

## Influence of electrodes polarization on the response of a soot resistive sensor

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### Summary

This study reports on the influence of the polarization applied between platinum electrodes of a soot resistive sensor. The conductance measured between these electrodes represents the sensor response which increases during soot deposition over time at fixed parameters (soot flow, polarization). It is observed that a maximum response is obtained for an optimum polarization. This behaviour is explained by equilibrium between the creation and destruction of inter-electrodes soot bridges.

### Motivation and results

A resistive soot sensor for diesel particulate filter (DPF) failure detection was developed in previous works [1]. The sensor consists in an alumina substrate with two platinum interdigitated electrodes. A platinum resistance heater on the other side is used for periodic regeneration. The conductance between the platinum electrodes (sensor response) as a function of time is recorded under a particulate matters (PM) flow produced by a mini-CAST soot generator from a propane/air flame at steady state condition. When a polarization voltage is applied, soot bridges form between the electrodes, contrary to a continuous soot layer deposited without polarization (figure 1) [1]. Sensor response versus time shown in figure 2 strongly depends on the polarization voltage, and an optimum polarization corresponding to a maximum response can be seen, 30 V for given conditions. It was also demonstrated that this optimum value is dependent on the soot characteristics [2]. In order to understand this behaviour, some observations were made in ambient air at fixed temperature of 200 °C, on soot preloaded sensors with optimum polarization (30 V for the considered operating point). Then, increasing electrode polarization is applied up to 200 V. Optical microscope image (figure 3) reveals flashes interpreted a soot combustion occurring under 200 V polarization. To confirm such visual observation, a similar experience with the simultaneous record of both the conductance and the signal of an avalanche photodiode was performed (figures 4). When polarization voltage ramp starts from 10 V, the conductance first increases without flash emission, corresponding to soot heating by Joule effect (carbon soot have a negative temperature coefficient). Then, for polarization above 40 V, the conductance decreases with flash emissions recorded by the photodiode. This result proves the destruction of soot bridges by combustion ignited by Joule effect and also explains the optimum observed value. Such interpretation was reinforced by high sampling frequency during previous experiment around 60 V (figure 5). It can be seen that each light flash coincides to positive conductance switch related to Joule effect.

To conclude, analysis of polarization voltage influence on sensor response allowed to understand the sensing mechanism. An optimum polarization voltage can be attributed to equilibrium between soot bridges creation promoted by polarization effect, and their destruction by combustion ignited at high voltage.

**Word count:** 443

### References

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- [2] D. Grondin, P. Breuil, J. P. Viricelle, & P. Vernoux (2015). Development of a particulate matter sensor for diesel engine. *Procedia Engineering*, **120**, 1237-1240.

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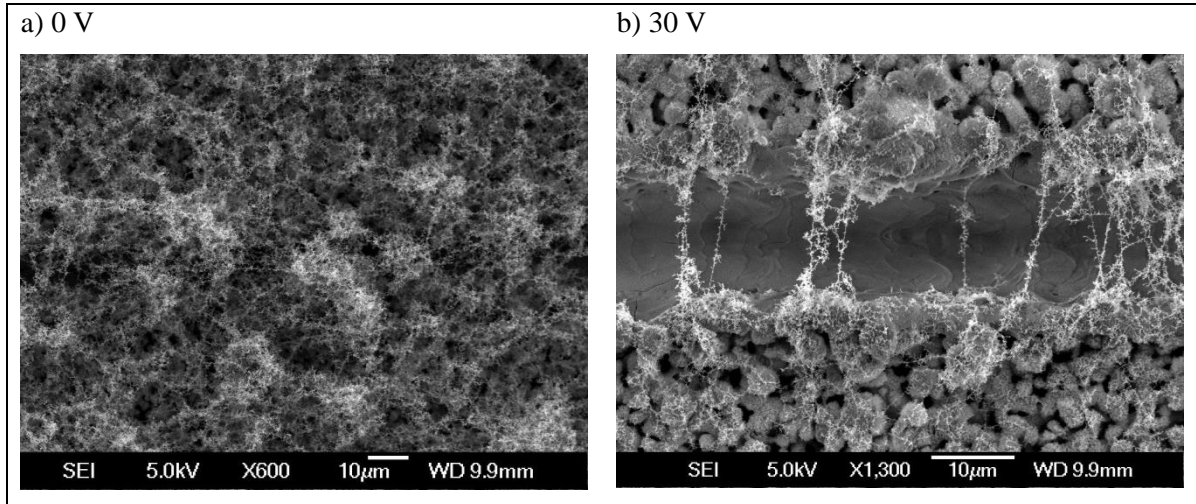


Figure 1: Scanning electron Microscopy of a sensor with soot deposited during 2 hours under a) no polarisation and b) a polarisation of 30 V.

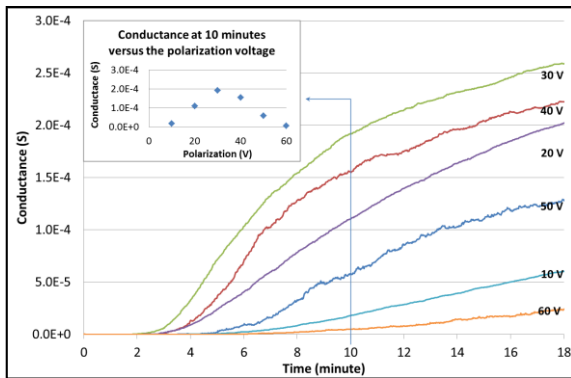


Figure 2: Conductance variation versus time for different polarization voltages and conductance versus polarization at 10 minutes (insert).

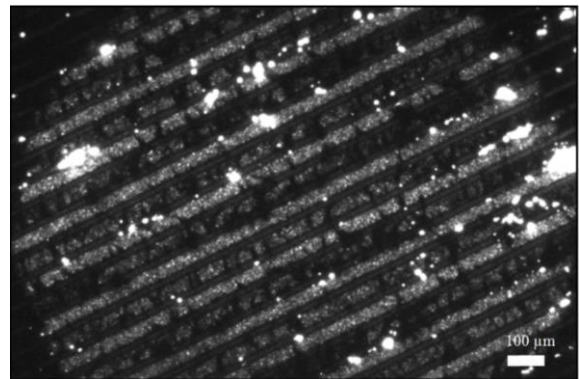


Figure 3: Optical microscopy image showing flashes on a soot pre-loaded sensor (30V) in ambient air with 200 V polarization.

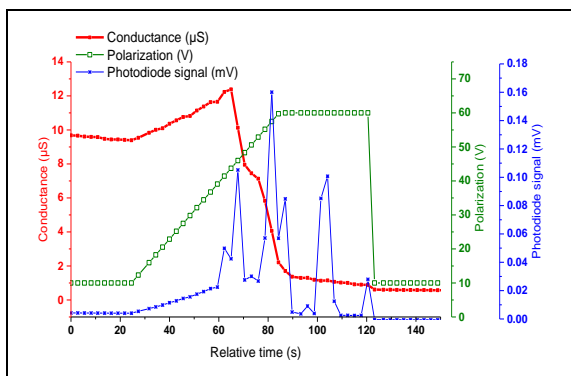


Figure 4: Measurement of conductance the photodiode signal over a polarisation voltage ramp with pre-loaded soot sensor (Low frequency sampling 1 Hz).

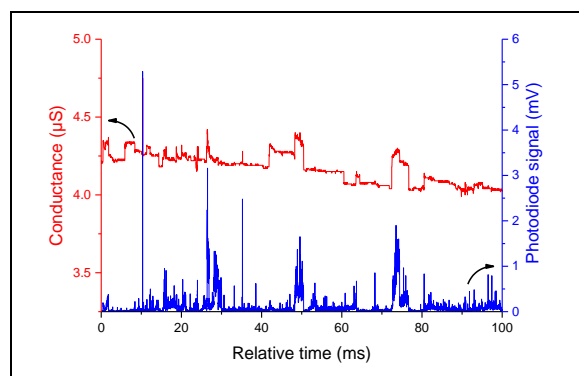


Figure 5: Zoom of figure 4 around 60 V with high frequency sampling (10kHz).