压边加工）的計算結果(時系列)与实验結果（t_3）

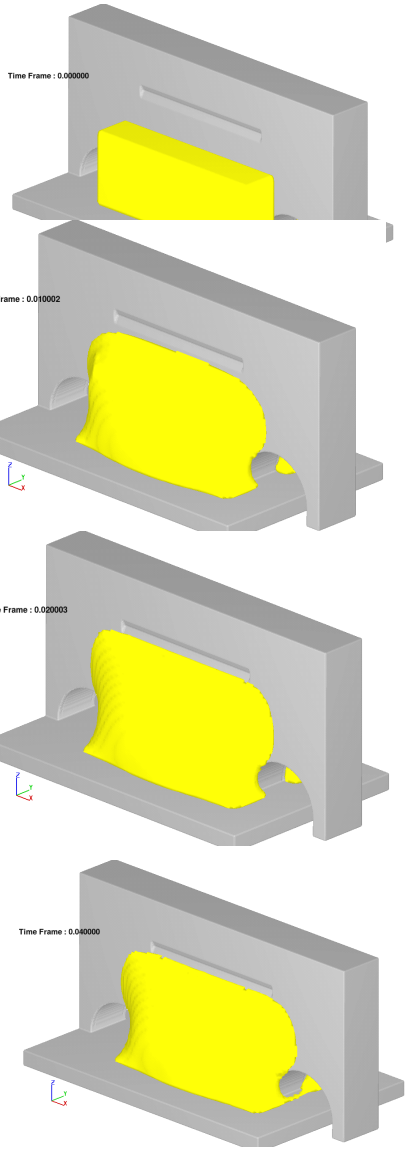
焊锡的融熔分布（有压边加工）

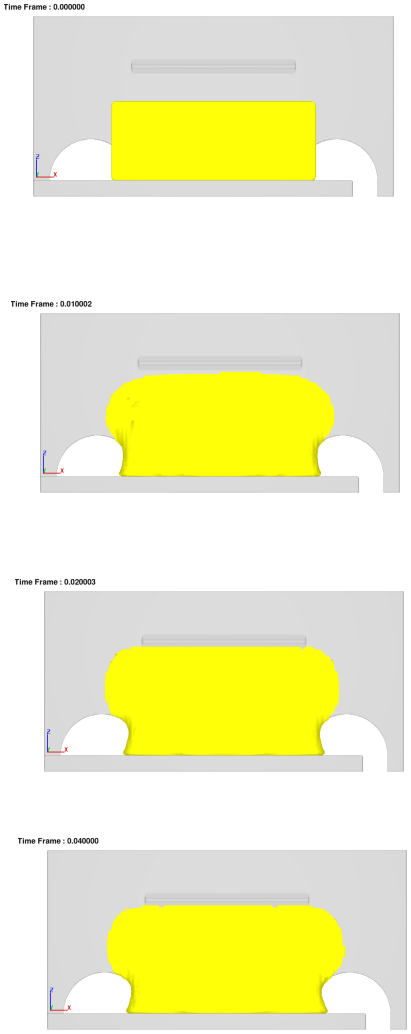
時刻：t_0

t_1

t_2

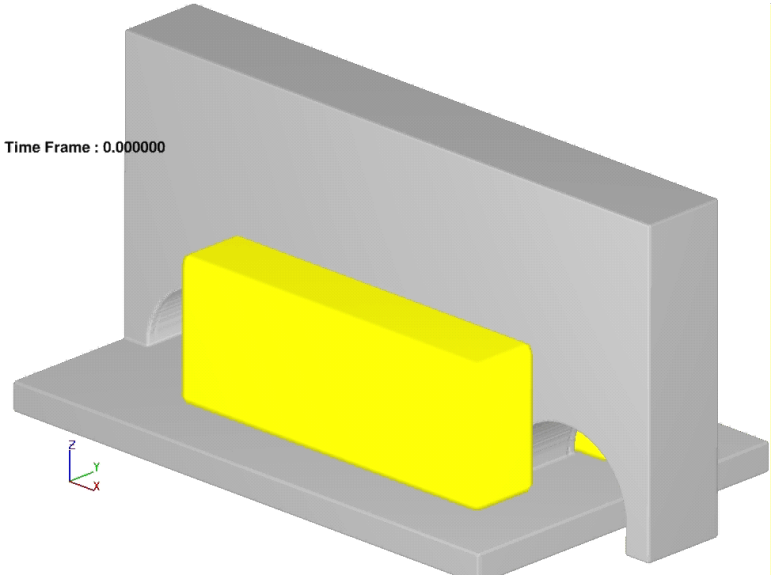
t_3

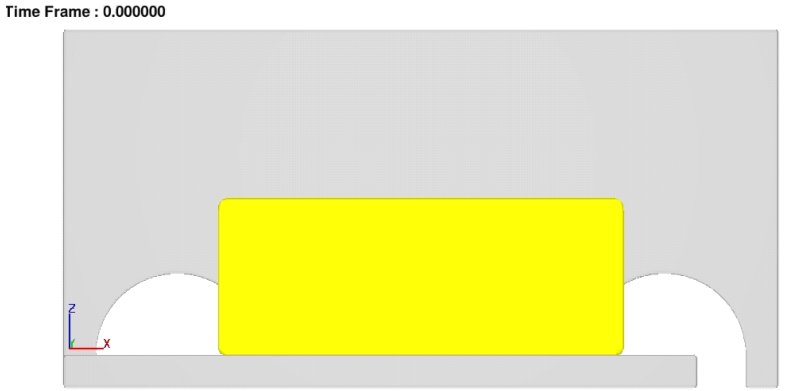


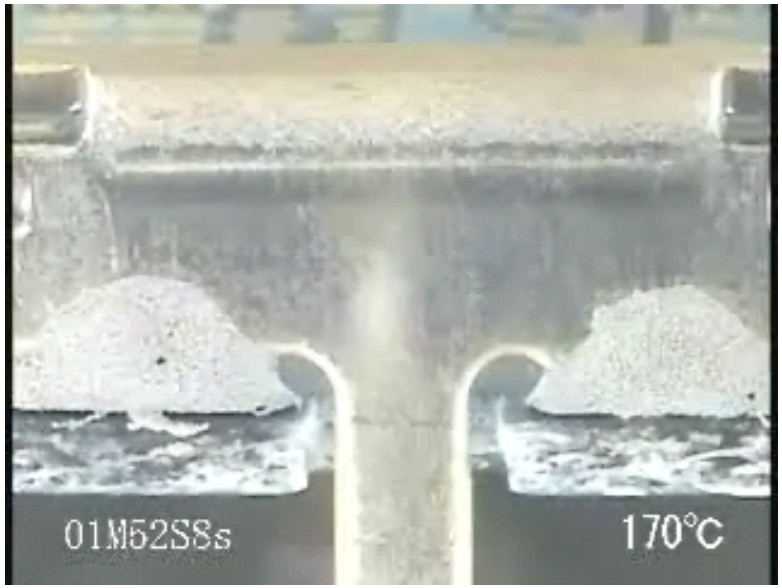


焊锡的融熔分布（有压边加工）的計算結果(時系列)与实验結果（t3 ）

焊锡的融熔分布（沒有压花加工）

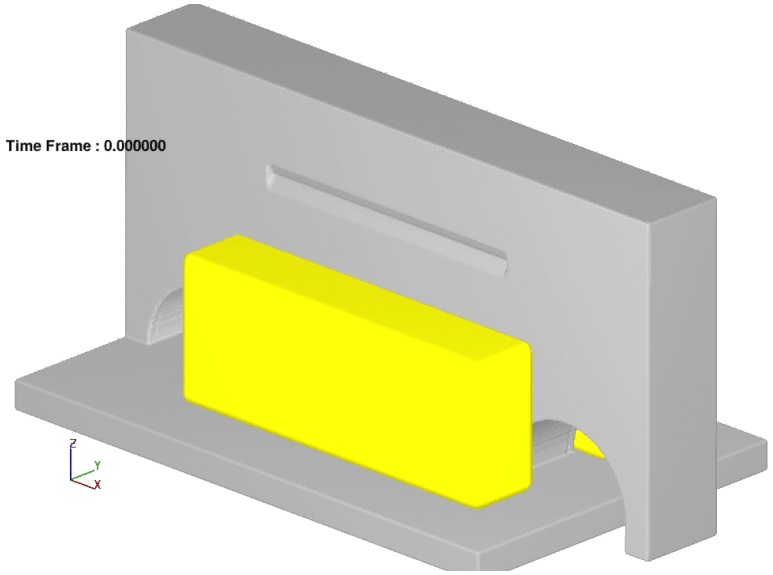


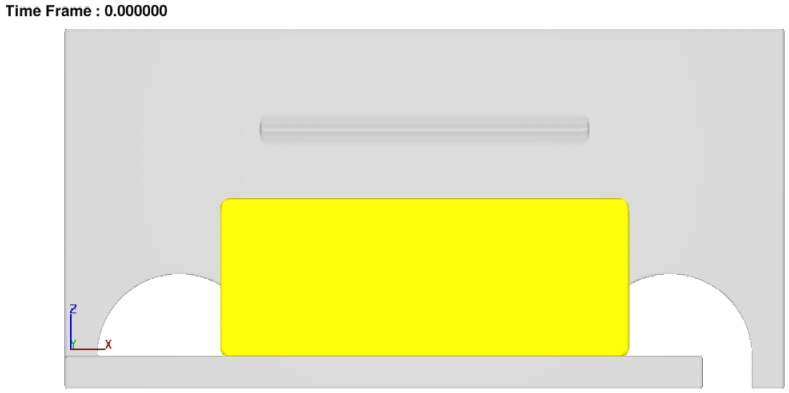


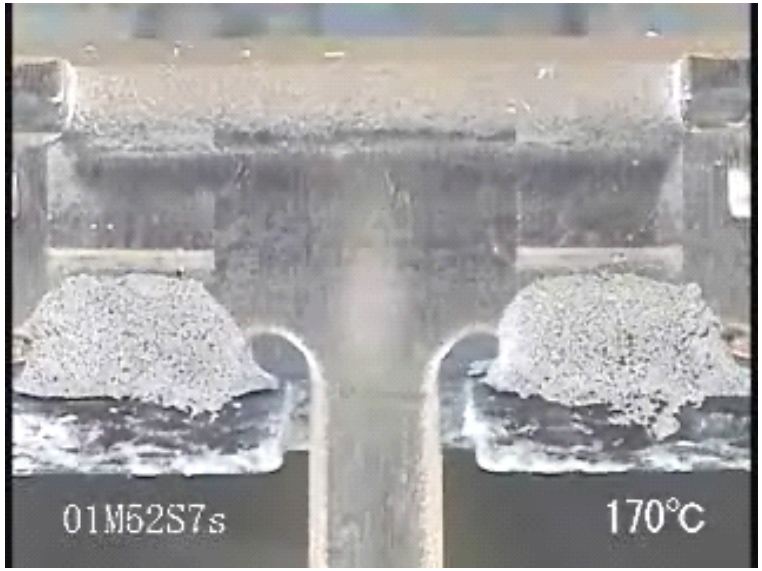


动画:焊锡的融熔分布（沒有压花加工）的**計算結果(左)**与实验**結果(右)**

焊锡的融熔分布（有压花加工）







动画：焊锡的融熔分布（有压花加工）的計算結果(左)与实验結果（右 ）

小　结

- 上述案例以钎焊工艺的熔融流动CFD模拟为重点，通过对自由液面的追踪、预测焊锡凝固后的形状，以评估短路、虚焊、翘起等缺陷；

- 为何基于FLOW-3D软件：
  - FLOW-3D是由自由流体之父Dr. C.W. Hirt.自1963年开发的著名CFD软件，基于TruVOF理论，以自由液面追踪为优势，较适合模拟焊接工艺的熔池流动、凝固等现象；
  - FLOW-3D能够考虑温度场、相变、气泡、电磁场、物体移动、应力等多种物理量；
  - FLOW-3D采用基于FDM的FAVOR网格技术，建模非常方便；
  - 相关国外发表的FLOW-3D模拟焊接的论文：
    www.simcae.com.cn/FLOW-3D/FLOW-3D_Welding_App.Htm

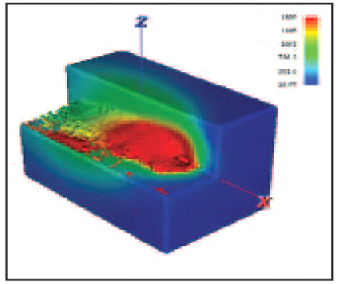
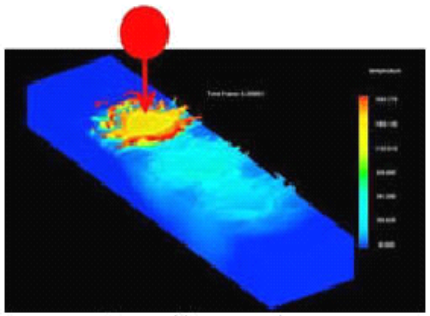
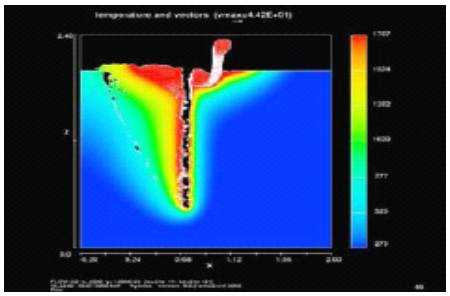


Fig. 9 — Three-dimensional temperature distribution for the horizontal T-fillet case.



Drop welding example



  - 更多关于FLOW-3D的信息：
    - 请参考：http://www.simcae.com.cn/FLOW-3D/
    - 或致电：021-31260876 18602195606