

Plastic Base PCB 에서의 Embedded Passive 기술 동향과 개발현황

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Embedded Passives

– Plastic Base PCB 에서 Embedded Passives –

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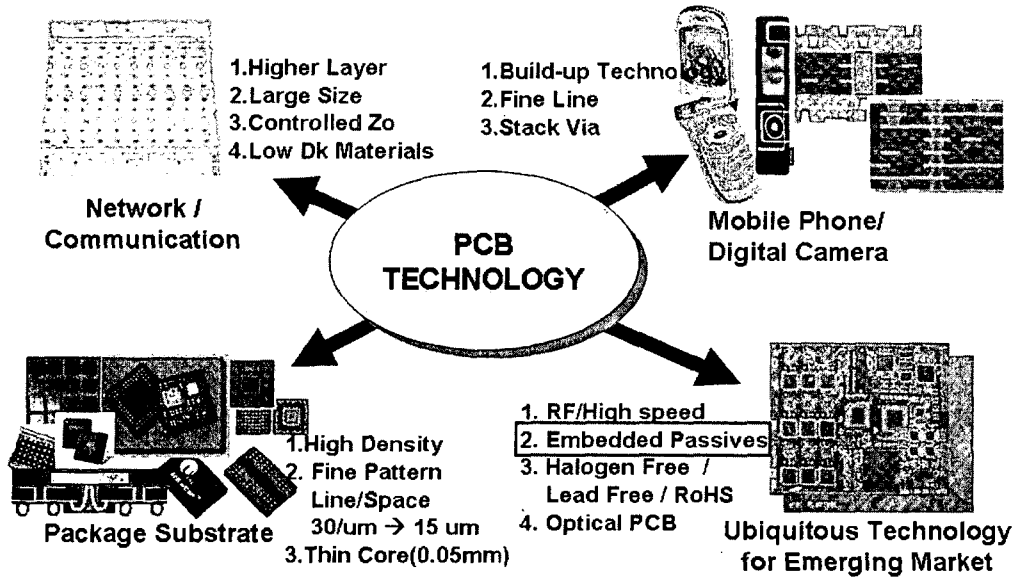


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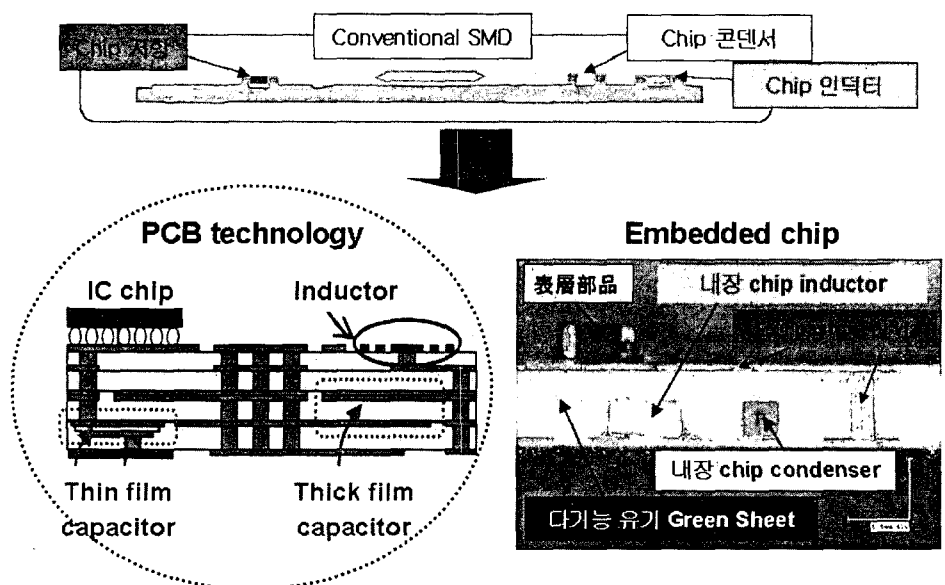
Technology Trends of PCB



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SMT/PCB REPAIR

Methods of Embedded passives

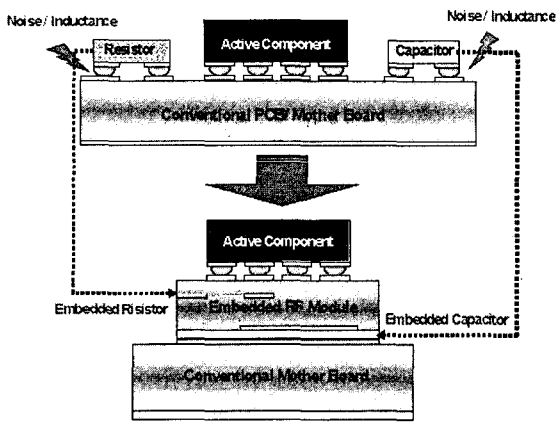


- Embedded chip : 부품 Assembly → PCB 제조 Process

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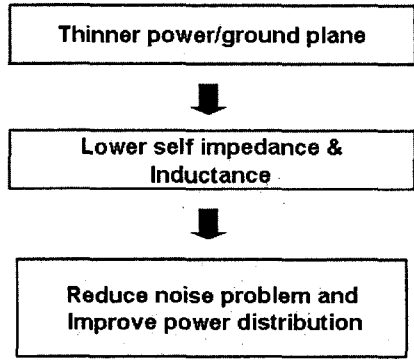
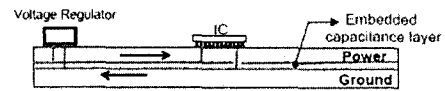
Why Embedded Passives ?



Features of Embedded Passives

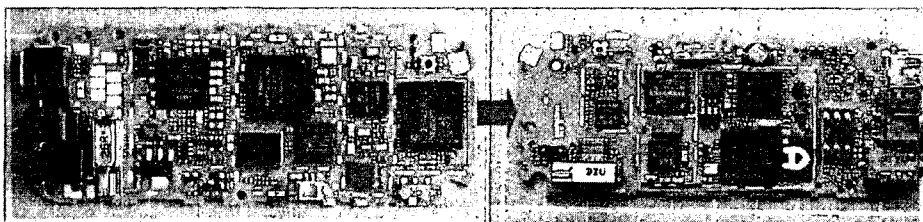
- 1) Reduce SMD area (Miniaturization)
- 2) Reduce parasitic capacitance
→ Improve electrical performance
- 3) Good reliability / Cost / Performance

Principle of Embedded Capacitor



Case study : Module for Mobile phone

GSM PHONE IMPLEMENTATION



C332

October 2002

- Dual-band GSM/GPRS
- 21 cm² ("guts on main board")
- 7 IC, 6 discretes, 1 RF module
- 143 passives, 3 others

C650

June 2004

- Tri-band GSM/GPRS
- 13 cm² ("guts on module")
- 6 IC, 5 discretes, 2 RF modules
- 120 passives, 3 others

KEY ENABLERS

- Integrated passives
- Stacked memory die package
- Smaller RF modules
- Smaller SMT passives

Source : IEPS prepared by PRISMARK



Case study : Module for Mobile phone

C650 GSM PHONE

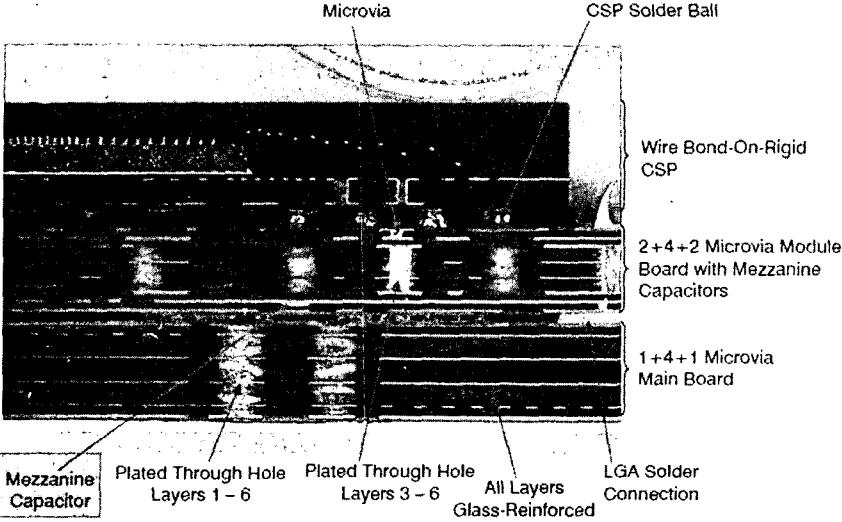


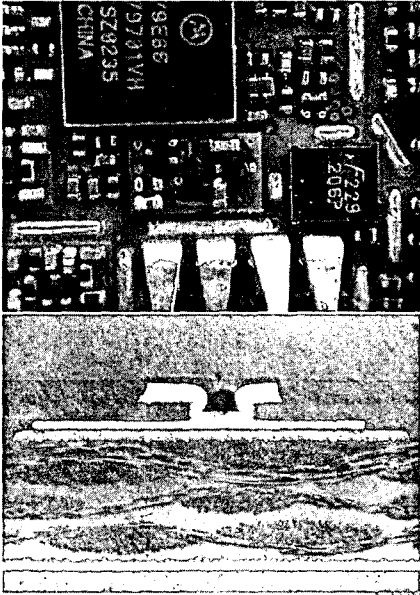
Photo Source: Prismark/Binghamton University



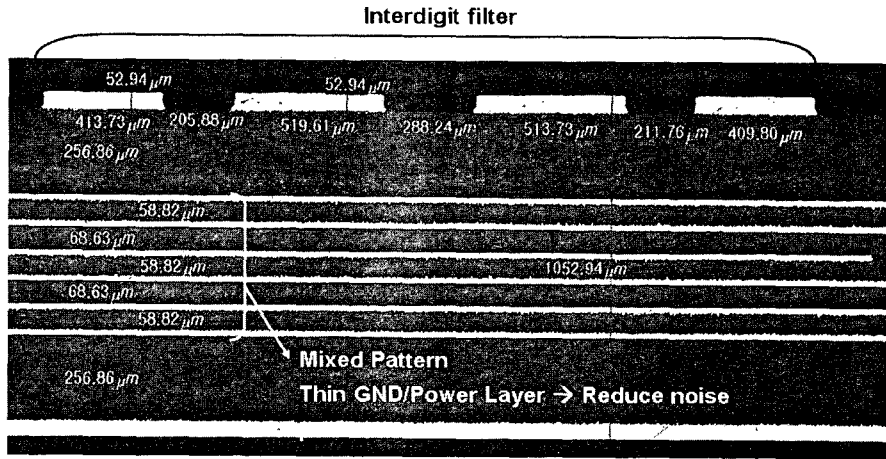
Case study : Module for Mobile phone

CFP Mezzanine Capacitor

- CFP Mezzanine Capacitor Capabilities
 - 10 - 30 pF/mm²: 16.8 pF/mm² for 11µm thick CFP dielectric
 - 20-25pF/mm² typical
 - 15% - 20% tolerance achievable; function of process control
- CFP Mezzanine Capacitor Infrastructure
 - Vantico CFP dielectric available commercially
 - PCB fabrication by AT&S, Wus, Ibiden, Unimicron
 - Motorola holds patents on mezzanine C structure and process
 - Motorola gave licenses to above PCB manufacturers
- CFP Mezzanine Capacitors in Motorola LO Module
 - Shipping in Motorola phones since October 2002
 - Prismark estimates price of 3-4¢/cm² for 1 mezzanine capacitor layer
 - Since this is area process, cost effectiveness depends on density of integrated capacitors



Case study : Noise Suppression

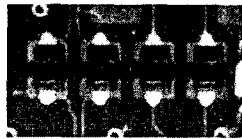
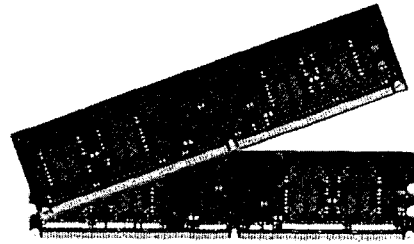


WiFi 무선 LAN Card : A 社

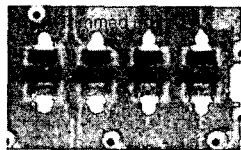


Case study : Embedded Resistor (Memory Module)

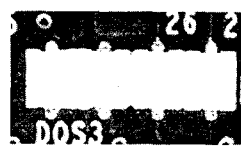
ITEMS	Thin metal	Thick polymer
Resistor material	Thin Metal (Ni - X)	Carbon paste
Sheet resistance	25, 50, 100, 250 Ω /Sq.	10 ~ 1 M Ω /Sq (15 Ω /Sq)
Key technology	Etching	Screen printing
Application	Inner layer	Outer Layer



10 Ω Resistor



Laser Trim



Overcoat



Embedded Capacitor – Capacitance Density

- Capacitance density with materials Dk & thickness

$$\text{Capacitance Density (pF/mm}^2\text{)} = \frac{C}{A} = \frac{\epsilon_0 \cdot Dk}{t}$$

C: Capacitance(pF)
A: Area of electrode(mm²)
ε₀: Permittivity of vacuum (=8.85pF/m)
Dk: Dielectric constant
t: Thickness of dielectrics(μm)

ε _r (Dk)	Capacitance density (pF/mm ²)		
	t=50μm	t=20μm	t=5μm
4.5 (FR-4)	0.8	2.0	8.0
10	1.8	4.4	18
45	8.0	20	80
100	18	44	177



Embedded capacitor – Materials

- CCL type composite materials for embedded capacitor

Company	Sanmina-SCI	Du Pont	3M	Matsushita Electric Works	
	Product name	Interra HK10	C-Ply	High-Dk	Condenser Film
Dielectric material	FR-4	Polyimide BaTiO ₃	Epoxy BaTiO ₃	Thermoset BaTiO ₃	Thermoset BaTiO ₃
Type	CCL	CCL	CCL	CCL	CCL
Dielectric constant, Dk	4	3-20	14-18	16	40
Dielectric thickness(μm)	25-50	8-25	4-26	50	10-30
Capacitance density (pF/mm ²)	0.7-1.4	1.4-22	8-48	3	11-40



Embedded capacitor – Materials

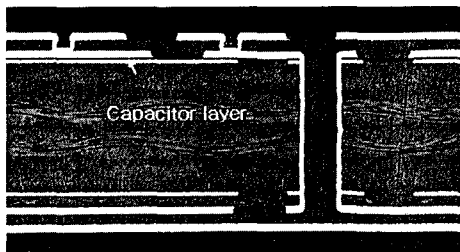
■ RCC, Paste and film type materials for embedded capacitor

Company	Oak-Mitsui	Hitachi Chemical	Vantico	Asahi Chem Res. Lab	Nippon Paint	Du Pont
Product name	FaradFlex	MCF-HD-45	CFP	CX-16	-	Inerra EP310
Dielectric material	Epoxy BaTiO ₃	Epoxy BaTiO ₃	Photo-polymer Ceramics	Epoxy BaTiO ₃	Thermoset BaTiO ₃	Sintered BaTiO ₃
Type	RCC	RCC	Paste	Paste	Film	Paste
Dielectric constant, Dk	30	~45	21	15-20	32	>1.000
Dielectric thickness(μm)	12~16	20-50	11	10-20	50	20-40
Capacitance density (pF/mm ²)	17~22	8~35	17	24-32	6	160-480



ECURL (Embedded Capacitor Using RCC Lamination)

- ECURL : Embedded Capacitor Using RCC Lamination
Daeduck's own technology (Patent pending)
- Capacitance : 0.8 ~ 35 pF/mm² (Dielectric thickness : 10~50 μm)

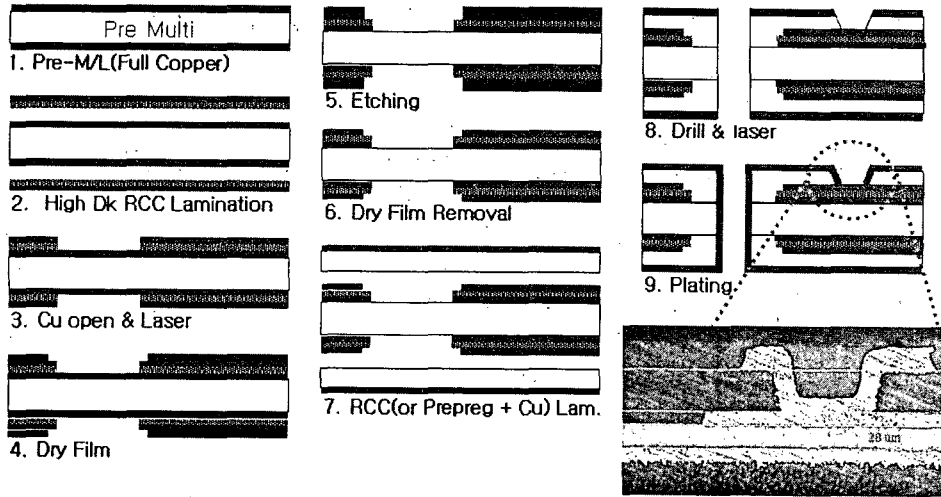


Item	2005	2006
Line/Space (μm)	70/70	50/50
Micro Via / Pad	100/250	90/225
IVH / Pad	200/400	150/350
Dielectric thick.(μm)	15~50	10~50



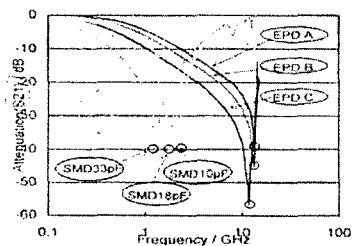
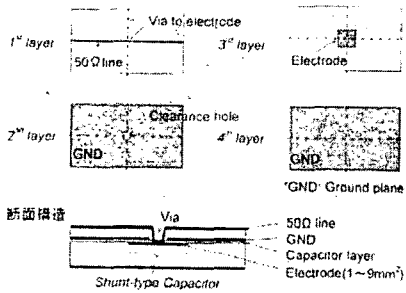
ECURL (Embedded Capacitor Using RCC Lamination)

◆ ECURL Process Flow

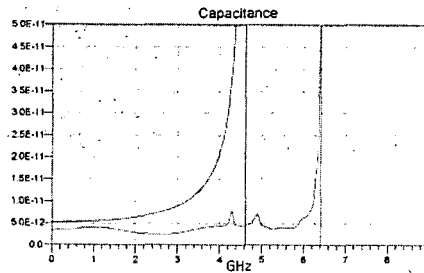
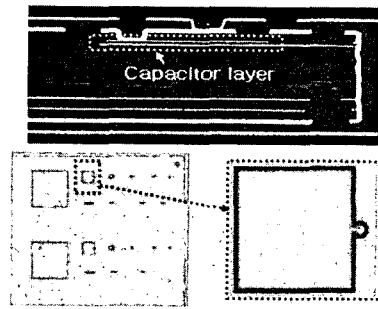


Embedded Capacitor for High Speed Application

◆ MES2005(JIEP) / Mitsubishi 전기

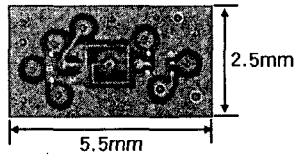


◆ ECURL Process : (基板 20 pF/mm²)



Embedded Capacitor for Duplexer with ECUPL

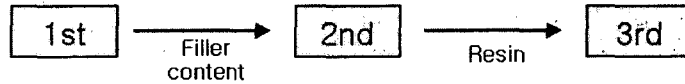
◆ Overview of Duplexer



Phase Shifter Capacitor : 1.6 pF
 Phase Shifter Inductor : 4.0 nH
 Tuning Inductor : 2~3 nH
 Q of C : Min. 35 at 2 GHz (dependent on that of L)

◆ Properties of Capacitor with respect to materials properties

Item	Electrode Area(mm ²)	Dielectric			Cap (pF)	SRF (GHz)	Q at 2GHz
		Thick. (μm)	Dk @ 1MHz	Df @ 1MHz			
1st	0.187	23	26	0.040	1.95	3~4	15
2nd	0.395	30	13	0.035	1.79	> 10	28
3rd	0.395	30	13	0.026	1.71	> 10	35



Embedded Resistor – Materials

■ Materials for Embedded Resistor

Method	Thin Film Etching			Plating	Thick Polymer	Ceramic
	Ohmega Tech	Gould	Shipley			
Maker	Ohmega Tech	Gould	Shipley	McDermid	Asahi	DuPont
Product	Ohmega-Ply	TCR	InSite	M-Pass	TU-XX-08	Interra EP20X
Sheet R(Ω/□)	25~250	25~250	1000	25~100	10~1Mega	10~10K
Materials	NiP	NiCr/ NiCrAlSi	Doped Pt	NiP	Carbon	-



Embedded Resistor – Application

■ Developing Status of Embedded Resistor

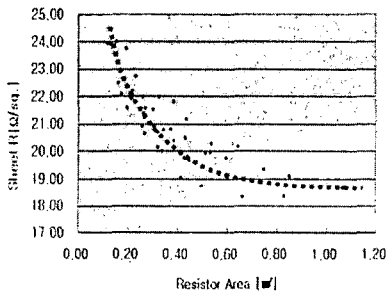
Item	Thin Film Resistor	Thick Paste Resistor	Remarks
Material	Ni-X 25Ω/sq.	Carbon Paste, 15Ω/sq.	
Layer	Inner Layer (10Ω, 22Ω, 200Ω ±5%)	Outer Layer (10Ω, 22Ω ±5%)	
Sample PCB			Apply Overcoat
Resistor 사진			Apply Laser Trim
Key Process	<ul style="list-style-type: none"> ◆ Cupric Etch. : Determine Resistor Width ◆ Alkali Etch. : Determine Resistor Length ◆ Laser Trim : Tolerance ± 10% → ± 5% 	<ul style="list-style-type: none"> ◆ Screen Print (Design) ◆ Laser Trim : Tolerance ± 20% → ± 5% ◆ Overcoat : Protect from humidity 	
Merits	<ul style="list-style-type: none"> ◆ Inner Layer → Remove SMD area ◆ Stable resistance (Higher Reliability) 	<ul style="list-style-type: none"> ◆ Low Cost ◆ Simple Process (Only Screen printing added) 	



Embedded Resistor – Resistance vs. Area

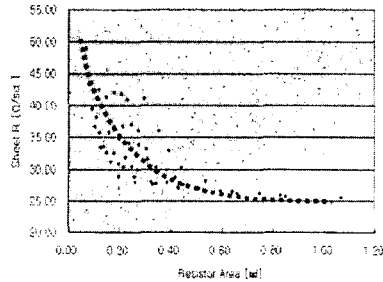
■ Resistance depends on paste and resistor size

Paste #1 (15 Ω/sq. at 25um)



Sheet Resistance : 18.2Ω/sq.
(for L=W=1 mm, thickness = 30um)

Paste #2 (30 KΩ/sq. at 25um)

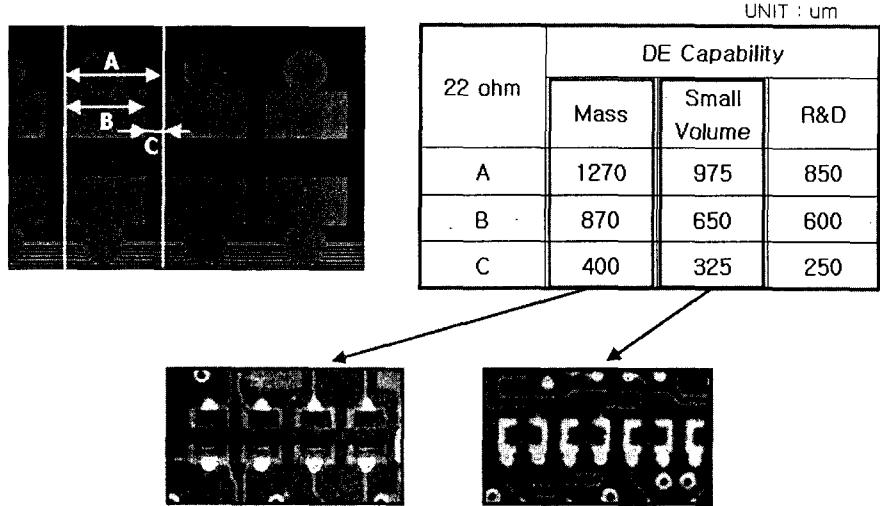


Sheet Resistance : 25.2KΩ/sq.
(for L=W=1 mm, thickness = 30um)



Embedded Resistor - Resistance vs. Area

Size capability of Daeduck in Carbon resistor



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SMT/PCB
REPCON

Summary

- ◆ PCB에 있어서 Embedded passive 는 chip 을 직접 내장하는 방법과 특별한 특성을 갖는 재료 및 공법을 사용하여 chip 을 대체하는 방법이 있다.
- ◆ Embedded passive PCB가 적용될 수 있는 유력한 적용 분야는, 소형화가 요구되는 분야와 고속 특성이 요구되는 분야를 들 수 있고, 따라서, Module, SOP/SIP, Package substrate 등이 우선적으로 적용될 수 있는 분야다.
- ◆ Embedded capacitor 를 적용한 경우, 일반적인 chip capacitor 를 적용한 경우보다 더 좋은 전기적인 특성(SRF, Q)을 얻을 수 있으며, solder joint 등의 영향을 포함하면 더욱 좋은 특성이 얻어질 수 있다.
- ◆ Embedded passive 의 상용화를 위해서, 공차를 관리하는 방법의 개발과 공차에 대한 합리적인 규격을 설정하는 것이 우선 과제이다.
- ◆ Embedded resistor 의 경우, Laser trim 을 적용하여 $\pm 5\%$ 또는 그 이하의 공차를 실현할 수 있고, $30 \text{ K}\Omega/\text{sq.}$ 의 고저항의 적용까지 가능하다.
- ◆ 고속 신호에서의 noise 감소, module, SIP/SOP 의 소형화를 실현하는데 Embedded passive(혹은 active) PCB 가 기여 할 수 있을 것이고, 이를 위하여 Set 업체, PCB 업체, 재료 업체간의 지속적인 협조가 필요할 것이다.

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REPCON



감사합니다.