Universal Module for Material Jet Application

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Abstract

The piezoelectric ink jet technology becomes the best way to address specific markets in the printing industry like decoration, high quality label, packaging, … .

The technology is now mature and reliable and the inks used in the print head are more and more attractive. A digital ink jet print engine is now able to address the needs of many companies looking for high throughput, low printing cost and mainly flexibility.

Starting from this point, some company coming from complete different world like semi-conductor, electronic, telecommunication are looking for the piezoelectric ink jet technology to use it not for jetting inks, but for jetting specific material like conductive, adhesive or insulation materials.

One of the key of the success is to formulate and to adapt the rheology of these specific chemistry to make them compatible with the print engine.

This paper will describe a complete module based on piezoelectric ink jet technology including different specific feature (like material re-circulation, specific high voltage pulse design, …) to facilitate and improve material jetting.

The universal module for material jet application should help these new generation of piezoelectric ink jet users to be more efficient in the material definition and development. They only have to be concentrated on the chemical formulation dedicated to their need.

IMPIKA thinks that one of the future of the industrial piezoelectric ink jet will be in the electronic field, and a good way to penetrate this market is to provide to this industry a simple, reliable and easy to use jetting module.

Introduction

The Drop On Demand Ink Jet technology is a new technology emerging in the industry since few years mainly for black and white personalization at the end of the manufacturing process. The reliability, flexibility and the throughput of the print engine used in this field are really attractive for companies who need the same basic characteristics : eject small, constant and precise drop of material, not for printing, but to fulfill other functions like conduction or insulation.

At the moment, the electronic industry (designer, chip manufacturer,…) is looking for a new technology able to replace the traditional soldering or wire bonding process to make the electrical connection between the chip pad and other devices.

IMPIKA have adapted and tested its IPS (Impika Printing System) to address the demand of the electronic industry and to check if the DOD inkjet technology will be a part of the future manufacturing process in the micro electronic field.

The chemical family selected to obtain a conductive and jettable material will be a formulation based on metallic nano-particles. Because of the physical particularity of this particles (size, weight, sedimentation, …) this kind of formulation needs an adaptation of the complete ink jet chain.

This article describes all the modifications, adaptations and test made on conductive material and on a standard Ink Jet print engine to use it as a Material Jet engine able to jet a conductive or insulating liquid. This new print engine should not be a lab engine, but a robust and industrial print engine able to reach the reliability and the throughput needed for the application.

Conductive Material Specification

In order to address the needs, the ink should be replaced by a conductive liquid able to be jetted by the print engine. At the moment, there are several ways to obtain a conductive liquid :

-use metallic particle dispersed into a solvent (water, alcohol,…).

-use conductive polymer.

At the moment, the conductive polymer gives the best result to manufacture electrical function like plastic transistor or diode, but the level of conductivity is not enough for the specified applications. So, Impika decides to use nano sized particles of metal (Ag, Gold or Cu) dispersed into an adapted solvent.

To be used in a Drop On Demand piezoelectric print head, the material should have adequate physical properties :

- Compatible size of particle to prevent nozzle clogging and sedimentation inside the different parts of the ink circuit.
- Adapted surface tension and viscosity to have a good rheology
- Good conductivity after the solvent evaporation.
- Good adhesion on several plastic substrates.

IMPIKA has designed in collaboration with a material company a conductive ink based on the following raw material :

Use of comb-shaped block copolymer as protective colloid to avoid sedimentation and
Metal type : Ag
Particle size: 1-50 nm

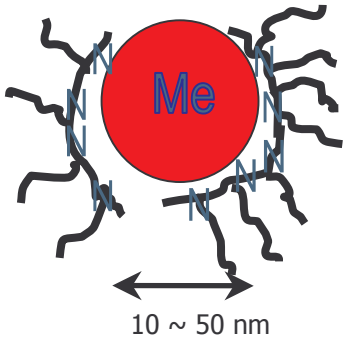


Figure 1. Nano particle use in conductive ink

This kind of paticles are dispersed in solvent like water and alcohol.
The ink characteristics are :
–**Viscosity:** 8-10 cP at 50°C
–**Surface tension:** 23-29 dynes/cm
–**Resistivity:** 0,1 Ω/m

The conductivity is given by connection between particles on the substrate

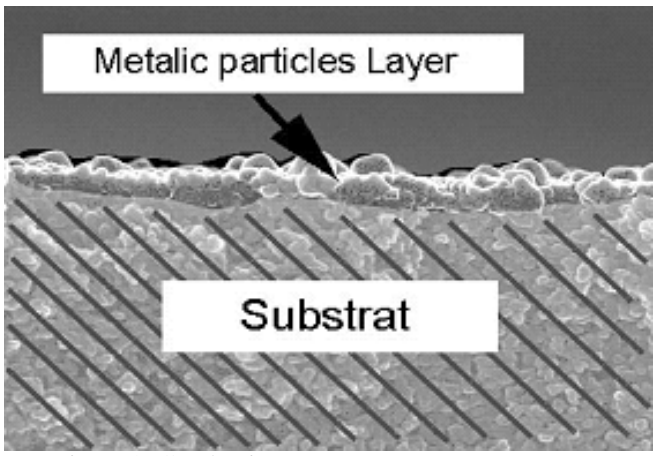


Figure 2. Conductive process

The solvent and the metallic particles should be adapted to the substrate that will receive the conductive material. The test have been made on coated paper with water-based ink and Ag nano particles.

Print Engine Adaptation

The goal is to start with a standard Drop On Demand print Engine and to implement some modifications to be able to jet liquid or material other that standard ink.

The print engine used as the base for the material jet system is the I.P.S. : Impika Printing System : it is a modular piezoelectric ink jet system that can address several ink jet heads. It is presented in the form of a 19" rack including all the environment needed by the piezoelectric inkjet technology:
-printing data management (R.I.P., data serialization, …),
-air vacuum and pressure management,
-ink circuit management : ink level, temperature regulation,
-high voltage pulses generation for piezo activation.

1°) The first adaptation of the print engine was the ink ciruit system :
To avoid any sedimentation of the conductive material, a re-circulation system was designed inside the main reservoir and also inside the print head itself. This system is able to pump the ink from the lower part of the reservoir and print head and to re-fill them by the top, so there is a continuous ink mixing and no sedimentation could occur.

2°) The second adaptation was the high voltage pulse apply to the piezo :
The IPS has a complete programmable high voltage electronic board. This functionality is required to adapt the pulse shape to the material rheology to be able to produce and eject a good drop, even if the liquid properties don't fulfill the print head specifications.

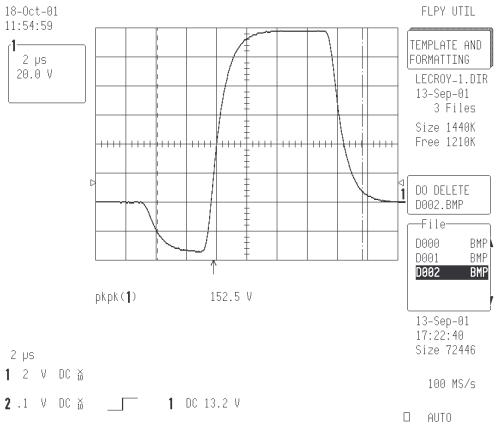


Figure 3. Standard FirePulse

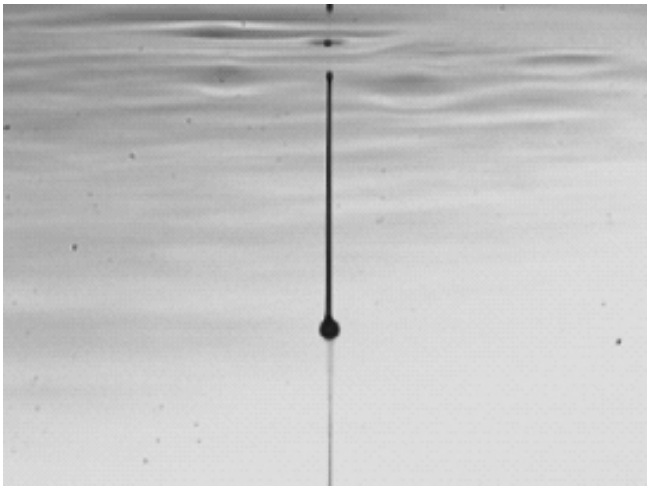


Figure4. : Drop Ejection

The drop ejection could be modified by applying a specific fire pulse shape on the piezoelectric chambers of a D.O.D print head.

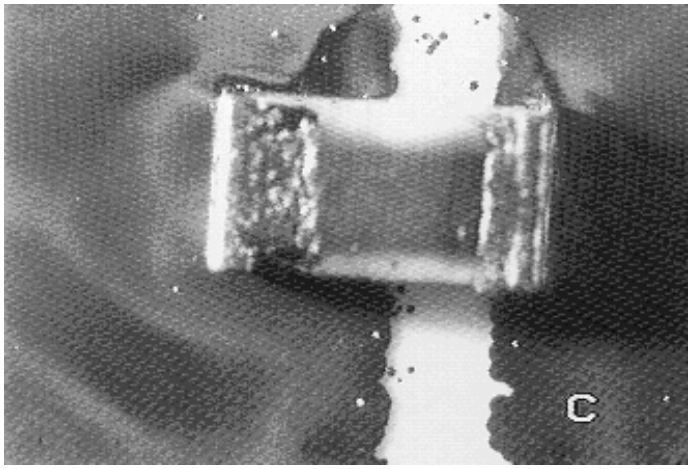
This functionality helps the print engine optimize the form, the volume as well as the speed of material drops ejected, which enables a bigger latitude for adjusting the operating points for different chemical formulation.

Applications

This conductive material and modified print engine have been tested to print several samples in the micro electronic and electronic tag field :

Electronic Industry Sample :

Figure 5.SMD component connected with conductive material jet



This technology is able to address the electronic industry to replace some soldering or wire bonding process to connect the very small component to specific PCB.

Micro Electronic Industry Sample :

Figure 6. Chip Connection

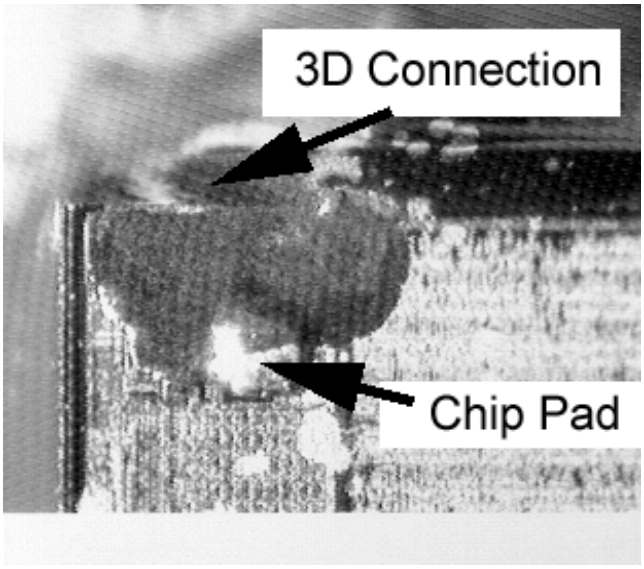
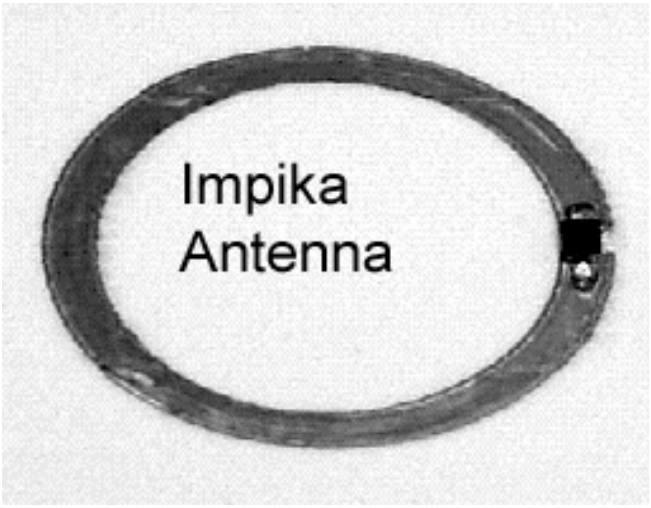


Figure 7. Electronic Tag



The figures 6&7. shows the possibility to connect the pads of a micro chip to an electronic board or an antenna to produce electronic tag with a very low cost at high volume and throughput.

One of the main advantage of this technology is the capability to connect the chip and to print the antenna (using a linear substrate movement at very high speed) AT THE SAME TIME, to print the connection with a 3D shape and the possibility to change the design of the antenna depending on the customer needs.

Conclusion

IMPIKA shows that the piezoelectric inkjet technology is able to jet conductive material on several substrate using an adapted metallic nano particle chemistry. This is possible by using a standard ink jet device including some improvement on the ink circuit and electronic driving circuits.
This capability will open the doors of the micro electronic and tag industry to flexible ink jet system like the IPS and give to the inkjet technology other field than the traditional decorating or printing field.
The material jet joins the printing world and the semi conductor world, this will produce a new generation of equipment and new manufacturing processes (low cost and high volume).

References

1. Morgavi Paul, Modular Ink Jet Print Engine for Industrail Applications, IS&T NIP19, pg 547-551 (2003)

Biography

Philippe SARRA-BOURNET is Technology Manager at IMPIKA company. He is an expert in ink jet technologies used in the industrial world. He was previously involved during 10 years in the Gemplus R&D team to develop printing technologies for plastic smart card industry. His background covers technologies such as Laser, Dye Diffusion and Ink Jet.