THERMAL INVESTIGATIONS ON LED MODULES REALIZED USING SOLDERLESS ASSEMBLY FOR ELECTRONICS TECHNOLOGY

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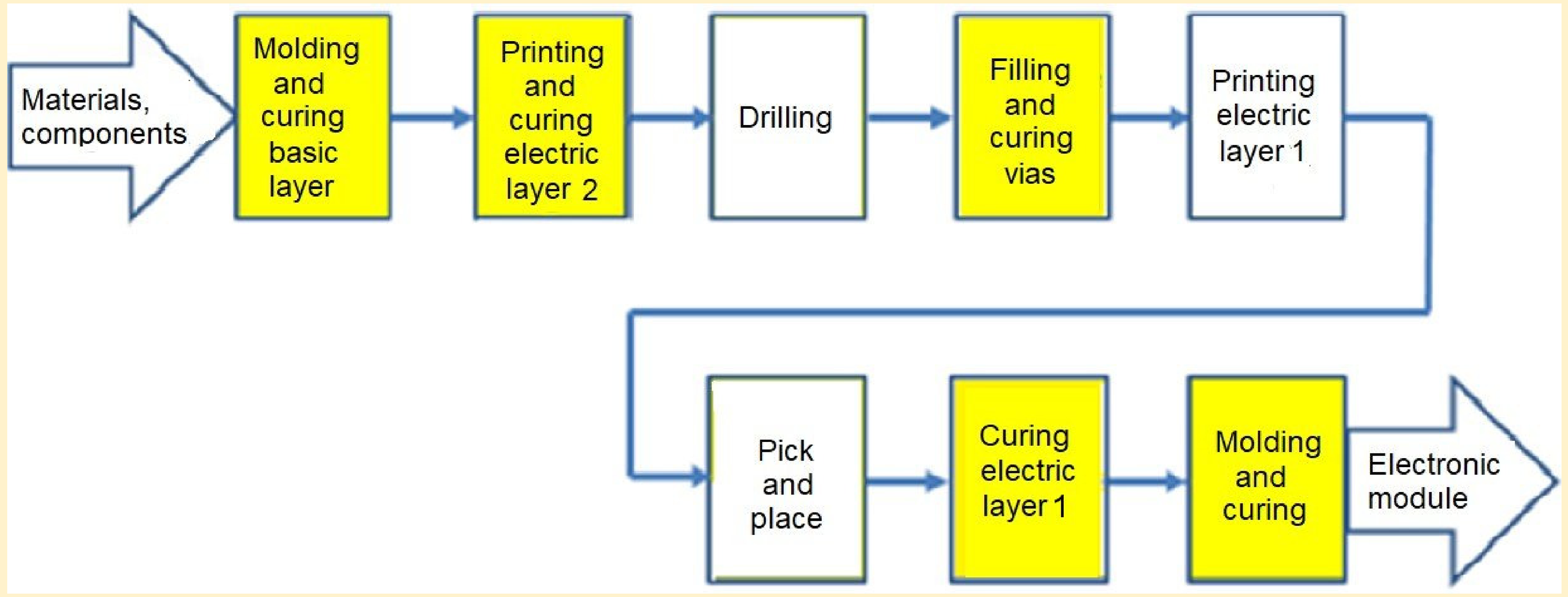
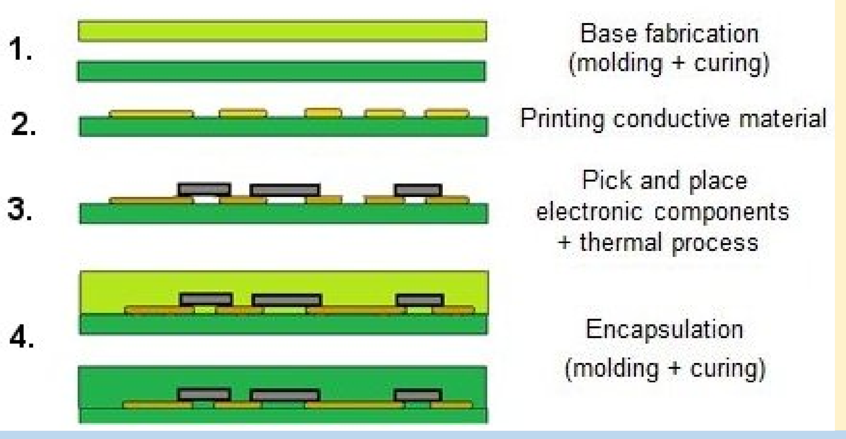
- This work is derived from our recent studies about the new approach for interconnecting the electronic components without the use of solder alloys. The concept is generally called Solderless Assembly for Electronics Technology (SAFE).
- We will present the results of thermal analysis and measurements of electronic modules that were realized in SAFE technology. In a SAFE module, the natural convection from the top of a component is blocked by the resin, as a result of molding process. The interconnection of components and simultaneously the conductive tracks are realized using the same printed conductive paste.
- For comparison purposes, there were investigated structures containing LEDs and fixed linear resistors.

INTRODUCTION

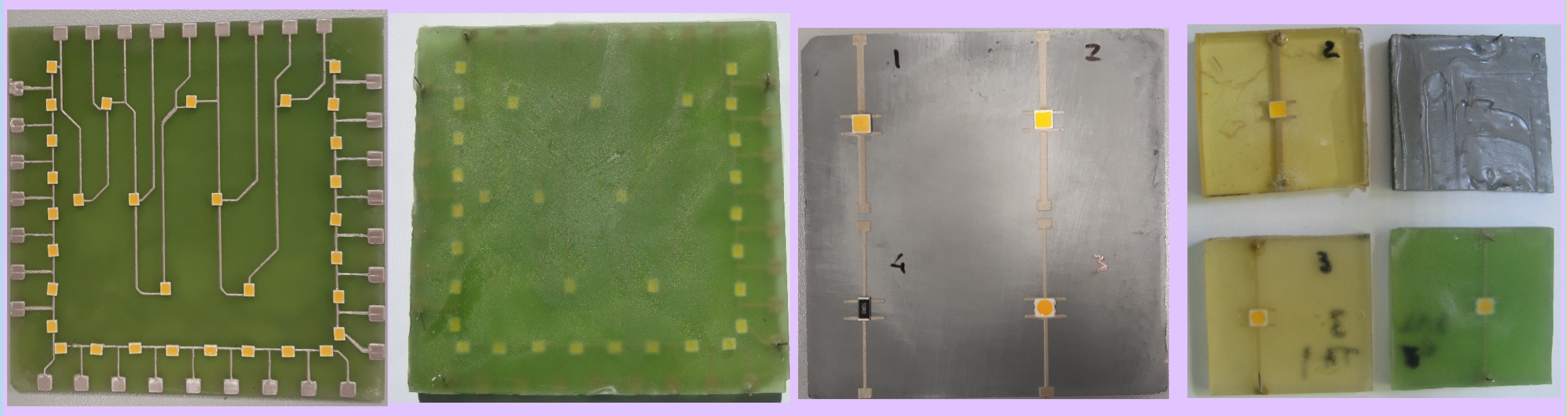
The main idea of realizing SAFE assemblies is to eliminate the solder alloy and all the associated soldering process. Some of the issues associated with soldering are expected to be eliminated. We mention here the thermal stress on components, tin whiskers, voiding, tombstoning, delamination of substrate, etc.
Because of the final stage of encapsulation, there are concerns regarding the thermal regime of these modules. The resulting electronic module, as a closed molded assembly will limit the heat flux from the sources to the outside. The internal heat that is generated will be conducted outwards by a relatively poor conductive material. The distribution of temperature will depend on the resin type that is used for module encapsulation.
There are different possibilities to implement an assembly process without the use of solder alloys. We present in Figure below a variant that was implemented for two conductive layers.



For the probes that were used in experiments in the current paper we have used the single layer variant, there was no need for a second conductive layer. The simplified process is presented in Figure aside.



TEST VEHICLES



(a) (b) (c) (d)

Test probes a) LEDs 2835 placed on substrate, test structure S6, see Table, on Resin 2, b) Test structure S6 encapsulated (Resin 2), c) Structures S1-S4, see Table 2, on Resin 4. d) Aspect of the molding resins, Resin 1 top left, Resin 4 top right, Resin 3 bottom left, Resin 2 bottom right.

Some properties of the dielectric materials.

Type	Mixing ratio	Curing temperature [^{o}C]	Curing time [min]	Color	Ref. Name
Epoxylite 235SG	5:1	60	30	Transparent	Resin 1
Technovit 4071	2:1	Room Temperature	5-7	Green	Resin 2
Technovit 4004	2:1	Room Temperature	9-12	White, opaque	Resin 3
Polytec TC301	1 comp.	150	10-15	Metal grey	Resin 4

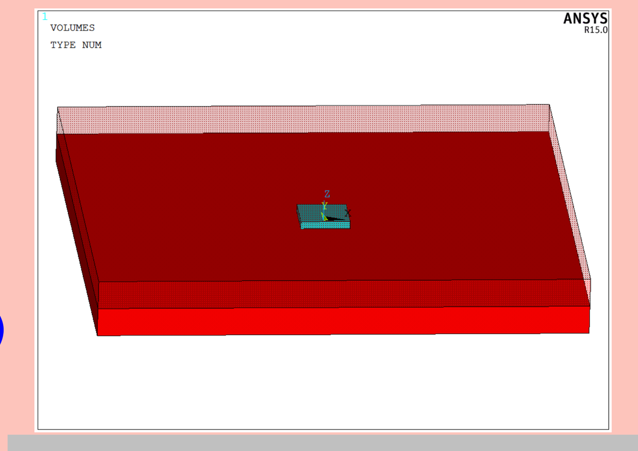
Dissipative electronic components used in experiments.

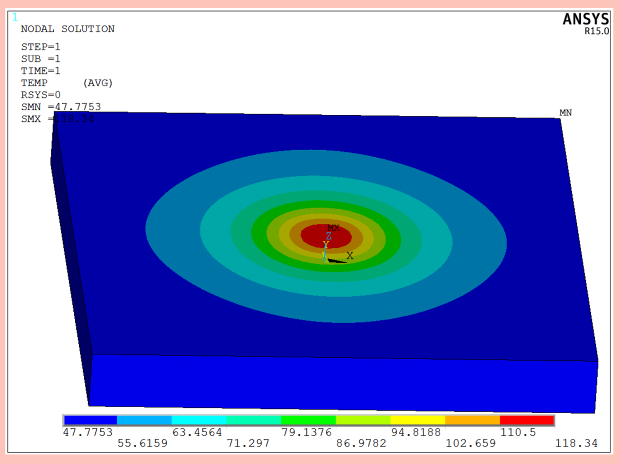
Comp. nr.	Ref. name	Type	Manuf./Type	Electric data
1	S1 (structure 1)	LED 5050	Osram/ Duris S8, GW P9LR31.EM	500 lm @ 3000 K, IF 10- 200 mA, VF=24.8V.
2	S2	LED 5050	Osram/ Duris S8, GW P9LR35.PM	215 lm @ 4000 K, IF 40-1050 mA, VF=5.5V.
3	S3	LED 5050	Osram/ Duris S8, GW P9LMS1.EM	385 lm @ 3000 K, IF 10- 240 mA, VF=19.8V.
4	S4	Thick film resistor 2512	Walsin/ WF25P	P=2W@70°C
5	Daisy chain	LED 3030	Cree JK3030 3V	156lm @ 4000 K, IF 400 mA, VF=3.2V.
6	Daisy chain	LED 2835	Cree JE2835 3V	82lm @ 4000 K, IF 240 mA, VF=2.85V.

For metallization we have used the conductive paste SW180.

THERMAL SIMULATIONS

The performed thermal simulations have offered also a "hidden" information, the temperature at component level, inside the mold. The difference between surface temperature (hot spot) and hot spot of the component depends on the thermal constant of the molding resin and also on the component itself. For instance, the surface temperature is 118.3 °C, while the temperature of the LED component is 132.4 °C

(a) 

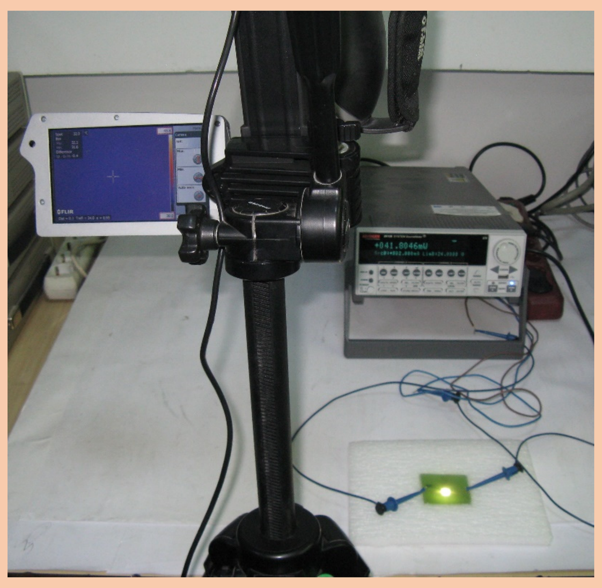
(b) 

a) Thermal 3D Model

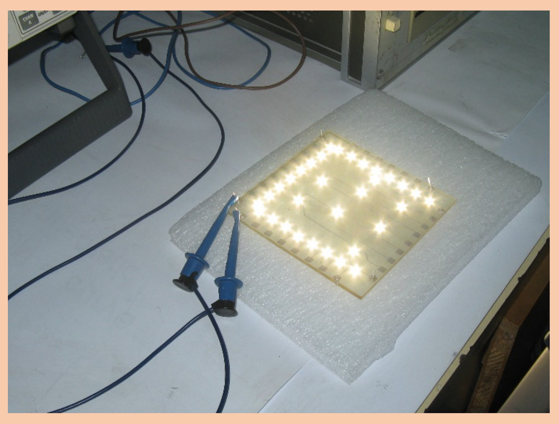
Temperature map for Resin 2 (100mm×100mm), applied power 1W.

MEASUREMENTS AND RESULTS

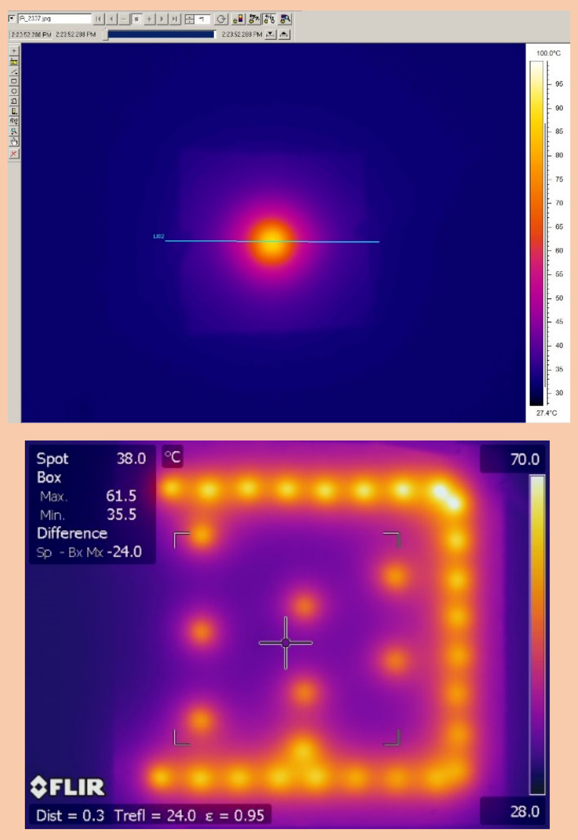
The IR camera is model ThermaCAM SC640, the source is Keithley 2612B, used also to monitor the applied power. The DUT is placed in a thermal insulating foam. The software ThermaCam Researcher was used for data extraction from IR pictures

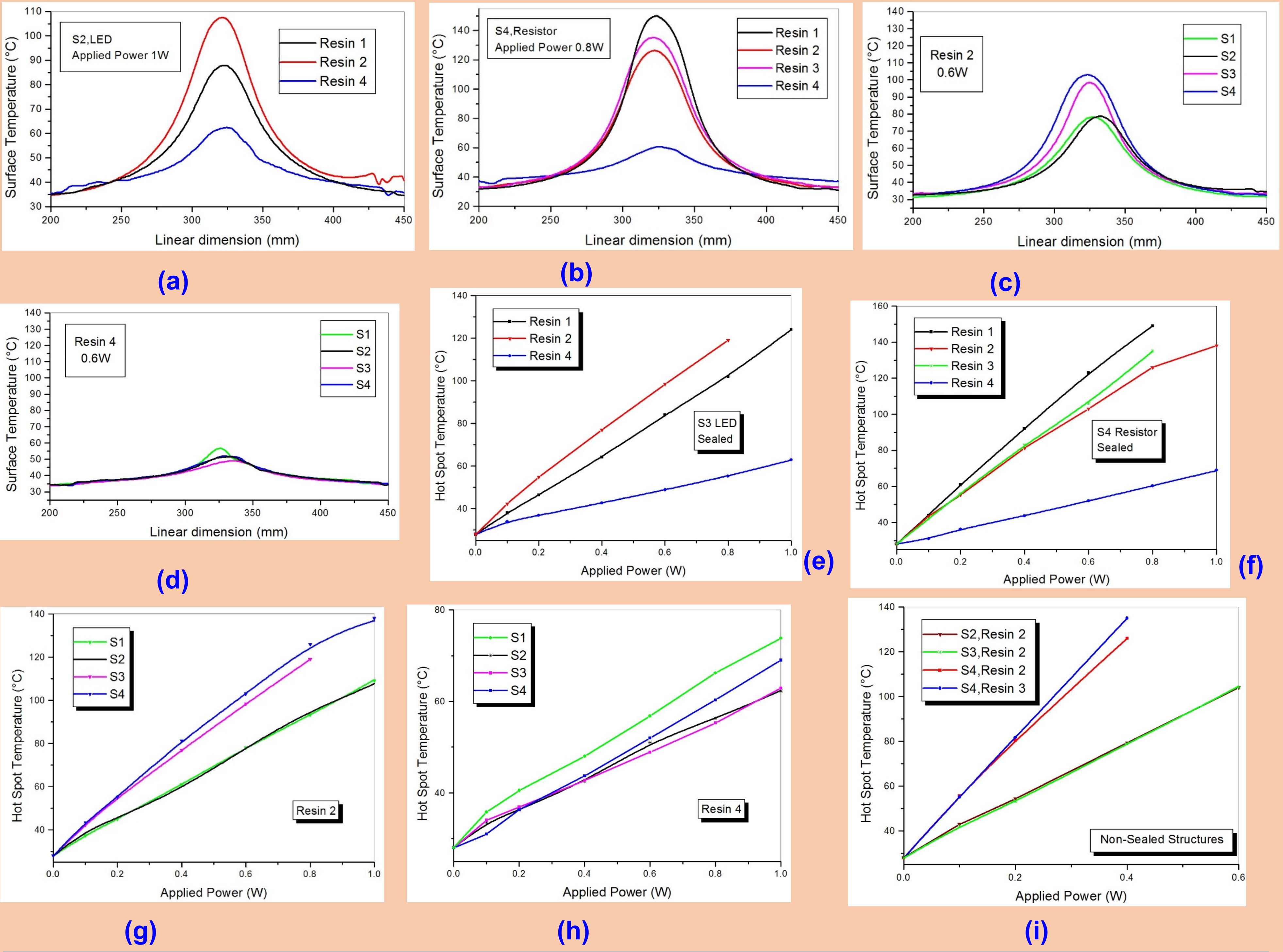


Experimental setup.



Thermal image of the module S2, Resin 1,1W and of module S5, Resin 1





(a) (b) (c) (d) (e) (f) (g) (h) (i)

Thermal profile of structures for different resins, a) structure S2,1W, b) structure S4, 0.8W, c) Resin 2,0.6W, d) Resin 4, 0.6W; Temperature vs. applied power, e) Structure S3 LED, f) Structure S4 Resistor, g) Resin 2, h) Resin 4, i) non encapsulated structures

ACKNOWLEDGEMENTS

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CONSIDERATIONS AND CONCLUSIONS

- As a main conclusion, modules realized in SAFE technology must be thoroughly investigated when thermal issues are suspected.
- The heating of the molded LEDs probes was similar with the one of resistors at the same power level. It means that molding has reduced the optical power of the LEDs.
- No self heating of the tracks was observed, even high current applied to resistor structures.
- A more conductive resin as Resin 4 can be used with better results concerning the heat spreading or similar, for having hot spots with lower temperature. The only technological problem is the high viscosity of this resin. Manual application of the resin was needed in our case, the molding by pouring in the form was impossible.