Thermal behaviour of screen-printed graphene based pastes

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INTRODUCTION

RESISTIVE HEATING

Resistive heating is the process by which an electric current passes through a conductive material (the resistor) and releases heat. Carbon based inks and pastes are promising materials for this application due to their self-limiting behavior with the temperature and because they can be printed on a variety of surfaces[1,2,3] .
This work analyses the thermal behaviour of different carbon formulations on glass substrates at different voltages.

EXPERIMENTAL PROCEDURE

CARBON PASTES

PASTE	FORMULATION
A	Comercial paint + 0,6%w RGO + 0,3%w CNT
B	Water based. Solids 17%w basically graphite.
C	Water based. Solids 54 - 55 %w (carbon + polymer)
D	Polyamide paste + resin 25%w + solid carbon 25%w (basically graphene)

Table 1. Pastes formulation

PROCEDURE

SCREEN PRINTING
· Glass substrate
* Mesh: 61-64 and 20-140
* Samples with several layers and thickness

Linear resistance characterization
Width 3mm
Length 30 mm

THERMOGRAPHY
· Different voltages have been applied: 15, 30 and 220 V
* Thermographic images registered the temperature increase

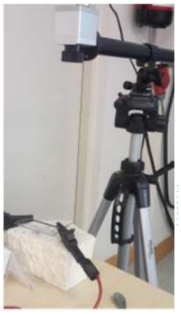

Figure 1. Thermography set-up

RESULTS

SAMPLE	RESISTANCE Ω	THICKNESS µm	RESISTIVITY Ω cm
A1	15600	340	53
A2	34300	160	55
A3	50000	150	75
B1	60	130	0,08
B2	90	120	0,1
C	147	55	0,08
D1	523	20	0,11
D2	627	18	0,11
D3	758	15,5	0,12
D4	1600	7,5	0,12

Table 2. This table shows the measured linear resistance, the thickness and the resistivity of the four paste samples.
Resistance values for the deposited pastes shows that for paste A they are in the order of MΩ, for paste D are between 523-1600 Ω (depending on the layer thickness) and for pastes B&C they are below 150 Ω.
The samples thickness is in the range of 7.5 to 340 µm.
The resistivity value of paste A is much higher than the values of the rest of the pastes.

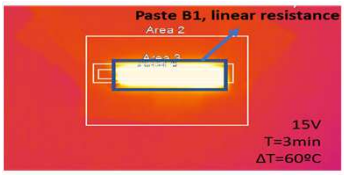

Figure 2. The thermographic analysis shows that samples are uniformly heated along the linear resistance

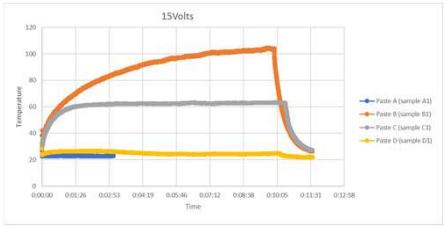

Figure 3.
Chemical composition of pastes is a key parameter in the thermal behavior stabilizing the temperature values.
Pastes B, C and D increase temperature applying 15volts, whereas paste A is not heated at this voltage.

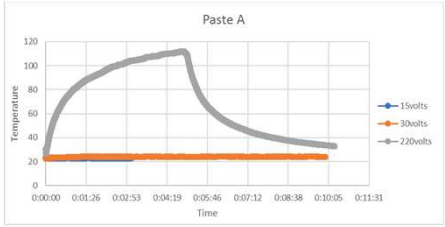

Figure 4. Paste A, due to its high resistivity value, needs high voltages to increase the temperature. An increase of 100ºC is registered in 4 minutes when 220V were applied

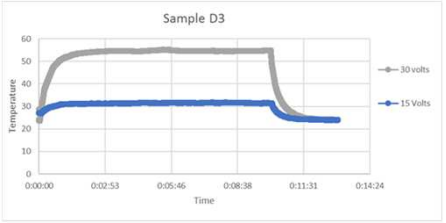

Figure 5. Temperature increases until a stabilized temperature determined by the chemical composition of the paste and the voltage applied. The figure shows the voltage influence.

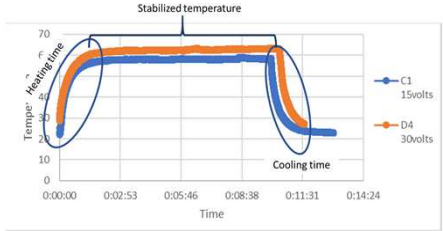

Figure 6. For all carbon formulations, when the appropriate voltage is applied, the temperature increases quite fast, stabilizes and decreases very fast when the voltage is switched off.

CONCLUSIONS

- Different carbon based pastes have been screen printed on glass and heating behaviour analysed.
- The highly loaded pastes have a resistivity value around 0,1 Ωcm whereas the lightly doped has a resistivity value two order of magnitude higher.
- All carbon-based formulations have shown similar behavior: when the appropriate voltage is applied, the temperature increases quite fast, stabilizes and decreases very fast when the voltage is switched off.

REFERENCES

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