

Development of Platinum Heater by Inkjet Printing onto Polyimide Substrate

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Summary:

Platinum inks were developed from nanoparticle suspensions obtained through a polyol synthesis route. These suspensions were then mixed with solvents such as ethylene glycol, water, and propan-2-ol to produce printable inks. After optimizing the deposition parameters onto polyimide substrates and the thermal treatment, functional platinum coatings were obtained. A sensor printed with our homemade inks on a flexible substrate was exposed to CO and NO₂ gases, and its response was found to be comparable to the one obtained for a sensor printed with commercial inks.

Keywords: Inkjet printing, platinum, metallic inks, gas sensors

Background, Motivation and Objective

This work is part of the development of a full inkjet-printed resistive sensor with controlled ink composition. Indeed, commercial inks are of unknown composition that can degrade sensors performances. We already worked on the feasibility of this kind of fully printed sensor, working on different aspects, SnO₂ [1,2], inkjet printing of commercial inks [1,3], development of homemade gold inks [4]. The objective of this new work was to complete the sensor with the heating element, in platinum, at the back side of the sensing layer.

Description of the New Method or System

For this, we proposed the development of a platinum ink. We study the formulation and the printability until getting a stable ink for a Dimatix DMP 2850 inkjet printer.

Results

For the fabrication of platinum conductive inks, the first objective was the synthesis of platinum nanoparticles (PtNPs) via polyol route. Polyol process is a type of liquid-phase synthesis that allows the production of finely divided metals from salts by reaction with polyalcohols. We choose to use ethylene glycol as the solvent and reducing agent, polyvinylpyrrolidone (PVP) as the stabilizer, and hexachloroplatinic acid as the platinum precursor.

After optimization of the synthesis parameters (reaction time, temperature and concentrations), platinum nanoparticles of 9 nm were obtained and are aggregated with 2 to 6 particles on

average as reported in figure 1 (DLS analysis and TEM micrograph).

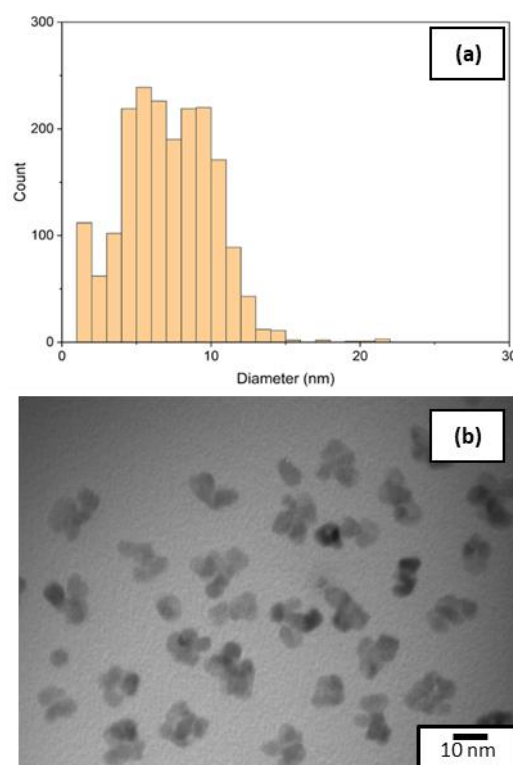


Fig. 1. Solution of PtNPs: (a) particle diameter distribution by DLS, (b) TEM micrograph.

Then, we formulated an ink by mixing the previous suspension with propan-2-ol in appropriate proportions in order to get viscosity and surface tension within the ranges of required values for inkjet printing, 12.5 mPa.s and 28.9 mN/m, respectively.

After several trials with the inkjet printer parameters, spherical drops without satellite droplets were obtained. As reported in figure 2, the spread drops have a diameter of 36 micrometres and by decreasing the distance between the drops, it is possible to obtain homogeneous and continuous lines.

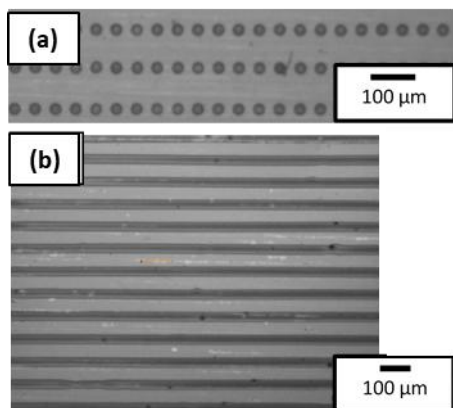


Fig. 2. Images obtained via the printer camera for a deposition of (a) droplets of PtNPs ink spread on polyimide and (b) lines.

Multi-layered films were thus deposited. Drying steps or intermediate curing were evaluated in regards of the final coating. After a final heat treatment at 400°C, a continuous coating was obtained. A SEM micrograph is reported in figure 3. The film was composed of very fine compacted particles.

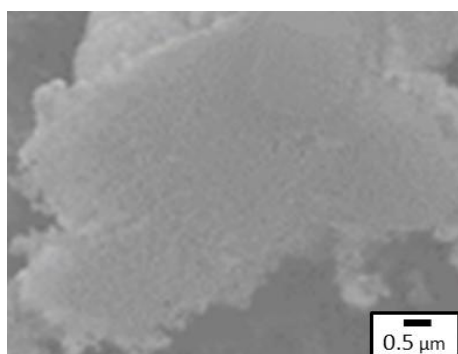


Fig. 3. SEM micrograph of the surface of a platinum coating

Finally, conductive layers were obtained and a pattern of a heater was printed in order to confirm the feasibility. Resistance and temperature coefficient of the heating element are under evaluation.

Conclusion

Finally, we formulated a stable and printable platinum ink to design the heating element. We succeeded in the preparation of a platinum heater to finalize our resistive gas sensor onto polyimide foil. It was possible to produce several platinum nanoparticle-based inks and print them using inkjet technology. Very few commercial platinum inks are available for inkjet printing. This synthesis technique is similar to existing options but is nonetheless promising for ink production, especially since the resulting mixture is very stable and perfectly meets inkjet printing requirements.

This work opens the way to new applications, as resistive temperature sensors for example.

References

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