Custom Packaging Design of Microsystem and Microelectronics Devices

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Abstract

The design, fabrication and characterization of packaging for integrated circuits and MEMS are presented. Thick Film and Low Temperature Co-Fired Ceramics (LTCC) Technologies were used to obtain the different packages prototypes. The performances of both technologies were compared.

Keywords: Microsystem, Microelectronics, Packaging, Thick Film, LTCC

Introduction

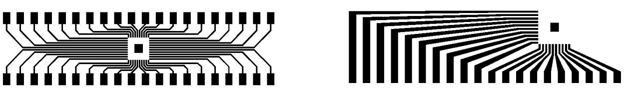
As it is well known, the integrated circuits (ICs) packaging allow, besides electrical connexions between the IC and the external world, mechanical protection and an adecuated power distribution and dissipation.

On the other hand, there are not standard solutions for MEMS and the packages in this case should be done depending on the specific application and environmental conditions.

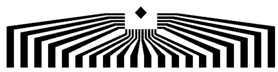
In this paper we present some custom packaging designs of ICs, fuel cell and RF devices, applying Thick Film Technology (TFT) and Low Temperature Co-Fired Ceramics (LTCC) [1]. These technologies are suitable to perform, besides standard packages for integrated circuits, appropriate packages for microsystems.

Packaging Design

All ICs package designs, were made with Autocad 2000, starting from chip (die) dimensions and distribution of pads connections. Fig. 1 shows the top view of connexions design for alumina substrate. In Fig. 2 the package designs fabricated with LTCC technology are presented. In the last case the X and Y shrinkage of LTCC were considered. The three dimensional layout of DIL 20 package designed for LTCC is showed in Fig. 3.

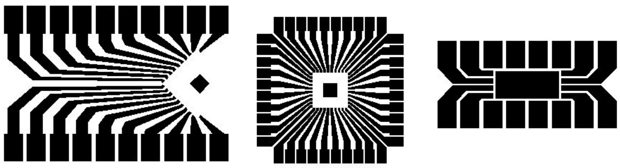


(a) (b)



(c)

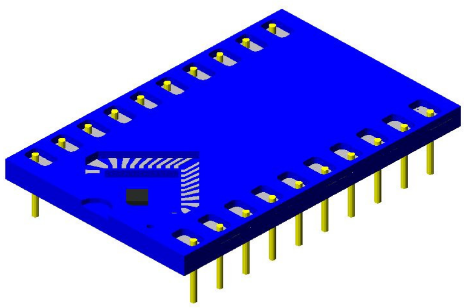
Fig. 1. Alumina package designs. a) Generic DIL 40. b) Lateral custom SIL 20. c) Central custom SIL 20.



(a) (b) (c)

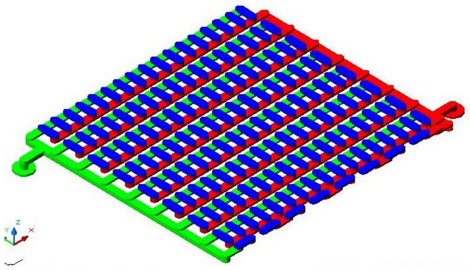
Fig. 2. LTCC package designs a) Custom DIL 20. b) Generic Quad 40 c) Generic DIL 16.

Fig. 3. 3D layout of DIL 20 Package based on LTCC



For the design of fuel cell package [2] we choose to design a functional test bed that can handle fluids, electrical contacts and exchange of parts such as: MEA (Membrane Electrode Assembly) and GDL (Gas Diffusion Layer). To accomplish the exchange of MEA and GDL, modular structures were proposed, resulting in comparative tests of performance among the various membranes. In Fig. 4 tree-dimensional circulation of the fluid is showed.

Fig. 4. Circulation of fluid (green - fluid input / blue - fluid in contact to GDL / red - fluid output)



For the first RF-Packages prototypes, CPW (Coplanar Waveguide) lines were designed in order to adjust the design parameters according to its characteristic impedance Zo. Three prototype of CPW lines were designed. Two models of CPW lines (different W and S) and one more to characterize the bonding wire (WB Model) [3].

Fabrication

Heraeus silver/palladium thick film C1218 was used as conductor lines for alumina prototypes of ICs packages. Standard thick film process was used.

For LTCC prototype of ICs packages, DuPont Palladium/silver thick film paste 6146 (<60mOhms/sq) was used as conductor lines. LTCC tapes were micro-machined using a CNC (Computer Numerical Control) milling machine [4]. After lamination, the device was sintered using typical LTCC temperature profile.

At die attach stage the chip was fixed with an Heraeus adhesive paste PD922 applied onto the substrate.

TPT HB10 Wire Bonder Machine as mode ball was used to bonding electrical connections. Fig.5 shows a wire bonding details.

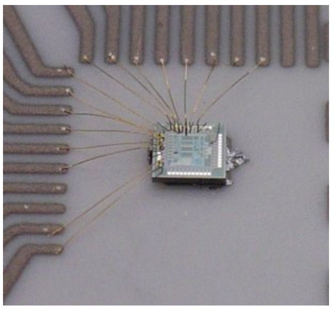


Fig. 5. Detail of IC wire bonding.

In Fig. 6. a photography of all models of thick film and LTCC ICs packages is showed.

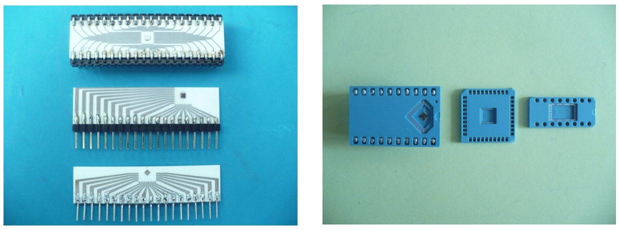


Fig. 6. Photography of alumina and LTCC packages.

To the package of fuel cell, DuPont 951 LTCC and thick film paste 6146 was used. To achieve a modular cell and easy replacement of MEA and GDL, an elastomer was used as seal between the structure of LTCC and membranes. In Fig. 7 a prototype of fuel cell with an elastomer is showed.

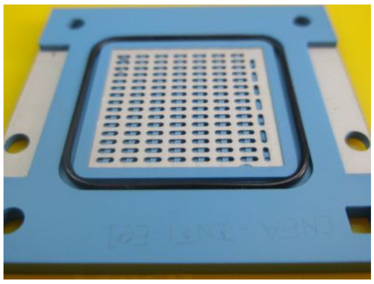


Fig. 7. Prototype of fuel cell with an elastomer

After sintered, gold thin film was deposited with sputtering method onto the surface of Pd/Ag, so that only gold surface contact to MEA o GDL. Fig. 8 shows the final prototype of fuel cell.

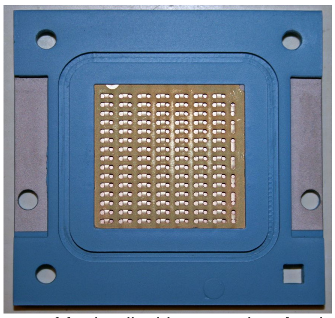


Fig. 8. Final prototype of fuel cell with sputtering Au deposit.

In the fabrication of CPW lines, standard LTCC process was used. Model I with W_I=380µm and S_I=127µm and Model II with W_{II}=760µm and L_{II}=254µm. SMA end launch connectors were used to characterize them. Heraeus F360 paste was used to solder SMA end launch connectors. Fig. 9 shows prototype of CPW lines with these connectors.

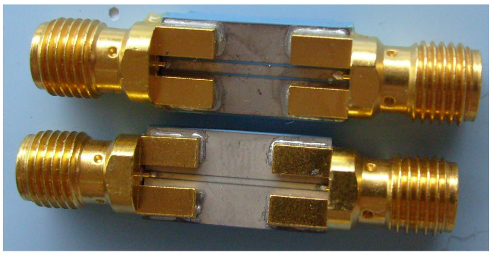


Fig. 9. Prototype of CPW line with SMA end launch connectors

TPT HB10 Wire Bonder Machine as mode wedge was used to WB-Model of CPW line [5].

Fig. 11 shows WB model of CPW line to analyze the wire bonding.

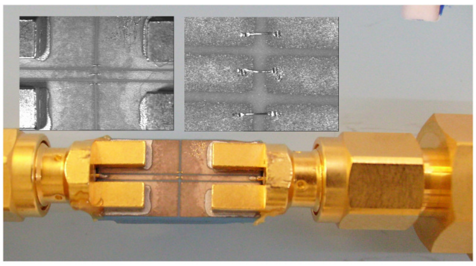


Fig. 11. WB model of CPW line. (Details of wedge bonding wire).

Measurement results

Fig. 10 shows the equivalent circuit diagram of ICs package traces.

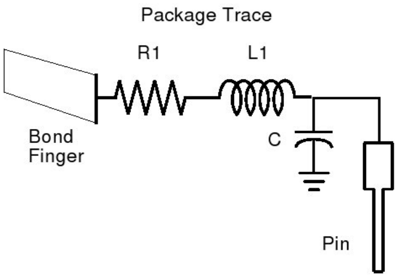


Fig. 10. Equivalent circuit diagram of packages traces.

Marconi Instruments Ltd TF 1245A Q-meter was used in measurement. Capacitance and Q factor at 30Mhz were measured. Eq. 1 shows how to calculate the inductance of trace.

$$Lx = \frac{1}{w^2 C} - L_{aux}$$

Eq. 1. Equation of trace inductance.

Lx = trace inductance w = resonance frequency

Laux = auxiliar inductor C = pattern capacitor

Keithley 4200-SCS characterization system and model 590 CV were used to measure trace resistance and capacitance. The values of measured capacitances were in order of 10^{-15} farad.

In Table I, comparative values of electrical characteristics of Central SIL 20 thick film and Custom DIL 20 LTCC packages are showed.

	Central SIL20 TFT Package		Custom DIL20 LTCC Package	
Pins	R[Ω]	L[nH]	R[Ω]	L[nH]
1,20	2,92	176	1,03	18,6
2,19	2,69	171	1,23	18,6
3,18	1,98	165	1,47	22,44
4,17	1,75	154	1,71	22,44
5,16	1,70	149	2,06	26,32
6,15	1,63	14,8	3,19	26,32
7,14	1,51	11	4,01	28,27
8,13	1,48	5,48	4,67	32,21
9,12	1,34	3,64	4,86	34,20
10,11	1,20	3,63	5,10	38,20

Table I. Comparative values of electrical characteristics.

In order to characterize the fuel cell prototype, the properly fluidic circulation, the electrical contacts and the seal were verified according to design specifications [6].

Vector Network Analyzer of 40Ghz was used to characterize CPW lines and WB Model. Table II shows S-Parameters obtained to different models.

f=8Ghz	[db]		
	Model I	Model II	WB Model
S11	-17	-20	-15
S12	-1,5	-0,95	-1,46

Table II. S-parameters of different CPW lines models.

In table II, we can see great values of S12 due to the resistance of the line. This may be improved using another thick film paste with less resistance by square.

Conclusions

- Thick Film Technology (TFT) and Low Temperature Co-Fired Ceramics (LTCC) Technology is a very suitable technology to fabricate standard packages for ICs and custom packages for MEMS.
- Electrical characteristics of ICs packages fabricated with both technologies, were compared.

- For the fuel cell prototype, two modules with LTCC technology were manufactured, one for methanol + products, another one for O_2 + products. We are using these modules in order to characterize commercial MEAs and GDLs.
- Three models of CPW lines applied to RF-MEMS packaging were fabricated and characterized.

References

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