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APPENDIX A

THE FEATURING OF ELECTRONIC ASSEMBLY TECHNOLOGY

A.1 Printed wiring boards

The "printed circuit" (or printed wiring) process [28] is the basic interconnection technique for electronic devices. Virtually every electronic packaging system is based upon this process. Surface mount technology (SMT) has emerged as a major interconnection and packaging technology. This technology is introduced to increase requirements for denser geometries, stricter process control, greater reliability, lower cost, and alternative materials and components.

The printed wiring board (PWB) is an essential part of a total electronic circuit packaging system. The system starts with the components required to achieve product functionality, continues with the component package that provides the connection to the internal component contacts, and ends with PWB interconnecting the package leads into a total circuit. With the introduction of semiconductor components, the technologies of packaging and interconnection have been considered to provide the capability to use smaller, faster, cheaper integrated circuit available.

A.2 Classification of printed wiring boards

a) Single sided boards

The single sided board (SSB) has circuits on only one side of the board (Figure A-1) and is frequently referred to as the "print-and-etch" board because the resist protecting the copper during the circuit-forming etching process is usually "printed" on by screen printing techniques. Its major applications are in packaging consumer electronic products.

b) Double sided boards

Double sided boards (DSBs) have circuits formed on both sides of the boards (Figure A-2). They can be categorized into two classes, one without through hole metallization and another with through hole metallization. There are two types of metallized through-holes: plate-through-hole (PTH) and silver-through-hole(STH).

c) Multilayer boards

By definition, multilayer boards (MLB) have 3 or more circuit layers; some boards have as many as 60 layers interconnection.

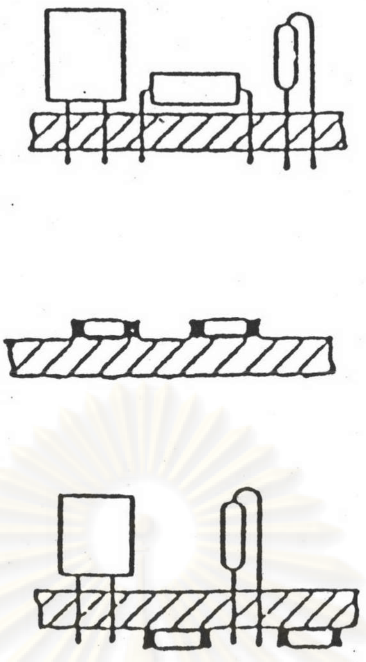


Figure A-1 Single sided boards [28]

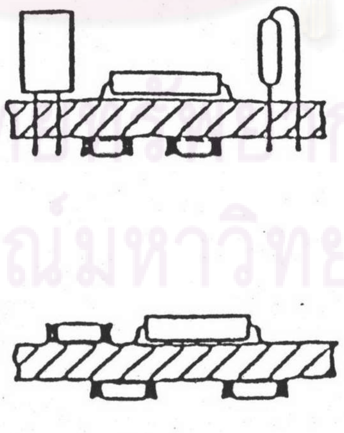


Figure A-2 Double sided boards [28]

A.3 Surface mount technology

Through-hole printed wiring technology [29] is no longer adequate to meet needs of high-performance electronic assemblies. Manufacturers faced with constraints on size, cost and electrical performance of through-hole components are finding that surface mount technology (SMT) is a promising alternative. SMT may be the most significant development in printed wiring technology in many years. SMT offers many benefits over conventional through-hole technology. Whereas through-hole components are mounted to the printed wiring board by way of leads inserted through the board, surface mount components (SMCs) are soldered directly to the copper conductors on its surface as shown below.

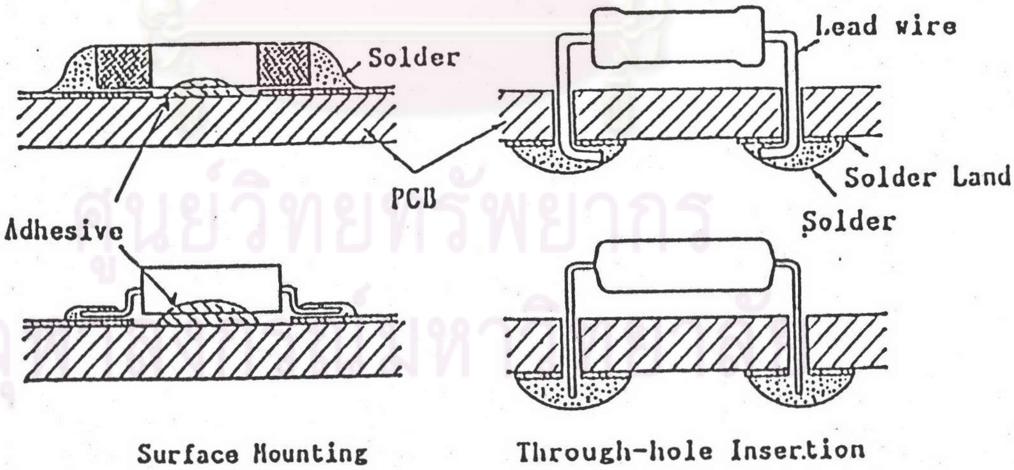


Figure A-3 Surface mounting VS Through-hole insertion

A.4 Manufacturing processes

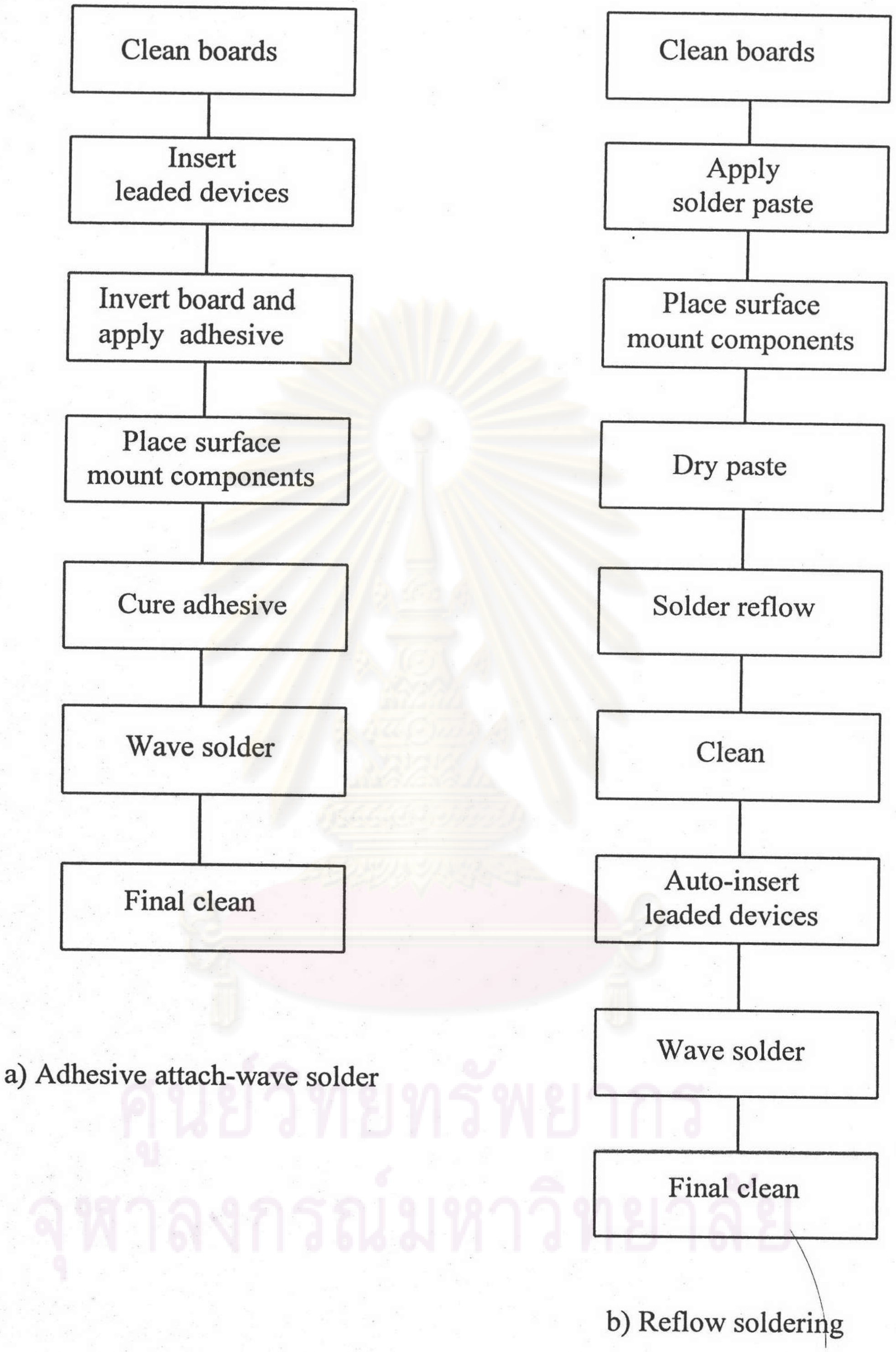
The two principal surface mount process technologies in use (Figure A-4) are adhesive attach-wave soldering and reflow soldering.

I) Adhesive attach-wave soldering

The adhesive attach-wave solder process was developed in part to increase the utilization of through-hole process equipment. In theory, by using existing wave-soldering equipment, a PWB containing both through-hole components and SMCs could be assembled with minimum impact on existing process flows. In practice, wave soldering of surface mount assemblies is different from through-hole soldering in two respects. First, the components must be mechanically attached to the board before soldering. Second, the wave dynamics that have worked for through-hole assembly must be modified when soldering SMCs.

II) Reflow soldering

The reflow soldering approach is to assemble the components such as variable resistors and some wire wound inductors which cannot survive immersion in a solder wave.



a) Adhesive attach-wave solder

b) Reflow soldering

Figure A-4 Surface mount process flows

A.5 Assembly adhesive property

Components to be wave-soldered must be adhesively attached to the board so that they remain in place during the wave-soldering process. The adhesive used must meet the following basic requirements.

a) It must hold components in the correct orientation upon placement, maintaining that orientation through the cure and wave-soldering operations. Although ideally the adhesive would cure without moving the part, movement of up to 0.010" has been ovserved in practice.

b) It must have adequate adhesion to different surfaces and be unaffected by exposure to the adverse environment of solder flux and wave-soldering.

c) For reliability, it must be chemically inert throughout the life of the assembly and thermal conductive in order to dissipate heat accumulation on board to environment when circuits in operation.

A.6 Type of adhesives

Two types of adhesives [30] are commonly used for SMT assembly : epoxies and acrylics. Other types are used on a more limited basis.

a) Epoxy adhesives used in SMT assembly are typically single-component heat-curing systems. Cure cycles from 2-10 min. at 100-150°C are typical. Epoxies provide good insulation resistance and bond strength. They are available in a range of formulations for special requirements.

b) Acrylic adhesives used for surface mounting are usually cured by a combination of UV and IR energy. The UV cure cycle requires that a portion of the adhesive extend outside the component body. This exposed adhesive is cured with a 15-30 second exposure. The subsequent IR cycle ranges from 90 seconds to 2 minutes at 150°C and cures the adhesive in areas that were not exposed to UV.

c) Other adhesives types such as cyanoacrylate adhesives cure rapidly, but their viscosity and poor working life make them unsuitable for general-purpose use. They have , however, been used successfully to hold quadpack ICs during the solder operation.

A.7 Adhesive application techniques

Adhesive can be applied through one of several techniques. The most common are syringe dispensing, pin transfer, and screen printing. [31]

a) Syringe dispensing

Adhesive is often dispensed by a nozzle on the pick-and-place machine immediately prior to placing the component. Adhesive is stored in an air-driven syringe mounted to the placement head or on a separate head proceeding it. Some machines apply the adhesive to the PWB, whereas others apply it to the component. Since adhesive is dispensed to only one component location at a time, syringe dispensing is most suitable for low to moderate speed assembly operations using sequential placement equipment.

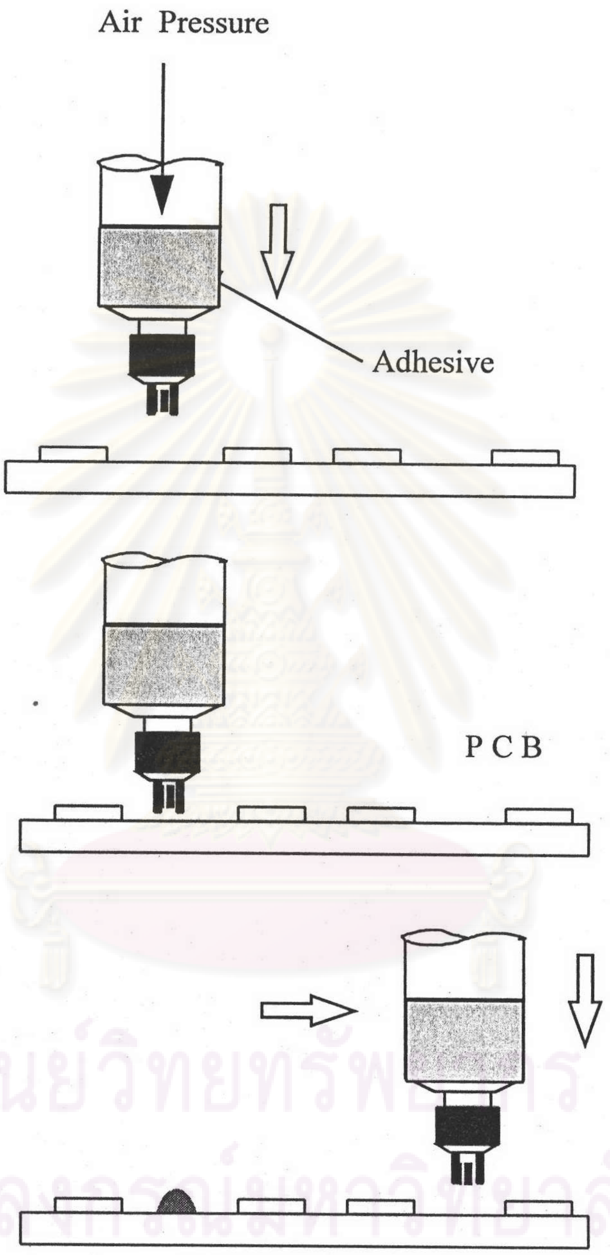


Figure A-5 Syringe Dispenser Epoxy Adhesive Applied Technique

b) Pin transfer

This technique makes use of a matrix of pins held in a fixture. The pins are arranged so that when the fixture is placed over the PWB, they touch the board in the locations where adhesive is to be dispensed. In operation, the pins are first dipped into a thin layer of adhesive. Surface tension causes a quantity of adhesive to remain on the pin after withdrawal. The fixture is located over the PWB and lowered to within close proximity of the board (the pins do not typically touch the board). The adhesive makes contact with the PWB, and a portion is transferred from the pins to the board. Adhesive quantity is controlled by carefully controlling the viscosity of the adhesive and the proximity of the pins to the board. The pin transfer method is suitable for high-volume applications.

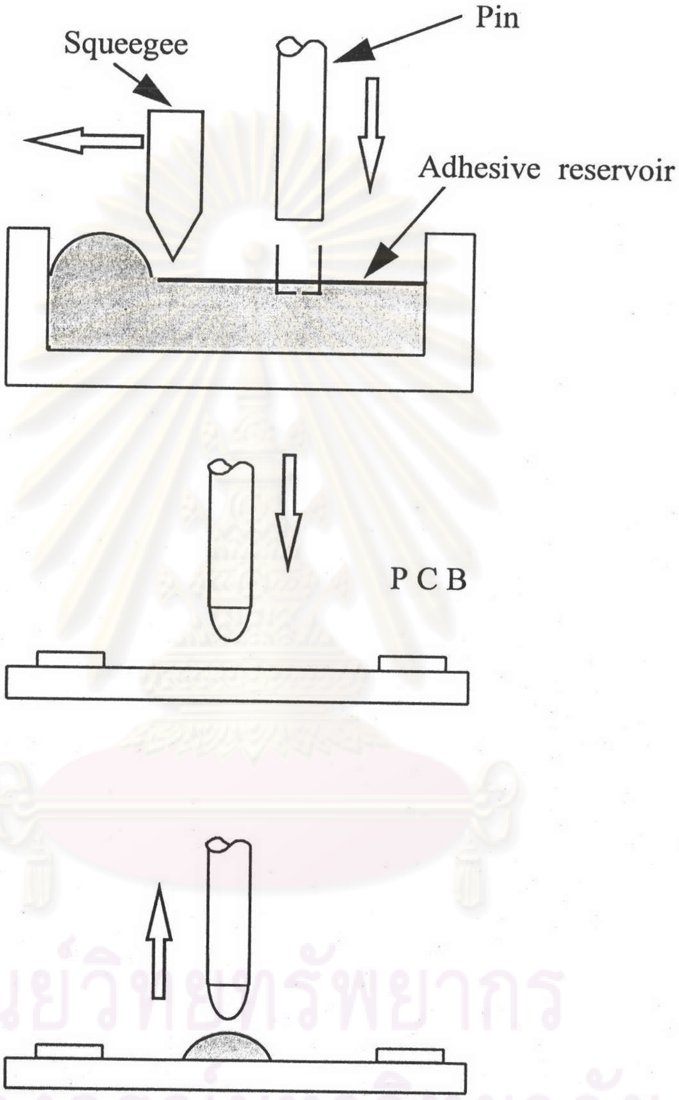


Figure A-6 Pin Transfer Epoxy Adhesive Applied Technique

c) Screen printing

Adhesive may be screen-printed onto a PWB in a manner similar to that used in the graphic arts. Adhesive is spread across the top of the screen, and a squeegee is drawn across it. This forces the adhesive through the windows onto the board. The amount of adhesive dispensed is controlled by the thickness of the wire mesh and the size of the windows. The adhesive used in screen printing should be thixotropic : its viscosity should drop during the application process. This ensures that it will flow onto the board properly. Since screen printing requires a flat board surface, it cannot be used on boards already containing through-hole components.

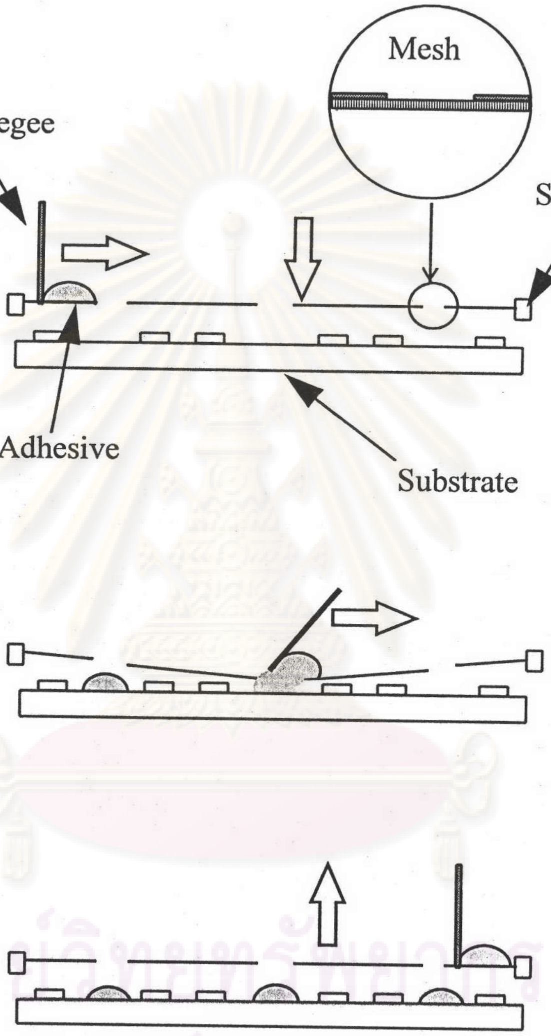


Figure A-7 Screen Printing Epoxy Adhesive Applied Technique

Surface mount components are placed on the board by one of three methods: automatic pick and place, robotic placement, or manual placement after adhesive was applied.

A.8 Wave soldering system

Once the components are attached, they are ready to be wave-soldered. [32] Wave-soldering system is shown in Figure A-8 and a typical thermal profile of this system is also shown in Figure A-9. Using the wave-soldering process, SMCs can be readily combined with through-hole components on the same board. When automated assembly equipment is used, through-hole components are first inserted and clinched (but not soldered). The board is then inverted and the SMCs mounted adhesively. Finally, both leaded components and SMCs are wave-soldered as shown in Figure A-10 to Figure A-12.

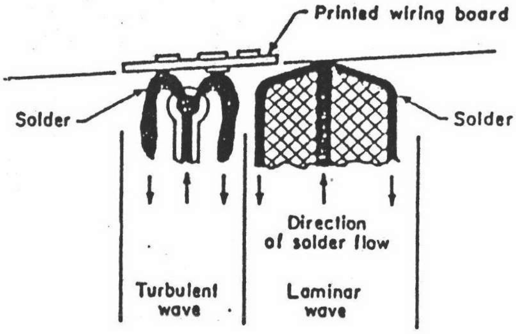


Figure A-8 Wave soldering system [32]

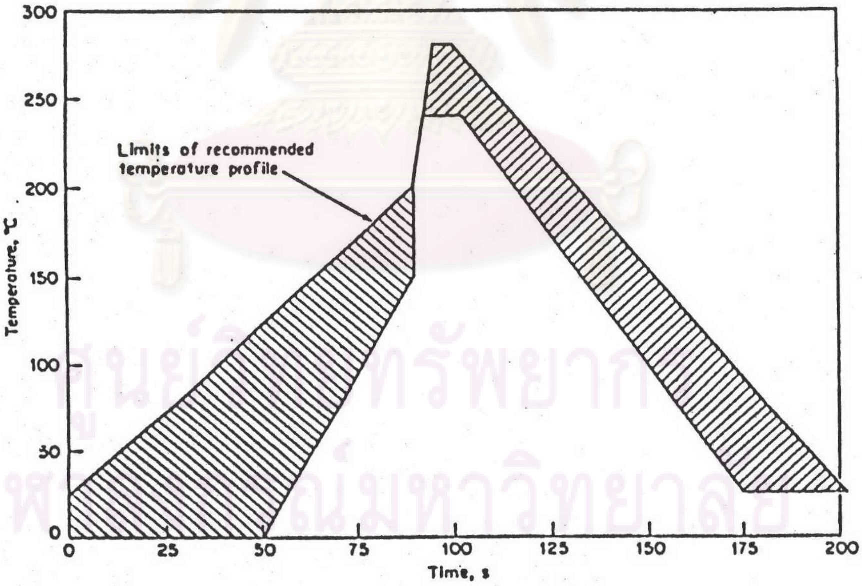
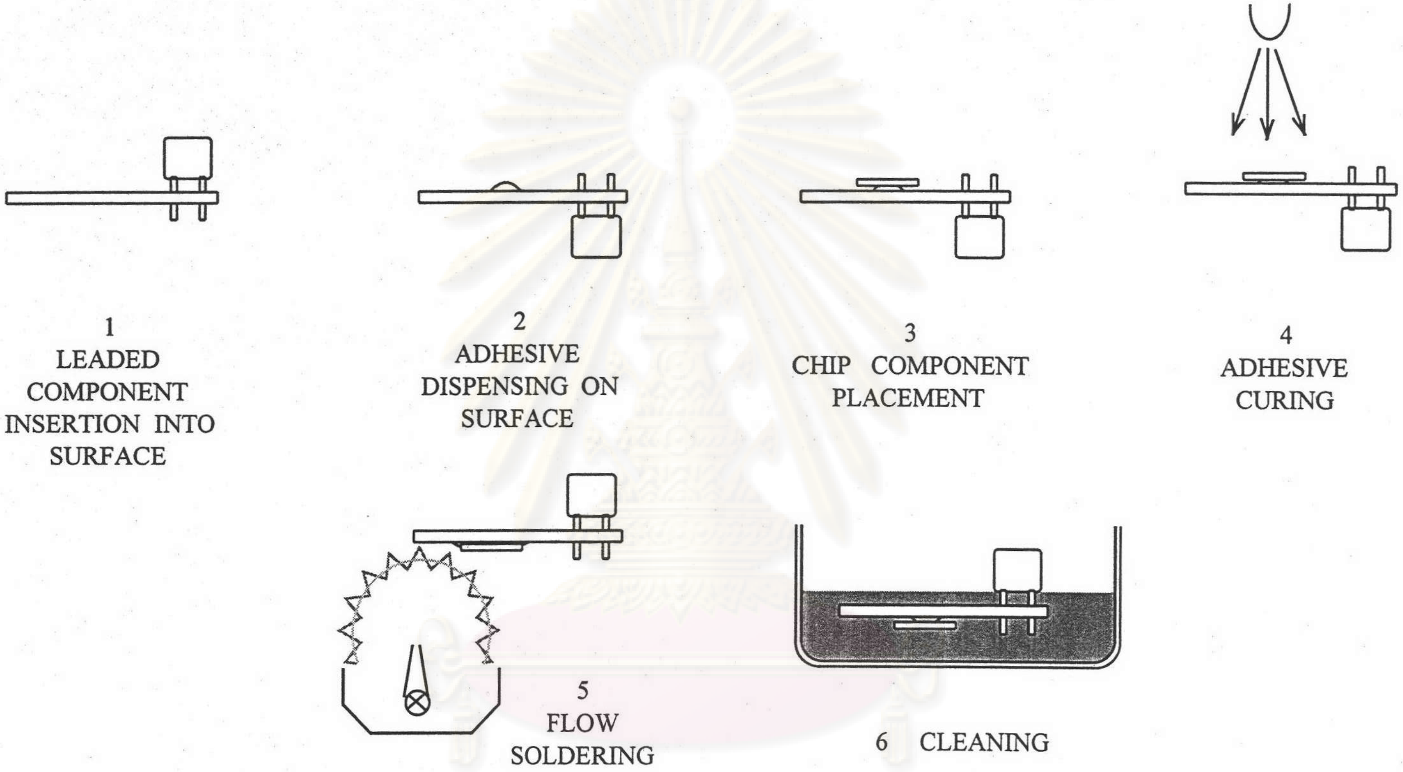


Figure A-9 Typical wave soldering temperature profile



CHIP PLACEMENT AFTER LEADED COMPONENT INSERTION

Figure A-10 Single Sided Chip Placement Process

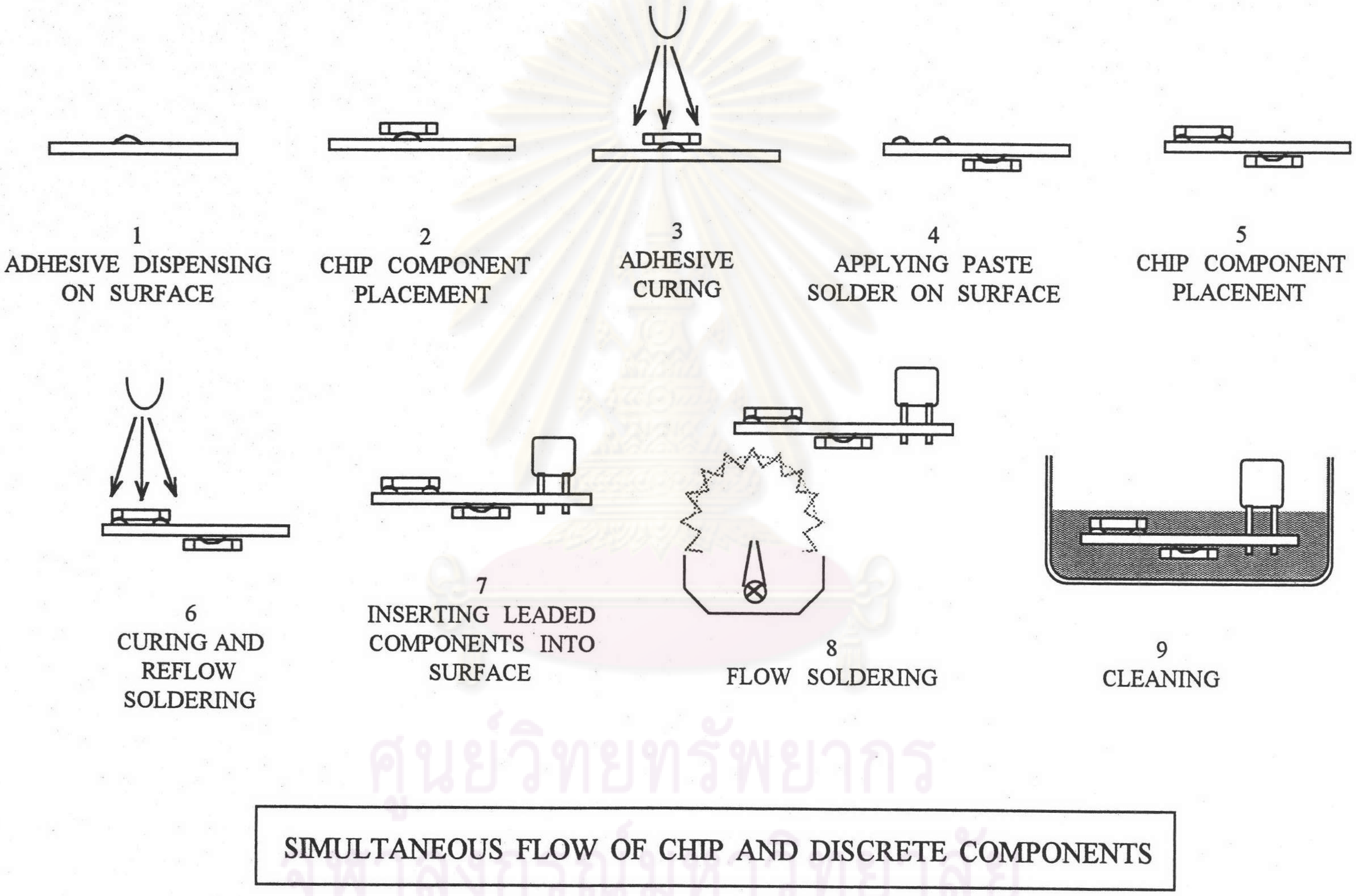


Figure A-11 Double sideed chip placement process

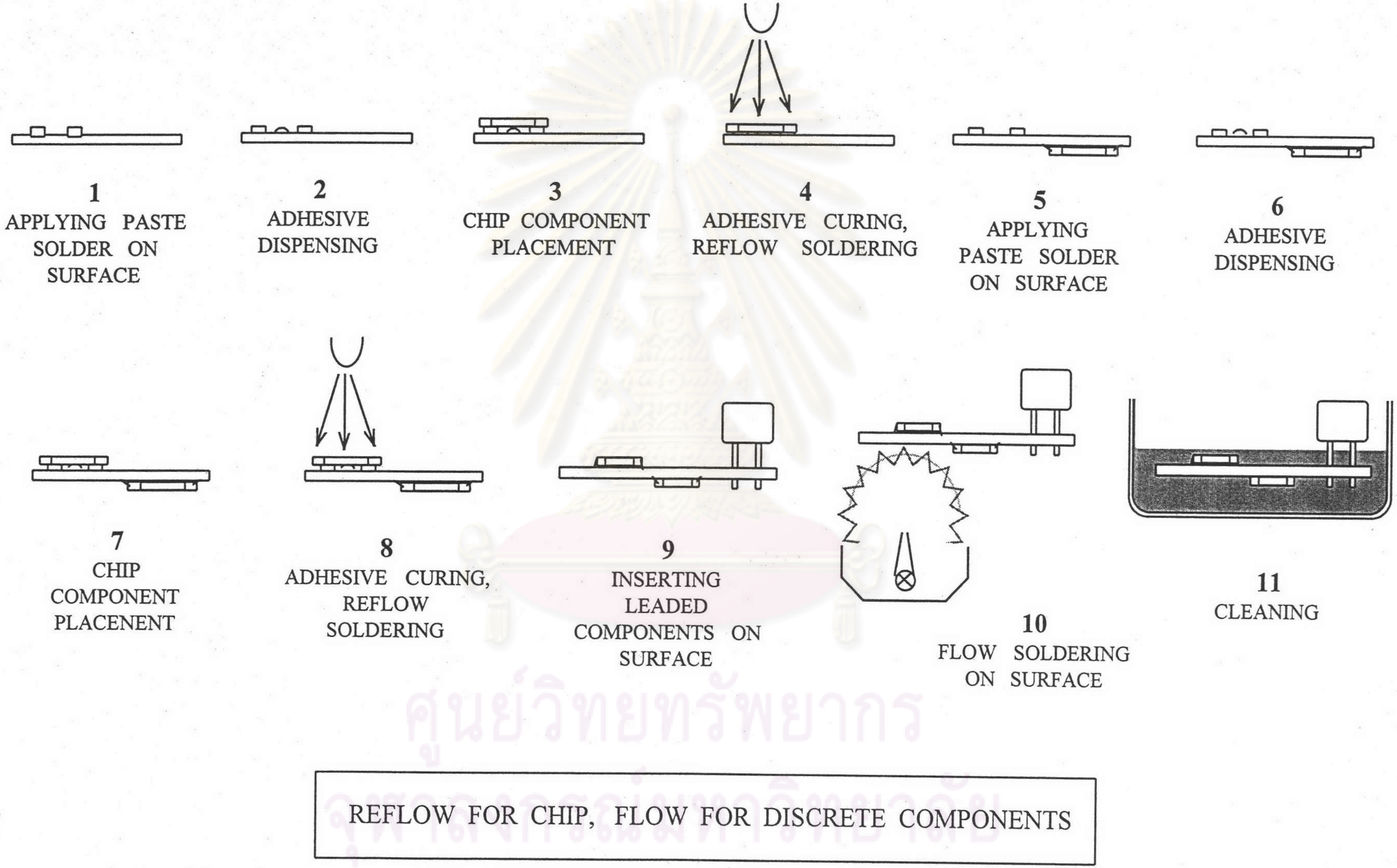


Figure A-12 Double sideed chip placement process (2)

APPENDIX B

CALCULATION OF FILLER PERCENTAGE

The calculation of % weight of filler to % volume fraction

Because the Lewis and Nielsen and the Ratcliffe models that are used to explain the experimental data in this thesis calculate the thermal conductivity of composites from % volume fraction of fillers and the real experiment has prepared the epoxy composites by varying percent weight of fillers, the calculation shown below is made to convert % weight of fillers to % volume fraction in each epoxy adhesive composite.

The calculation procedure for convertion % weight of 100 g of epoxy composite which has 20 % weight of berylium oxide filler and 80 % weight of epoxy adhesive A to volume fraction ratio can be done as the following :

weight of berylium oxide filler = 20 g

density of berylium oxide filler = 3 g/cm^3

volume of berylium oxide filler (V_d)

= weight of berylium oxide/density

= 20 g / 3 g/cm^3

= 6.67 cm^3

weight of epoxy adhesive A = 80 g.

density of epoxy adhesive A = 1.15 g/cm^3

volume of epoxy adhesive A (V_c)

= weight of epoxy adhesive/density

= 80 g / 1.15 g/cm^3

= 69.57 cm^3

volume of composite (V_t) = $V_d + V_c$

= 6.67 + 69.57 cm^3

= 76.24 cm^3

% volume fraction of aluminium filler

= V_d / V_t

= 6.67 cm^3 / 76.24 cm^3

= 0.0875

APPENDIX C

CALCULATION OF THERMAL CONDUCTIVITY

C.1 The calculation for the Lewis and Nielsen model

In chapter II where numerous theoretical, semi-empirical and empirical models for thermal conductivity explanation of different materials and composites were mentioned, this thesis brings the Lewis and Nielsen semi-theoretical model to elaborate thermal conductivity characteristic of studied epoxy composites.

This model consists of the following equations :

$$k_e = k_c\,[(1+AB\phi)/(1-B\psi\phi)]$$

$$\psi = 1+[\phi(1-\phi_m)/\phi_m^2]$$

$$B = [(k_d/k_c-1)/(k_d/k_c+A)]$$

This model can calculate the thermal conductivity of composite, k_e, by using the convertion data of volume fraction from Appendix B, This sample shows the calculation of thermal conductivity of epoxy adhesive composite filled with 20 % weight of berylium oxide.

% volume fraction of berylium oxide filler = 0.0875

the assumed maximum packing fraction = 0.64

(from Table 2.2 : random close pack of spherical particles = 0.637)

and parameter shape of sphere, A = 1.5

thermal conductivity of epoxy adhesive A, k_d = 0.12 W/mK

thermal conductivity of berylium oxide, k_c = 272 W/mK

substituting all above values into the model :

$$B = [(k_d/k_c-1)/(k_d/k_c+A)]$$

$$= (272/0.12-1) / (272/0.12+1.5)$$

$$= 0.9989$$

$$\psi = 1+ [\phi(1-\phi_m)/\phi_m^2]$$

$$= 1+[0.0875(1-0.64)/0.64^2]$$

$$= 1+[0.0875(0.36)/0.4096]$$

$$= 1.0129$$

$$k_e = k_c\ [(1+AB\phi)/(1-B\psi\phi)]$$

$$= 0.12[(1+(1.5*0.999*0.0875))/(1-(0.999*1.0129*0.0875))]$$

$$= 0.15 \quad \text{W/mK}$$

C.2 The calculation for the Ratcliffe model

This model is the correlation of :

$$k_e \quad = \quad k_c{}^{\phi} \quad k_d{}^{(1-\phi)}$$

The sample is the calculation of epoxy adhesive A filled with 20 % weight of berylium oxide.

thermal conductivity of epoxy adhesive A, k_d = 0.12 W/mK

thermal conductivity of berylium oxide, k_c = 272 W/mK

% volume fraction of berylium oxide filler = 0.0875

$$= \quad [\ 0.12^{(0.0875)}\ ] \times [\ 272^{(1-0.0875)}\ ]$$

$$= \quad 0.236 \quad \text{W/mK}$$

APPENDIX D

PRICE OF FILLERS

Table D-1 Price of fillers

Fillers	Price (Baht / gram)
Aluminium metal	2.8
Berylium oxide	70
Berylium metal	15
Copper metal	2.8
Silicon carbide	6

VITA

Miss Benjang Mongkollertsirisuk was born in Bangkok on September 4, 1965. She received her Bachelor of Science Degree in Chemistry, from the Faculty of Science, Chulalongkorn University in 1988. She has furthered her study for a Master's Degree in the Faculty of Chemical Engineering, Chulalongkorn University since 1992. Presently, she is working for Rhone-Poulenc Chemicals (Thailand) Ltd.