

# Applications of hybrid graphene pastes for functional printing

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Functional printing enables new business lines applied to diverse sectors such as industrial sector (circuits, antennas, sensors, batteries, etc.), the agri-food sector (bio-sensors, smart packaging and labels, etc.) or the health sector (biochemical diagnosis devices, biological testing, etc.). In this work we present several applications currently under development based on functional graphene pastes combined with silver nanowires.

The excellent thermal and electrical properties of graphene spread heat rapidly, this together with the piezoresistive behaviour of graphene opens the field to novel devices, like efficient heating elements, pressure sensors or structural health monitoring. Moreover, graphene's large surface area, high electrical conductivity, unique optical properties and high thermal conductivity make it especially ideal for sensors. Ultra-sensitive graphene-based sensors can also be smaller, lighter and less expensive than traditional sensors.

The following functionalities will be presented. (a) Heating elements. Temperatures in the range of 80°C-160 °C are achieved with voltages between 20-30 V. Good behaviour after long cycles, reaching the same temperatures in each cycle (b) Structural health monitoring. Gauge factors up to 30 have been reached in steel samples coated with different graphene-based materials when subject to mechanical strain. (c) Pressure sensing. Preliminary results of bending tests on printed textiles show good correlation between curvature ratios and resistivity; behaviours in long time cycles. (d) Temperature sensing. Screen printed sensors based on resistive graphene-pastes integrated in a Wheatstone bridge show high sensitivity and quick answer.

The potential industrial applications will be also presented.

## Figures

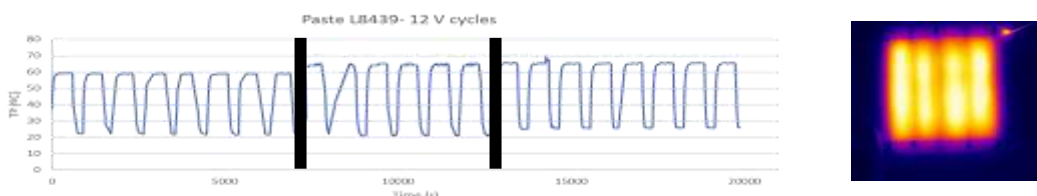


Figure 1. Electrothermal behaviour of printed graphene paste after several cycles

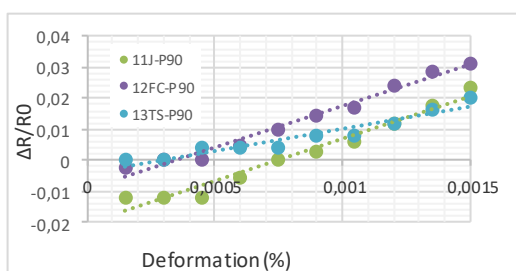


Figure 2. Piezoresistive behaviour of several graphene pastes



Figure 3. Temperature sensor