# Overview and Future Trend of Microelectronic Packaging

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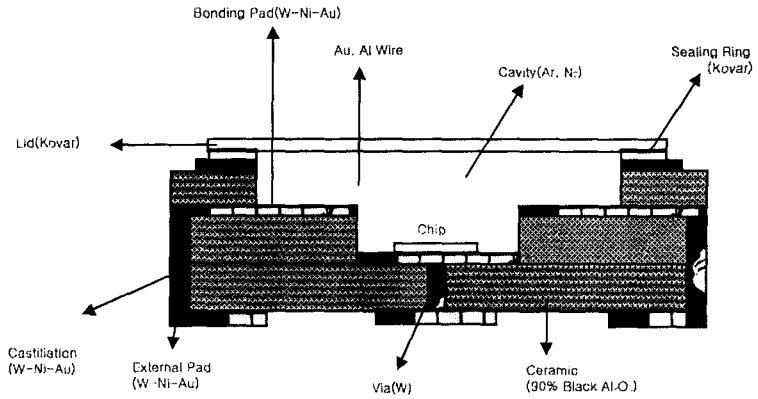
CeraSTACK



## Fuctions of Package

- Protection from Mechanical Attack
  Chemical / Environmental
  Thermal
- Electrical Connection
- Special Functions

## Schematic drawing of package structure

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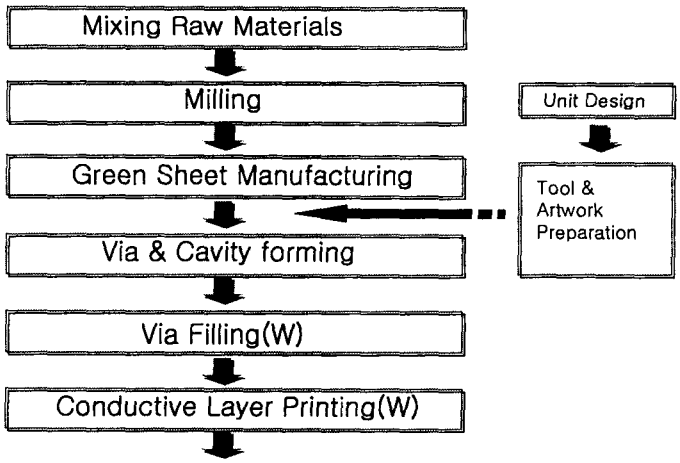
## Manufacturing Process 1

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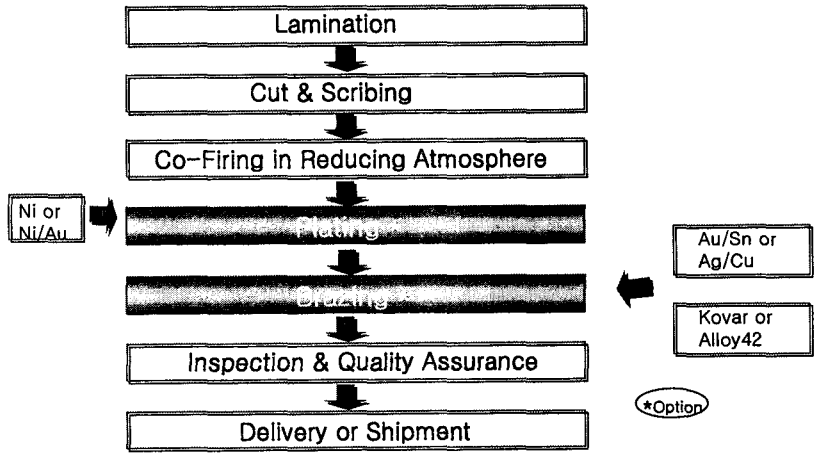
## Manufacturing Process 2

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| Process | Description | Check Point |
|---|---|---|
| Composition | • Ceramic Powder<br>- 90% $Al_2O_3$ ; Thermal, Mechanical, Electrical, Properties<br>- Flux ; $SiO_2$-CaO-MgO Sintering Aids<br>- Coloring Agent ; $TiO_2$-$Cr_2O_3$ Protection from Soft Error | Purity(Low Soda)<br>Particle Size |
| | • Organic Materials<br>- Dispersant ; Protection from Re-Agglomerate<br>- Binder ; Strength<br>- Plasticizer ; Ductility<br>- Solvents | Hydration |
| | • Metal<br>- W ; Conductor, Unstable<br>- Ni ; Base Plating, Protection<br>- Au ; Electrical Properties, Wire Bondability | |

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| Process | Description | Check Point |
|---|---|---|
| Mixing/Milling | Slurry<br>- Mixing(Ceramic Powder+Organic)<br>- Milling ; Size Reduction(Ceramic) | Rheological Properties<br>Degree of Mixing<br>Particle Size Distribution |
| Tape Casting | Green Sheet Fabrication | Thickness Tolerance(±10㎛ for 350㎛)<br>Crack, Separation of Ceramic Powder<br>Green Density, Strength, Ductility<br>Sintering Shrinkage |
| Punching | Cavity, Via, Castillation Forming | Dimension Accuracy(±5㎛)<br>Crack at Cavity Edge and Via |
| Printing | Via Filling<br>-Surface Conductor Pattern Printing<br>-Coating of Castillation | Degree of Filling<br>Printing Accuracy(±10㎛)<br>Short/Open Pattern<br>Sheet Deformation |
| Lamination | Monolithic Structure Forming | Deformation<br>De-Lamination |

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| Process | Description | Check Point |
|---|---|---|
| Cut/Scribing | Edge Shaping | Depth of Edge |
| Sintering | De-Binding<br>Co-firing of Ceramic and Metal | Carbon Residue<br>De-Lamination<br>Temperature(~1600℃)<br>Atmosphere($N_2$/$H_2O$/$H_2$)<br>Sintering Shrinkage, Bonding Strength<br>Final Properties |
| Plating | Ni Base Plating<br>Au Plating(Option) | Thickness<br>Contamination<br>Bonding Strength<br>Wire Bondability |
| Brazing | Sealing Ring Attachment | Position Accuracy<br>Bonding Strength<br>Hermeticity |

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## Focus !

1. Small size
2. Multi - function
3. High quality
   - Material
   - Design

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## Small size

1. Process limitation
2. Structural limitation
3. Functional limitation

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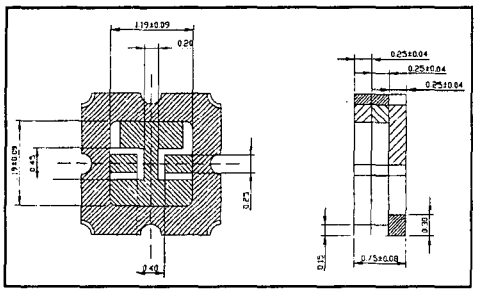
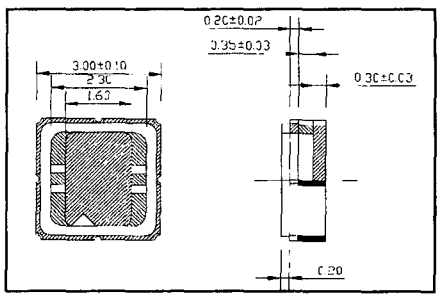
## RF SAW Filter





2x2 mm

3x3 mm

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## Differences

A. Size reduction 3x3 ⟶ 2x2 mm

B. Wire bonding ⟶ Flip chip bonding

C. Seam sealing with Kovar ring ⟶ No ring
Solder sealing
Eutectic sealing
Clad lid

D. Camber 20㎛ Max. ⟶ 5㎛ Max.

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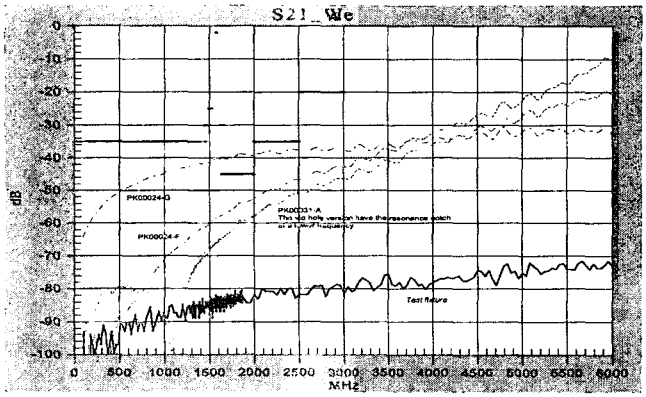


No more standard package !
(Customized package)

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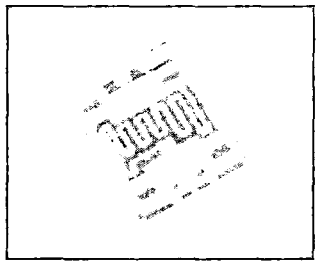
## Multi-Function



SAW duplexor
package

Imbedded matching

Circuit in the package

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## High Quality

- Low dielectric constant
  (minimize the parasitic capacitance)
- Low loss (for RF application)
- Low resistance conductor
- High thermal conductivity
- Close matching of TEC



## LTCC ( Low-Temperature Co-fired Ceramic)

Co-firable at Low Temperature of 800~900℃

Suitable Substrate for Ag, Au, Cu Conductor

Imbedded Element is Possible

Poor Thermal and Mechanical Properties

## Properties of Commercial Low-Temperature Co-fired Ceramics

| | | Dupont | | | Ferro |
|---|---|---|---|---|---|
| Property | Units | 851 | 951 | 943 | A6 |
| Density | g/㎤ | 3.02 | 3.1 | 3.2 | 1.8 |
| TCE(25 to 200℃) | $10^{-6}$/K | 7.9 | 5.8 | 5.3 | 7.7 |
| Dielectric constant | | | | | |
| 1MHz | | 7.9 | 7.8 | 7.5 | 5.8 |
| 10GHz | | | | | |
| Loss Tangent | | | | | |
| 1MHz | | | 0.0015 | 0.0009 | 0.002 |
| 10GHz | | | | | |
| Volume resistivity,25℃ | Ω-cm | | $>10^{12}$ | | |
| *Flexural strength* | MPa | | 320 | | 130 |
| | PSI | 3 X $10^4$ | | | |
| Thermal Conductivity | W/m-K | 2 | 3.0 | | |



## Conductor materials

| | W | Ag | Cu | Ag-Pt |
|---|---|---|---|---|
| Sintering temp. | ~1600℃ | ~900℃ | 900~ 1000℃ | ~900℃ |
| Atmosphere | $N_2/H_2$ | Air | $N_2/H_2$ | Air |
| Electrical resistivity (μΩ•cm) | 5.6 | 1.6 | 1.7 | |

## Properties of high purity AlN Substrate.

| Property | Units | Value |
|---|---|---|
| Density | g/㎤ | 3.27 |
| Melting point | °c | 2232 |
| Modules of elasticity | GPa | 300 |
| Compressive strength | MPa | 2000 |
| Thermal conductivity** | W/m-K | 270 |
| TEC* | $10^{-6}$/K | 4.4 |
| Dielectric constant*** | | 8.9 |
| Loss tangent*** | | 0.0004 |
| Volume resistivity** | Ω-cm | $>10^{12}$ |

*25~200 °c **at 25 °c ***at 1 MHz

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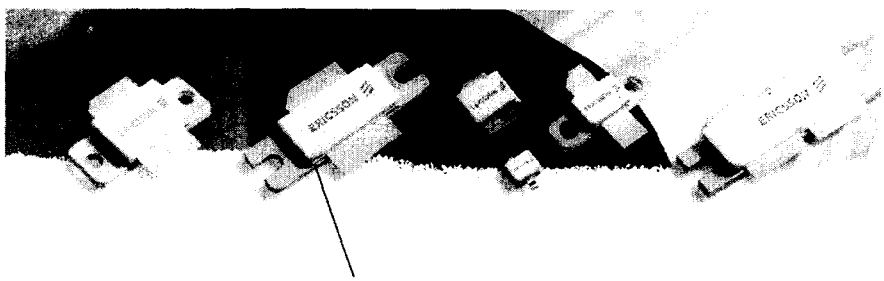


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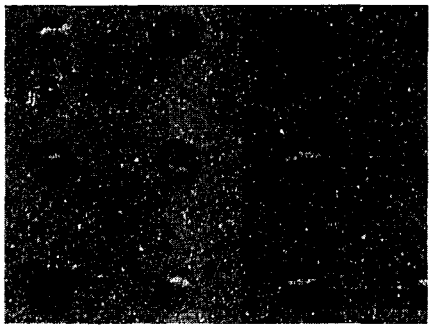
## Crack at the interface of $Al_2O_3$ and W due to the mismatch of TEC



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## HTCC ( High-Temperature Co-fired Ceramic)

A. W conductor 8~10mΩ/ ⟶ 3~6mΩ/

B. Compositional change of $Al_2O_3$
⟶ TEC matching to W

C. Compositional change of W
⟶ TEC matching to $Al_2O_3$

D. Compositional change of $Al_2O_3$
⟶ TEC matching to PCB

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## New heat sink material

*Cu-W* composite ⟶ *Cu/Mo/Cu* laminate

-Easy to machine
-Easy to control the properties
-Different thermal behavior of vert. & horiz. direction

Al-Si composite

-Easy to machine
-Easy to control the properties
-Not expensive
-Hard to plate & braze

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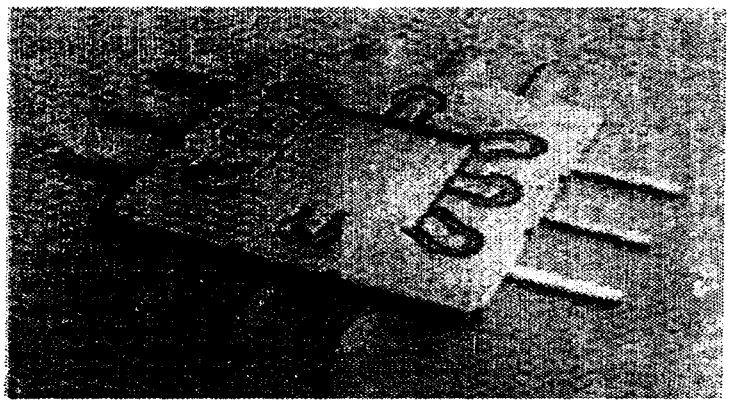

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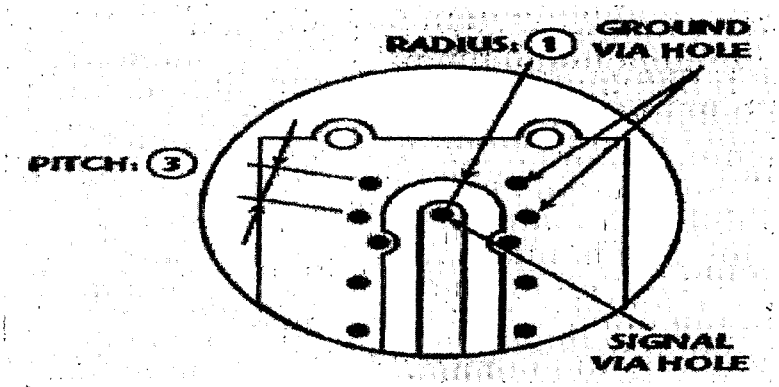


*Fig. 6 Detail of signal and ground via holes.*

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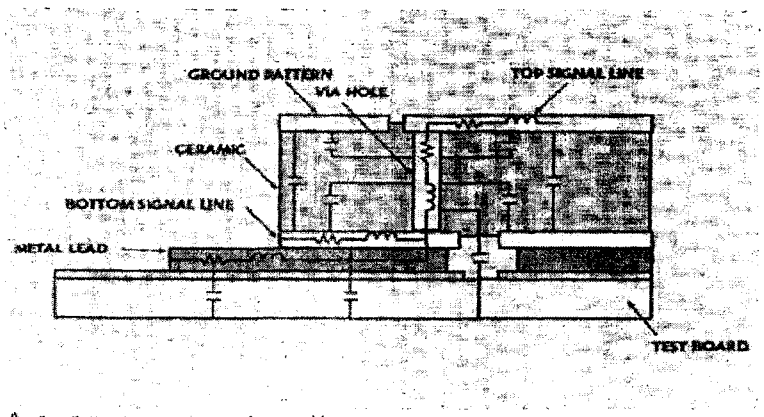


*Fig. 5 Equivalent circuit of a signal line.*

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## What is Needed for MCM?

- Fine line conductors – 50 micron or better
- Small vias in dielectric layers – 100 micron or better
- Precisely defined via electrical characteristics
- Multiple layers – BUT layer count requirement dramat ically reduced by small geometries – at 50 micron ge ometries 2 layers route most circuits
- High conductivity lines due to high aspect ratio
- Materials suitable for wire bonding and flip chip

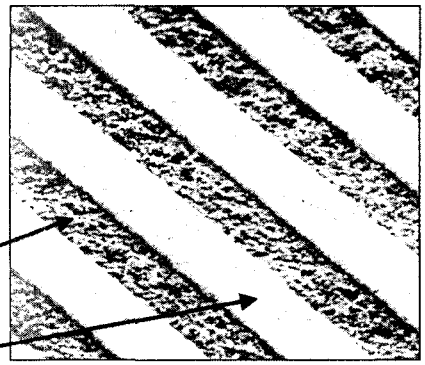


## Photo-processing Techniques

- Two main types:–
  - Photodefinable – paste (normally conductor) is optimised for etching. Patterned after firing, using a resist, then etched.
  - Photosensitive – paste contains photosensitive material. Patterned by exposing and washing before firing.

## Photo-processed Conductor

- Fine lines < 25 micron with 1 micron precision
- High density, 4 micron thick conductor
- High conductivity - 95% of bulk
- Gold & silver available

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