Technology Trends in MLCC and LTCC

Jong-Hee Kim

SAMSUNG ELECTRO-MECHANICS

LTCC Technology for Mobile Communication System

SAMSUNG Electro-Mechanics

2001. 9. 13

Jong-Hee KIM

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TECHNOLOGY TREND

- ***Mobile Phone*** →
  - ***Miniaturization***
  - ***Multifunction***
  - ***Low Cost***

↓

- ***Component*** →
  - ***IP(Integrated Passive)***
  - ***IPA(Integrated passive & Active)***

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Comparison of LTCC and other process

LTCC

Advantages
.High conductivity metal (Au,Ag)
.Low Dielectrics
.Printed Resistors
.Low processing temperature
.Si TCE Match
High Print Resolution of Conductors
.Single Firing
.Good Dielectric thickness control
.Low surface roughness
.Unlimited Layer Count

Thick Film

Disadvantages
. Multiple Printing Steps
.Multiple firings
.Thickness Control of dielectric
.Limited Layer count

HTCC

Disadvantages
.Low Conductivity Metal(W,Mo)
.Complex Process
.No Printed resistors
.High Capital Investment

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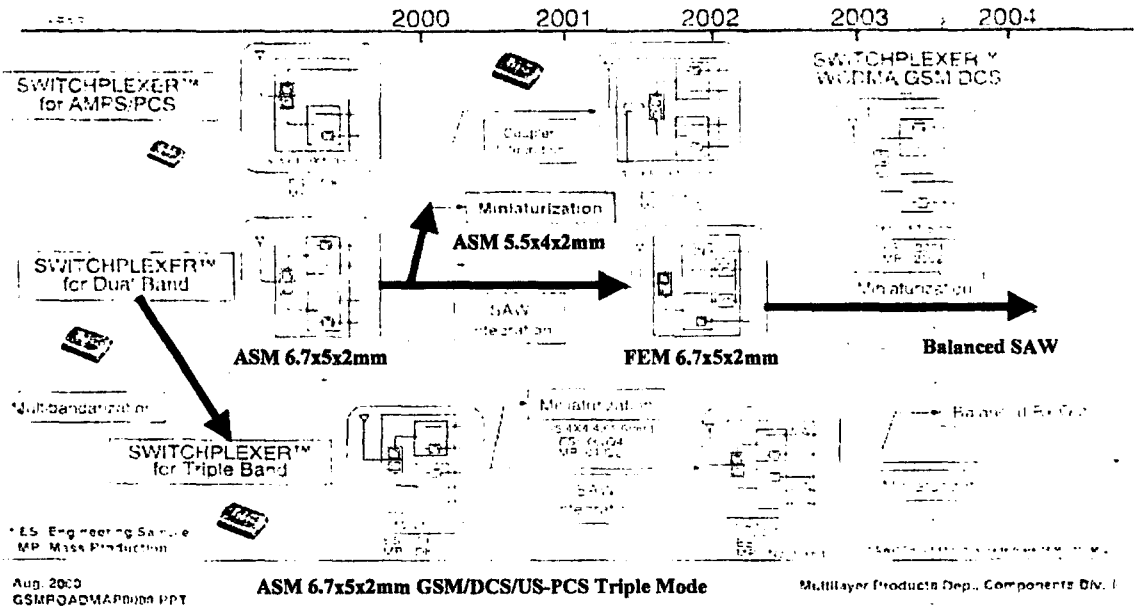
MURATA ROAD MAP FOR LTCC MODULE



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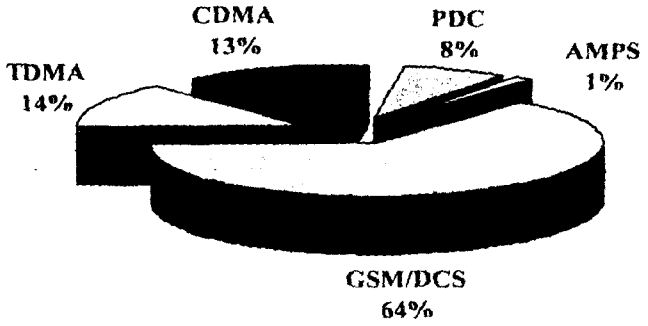
Cellular Market Share at 2000



Total:414,100

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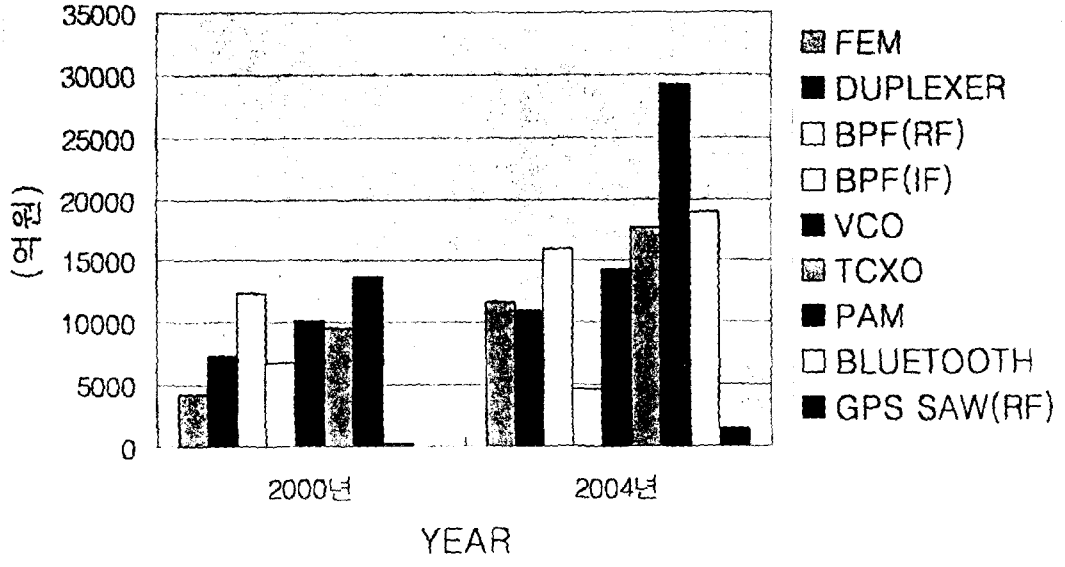
MARKET FORECAST FOR RF DEVICES & MODULES



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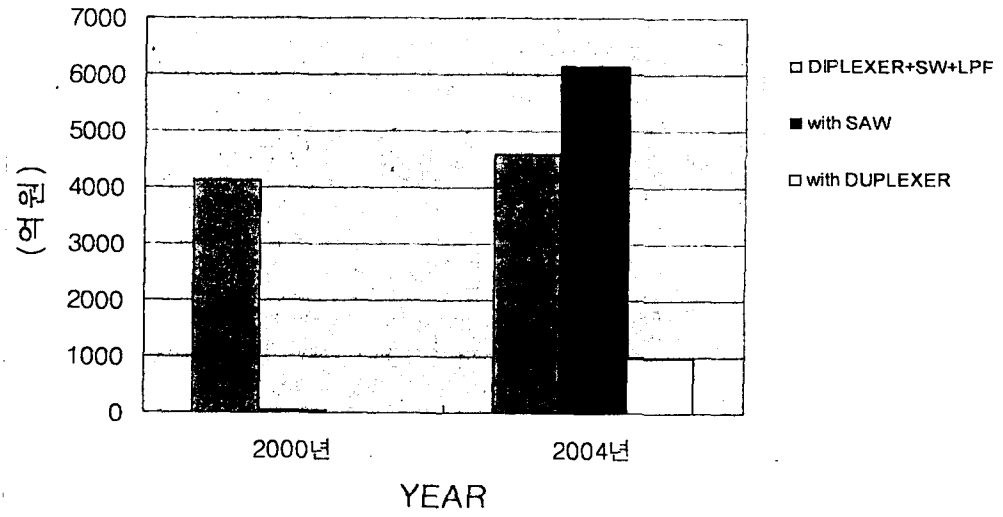
MARKET FORECAST FOR RF Front End Module(FEM)



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Performance Benefits – LTCC

• Loss, High Q, Low Tf	➢ Performance, lower power IC, Smaller
• High thermal conductivity, matched CTE	➢ Reliability, high density, small size
• Precisely defined properties	➢ Ease of design, time to market
• Integral components, packaging	➢ Low cross-talk and stray L & C
• Environmental Stability	➢ Stable operations over temperature & humidity

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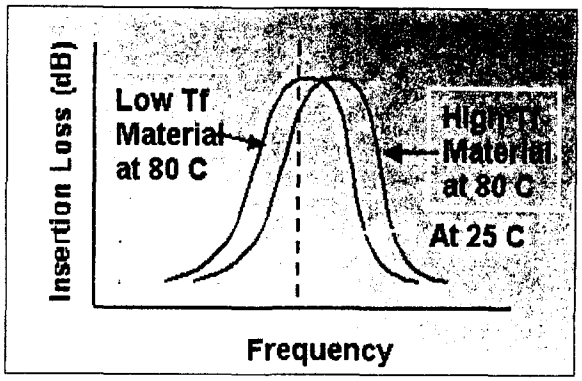
Performance Benefits – LTCC



LTCC Tf <10 ppm/C
For FR4 Tf = 80 ppm/

System Works!...
Cold (Alaska)
Hot (Arizona)

High Tf Material at 80 C
Low Tf Material at 80 C

Frequency & Temperature Stability: Ceramic vs. Organic

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Maior point of LTCC Technology

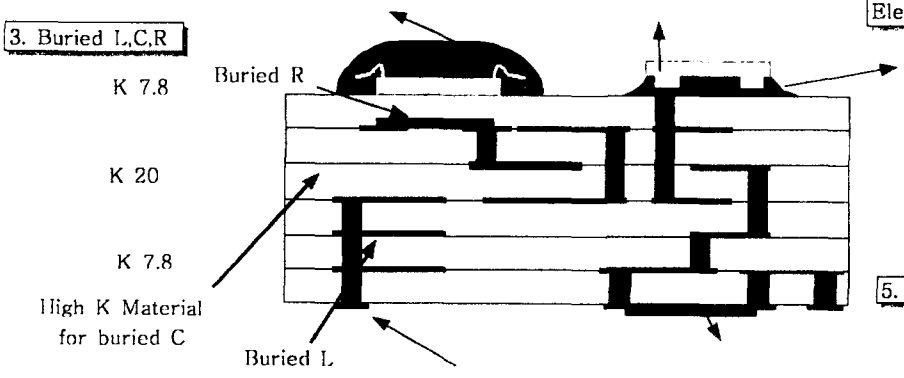
Wire Bonding

Flip Chip

2. IC, Active Device Integration

4. Fine Line/Pitch Electrode

3. Buried L,C,R



L/S =40/40㎛
10/20㎛(Developing)

5. High Density

Ni/Au Plating

Inner and Via Conductor

Printed Resistors

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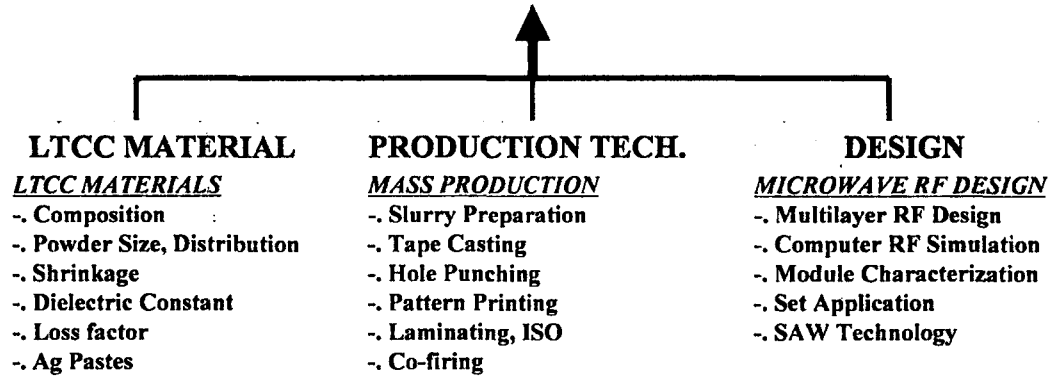
Core Technology in LTCC



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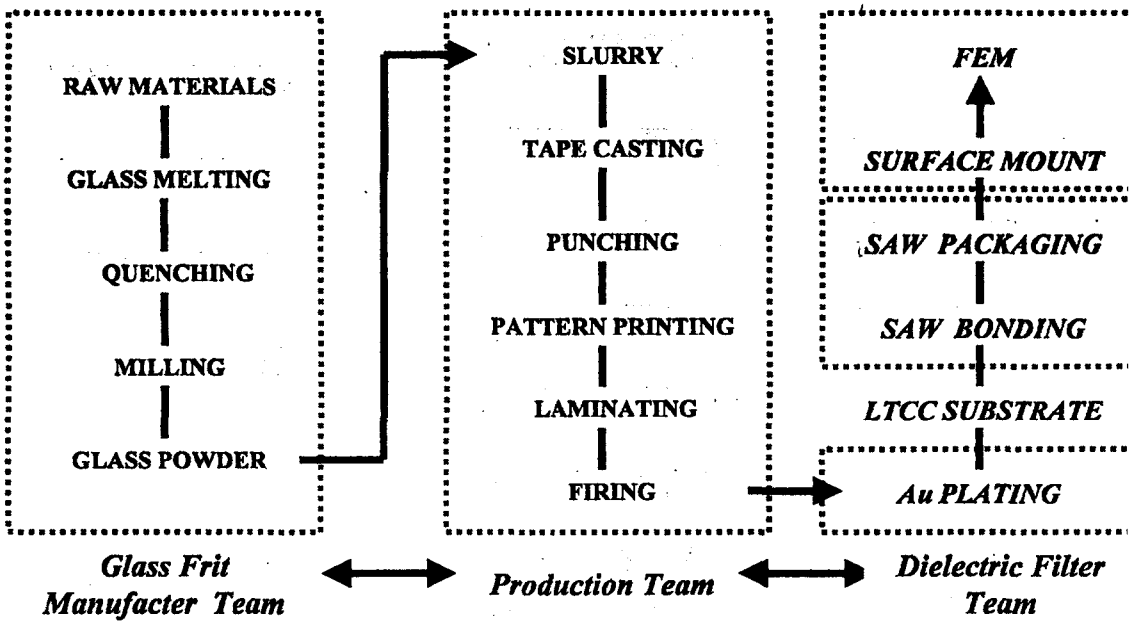
FEM PROCESS



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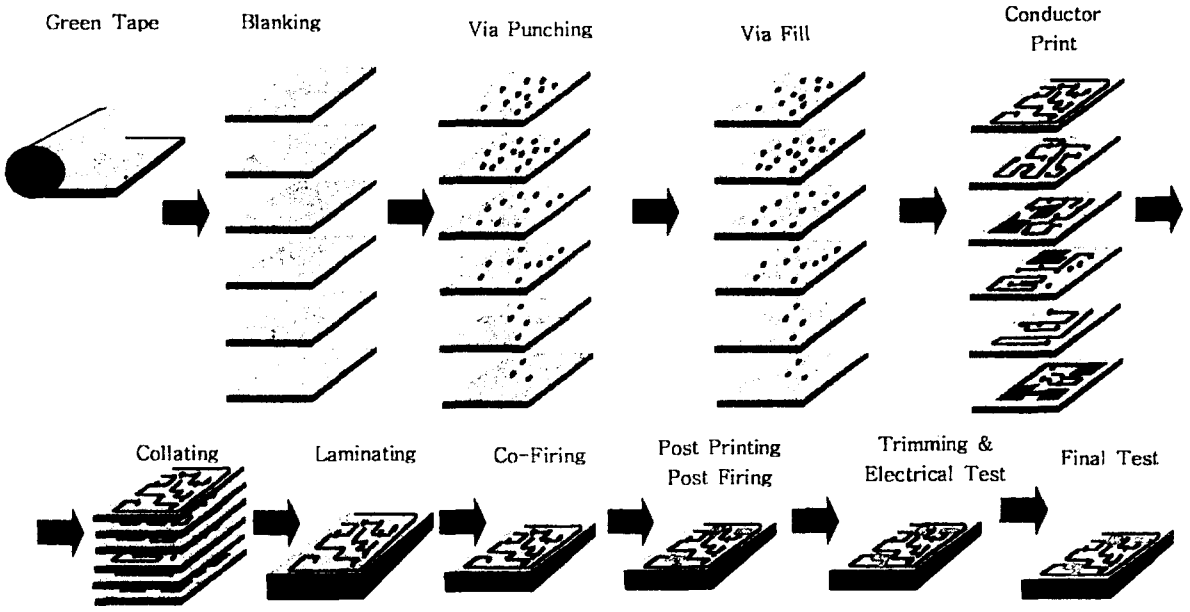
Co-Fire Multilayer Ceramic Process



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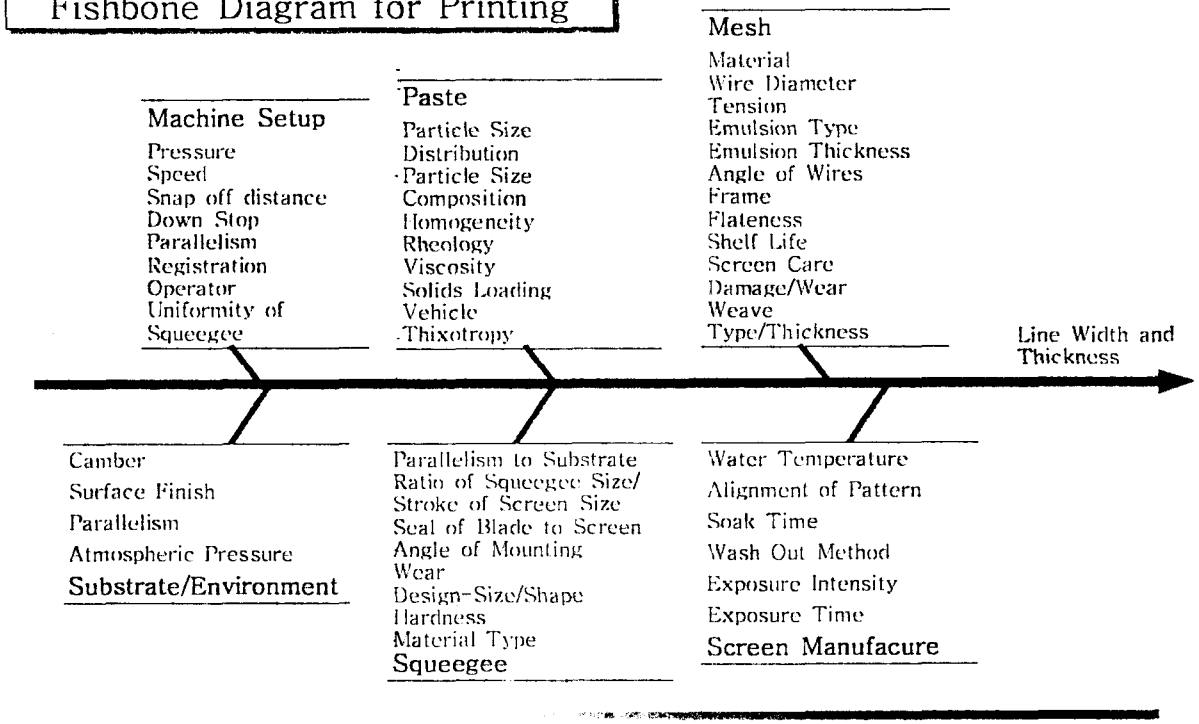
Fishbone Diagram for Printing



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Common Problems of Highly Integrated LTCC Module Designing

Can not do cut & try approach?to the embedded passives!

↓

Performance optimization with trial consumes a lot of time and resources.

Performance of individual passive is not measured correctly.
Some of the passives are not optimized at early stage of the designing

↓

It makes more difficult to identify functional problems of the module.

LTCC substrates have three dimensionally complicated.
In many cases,designers have to design each substrate from scratch.

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Structures can not be intellectual property.

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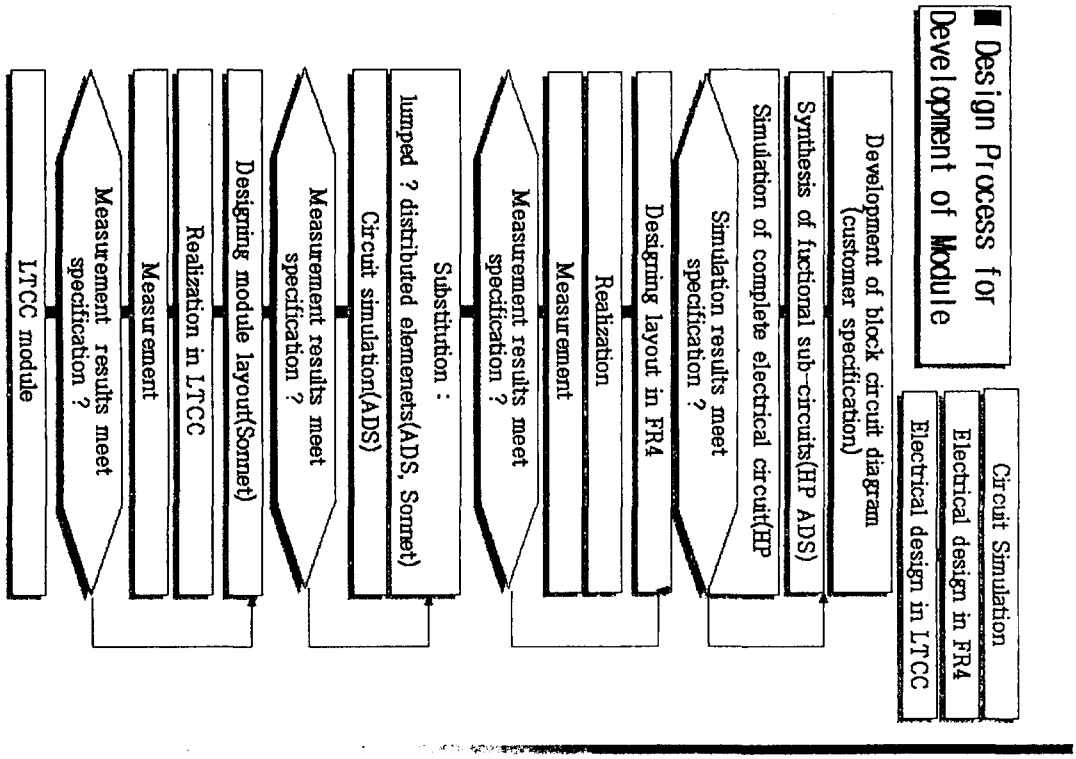

LTCC Technologies

. *Dominantly passive components*
  . **Inductor- simple spiral, multi-layer spiral (helical)**
  . **Capacitor- MIM, inter-digital, multi-plate**
  . **Cavity**
  . **Vias**
  . **Transmission lines**
  . **Pads- bonding, BGA, solder ball, surface mount, welded lead, etc.**
. *Complex substrate*
  . **many layers (~120) of ceramic**
  . **tight tolerances difficult**

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Example of Microwave Ceramics and Modules

Antenna Switch Module Development

LTCC module development (1): definition of cross sectional layout

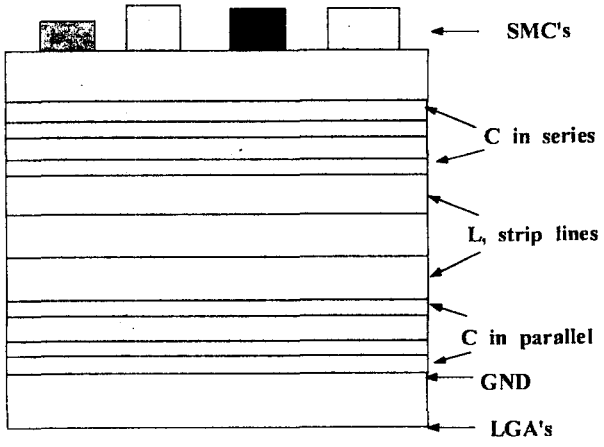
. Calculation of total capacitance

. Estimation of capacitive layers

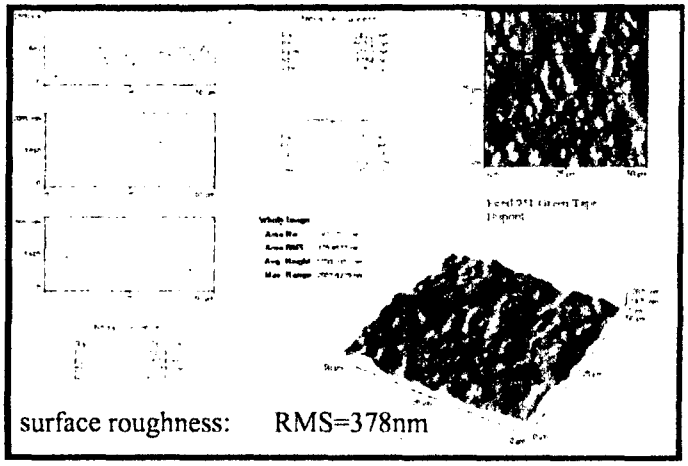
. Calculation of total coil area

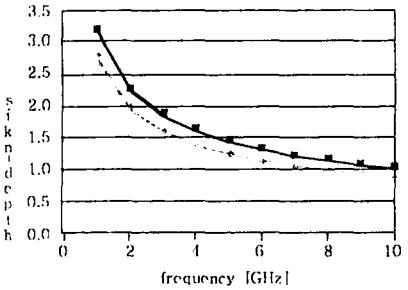
. Calculation of area for strip lines

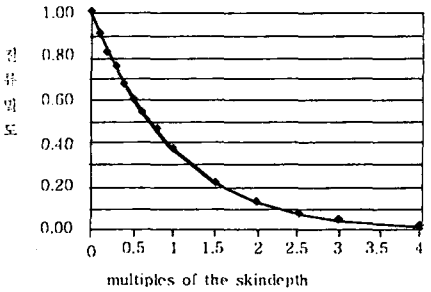
. Estimation of layers for inductors



■ Surface Roughness







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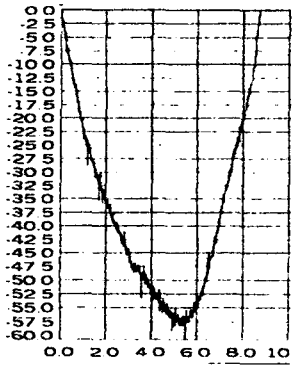
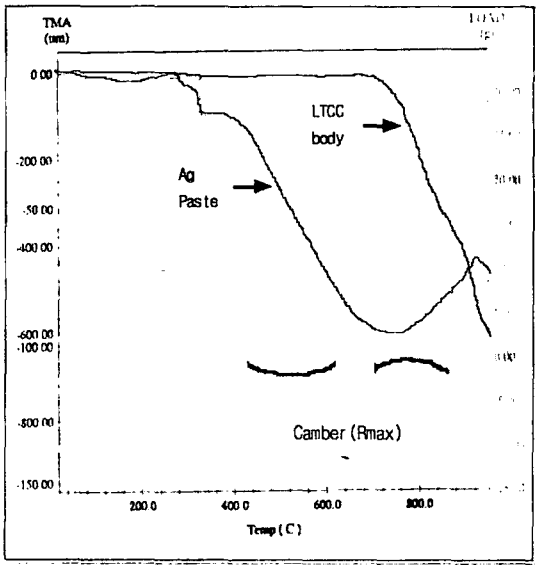
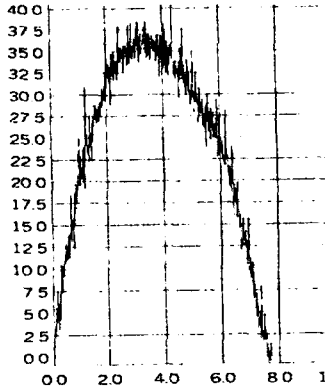
Camber Mechanism



The direction of Camber in low temperature region



< TMA Curve of AG-paste & LTCC-Body >



The direction of Camber in high temperature region

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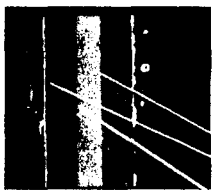
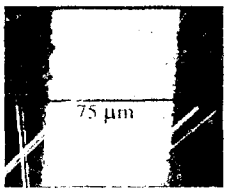
■ Material Integration

LTCC AS BROAD PASSIVE INTEGRATION TECHNOLOGY

Low k; 5~10	for High frequency Inductor(nH), Signal Line, High Q
Medium k; 50~80	for Capacitor(nF), LC Filter, High Q
High k; 5~10,000	for High Capacitance(μF), Smoothing C , Bypass C
Magnetic	for EMI Noise Filter, High Inductance(μH)





ε : 75 ε : 8

(Philips)

ε: 7.8

ε: 20

ε: 7.8

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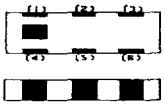
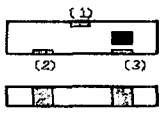
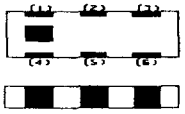
LTCC STRUCTURE & TERMINAL CONFIGURATION

ITEM	STRUCTURE	SHAPE	TERMINAL
DIPLEXER			(1) AMPS (4) GND (2) GND (5) COMMON (3) PCS1900 (6) GND
SPLITTER			(1) INPUT (2) OUTPUT 1 (3) OUTPUT 2
COUPLER			(1) COUPLE PUT (4) IN (2) GND (5) GND (3) TERMINATE (6) MAIN OUT
LC FILTER			(1) INPUT (4) GND (2) OUTPUT (5) GND

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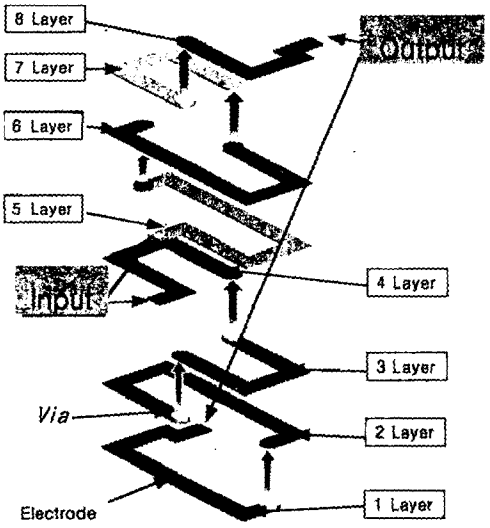
CDMA, PCS用 Splitter Design

Internal Structure



Appearance

CDMA 3216 | PCS 3216 | CDMA 2012

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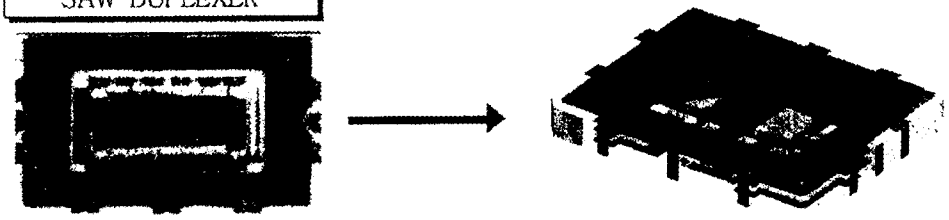
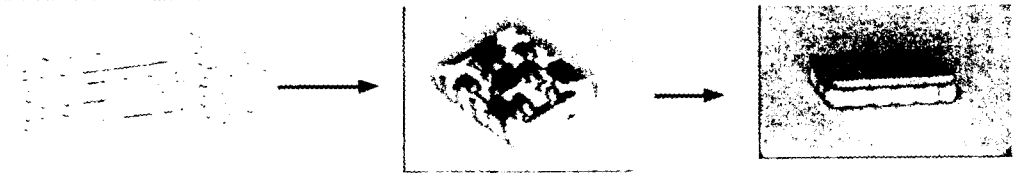
LTCC STRUCTURE (SAW DUPLEXER, ASM)

SAW DUPLEXER

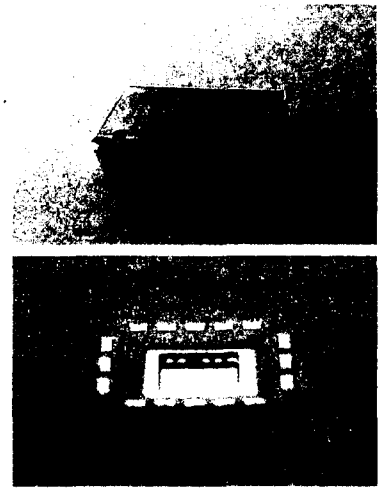


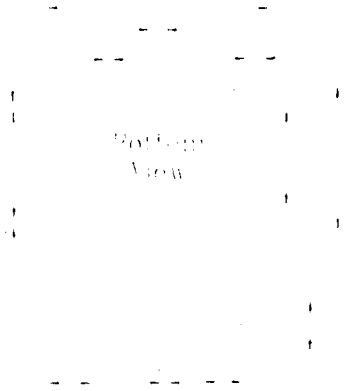
ASM



FEM (Front-End-Module)

PART NO.: FEM8450A





-.: Integration of Antenna Switch Module with Two GSM/DCS-1800 Rx SAW Filters.

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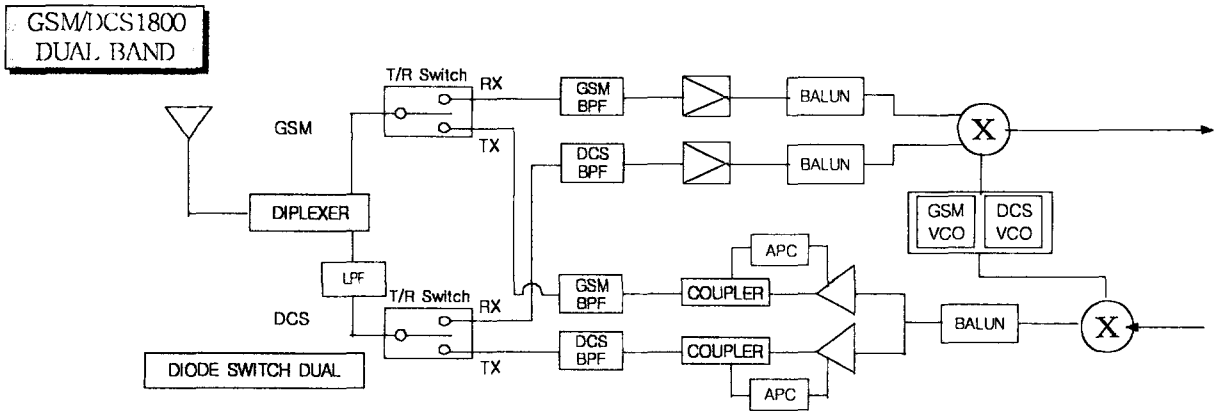
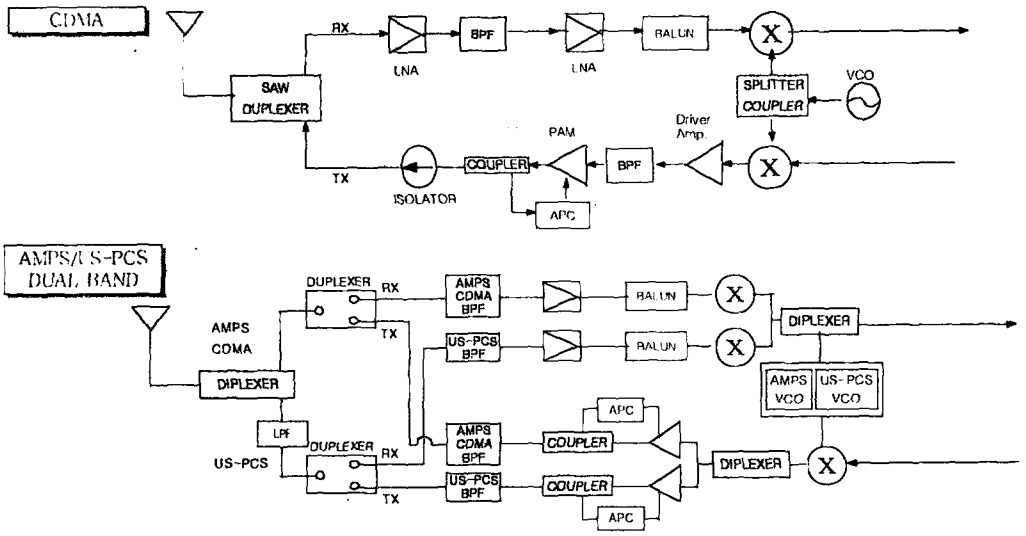
LTCC BLOCK DIAGRAM FOR MOBILE COMMUNICATION



LTCC BLOCK DIAGRAM FOR MOBILE COMMUNICATION



LTCC CUSTOMER

	ITEM	SYSTEM	SIZE(mm)	MAIN CUSTOMER
1	INDUCTOR	-	ALL	MOTOROLA, SEC.
2	DIPLEXER	AMPS/PCS1900	3216 2012	MOTOROLA, MITSUBISHI, TRL, SEC
		AMPS/W-CDMA	2012	
		AMPS/GPS	2012	
3	SPLITTER	PCS,CDMA	3216 2012	SEC.
4	COUPLER	ALL (SINGLE TYPE)	2012	SEC.
5	LC FILTER	PCS RF BPF DIGITAL-CLP WLL BLUE-TOOTH	4532 3225 3216 2520	UNIDEN, SONJS TEL.
6	ASM (FEM)	GSM/DCS1800 DUAL MODE	6750	DBtel, SAGEM, SEC.
7	SAW DPX	CDMA	9575/5050	MOTOROLA, SEC

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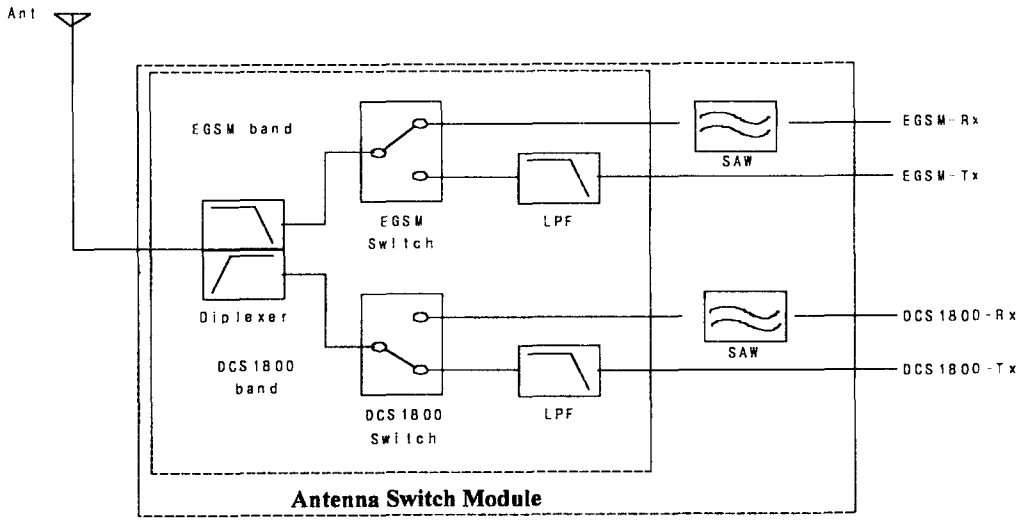
FRONT-END-MODULE



Front-End-Module