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# STUDY OF A HIGHLY LOCALIZED ACTIVATED CARBON DEPOSITION PROCESS USING INKJET PRINTING TECHNOLOGY

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*Topic : Intégration of technologies*

**Abstract - An activated carbon deposition technique based on inkjet printing is proposed for the fabrication of supercapacitors electrodes. By mastering the activated carbon suspension in ethylene glycol through the use of a surfactant and by functionalizing the substrate with OTS, 10µm wide structures were obtained with 50 µm ink jet nozzles.**

## I. INTRODUCTION

Supercapacitors come usually in roll-type or button cell type package [1] compatible with large-size systems. For low profile applications, integration of supercapacitors on silicon substrate can be of great interest. Microtechnology approaches have been proposed in the literature [2,3]. One of the difficulties lies in the deposition of activated carbon. As a result, a deposition process based on inkjet printing was developed with the objective of limiting the number of steps needed in terms of technology, low-temperature elaboration and collective treatment. Another challenging task is the integration of the highest number of devices onto the smallest possible surface. Unfortunately, a major constraint imposed by the state of the art inkjet technology is the limited diameter of the nozzle head orifice to 15 µm. Thus, the use of the activated carbon powders with particle diameters as high as 10µm can hardly be considered and jetting becomes almost impossible due to inevitable clogging caused by the accumulation of particles in the nozzle of the print head. To circumvent these obstacles, a regular 50µm diameter nozzle was selected and work focused on maintaining the particles in suspension in the emulsion by adding surfactant Triton X 100 and on locating the emulsion during the impact on the gold electrode by means of a localized OTS (otadecyltrichlorosilane) hydrophobic treatment on silicon oxide.

## II. IMPLEMENTATION TECHNOLOGY

### A. Ink preparation

Ink is an ethylene glycol emulsion of activated carbon and 5% DuPont PTFE aqueous solution which provides the ligand for carbon particles [1]. Surfactant

concentration was optimized by measuring the contact angle on the OTS-treated silicon surface and on a gold contact. Figure 1 shows how this angle changes with Triton concentrations from 0.0001% to 5% in weight. Likewise, we have monitored the behaviour of the solution in test tubes. Following storage for 48 hours, three behavioural types were found:

- from 0.0001 % to 0,1%, three phases were observed (ie, an upper transparent phase, an intermediate homogeneous phase and a lower deposition phase),
- from 0.1 % to 1 % , two phases were noted (an upper homogeneous phase and a lower deposition phase);
- for a concentration in excess of 1% , only one homogeneous phase remained.

It can be pointed out that above 3% Triton concentration, the contact angle stabilizes at 60° on silicon oxide and becomes almost zero on gold. As a result, a 3% Triton concentration was selected, with an activated carbon emulsion of 3% (beyond this value, jetting conditions tend to be more random).

### B. Surface preparation

A silicon substrate was used with a 1000 Å thermal oxide layer; the metal electrodes were obtained by means of vacuum deposition of a 150Å Cr and 2000Å Au. These electrodes were patterned by photolithography ; the patterns obtained consist of interdigitated lines with the width varying from 10µm to 50µm. Surface functionalization is the result of quenching of a 2% OTS solution in trichorethylen .

### C. Results

#### a. Deposition at room temperature

Figure 2 shows the behaviour of grain distribution after heating to evaporate glycol. The so-called 'coffee cup effect' can be noted with a specific distribution of particles around pattern edges [3]

#### b. Deposition at 140°C

Distribution is much more homogeneous, as shown in Fig. 3. 10µm wide structures were obtained.

## III. CONCLUSION

A method was validated for the deposition of large size particles in suspension. Thanks to a tune surface treatment and by adding a surfactant, pattern dimensions as low as 10  $\mu\text{m}$  were obtained with the ink jet printing technology with nozzles that are much larger than the final structure. This method could be applied to other types of materials while potentially paving the way for a higher resolution.

#### IV. ACKNOWLEDGEMENT.

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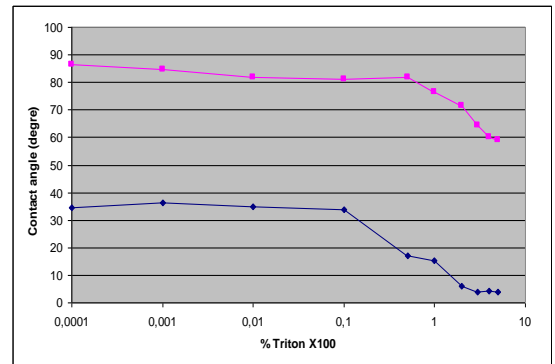


Fig. 1: Variation of the angle of contact of Au and Si as a function of percent concentration in Triton X 100 weight.

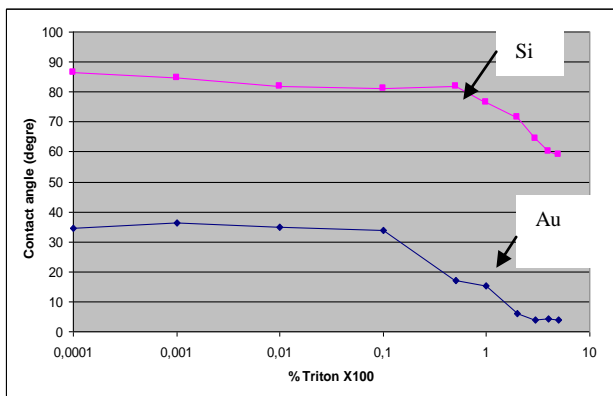
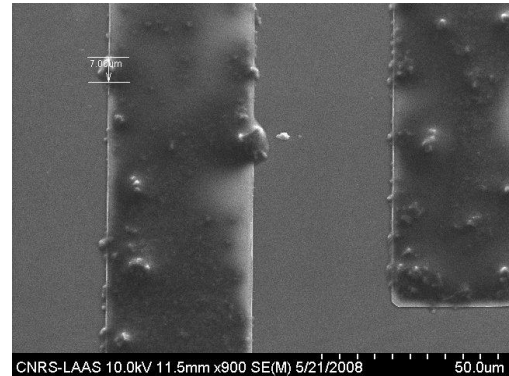


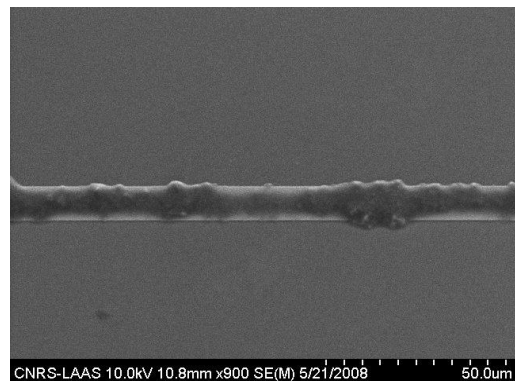
Fig. 1 Contact angle variation on gold and silicon versus % Triton X100



Fig. 2 : Room temperature deposition ; the so-called ‘coffee cup effect’ with particles distributed around pattern edges



a)



b)

Fig. 3 SEM of a deposition at 140°C. a) 40 $\mu\text{m}$  wide electrode ; b) 10 $\mu\text{m}$  wide electrode