

TonerJet® Tandem Color has Reached Prototype Stage

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Abstract

The TonerJet® print technology is invented and developed by Array Printers AB in Sweden. During the last years, the TonerJet® print process have taken some big steps forward in color printing.

A focus on toner development at the TonerJet® Center in Yokohama, Japan, has been fruitful. The speed and performance of the print process have improved when implementing a chemical toner. The spherical shaped particles enables higher density and edge sharpness at higher print speed (10-20ppm). This is a result of the increased release properties at higher toner charge.

TonerJet® is a direct print process that easily achieves extremely good and stable color registration at low manufacturing cost. The dot registration can be controlled by a feedback loop that measures the print media position.

Pulse width modulation enables true gray scale printing down to few particles per dot. This in combination with the dot deflection control technology gives high image print quality.

TonerJet® is now the print technology that combines color printing at a high speed, good print quality and a low manufacturing cost.

Introduction

TonerJet is a direct print process[1] where the image is formed directly on to the print media e.g. paper or belt. The print media passes at single pass[2] four print heads, one for each color, mounted in fix positions. Each print head covers the full width of the print media.

The adressability is usually 600 dpi and the printhead prints dots in a print sequence that is repeted in correlation with the print media movement. This gives a horizontal adressability (parallell to the print head) that depends on the print head, and a vertical adressablity that depends on the print media movement and the interwall between the print sequences. The print media is paper or an intermediate image transfer belt. Figure 1 shows a printer model with four print heads, one for each color, using a transfer belt as print media.

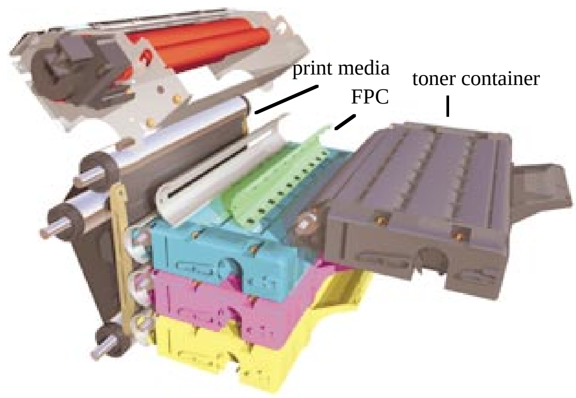

Figure 1. TonerJet® printer with four printheads, CMYK, using a transfer belt as print media.

How does the TonerJet® print head adress toner to the print media? The toner particles (negative charged) are attracted to the print media by electrostatic forces created by a potential difference between a toner supply sleeve and a back electrode. The back electrode is located behind the print media and has a higher potential than the toner supply sleeve. The potential difference creates an E-field that transfers the toner particles from the toner sleeve to the print media. The FPC (Flexible Printed Circuit) is mounted in this E-field. The FPC has an array of small apertures.

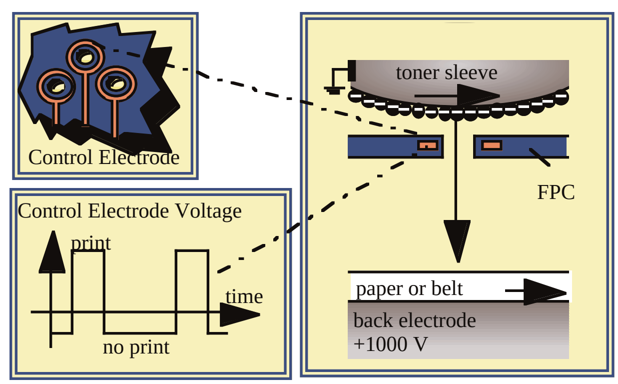

Figure 2. The control electrode in the Flexible Printed Circuit, FPC, controls the toner transfer through the aperture.

The toner can pass through these apertures and form dots on the print media. The apertures are surrounded, or partly surrounded, by control electrodes and the toner transfer to the print media is then controlled by the potential of the control electrodes. It is thus the control electrode potential that decides if the toner particle will remain on the sleeve or pass through the aperture and form a dot. Figure 3 shows the array of control electrodes in the FPC, and figure 2 shows how the control electrode potential is pulsed to a print voltage that allows toner transport to the print media.

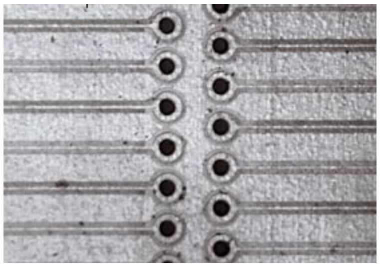

Figure 3. Top view of the FPC and its two rows of apertures. Control electrodes surround each aperture.

Dot Deflection Control

The array of apertures in the FPC forms dots. Due to the dot deflection control (DDC) technology[3], one aperture can adress more than one horizontal (parallell to the print head) dot position. Two deflection electrodes partly surround the aperture and create an assymetry in the E-field. The trajectory of the toner particles is then easy controlled by the applied voltage difference between the two DDC electrodes, see figure 4:

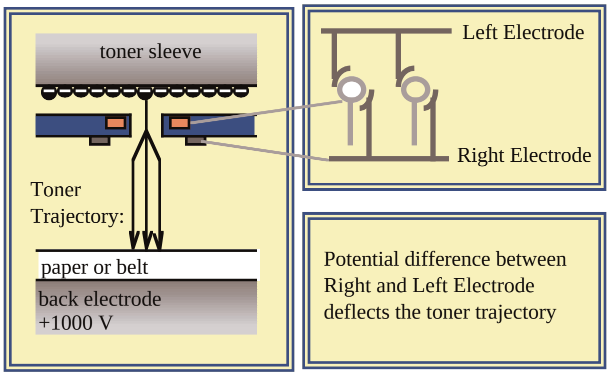

Figure 4. Dot Deflection Control (DDC) increases the dot adressability.

The advantage with the DDC printhead is that the number of apertures is less than the number of adressable horizontal dot positions. For example, if we print with 600 dpi dot resolution, and each aperture adresses three horizontal dotpositions, the aperture lay-out in the FPC will be 600/3=200 api (apertures per inch). A reduced api is advantagous for a number of reasons:

1. A print zone with fewer aperture rows has toner supply advantages.
2. Less apertures requires fewer IC:s.
3. The FPC is easier to manufacture

DDC also enables the software to control the horizontal dot resolution.

Spacer Technology

The most critical distance in TonerJet® is the distance between the toner sleeve and the control electrode in the FPC. The E-field near the sleeve surface decides if the toner will remain on the sleeve or pass through the aperture, i.e. the E-field in this area decides the amount of toner that will release from the toner sleeve and form a dot and thus the optic density of the printed dots. It is therefore important to keep the distance between the control electrode and the toner sleeve constant to avoid inadvertant optic density variations in the print samples.

A solution to keep the distance constant is to apply a layer of insulation material with a certain thickness to the control electrode to form a spacer. The toner layer is then put in contact with the surface and the distance is thus kept constant. The surface of the insulated material is coated with a special material preventing wear, charge up and toner filming.

Before implementing the spacer technology, one problem in TonerJet® has been the demand for high accuracy toner sleeves. If the toner sleeve axis was not centered, it gave an optical density banding in the print sample. Since implementing the spacer technology, this optical banding problem has disappeared and it also allows the use of less accurate sleeves, thus lowering manufacturing cost.

An example of a spacer is the “trench” type spacer where the downstream trench enables contact, without toner inadvertantly being leaking through the aperture, see figure 5.

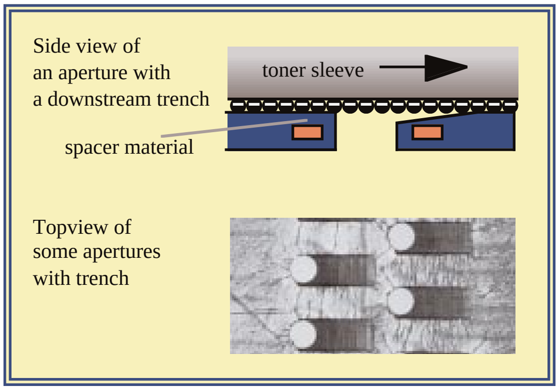

Figure 5. One example of a spacer lay out.

Toner Release and Print Performance

The toner transfer from toner sleeve to print media has to be fast and uniform to obtain 10-20 ppm output speed. If the toner releases easily from the sleeve, the toner particles will start to accelerate almost directly and obtain a high speed when passing through the aperture and further towards the print media. With good release properties, all the adjacent toner particles will release simultaneously from the sleeve surface and the jet of toner particles will be kept together. This gives a short jet of toner which, together with higher toner charge, is needed when printing at 10-20 ppm, see figure 6.

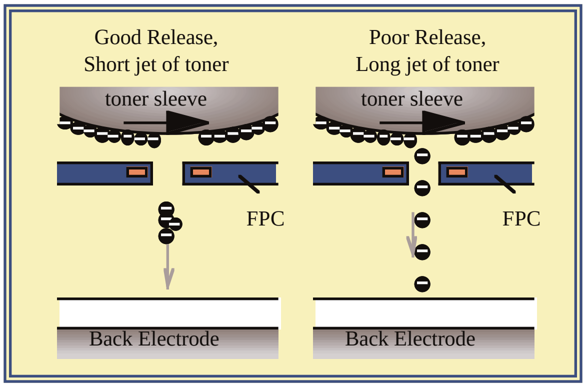

Figure 6. The release properties decide the shape of the toner jet.

When using a toner with poor release properties, the jet of toner particles tend to spread out between sleeve and print media, resulting in speed limitations for DDC.

Array has established a laboratory in Yokohama, Japan, to optimize the toner properties for TonerJet® . The speed and performance of the print process have improved when implementing a chemical toner. The chemical toner has spherical particles with smooth shape and a very uniform charge distribution on the toner particle surface. The image force towards the sleeve is therefore reduced and this gives better release properties than conventional crushed toner at higher charge. Figure 7 shows a picture of some chemical toner particles.

Figure 7. Chemical toner.

The chemical process also enables a narrow size distribution of the toner, which is good for uniform acceleration of the toner particles and thus a short toner jet. This chemical toner has increased the speed performance of TonerJet® up to 90 mm/s when printing at DDC with 3 dots per aperture. The dot sharpness and dot uniformity is very good. Figure 8 shows some dots printed with chemical toner. Two circles is added in the figure to measure the dot size. The diameters of the circles are 80 µm and 100 µm.

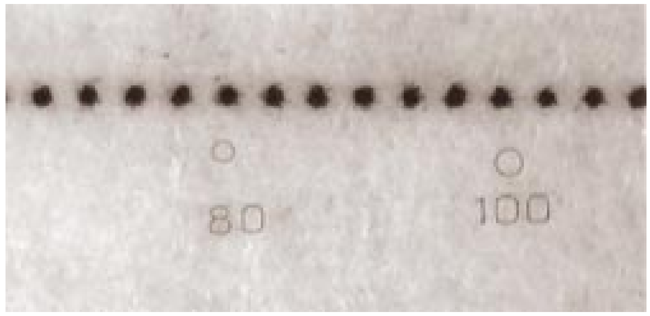

Figure 8. Dots printed with chemical toner. The two circles have diameters of 80 µm and 100 µm.

Grey Levels

Grey levels are created by controlling the amount of toner in each dot. One dot is made in a print sequence, where the control electrode is pulsed to a print voltage during a short time, the pulse-width, see figure 9.

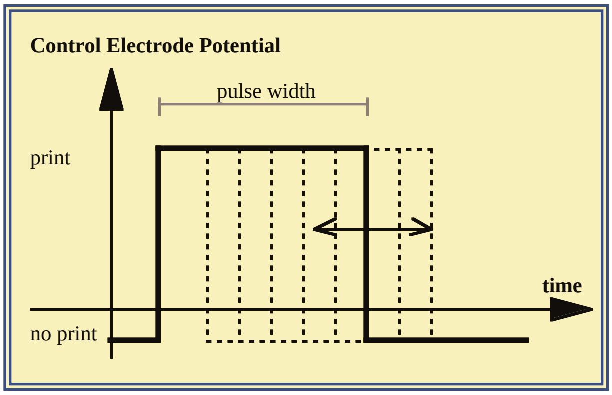

Figure 9. A print pulse and its pulse-width.

The software controls the pulse width for each dot. A short pulse-width releases few particles from the toner sleeve and gives a light grey dot. A long pulse-width releases all toner from the toner sleeve above the aperture, and gives a solid black dot. The software can therefore create true grey scale printing down to a few particles per dot.

Registration

The print heads are in fixed positions and the print media is the only moving part that needs registration control. The print media position can give direct feed back to the timing of the print sequences, enabling extremely good and stable registration at very low cost.

Cleaning

When charging the toner particles in a toner system, a small amount of particles will get an opposite charge than expected. These wrong polarity toner particles will follow the jet of toner through the aperture and some of them will end up on the FPC after the print sequence, see figure 10.

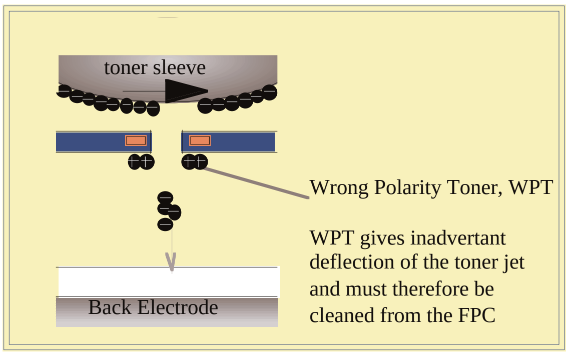

Figure 10. Wrong polarity toner on the FPC surface necessitates a cleaning cycle.

If the FPC has charged toner particles in the vicinity of the aperture, these particles will interfere with the E-field and deflect the toner trajectories. The toner on the FPC must therefore be removed in a cleaning sequence. When using non magnetic toner, the tonerparticles can be affected by electric and mechanical forces. Because of the low charge level of the particles on the FPC, it is difficult to use only electric forces to clean the FPC. A slight air flow has proven to be a good complement when removing the particles from the FPC.

Commercial usage

The market for low cost color printers that print faster than 10 ppm is huge. TonerJet® is a technology that can meet this market demand.

During the last 12 months, toner development and spacer technology has vastly improved the print performance and speed of TonerJet. A four color engineering model, called Chroma EM, was showed at CeBit in March -98. This engineering model prints in four colors at a process speed of 65 mm/s at 600 dpi, which enables an output speed of about 20 A4 pages per minute if printed in landscape position. Because Chroma EM is an A4 printer and has an unoptimized cleaning cycle, the current output is 10 pages per minute. The DDC adresses three dotpositions each print sequence and color registration is ±30 µm. Figure 11 shows a picture of the Chroma EM engineering model.

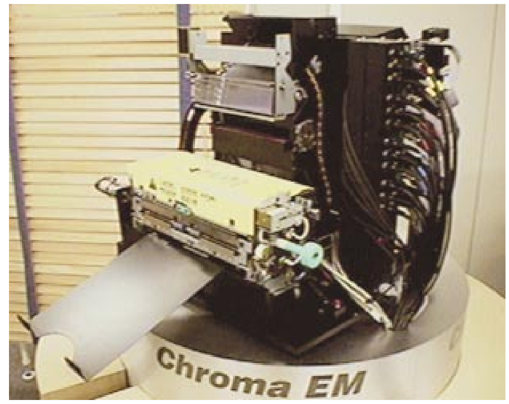

Figure 11. The Chroma EM engineering model showed at CeBit -98.

TonerJet® has during the last 12 months taken some big steps forward in color printing and it has now reached a prototype stage.

References

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Biography

Agneta Sandberg has received her M.S. in Engineering Physics from Chalmers University of Technology in Göteborg, Sweden. Ms Sandberg joined Array Printers 1993, working with the development of the TonerJet print process. In 1996-97, she was located in Japan working with R&D cooperations between Array and Japanese companies. She is now group leader of the TonerJet development at Array in Göteborg, Sweden.