Selective Metallization of Non-Conductor Substrates by Ink-Jet Printing

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Abstract

Selective metallization of non-conductors is desirable for electronic as well as decorative applications. In this paper, we describe a new method for direct writing of metallization patterns by ink-jet printing. In contrast with previous techniques, this process combines three dimensional capabilities and allows for large precious metal savings. The method involves substrate modifications, electroless catalysts especially formulated for ink-jet deposition and final electroless plating.

We report in this paper direct writing of Ni, Cu and Au patterns on a wide range of substrates such as ceramics, glass, silicon and plastics. Particular emphasis is paid on the physico-chemical properties of the deposited patterns. We check that this method fulfills the requirements for various standard electronic and decorative applications. Applications of the proposed technique for selective metallization of complex three dimensional shapes are described. Potential improvements of performances leading towards very high resolution patterning are discussed.

Introduction

The selective metallization of non-conductor substrates is desirable for the industry for decorative applications as well as for electronics.

For the time being, the metallization of non-conductors is processed following the hereunder main stages[1]:

a. deposit of a Pd initiating coat,
b. deposit of a metal coat by Electroless plating,
c. engraving and cleaning, in order to obtain the desired pattern.

This classical method is substractive:

- all the substrate area is covered,
- the engraving and the cleaning are heavy stages and are polluting.

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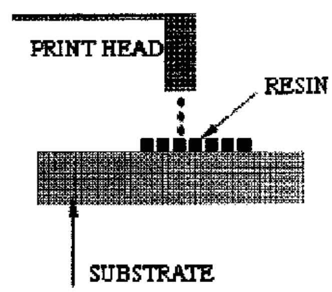
We have created an appropriate method to selectively put down the initiating coat with an ink-jet printing machine from Imaje S.A.

To achieve this objective, we have developed an ink with catalytic properties[2].

So this metallization process (see Figure 1) is additive, the ink being the initiating coat. Moreover, the deposit is selective: the ink is only deposited according to the metal pattern.

1. Resin jet: spraying the resin onto the future track locations



2. Drying and or activation: reduction of the resin.
3. "Electroless": thanks to the catalytic effect of the SENSUL resin, a film of a few microns of metal is deposited.

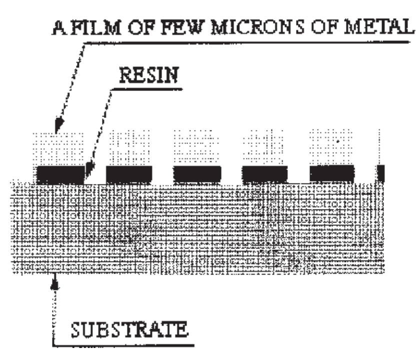


Figure 1.

4. Electrolytic metal deposition: a film of tens of microns thick can be deposited on the electroless coat. The track is now finish.

Following our experience[3], we have prepared the ink abiding by the compoudings as follows :

1. Pd compound,
2. complexing agent,
3. viscosity regulating polymer,
4. solvent.

For obvious mechanical and ecological reasons, water has been the solvent of choice.

Working Principles of the Ink-Jet Printing Machine

The ink is projected under high pressure in a drops gun. This drops gun enclose a piezo electric device (gun) that transmits an acoustic vibration to the ink jet and breaks this jet.

Every second 62.500 drops of the same size are setted. The size is determined by the opening of the gun. Depending on current ink jet printer available impact from 200 microns to 420 microns has been experienced.

However, it is certain that higher resolution would be achieved by the use of drop and demand printhead or by the adaptation of the fluid to very high resolution continuous jet printer, like for example those which are using satellites drops to print on the substrate. With similar fluids impact sizes of 25 microns have been already achieved at TOXOT laboratory.

An electrode, placed around the jet breaking point, transmits a proportional carge to its assigned tension (adjustable to a mock-up machine).

The drops group flows between two deflection plates between which a high potential difference is applied. They are deflected from their initial trajectory proportionally to their charge.

The uncharged and unused drops are recovered and recycled in the ink container (apart from the source container in a laboratory prototype).

The combination of the drops deflection and the perpendicular to this deflection movement of the objects allow for a large diversity of patterns.

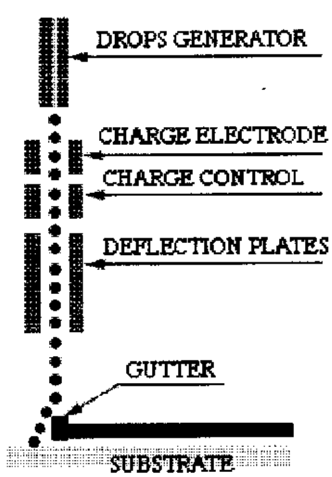


Figure 2.

Our laboratory prototype is equipped with a 35 micron nozzle.

The parameters to be controlled for the ink flow through this head are:

- the jet pressure,
- the drops frequency (width of fonts),
- the tension applied to the piezo,
- the jet breaking point.

The controlled ink has been called "SENSUL PC4C"[2] and its parameters are:

1. jet pressure: 3.7 bars,
2. tension applied to the piezo: from 40 up to 100 V,

Process Validation

We have chosen to valid our SENSUL PC4C selective metallization process on substrates frequently used just as polyimid, "Kapton type HN200" from Dupont, alumine ceramic, PVC and epoxy.

This metallization process is realized as following:

1. First processing of the substrates.
2. Ink disposal in a laboratory prototype based on an ink-jet machine "JAIME 1000" from Imaje S.A.
3. With the help of the assembly schematized in Figure 3 from the drawing program 2D DRAFIX and from the translation program HPGL in IP28 "HP2IP28", we have designed the validation circuit (Figure 4).
4. Drying of the deposited ink in an oven (at 50 up to 250 C) during 60 minutes and rinsing under a demineral water flow.
5. Nickelling of the deposited catalytic Pd throughout an Electroless bath of Ni, Cu and Au from Shippley.

The parameters to be controlled are the following:

1. the table xy moving speed (IP28 microcontrol),
2. the time between each drop pouring from the Imaje JAIME 100 head (drop frequency),
3. the resolution of this technique: width of the tracks and minimum of space between two tracks,
4. the conductivity of the resulted metallic tracks.

The Imaje ink-jet system is an engineering system which allows for moving speeds of several cm/sec. So we have fixed at its maximum the speed of our tables IP28 : 04 cm/sec.

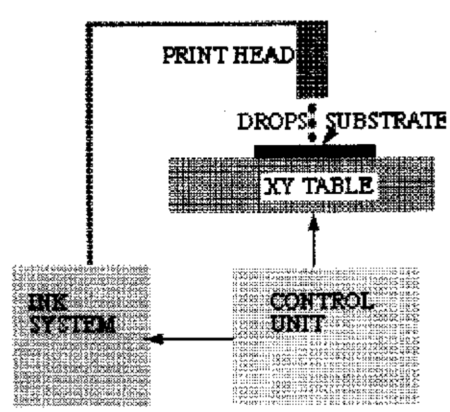


Figure 3.

After enhancing we have got a selective metallization of the different substrates within the following conditions:
1. drops frequency: 1000 up to 5000 µs,
2. tracks minimum width: 300 µm,
3. minimum space between two tracks: 200 µm,
4. resistivity of the Ni tips: 1.02 10-7 *.m.

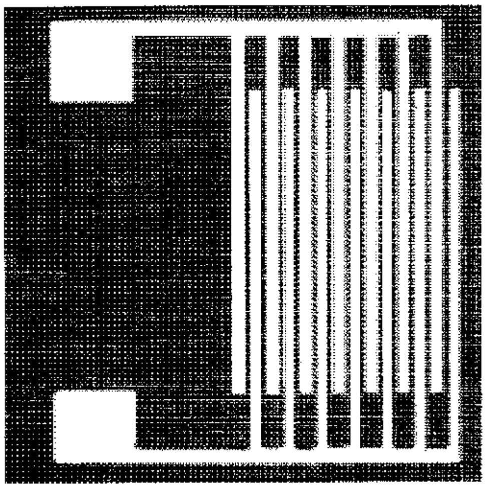


Figure 4.

Conclusions

We have synthesized an ink which can be projected by an ink-jet machine, allowing for a self-catalytic selective metallization.

We have settled an ideal and stable compounding which allows for a metallic self-catalytic deposit of Ni or Cu on polyimid, Al2 O3 ceramic or epoxy.

At the same time we have proved that, with the help of some minor fittings, this ink is compatible with Imaje S.A. serial machines.

During this study we have created a new technology of selective metallization (Electroplastie).

Our process allows for an additive method of deposit of the initiating coat. The deposit is selective: the catalytic ink is dropped only on the areas where tracks will be drawed.

The quality of the results has led to the creation of an association of SENSY and PINEAL to launch the process on the market. A dedicated structure will be created and managed by Jean-Claude MILLET, President of PINEAL and former founder of the ink jet leading company IMAJE SA.

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