Inkjet Printing in the Electronics Industry

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Abstract

In the electronics industry different printing technologies are used for finishing, decoration,coding, and labeling of products and components.

The applied printing technology depends on the product to be printed, the requirements the printings have to fulfil, and the quality of the prints (labeling, coding, decoration, or finishing). In this presentation an overview will be given of the requirements and the methods for the different applications.

Ink jet printing is applied on different materials, which varie between paper/card board and high temperature resistant materials like printed circuit boards (PCB), metal, glass, and ceramics.

The presentation will pay most attention on printing on heat resistant materials and the requirements the printed materials has to fulfil.

The techniques used can be divided in impact printing and non-impact printing technologies. Applied impact technologies are pad printing, screen printing, hot foil stamping, off-set printing, and flexography. For non-impact printing technologies ink jet printing, laser engraving,and laser marking are applied.

In the praxis also combinations of different technologies are common.

Printing is not only executed on flat products but also on curved products. This implements that this has influence on the choice of the printing technology.

Non-impact, software driven, printing technologies have the possibility to print unique information onto each single product, substrate, or component.

Ink jet printing and laser engraving are today the only technologies which can fulfil this requirement.

Both technologies have their own specific advantages and disadvantages compared to the impact printing technologies.

This presentation will give a review of the use of the different printing technologies in the electronic industry with the emphasis on ink jet printing.

Introduction

The exterior, i.e. the visual appearance, of a consumer product is determined in its entirety by the following six terms:

- material (or basic material coating)
- shape
- texture
- graphics
- colour
- gloss

Material

In this presentation, we limit ourselves to the materials plastic, metal, ceramic, glass, paper, and thermosets.

Shape

The shape is determined in teamwork between the industrial and mechanical designers. When determining the shape, account must be taken of the later applied techniques such as decoration, finishing and labelling. For example, screenprinting can only be applied to reasonably flat surfaces and hot foil stamping cannot be applied to sharp corners.

Texture

The texture (coarse, fine, ribs etc.) of a plastic product is not only visually, but also tactually important especially with “hand-held” products.

Graphics

By graphics, we mean the technical information on the rear of the product, the functional information on the front, and also the more decorative items such as logos and accentuating lines, etc.

Colour

Certainly not the least important is the colour (or colours) of a product. This/these can be chosen by means of coloured plastic or metal, and also by painting the product or printing with foil.

With this overview, we would like to make it clear that decoration, finishing and labelling are an integral part of the industrial and mechanical design process.

The chosen decoration, finishing or labelling techniques give limitations, but also possibilities. In the following chapters, we discuss the most important techniques that can be involved;

- Laser decoration
- Lacquering
- Inkjet printing
- Screenprinting
- Pad-printing
- Hot foil stamping
- In-mould decoration
- Texturing
- Metallisation

Besides this, attention will also be paid to:
- test methods
- pre- and post-treatments for surfaces

Printing Technologies

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The applied printing technology depends on the product to be printed, the requirements the prints have to fulfil, and the quality of the prints (labelling, coding, decoration or finishing).

In *table 1* a review of the different printing technologies is given.

Table 1. Strengths and Weaknesses of Different Printing Technologies

	Colours	Resolution	Software driven	2D/3D	Yield
Pad Printing	+	+	-	3	0
Hot foil stamping	+	+	-	2	0
Screen Printing	+	+	-	2	0
Laser Engraving	0	+	+	2/3	+
Ink jet Printing	0	-	+	2/3	0
Off-set Printing	+	+	-	2	0

(+ is good, 0 is average, and – is bad).

In the presentation an overview will be given of the requirements and the test methods for the different applications.

Inkjet printing is applied on different materials, which varie between paper/card board and high tempetrature materials like printed cicuit board materials (PCB), metal, glass and ceramics.

In praxis also combinations of different printing technologies are common.

Test Methods

For the different applications, the requirements the printed layers has to fulfil can differ very much. The requirements for a printed layer on a capacitor differs very much from an automotive lamp. So for the different applications different tests have to be carried out.

Test methods can be divided in mechanical, chemical, physical, decorative, and climatic tests.

Mechanical Properties
- micro indentation hardness
- conical mandrel test
- falling nuts test
- falling ball impact test
- Mar resistance test
- abrasion resistance test

Physical Properties:
- layer thickness
- adhesion test

Decorative Properties:
- colour
- gloss
- texture

Chemical Properties:
- artificial perspiration test
- alcohol resistance test
- spirit resistance test
- water resistance test
- MEK resistance test
- 'lotion' resistance test

Climatic Properties:
- light fastness test
- salt spray test
- water resistance test
- humid air test
- outdoor exposure test: town and sea
- cold sensitivity test
- heat sensitivity test
- cyclic temperature test
- cyclic humidity test

Depending on the product a selection of above-mentioned tests has to be carried out.

Post-, and Pre-Printing Treatment Methods

As a result of the requirements the printed layers have to fulfil (f.e. adhesion, abrasion resistance, etc.), the substrate to print on has to be pre-treated or after printing the layer has to be post-treated.

Pre-Treatment Methods
- cleaning from dust, oil, fingerprints, etc. by wiping with a cloth wether or not wetted with water or a solvent
- physical and chemical surface modification methods, like corona, plasma, UV-ozone, chemical oxidation, etc. for the introduction of active sites on the surface of the substrate in order to improve the adhesion of the ink
- mechanical methods, like polishing, blasting, etc. for cleaning and adhesion improvement by increasing the surface area (mechanical interlocking)

In *table 2* the influence of different surface pre-treatment methods on the dot-diameter is given.

Post-Printing Treatments

These methods are mainly used to improve the properties of the printed layers: UV-light exposure for polymerisation, and heat-treatments, like (hot) air, infra-red radiation for drying and/or stoving/enameling of the printed layers.

Ink Jet Printing

Ink jet printing is a non-impact printing technique and can be divided into two primary areas, continuous ink jet and impulse ink jet, which is also referred as drop on demand. Under continuous ink jet are the raster, binary, and hertz types. Impulse ink jet comprises electrostatic, piezoelectric, and thermal types.

Non-impact means that there exists no physical contact of the printhead and the substrate during the printing process. This in contradiction to the impact printing technologies, like screen-printing, pad printing, flexography, off-set, etc..

Printing technologies based on the use of laser light, like laser engraving, laser marking, and laser decoration are also non-impact printing technologies.

The advantages of the non-impact printing technologies are their software-driven generation of effects (droplets or heat pulses) for the creation of the wished printings onto each single product, substrate, or component, which implements that each product will have its own and unique information (texts, codes, graphics, etc.).

For the so-called impact printing technologies non-flexible printing adaptors, like screens, clichés, etc. are necessary which means that these technologies are not flexible. The application of ink jet printing in the electronics industry can vary very much, since the requirements can be so different. The application of ink jet ink on packaging cartons for TL-tubes or light bulbs differs completely from the application of inks on the lamps itself or on a plastic part of a flat-iron.

As a result of printing on different materials the print quality can differ too.

The quality depends on the surface tension of both the ink and the substrate. It also depends whether the surface is absorbent or not.

Due to the application the requirements for mechanical, physical, and chemical resistance can differ exceptionally. This implicates that different applications ask for different inks.

For the application of barcodes, dotcodes, etc. eventually firstly a basecoat must be applied before the application of the codes itself, since not only the width of the bars/dots is important but also the space between the bars/dots. It also improves the contrast and as a result the read-out.

In *table 2* the influence of the substrate material and some surface treatment methods on the dot diameter is given.

Applications For Ink Jet Are:

- light bulbs
- low energy lamps
- automotive lamps
- TV tubes
- packaging for TL-tubes
- flat-irons
- cartons for light bulbs
- resistors
- capacitors
- diodes, etc., etc..

Table 2. Influence of substrate material and substrate pretreatment on the dot-diameter (μ-meter).

Material	No Pre-treatment	UV-ozone treated	Plasma treated
PP	227	375	365
ABS	366	461	411
Acrylic paint	502	548	606
PMMA	424	451	502
Aluminium	230	478	425
Glass	348	372	381
PC	396	460	459
PS	373	459	429
SAN	422	568	493

At this moment most of above-mentioned applications are done with continuous ink jet printing.

This ink jet technology will never reach the quality that is asked for decoration/finishing of products. It will be used only for coding and labeling of products in this industry.

Since the development in the area of impulse printing is going on very fast, especially in the piezo technology, it is expected that in the future this ink jet technology will become important in other areas in the electronic industry as replacement for impact printing technologies like screen printing, off-set printing, flexography, etc., as a result of the development of ink jet heads which can generate smaller droplets. With these new heads it is expected that also on non-absorbing materials, like metal, plastic, glass, and ceramic, decorative patterns can printed.

Also printing of functional layers, used in electronical devices will become an interesting appplication area for this impulse ink jet technology.

Conclusion

Ink jet printing in the electronic industry needs a lot of understanding of the process and the used materials, since it is used for many different applications.

In the future the ink jet technology will not only be used for coding and labeling, but also for the the application of functional layers as possible replacement for impact printing technologies, like screen printing, flexography, etc. since ink jet printing is a software-driven and non-impact printing technology.

References

1. Peter E.J. Legierse, Properties of ink jet printing inks compared to pad-printed and screen-printed layers used in the electronic industry, Second Annual European Ink Jet Printing Workshop, 1994, Maastricht, The Netherlands.
2. Peter E.J. Legierse, Adhesion improvement of ink on polymers by laser activation, First International Congress on Adhesion Science & Technology, 1995, Amsterdam, The Netherlands.
3. Peter E.J. Legierse, Ink jet printing in the electronics industry, 18th International Ink Jet Printing Conference, 1995, Berlin, Germany.

4. Peter E.J. Legierse, Ink jet printing in the electronics industry, 4th Annual European Ink Jet Printing Workshop, 1996, Amsterdam, The Netherlands.

Biography

Peter E.J. Legierse is currently working within the Coating and Printing group at Philips-Centre for Industrial Technology in Eindhoven, The Netherlands. Since joining Philips, in 1966, he has held a number of positions including manager for the process technology of optical disc mastering and project manager for decorative technologies. He has also worked in the development for the replication of optical discs such as Compact Disc and Laser Vision and he has experience on photo chemical milling and electrochemistry. He is/was involved in several European projects, sponsored by the EC, as the (overall)project leader. He was also an evaluator of Brite Euram project for the EC in Brussels, Belgium.

Peter E.J. Legierse is the (co-)holder of ca. 20 patents, (co-)author of over 20 papers on optical disc mastering, electroforming, and replication, and photo chemical milling and speaker on many conferences, including ink jet conferences. He is a fellow of the Institute of Metal Finishing (UK) and he is the author of the book Decoration of Packaging (1999).