Surface Mount Technology Introduction
表面贴装技术简介

Definition/定义

➢ SMT-Surface Mounting Technology:

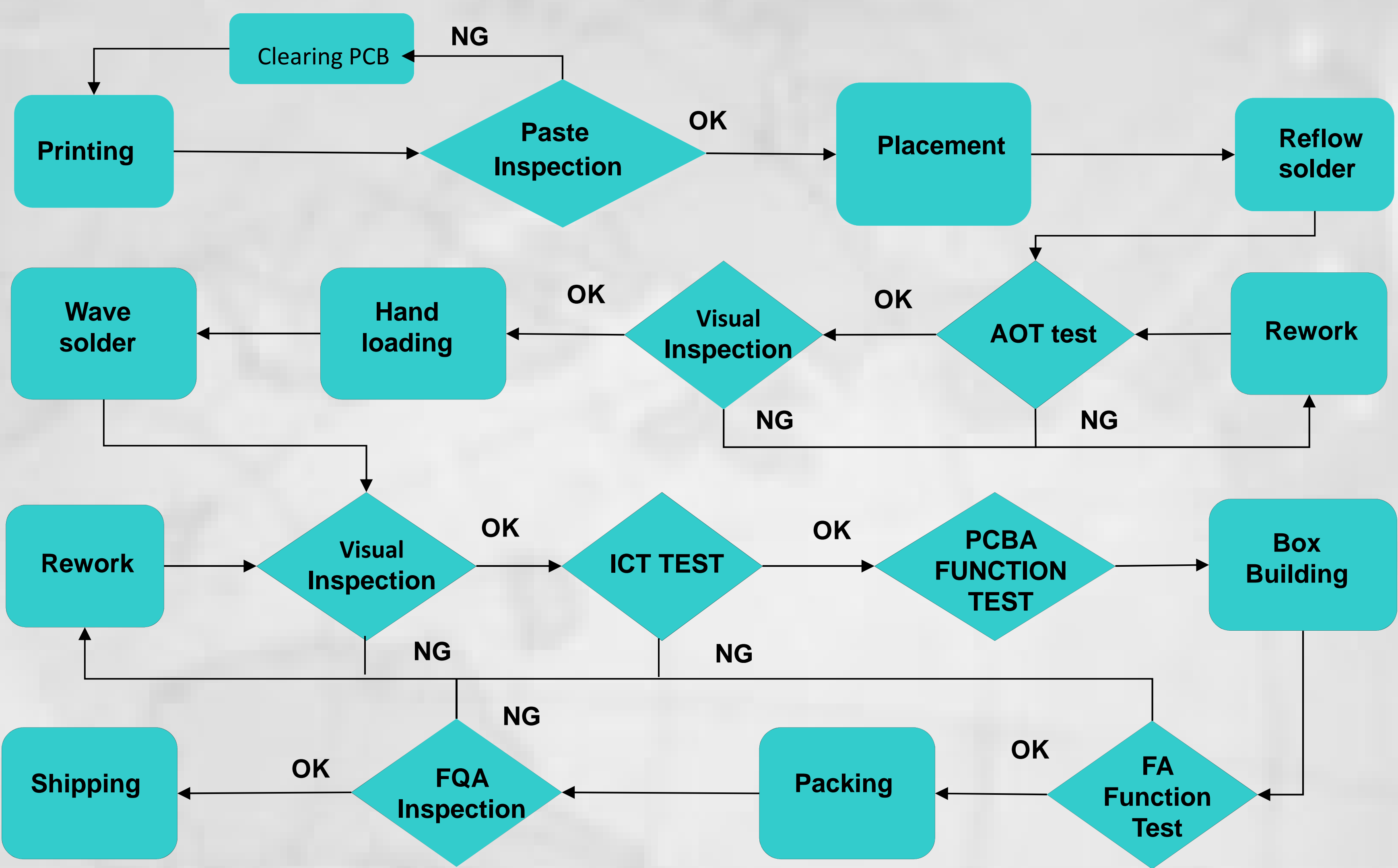
SMT is a process or assembly technique by which components are soldered onto the board surface./SMT 是把零件焊接到印刷线路板表面的工艺或装配技术.

Learning Objective

- 》 General Process Engineering Introduction/一般的工艺流程介绍
- 》 SMT vs THT/表面贴装技术 vs 通孔装配技术
- Composition/组成
- Assembly Classifications/装配分类
- Advantages/优点
- Development Trend /发展趋势
- SMT defect & Countermeasure /SMT 不良及改善对策

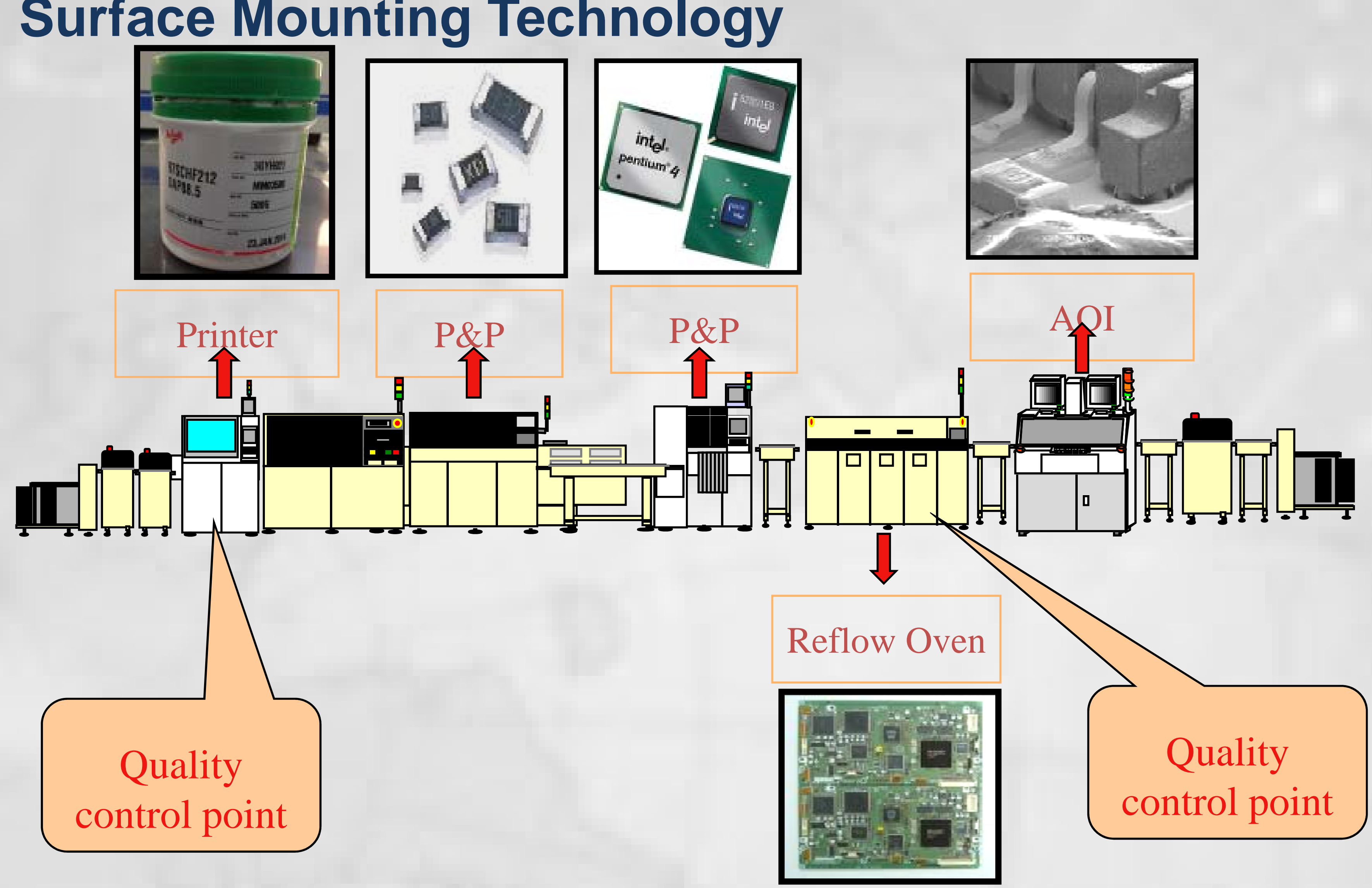
PCBA Process Flow Chart/SMT工艺流程图

》Process flow/工艺流程图



SMT Equipment Overview/ SMT 设备纵览

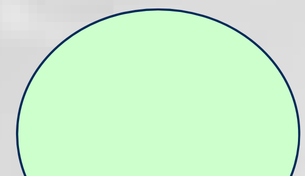
Surface Mounting Technology



Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图



Process Description: 过程描述	**Receiving Material / 收料**
Key Parameter: 关键参数	Part Number and Quantity
Responsibility: 责任	Store

Process Description: 过程描述	**Incoming Inspection / 来料检查**
Key Parameter: 关键参数	Inspection on Incoming
Responsibility: 责任	IQC

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述	**Storage and Material Kiting / 物料存放**
Key Parameter: 关键参数	Part Number, Work Order Quantity, FIFO,WIP
Responsibility: 责任	Stores

Process Description: 过程描述	**Label Application and board tracking / 贴标签板的跟踪**
Key Parameter: 关键参数	Label Verification and Correct Kit Release on Network
Responsibility: 责任	MBU/制造部门

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述 **Screen Printing / 丝印**

Key Parameter: **Stencil selection, Supporting jig, Paste Height, Machine Parameters, Stencil cleaning, Solder Paste Usability**

Responsibility: IPQC,Eng.,MBU,Stores

Process Description: 过程描述 **Pick and Place (surface mounting)表面贴装**

Key Parameter: 关键参数 BOM, Loading List, Layout

Responsibility: 责任 QA,Eng., MBU制造部

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述 — **Reflow / 回流**

Key Parameter: 关键参数 — Temperature Profile to Match Specific Product

Responsibility: 责任 — Eng.

Process Description: 过程描述 — **Post Reflow Inspection /回流后检查**

Key Parameter: 关键参数 — IPC-A-610, Customer BOM

Responsibility: — MBU

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述 — **Hand Insertion （PTH)/ 手插件**

Key Parameter: 关键参数 — Hand Insertion of Components as per instruction / layout

Responsibility: 责任 — MBU

Process Description: 过程描述 — **Wave soldering / 波峰焊接**

Key Parameter: 关键参数 — Temperature Profile , Flux, Solder bar, Wave pallet,

Responsibility: 责任 — Eng.

Process Flow/工艺流程

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述 **De-panelize of PCB / 分板**

Key Parameter: 关键参数 Tab Removal and PCB De-panelize

Responsibility: 责任 MBU

Process Description: 过程描述 **Visual Inspection and Date Collection / 目检和系统跟踪**

Key Parameter: 关键参数 IPC-A-610D, layout

Responsibility: 责任 MBU

Process Flow/工艺流程

Generic Process Flow / 一般的工艺流程图

Flow Chart

Process Description: 过程描述 — **In Circuit Test / 在路测试**

Key Parameter: 关键参数 — Test PCB Assembly Circuitry/测试PCB装配线路

Responsibility: 责任 — MBU

Process Description: 过程描述 — **Screwing / 打螺丝**

Key Parameter: 关键参数 — Torque / screw tip

Responsibility: 责任 — MBU / Eng.

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述	**Manual Assy / 装配**
Key Parameter: 关键参数	Fixture / Critical inspection card /夹具/鉴定检查卡片
Responsibility: 责任	MBU, Eng.

Process Description: 过程描述	**Functional Test / 功能测试**
Key Parameter: 关键参数	Functional Test or E-Prom Flash/功能测试
Responsibility: 责任	MBU, Testing

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: 过程描述 — **Reliability Test / 可靠性测试**

Key Parameter: 关键参数 — Cyclical Reliability Test/循环可靠性测试

Responsibility: 责任 — OQA

Process Description: 过程描述 — **Final Inspection / 最后检查**

Key Parameter: 关键参数 — IPC-A-610D

Responsibility: 责任 — MBU

Process Flow/工艺流程

Flow Chart

Generic Process Flow / 一般的工艺流程图

Process Description: **Label Printing / 标签打印**
过程描述
Key Parameter: Programming / Label Printing and Serial# tracking /设计/打印标签和S/N的跟综
关键参数
Responsibility: Eng. , MBU
责任

Process Description: **Label Application and Packing / 贴标签和包装**
过程描述
Key Parameter: Apply Label to PCB and Pack with Correct User Documents/根据使用文件申请PCB和包装的标签
关键参数
Responsibility: MBU
责任

Process Flow/工艺流程

Generic Process Flow / 一般的工艺流程图

Flow Chart/流程图

Process Description: 过程描述 — **Post Pack Audit (PPA) / 封箱前检查**

Key Parameter: 关键参数 — Visual Audit on Workmanship,Labeling, Packaging,User Document Contents and Electrical Audit/目检技艺,标签,包装,使用文件内容及有关电的审查.

Responsibility: 责任 — OQA

Process Description: 过程描述 — **Palletization and Shipping / 打包和出货**

Key Parameter: 关键参数 — Conformance to Customer Packaging Instructions/与消费者的包装只是一致

Responsibility: 责任 — MBU,OQA

Equipment introduction/设备介绍

》SMT / 表面贴装技术

Screen Printing

Solder paste inspection

Chip Placement

QFP /BGA Placement

Equipment introduction/设备介绍

Reflow Oven

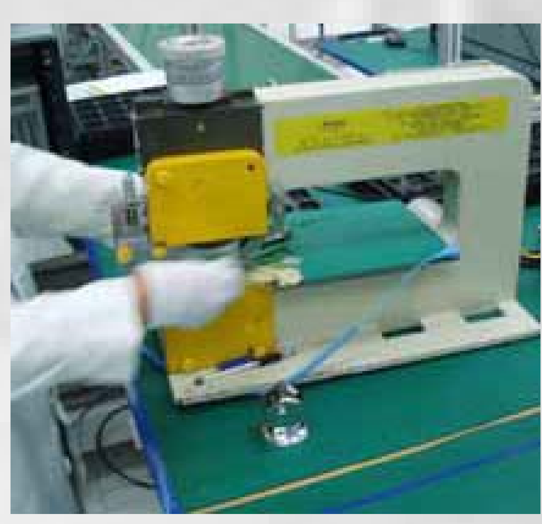
Wave Soldering

Equipment introduction/设备介绍

➢ **Depanelization machine / 分板机**

Router R-168

Punching machine



V-cut

Equipment introduction/设备介绍

》Testing equipment / 测试设备

In Circuit Test

Programming & Functional Test

》Inspection equipment / 检查设备

X-ray
5DX

AOI

Equipment introduction/设备介绍

》Other equipment / 其他设备

BGA Rework station

Underfill Machine

Baking Oven

SMT vs THT/表面贴装技术 vs 通孔装配技术

》**THT stands for "Through Hole Technology".**

THT components has long leads and are insert mounted through the printed circuit board. The solder joints are formed using wave soldering technology./通空元件有长的元件脚，装配时将长脚插入并穿透印刷线路板，通过波峰焊接技术形成焊点.

- SMT components have no or short leads. They are mounted on the surface of the printed circuit board. The solder joints are formed using both wave soldering or reflow soldering technology

表面贴装元件没有或者只有很短的元件脚，元件被贴装到印刷线路板的表面，通过波峰焊接或者回流焊接技术形成焊点

SMT vs THT/表面贴装技术 vs 通孔装配技术

		Comp Type 元件类型	Board Type 板的类型	Assembly Method 装配方式	Soldering Technology
T H T 通孔技术	60'S~ 80S 年代		Single/ Double side PCB 单面/双面PCB	Manual/ Semi-auto insertion 手动/半自动插件	Manual soldering 手工焊接
	70'S ~ 90S 年代	Single Line/ Dual In Line/ Axial	Single side/ Multiple layer PCB 单面/多层PCB	Manual/ Semi-auto/ Auto Insertion 手动/半自动/自动插件	Wave soldering/ Manual soldering 波峰焊接/手工焊接
SMT表面贴装技术	80'S ~ Now 现在	SMD, Chips, LSI, VLSI	High Density Board 高密度板	Fully Automatic 全自动	Wave soldering/ Reflow soldering 波峰焊接/回流焊接

Composition of SMT/SMT 组成

SMT is comprised of/表面贴装技术组成

Material >/原料

- Components/元件
- Printed Circuit Board/印刷线路板
- Adhesives, Solder paste, Cleaning solvents/粘胶，锡膏，清洗容剂

Process >工艺

- Glue dispensing/点胶
- Printing/丝网印刷
- Wave/Reflow soldering/波峰焊/回流焊
- Inspection/Testing/检查/测试

Composition of SMT/SMT 组成

SMT is comprised of/表面贴装技术组成

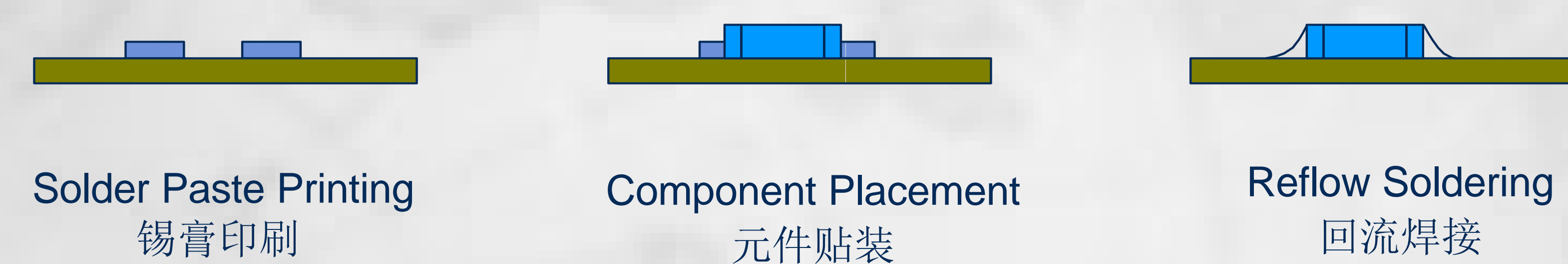
Equipment >/设备

- Dispenser/点胶机
- Solder paste Printer/丝网印刷机
- SPI/锡膏检测
- Placement/贴片机
- Soldering/焊接设备
- AOI/自动光学检测
- In-Circuit-Test/Functional Test/ICT在线测试设备/功能测试设备

SMT Assembly classifications/SMT装配分类

- **Classification by Soldering Method/按焊接方式分类:**

a. Reflow Soldering – Most commonly used method./回流焊接-最常用的方法.

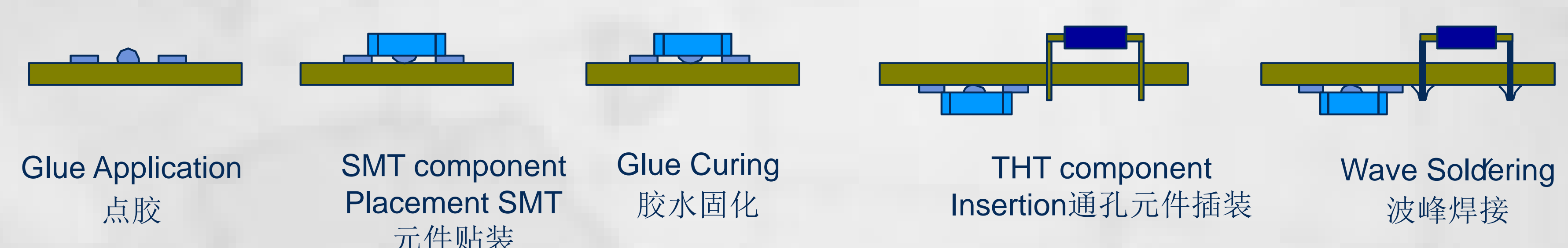


SMT Assembly classifications/SMT装配分类

b. Wave Soldering Method/波峰焊接方法

Sufficient glue is first applied to hold the SMT component in place without interfering with other parts of the board by printing or dispensing. When the component has been placed, the glue is cured to make the bond firm. This is done by either applying heat or ultra violet radiation (UV). The THT components are inserted through the PCB and the entire board enters the wave soldering machine.

通过印刷或点胶在不影响板上其他部件的前提下，用足够的胶水固定表面贴装元件在相应位置，当元件贴装完成之后，通过加热或红外线辐射将胶粘点固化，在插上通孔元件之后，让整个板通过波峰炉进行焊接



SMT Assembly Classifications/SMT装配分类

- **Classification by assembly type/按装配类型分类**

The assembly classifications are divided into pure SMT, single side mixed and double side mixed assembly/装配类型可以分成：纯表面贴装/单面混合贴装/双面混合贴装

Assembly Classifications		Schematic	Substrate	Soldering Method	Remarks
	Single Sided SMT		Single side PCB Ceramic board	Single Reflow	Simple, suitable for small and thin products
	Double Sided SMT		Double side PCB Ceramic board	Double Reflow	Suitable for high density and thin products
	SMD and THC On Side A		Double side PCB	Side A Reflow Soldering Side B Wave Soldering	Usually the SMT is done prior to THT
	THC on side A SMD on side B		Single side PCB	Side B Wave Soldering	Usually the SMT is done prior to THT. The cost of PCB is low
	THC on side A SMD on both side A and B		Double side PCB	Side A Reflow Soldering Side B Wave Soldering	Suitable for high density and complex products
	THC and SMD on both side A and B		Double side PCB	Side A Reflow Soldering Side B Wave Soldering THC on side B maual soldering	Rarely used because of the complicated processes

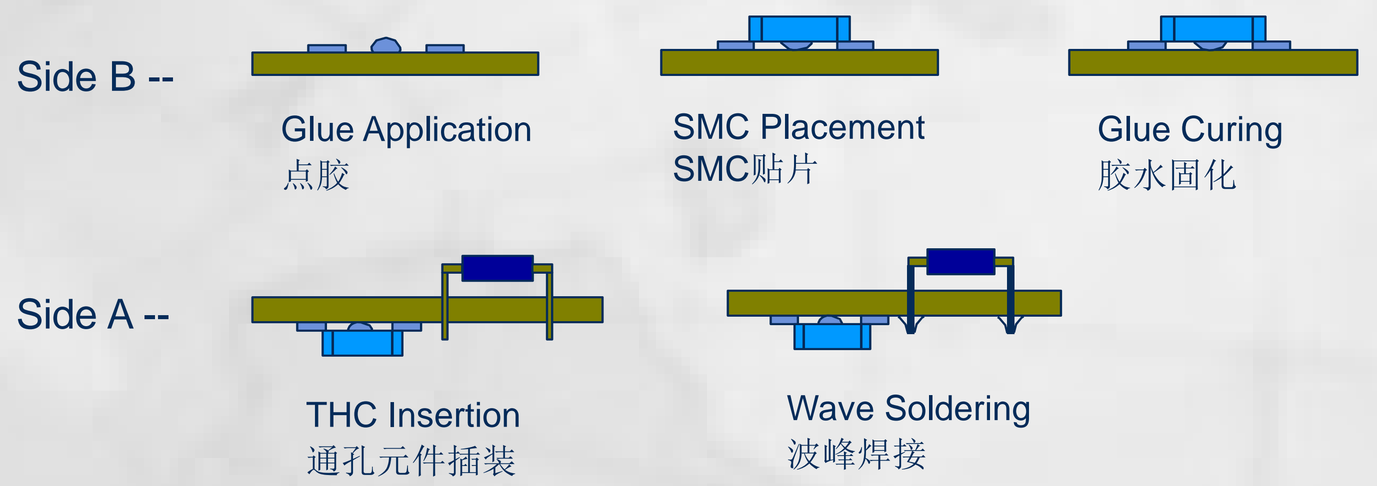
Mixed Technology

Mixed Technology (Low Component Density)

– 混合安装（低元件密度）

a. For single side PCB:/对于单面PCB

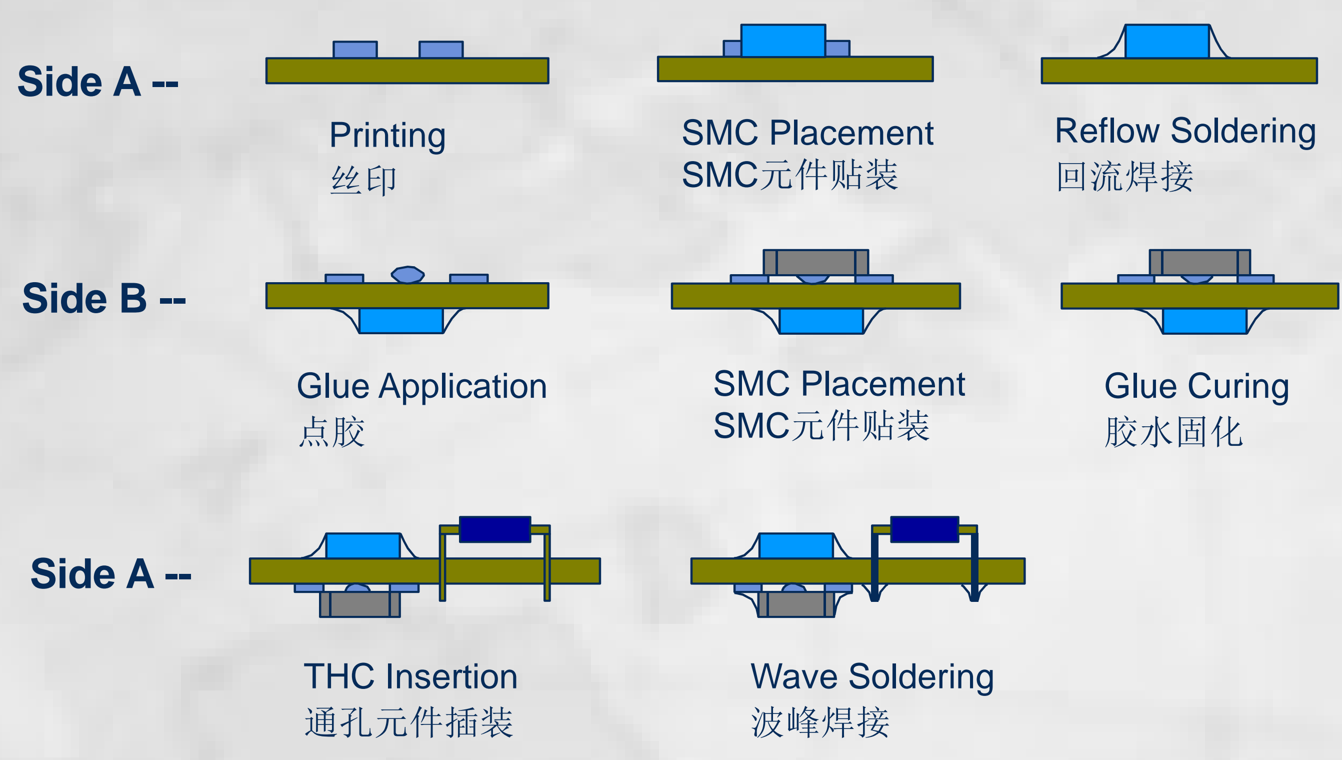
b.For double side PCB:/对于双面PCB



Mixed Technology

Mixed Technology (High Component Density)

– 混合装配技术（高元件密度）



SMT Advantages/SMT的优点

Why using SMT/为什么要使用SMT

- Increased Density/增加密度
  - V"SMC is only 1/3 ~ 1/10 in size compared THT components, as such the board real estate can be maximized and the weight of the assembled board is reduced. By using SMT, the assembled product could be reduced by 40%~60% in size and by 60%~80% by weight

    表面贴装元件只有通孔元件大小的1/3 ~ 1/10，这样板可以得到最大限度的利用同时装配后的板重量会减轻，与通孔装配相比，表面贴装的大小可以缩小40%~60%， 重量可以减轻60%~80%

- Increased Reliability/增强可靠性
  - V"SMC has no or short leads; therefore they are light weighted and possess good resistance to shock and vibration. In comparison to THT, the SMT component can reduce the solder joint failure in the order of 10.表面贴装元件没有或只有很短的元件脚, 因而重量很轻并且具有良好的抗冲击/震动性能，与THT相比，SMT焊点故障能够减少10倍

SMT Advantages /SMT的优点

Why using SMT/为什么要使用SMT

➢ Increased Performance/提升性能

- v"SMT offers better interconnectivity due to shorter paths, providing lower inductance and capacitance.

  表面贴装有更短的连接线路因此拥有更好的连接性能，更低的电感/电容系数

- v"SMT reduces the package propagation delay, which is the time the signal needs to move from one component to another. (Typically the longest delays in the system are off-chip). In comparison, THT components will not work if the operating cycle is more than 500Mhz.

  表面贴装技术减少了由于封装引起的传导延迟，传导延迟指的是信号从一个元件传到另外一个元件的时间。（通常系统里最长的延迟在元件与元件之间），相比较而言，如果系统的工作频率超过500Mhz，通孔元件将不能工作

➢ Increased Efficiency/提升效率

- v"SMT is more suitable for large scale automated production. By using the CIMS, the production process is highly automated, and it brings the efficiency to a even higher level

  自动贴片技术更适合大批量自动化生产，通过运用CIMS，生产工艺高度自动化，并且将将效率带到一个更高的层次

SMT Advantages/SMT的优点

Why using SMT/为什么要使用SMT

➢ Reduced Cost/节约成本

- SMT reduces the cost of bare boards, simplify the assembly process and reduce the cost related to THT equipment. It is expected that the cost of the manufacturing could be reduced by as much as 30% when using SMT

  表面贴装技术减少光板成本，简化装配工艺，节约相应的通孔工艺设备的成本，与通孔技术装配相比，表面贴装技术可以节约30%的制造成本。

SMT Development Trend/SMT发展趋势

Lead Free and No Clean Soldering Process/无铅和免清洗焊接工艺

- The environment concern of lead toxicity has pushed the search for the alternative material of Pb-Sn eutectic solder.

  铅的毒性引起的环境方面的顾虑推动锡铅合金焊剂的替代产品的研究

- Ideal Sn-Pb solder replacement should possess the following characteristics:/理想的锡铅焊料的替代品应该拥有如下特性
  - Low melting point similar to Sn-Pb (close to 183°C, should not be higher than 200°C)

    与锡铅类似的低熔点（接近183°C，不高于200°C ）
  - Low cost/低成本
  - Mechanical strength and resistance to thermal fatigue similar to that of Sn-Pb

    机械强度和热疲劳系数与锡铅类似
  - Compatible with the current equipment and process used in production

    兼容目前生产中的设备和工艺
  - Good wetting and mechanical stress reliability

    良好的焊接性能和机械应力可靠性
  - Good electrical conductivity

    良好的电传到性能

SMT Development Trend/SMT发展趋势

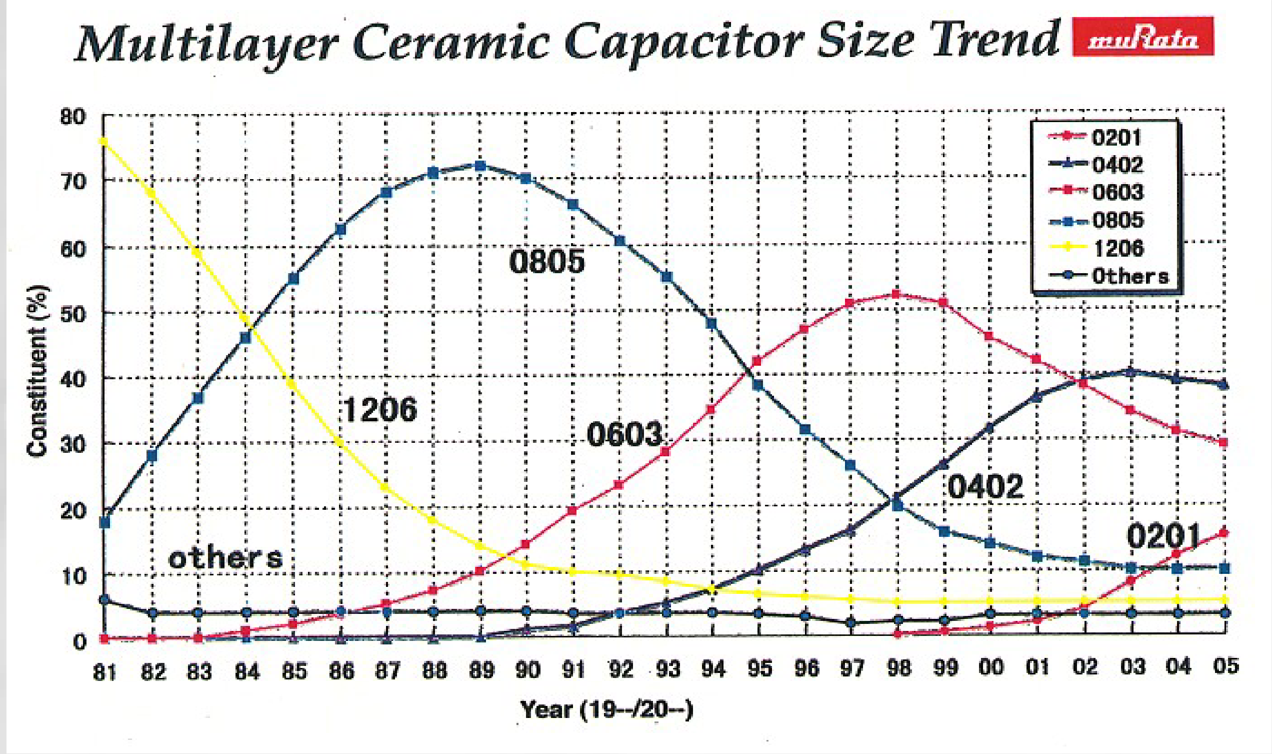
Lead Free and No Clean Soldering Process/ 无铅和免清洗焊接工艺

- Current Lead Free development status/当前无铅的发展状态
  - Binary（二元） – Sn-Bi/锡-铋, Sn-In/锡-铟, Sn-Ag/锡-银, Sn-Zn/锡-锌
  - Ternary （三元）– Sn-Ag-Cu/锡-银-铜, Sn-In-Cu锡-铟-铜, Sn-In-Ag锡-铟-银

- The most promising Sn-Pb replacement candidate is Sn96.5-Ag3.0-Cu0.5. The melting temperature of which is at 217°C/锡铅替代品候选者是：锡95.5-银3.8-铜0.7，这 种合金的熔点是217^{o}C

Trends in Chip Component/片式元件的趋势

Size Trends & Life Cycle/片式元件大小趋势&生命周期



•Driven by system miniaturization and lower manufacturing cost

• 系统小型化和减小制造成本推动片式元件发展

•0201/01005 Size Market Penetration 0201/01005开始渗透市场

– 0603 market share already in decline 0603市场开始下滑

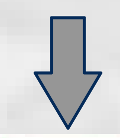
– 0402 has moved beyond mobile phones 0402 撤离手机市场

– 0201 widely used in RF modules from 0201广泛运用于无线电产品

1206 0805 0603 0402 0201 01005

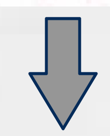
Progression of Packaging/封装方式的发展

Quad Flat Pack
Tape Carrier Package



Leads to Balls

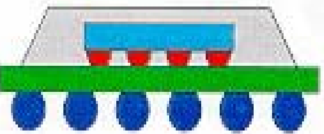
Ball Grid Array



Wires to Bumps

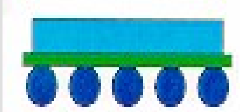
Flip Chip Ball Grid Array

Flip Chip In Package (FCIP)



Packages to Packageless

(near Packageless)



Chip Size Package

Flip Chip On Board (FCOB)

Source: TechSearch International, Inc.

SMT defect & countermeasure/SMT 不良及改善措施

Defects Identification：

- Identify the SMT defects according to IPC-A-610 (Rev: F)

- IPC-A-610 standard is a collection of visual quality acceptability for electronic assemblies (PCBA).

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Excess solder 多锡

1. Excess solder paste:
   Root cause:1).Solder paste height out of UCL
   2). Nonstandard of stencil aperture opening.
   Action:1). Adjust printing machine to under control the paste height.
   2). To standard the stencil aperture opening.

2. Low conveyer ramp, long wave soldering time: Adjust conveyor ramp angle to 5~7 degree and soldering time to 3~5 second (wave solder).
3. High preheat temperature to dry off the flux: According to flux spec to control the preheat temperature, at normally the PCB surface preheat temperature should under 100 degree C (wave solder).

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Solder Bridging /短路

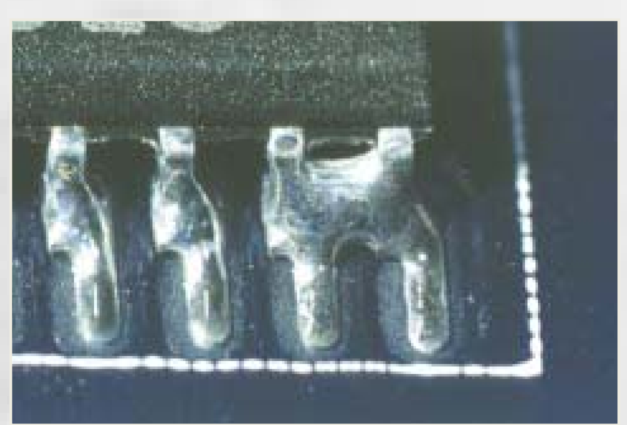
Occurrence: Due to poor print/component place misalignment and/or due to over deposition of solder. /印刷或贴片偏位或多锡

Troubleshoot/解决方法:

1) Check the print alignment setting /检查锡膏印刷正确

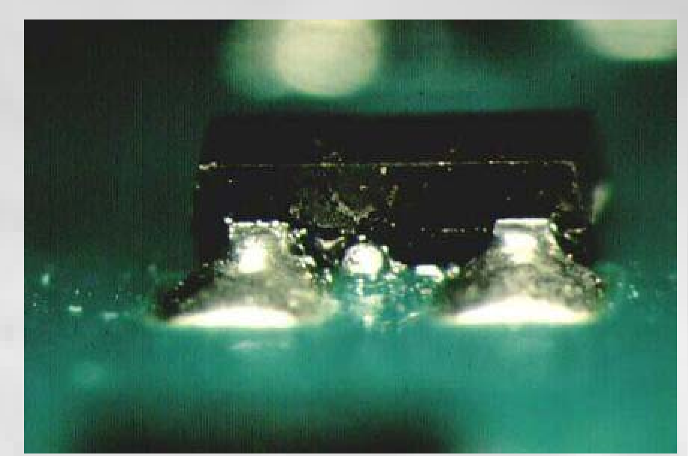
2) Check design of PCB /检查PCB焊盘

3) Check design of the stencil/检查网板设计



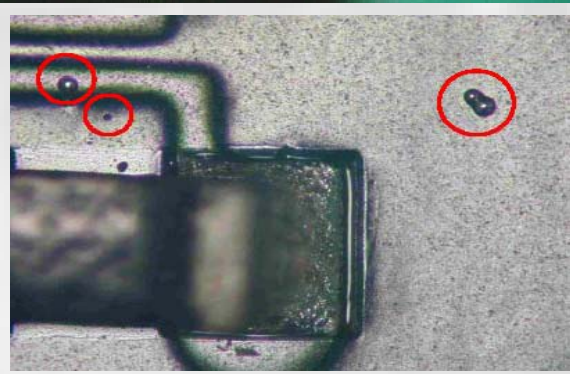
Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Solder Balls/锡球



Troubleshoot/解决方法:

1) Make sure the bottom side of the stencil is clean/确认网板底部是否干净



2) Make sure misprinted boards are cleaned well and no waste paste is left on the board

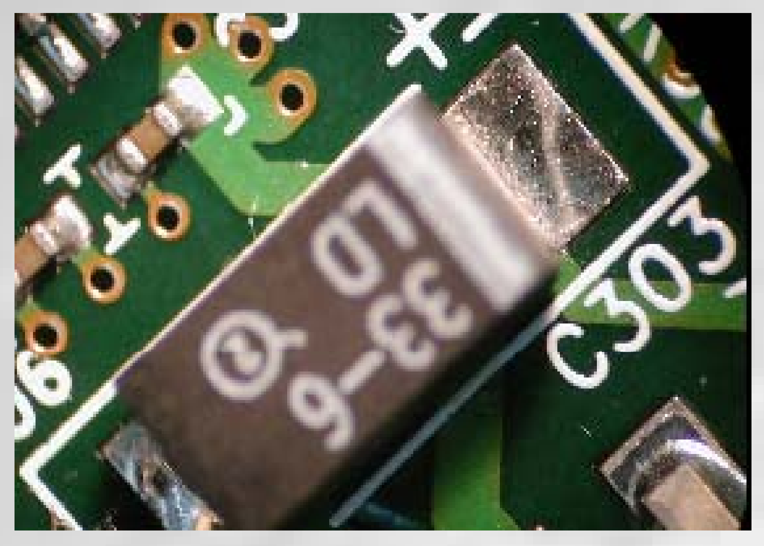
确认错印的板是否清晰干净

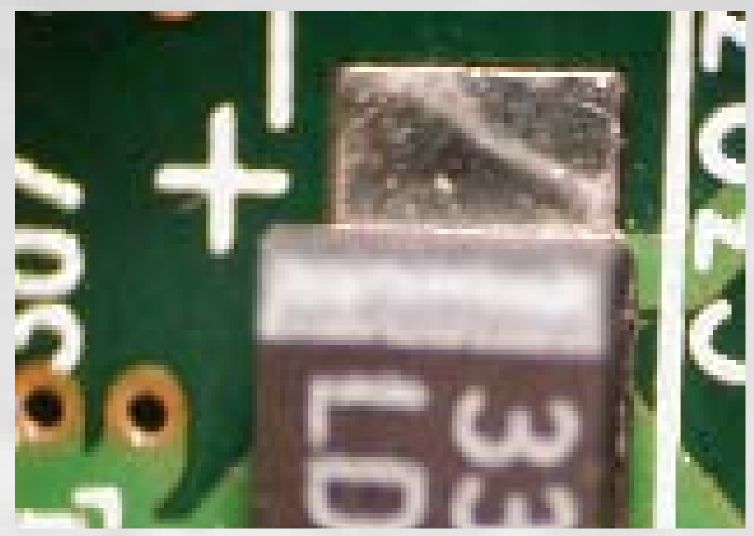
3) Make sure Stencil aperture is correct

确认网板开孔是否正确

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

No solder 无锡





1. Missing printing

Root cause:1). Stencil aperture was jammed.
2). High viscosity of solder paste.

Action:1). Clean stencil;
2). Replace the recycled paste with fresh one.
3). Printing machine parameter adjustment.

2. Poor solder ability of component or pad

Root cause:1).Old date date component or PCB.
2).Contamination on component or PCB.

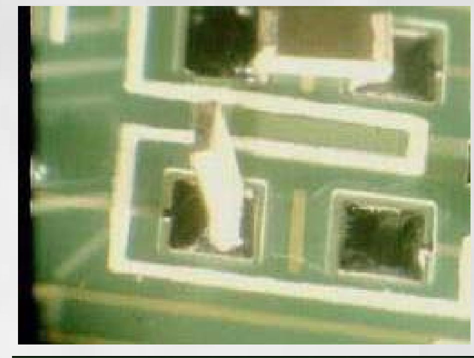
Action: Hold the lot material for further disposition

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Tombstoning/墓碑现象

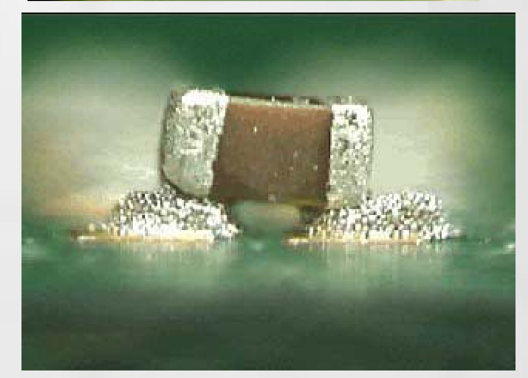
Occurrence: Due to different and unbalanced surface tension force between two end-terminals of chip parts. This results in the device lifting on one side after reflow.

原因:由于元件两端的表面张力不平衡导致在回流焊时元件一端升起



Troubleshoot/解决方法:

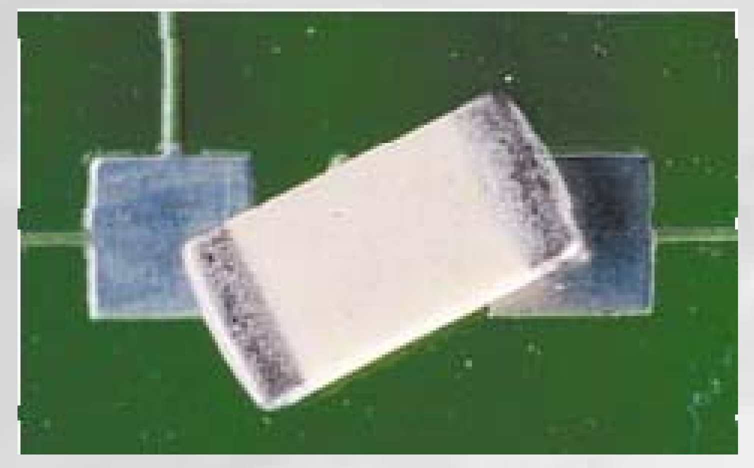
1) Minimize hold-down moment: minimum paste volume/stencil aperture size under component body /尽量减少元件体下的锡膏量

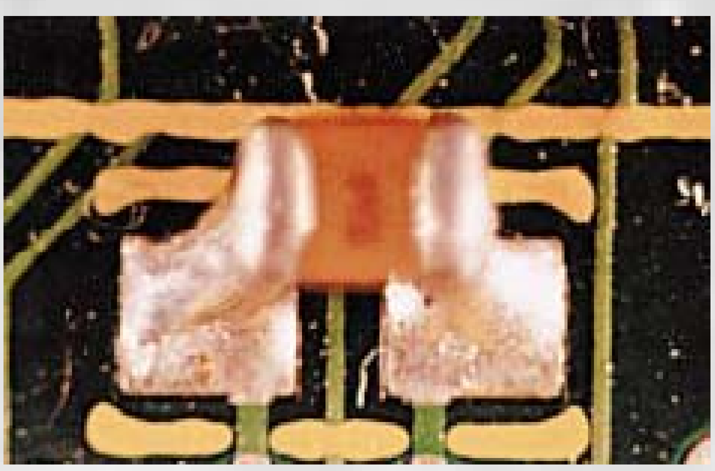


2) Maximize force balance: optimum paste/component registration/尽量使力平衡,优化锡膏和元件焊盘

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Misalignment 偏位





1. P&P machine function is unstable: Fine tune the P&P machine.
2. Component termination oxidized : check and hold the lot material..

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Cold solder /冷焊

Cold Solder indicates the incomplete re-melt condition of solder joints. /冷焊是指焊点的锡没有完全融化.

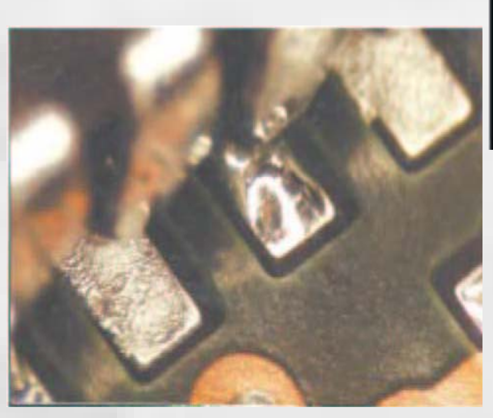
Occurrence: This condition may be caused by improper paste or reflow profile

原因:可能是因为锡膏或温度不对

Troubleshoot/解决方法:

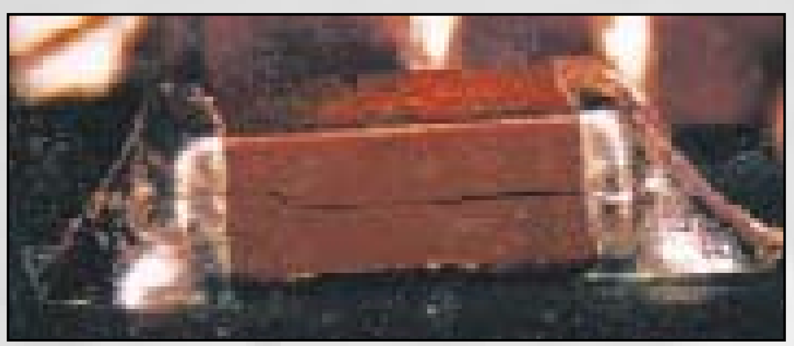
1) Check the reflow profile /检查回流焊曲线

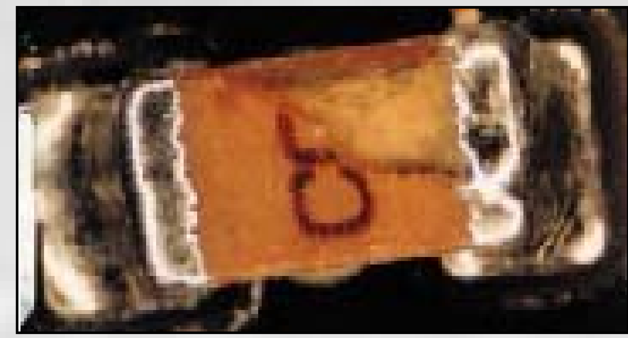
2) Check solder paste /检查锡膏



Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Component damage 坏件

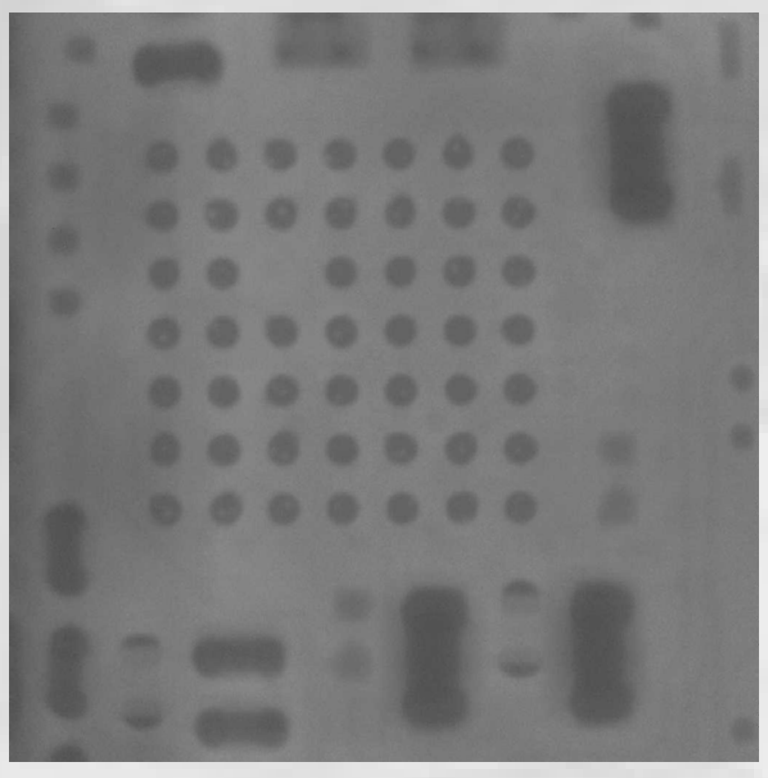




1. Raw material damaged: purge the batch material.
2. Damaged on SMT process (Fixture or machine touch it) : Investigated and take action on nonstandard operation.
3. Fast cooling on reflow process : Should control the profile cooling scope to 3.5~4degree per second.

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

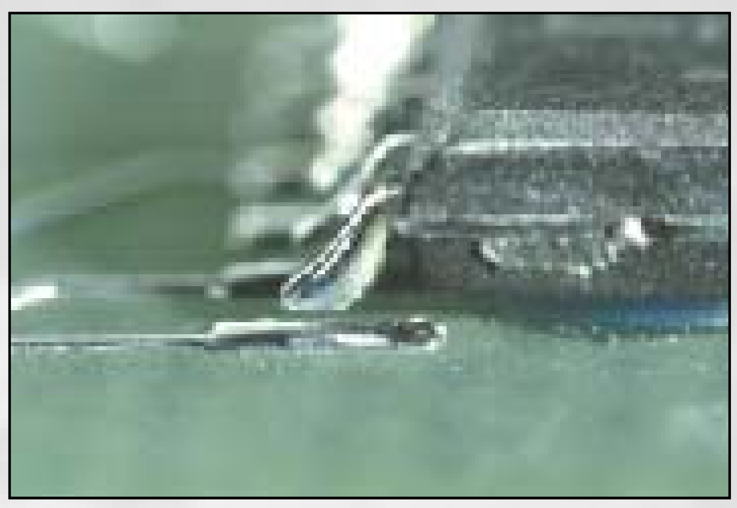
Bubble on ball of BGA / BGA空洞



1. Damp PCB: Bake the PCB before load it to SMT.
2. Ball oxidized : Bake the BGA and special control the expose time.
3. Short time and low temperature on soak section : Optimize the reflow profile.

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Component lead lifted 元件翘高



1. Component lead bent before placement : Sort out the defect part or hold the lot material and then return it to vendor.
2. Manual or machine touch it : Inspect the touched part before pass it to reflow

Typical Soldering Defects and Troubleshoot /典型的焊接缺陷和解决方法

Solder Opens /开路

Occurrence: Due to insufficient deposition of solder paste during printing process. Sometimes, epoxy has been deposited over a pad by error, and prevents the solder from wetting the pads./原因:印刷少锡. 胶水上焊盘.

Troubleshoot/解决方法:

1) Ensure that the stencil is clean and that the paste has the correct preconditioning clean/ 确认网板干净锡膏操作正确

2) Check the epoxy dispenses process

确认胶水不上焊盘

SMT Video