Passive Components Embedding 기술

조 한 서 수석연구원
(삼성전기)

2006 SMT/PCB NEPCON

Passive and Active Components Embedding 기술

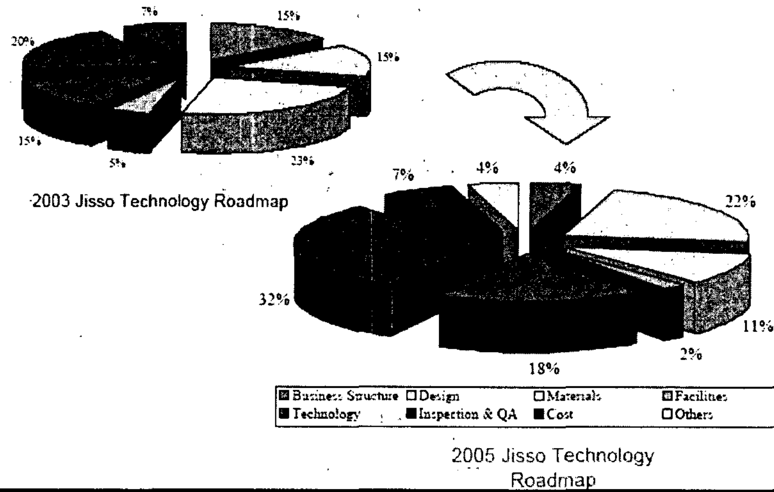
Feb. 15, 2006

삼성전기
ACI R&D Center
Samsung Electro-Mechanics Co., LTD.

Outline

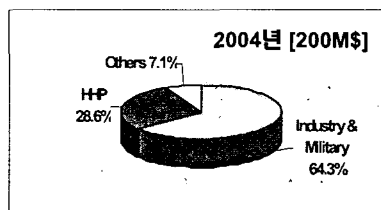
1. Introduction of Embedded PCB
2. Thick Film type Embedded Capacitor
3. Thin Film type Embedded Capacitor
4. Discrete Chip Embedding
5. IC Embedding

Issues for Embedded PCBs in '03 & '05

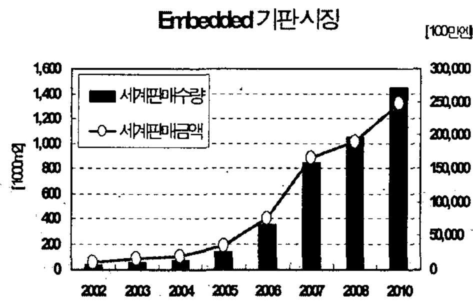


- Material issue ↓ (23 → 11%)
- Inspection & Quality Assurance ↑ (20 → 32%)

Embedded PCBs Market



Source : Fuji Chimera 2005



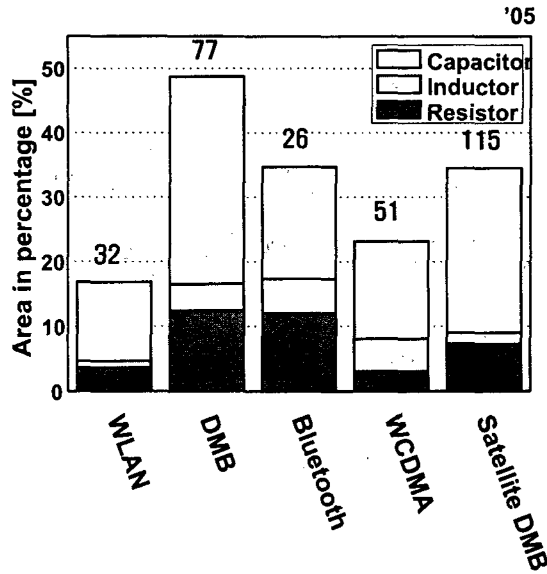
2010년 2.5조원

Worldwide embedded 기판 양산 동향

- Film type passives: 2003~2004년 HHP daughter board에 적용
- IC embedded 기판: 2005년부터 양산
- Passive chip embedding: 2006년 HHP용 모듈

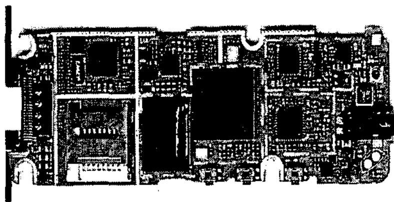
Needs for HHP RF Modules

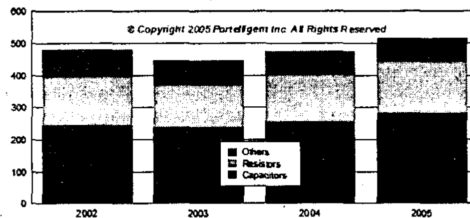
막대위의 숫자:
Passive 갯수



Needs for HHP main boards

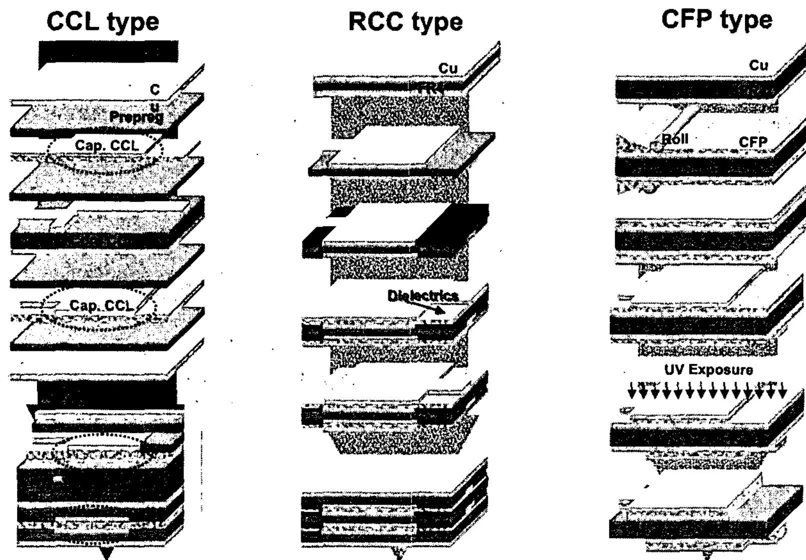
- HHP Mother에서 passive소자가 차지하는 면적 비율 : 40~50%
- HHP Mother board에 실장되어 있는 passive 소자의 년도별 평균 개수: 450~500개





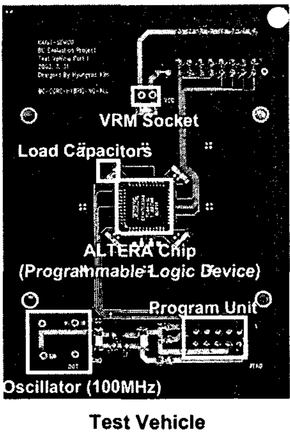
Thick Film Type Embedded Capacitor

Thick Film EC Processes

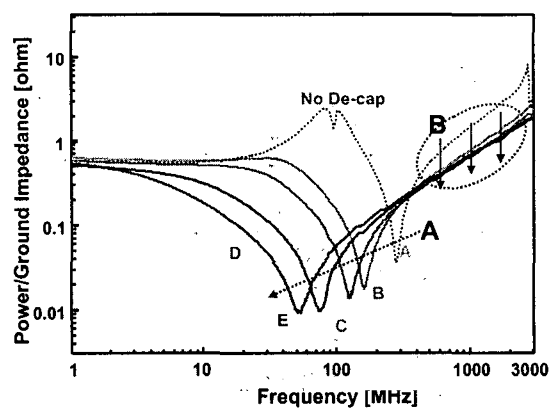


CCL : Cu Clad Laminate, RCC : Resin Coated Cu foil, CFP : Ceramic Filled Photo-dielectric

Electrical Performance of CCL Type EC



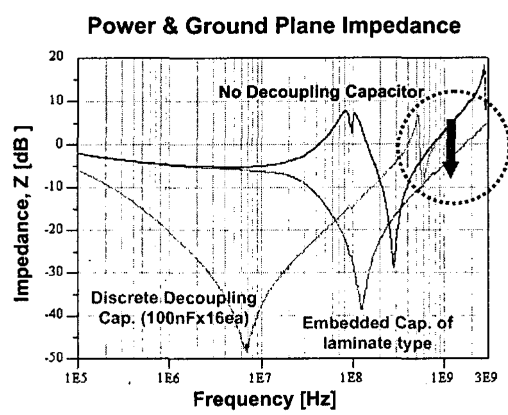
Test Vehicle



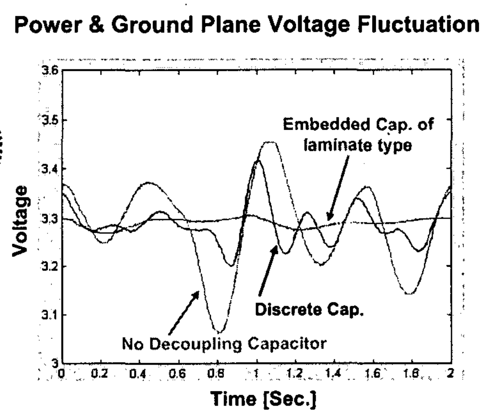
- Higher capacitance materials show lower impedance distribution in low frequency range.
- Thinner dielectric materials show lower impedance distribution in high frequency range.

Electrical Performances of CCL Type EC

Power & Ground Plane Impedance

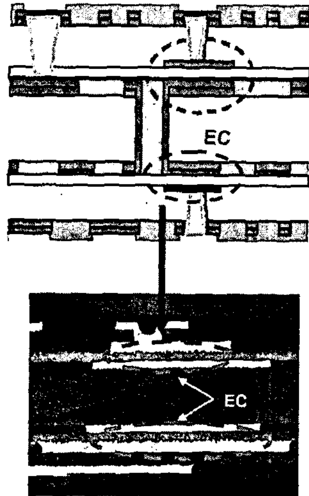


Power & Ground Plane Voltage Fluctuation



> **Embedded Capacitors showed significant Improvement at high frequencies.**

Material Properties of RCC Type EC



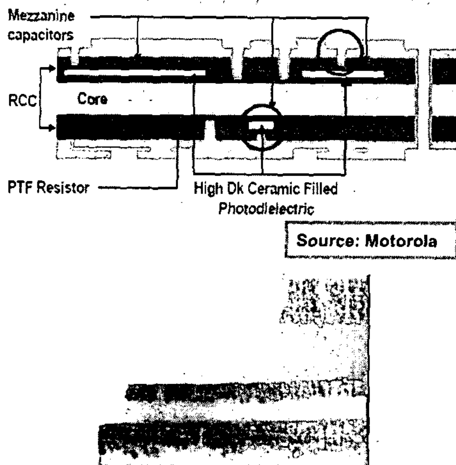
■ EC Material Properties (RCC type)

Item	Unit	Properties
Dielectric Thickness	um	16
Capacitance	nF/mm²	0.016
Dk @ 1MHz	-	29
Df @ 1MHz	-	0.019
Copper Thickness	um	12
BDV	Volt	200
Peel Strength	Kgf/cm	0.7

30% size reduction

Material Properties of CFP Type EC

■ CFP Type



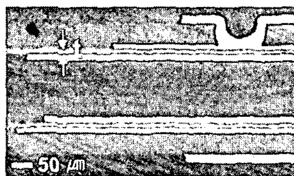
■ Huntsman CFP

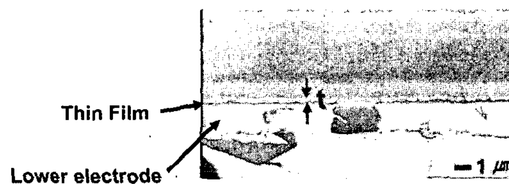
Item	Unit	Properties
Dielectric thickness	μm	12±1
Capacitance density	nF/mm²	0.017
Dk	-	26
Df	-	0.01
Breakdown voltage	Volt	>100
Peel strength	Kgf/cm	1.0~1.2

CFP (Ceramic Filled Photodielectric)

Thin Film Type Embedded Capacitor

Introduction of Thin Film Type EC





Thick Film Type

- ❑ Thickness : over 8 ㎛
- ❑ Low capacitance density
  : 0.1 ~ 3 nF/cm^2
- ❑ Poor TCC grade
  : X7R

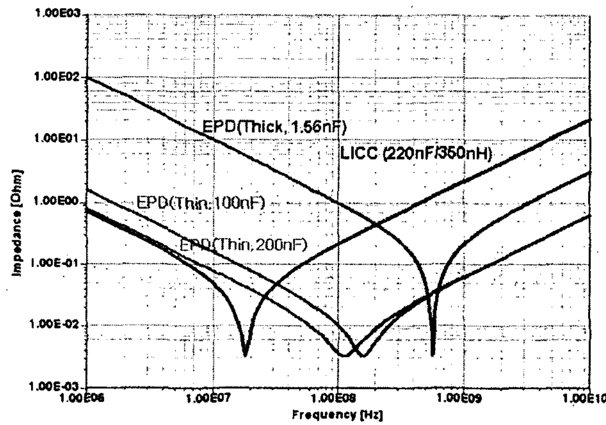
High Capacitance
Better TCC

Thin Film Type

- ❑ Thickness : below 1 ㎛
- ❑ High capacitance density
  : 10 ~ 400 nF/cm^2
- ❑ Better TCC grade
  : X7R, COG

TCC : Temp. Coefficient of Capacitor

Simulation Result of EC



High capacitance density at low frequencies

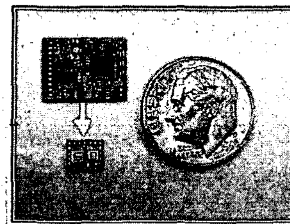
Lower parasitic inductance at high frequencies

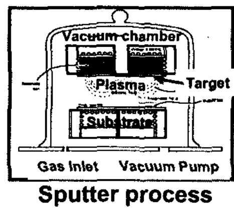
Improved power distribution performance!

LICC : Low Inductance Ceramic Capacitor

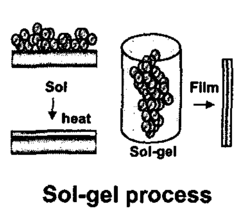
Characteristic of Thin Film Type EC

- **Very thin dielectric layers**
- **High capacitance density**
- ***Good for decoupling capacitors***
- **More size reductions**
- **Reduced parasitic inductance**

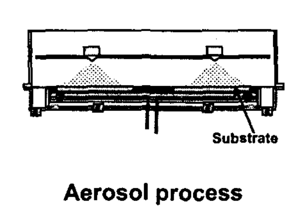




Sputter process



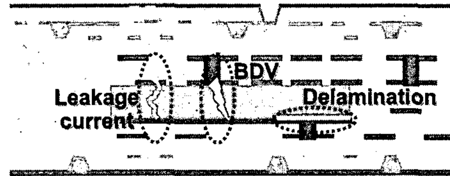
Sol-gel process



Aerosol process

Issues of Thin Film Type EC

➢ Poor Reliability
- High leakage current
- Low breakdown voltage
- Low peel strength due to contact of different materials



Thin film process

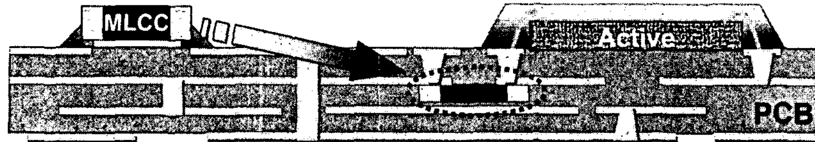
➢ Poor Processibility
- Difficulty in large scale processing

➢ High cost
- Expensive process (Vacuum system, clean room, etc.)

Not ready for commercial products yet

Discrete Chip Embedding

Introduction of MLCC Embedding



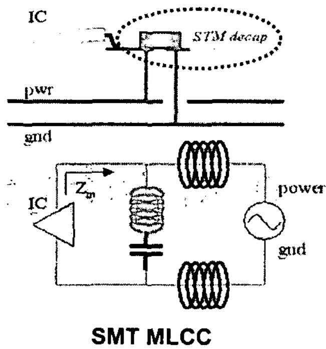
Current Limitations of film type

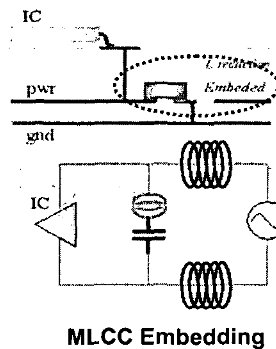
- Thick Film Type
  - Poor tolerance
  - Low capacitance density
  - Poor TCC grade
- Thin Film Type
  - Unable to process large scale
  - High cost

MLCC embedding

- Use already proven MLCCs
- Wide range of capacitance
- Good tolerance & TCC
- Re-use of discrete library
- Relatively sufficient design tool

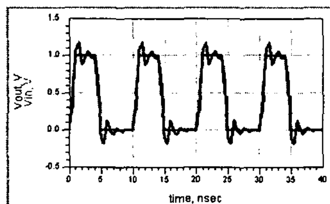
Simulation Result of MLCC Embedding



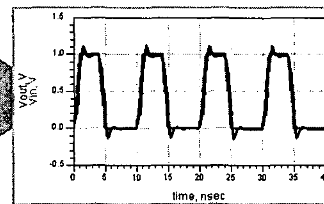


SMT MLCC

MLCC Embedding



Noise Reduction
due to
low parasitic inductance



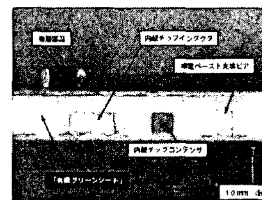
MLCC Embedding Processes

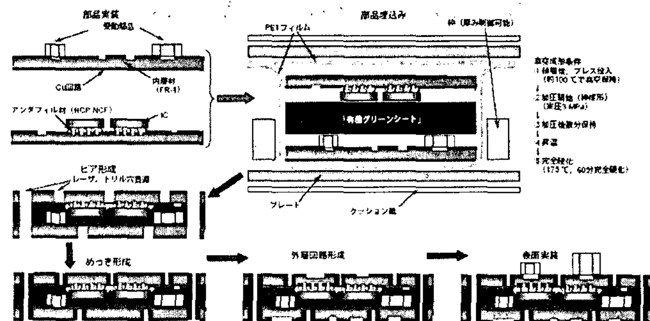
	Molding Type	Cavity Type
Concept	Press Molding Chip	Press Chip
Process	**Bonding (SMT)** **Molding** **Lamination**	**Cavity** **(Molding)** **Lamination**

Chip 부품 내장 기술_Molding type

- **CCL상에 solder 실장 후 적층**

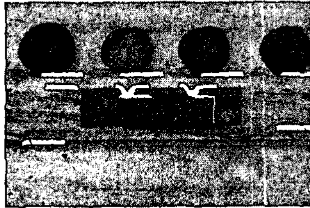
"Organic green sheet"로 충진: 75vol.% filler



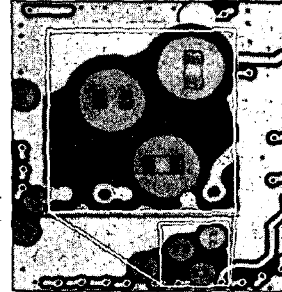


Source: 松下電工技報 [Vol. 53 No. 3]

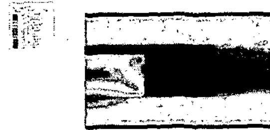
Chip 부품 내장 기술_Cavity type



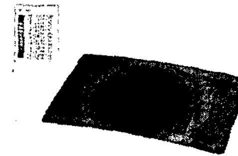
Chip size: 0603
Filling material: Resin with filler



Source: KPCA 매거진 No. 11 (2005)



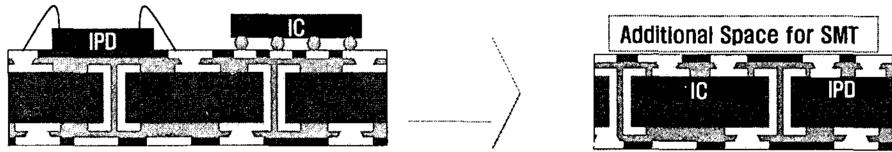
Stress analysis under bending condition
- Von Mises Stress :21MPa
- Position of Max. stress : Bottom center and corner of the chip

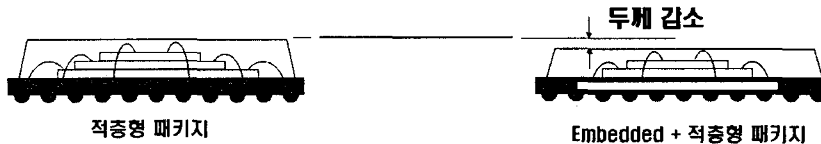


Warpage simulation
- comparable with normal PCB

IC Embedding

Introduction of IC Embedding



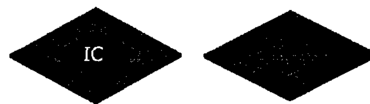


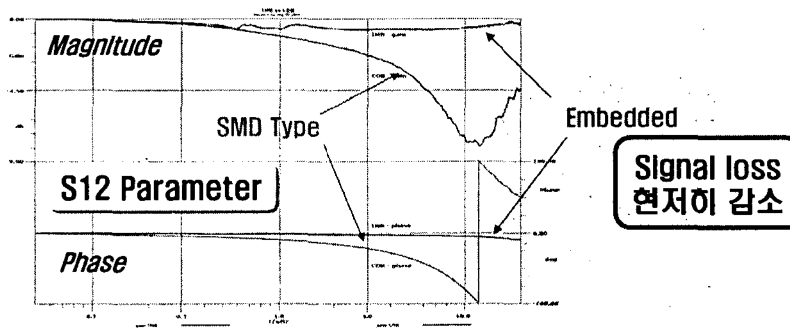
Source: KPCA 매거진 No. 10, 11 (2005)

- **Expected Benefits**
  - **Package size and thickness reduction**
  - **Simple package process**
  - **Multifunction**
  - **High interconnection reliability**

Electrical Performance improvement

SMD Type Embedded





* *P. Palm etc. 2005. Proc. Advanced Packaging Materials: Processes, Properties and Interfaces,.2005 pp. 1 - 4*

Development history

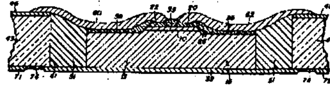


그림. 1957년 출원된 미국방성 특허 대표도면

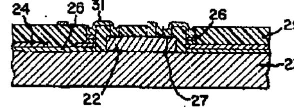
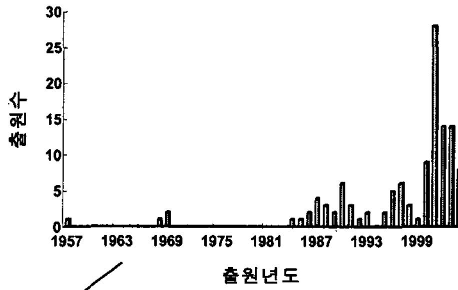


그림. 1969년 출원된 GE 특허 대표도면

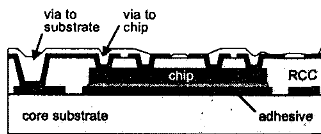


IC를 시스템과 연결　　Wire bonding　　경박단소

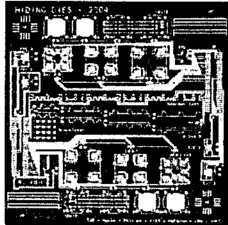
Source: KPCA 매거진 No. 12 (2005)

IC embedding 기술

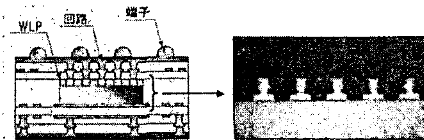
Fraunhofer IZM의 IC 내장기술



T < 50um , RCC 적층



Casio/CMK WLP 내장기술



Source: 2005 JPCA show 전시회 CMK booth 배포자료

Imbera의 내장기술

Core에 cavity 가공
Chip부품 내장기술에서 molding type과 유사

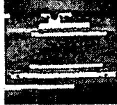
Source:
E. Jung, D. Wolakowski, A. Neumann, C. Landesberger, A. Ostmann, R. Aschenbrenner, H. Reichl, "Chip in Polymer: Volumetric Packaging Solution using PCB technology", SEMI Technology Symposium: International Electronics Manufacturing Technology (IEMT) Symposium, IEEE, 2002, pp. 46-49.
A. Ostmann, A. Neumann, E. Jung, R. Aschenbrenner and H. Reichl, "Stackable Packages with Integrated Components", Electronics Packaging Technology Conference, IEEE, 2003, pp.19-23.

Source:
P. Palm, R. Tuominen, and A. Kivikero, "Integrated Module Board (IMB): an Advanced Manufacturing Technology for Embedding Active Components inside Organic Substrate", The 54th Electronic Components and Technology Conference, IEEE, 2004, pp.1227-1231.

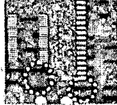
Embedded PCB Summaries

Embedded PCB

Embedded Capacitor



Embedded Resistor



Embedded Inductor

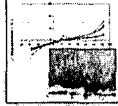
MLCC Embedding

Embedded IC

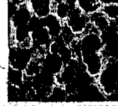
Materials

High Dk Material

Low TCC Material



Hybrid Material



Optical Material

Design

Simulation

Design Tool

Electrical

Modeling