High Resolution Thermal Transfer Technology (Micro Dry™ Technology)

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At First

600 dpi serial thermal transfer printing using Micro Dry™ technology was released last year. This new method completely changes the image of the previous thermal transfer printing. We received a lot of praise, requests and opinions about print quality from people in the professional printing industry. It seems that Micro Dry™ technology was paid attention to the point that it was developed to represent print quality which is close to that of offset printing in a rapid spread of color inkjet printers.

Thermal transfer printing method has been active as a practical color printing method since 1985 which was the dawn of the color printer and the time it was released in the market. This method has been widely used mainly for CAD/CAM outputs and the field of color presentations.

Recently, color printing by inkjet method and toner method have progressed rapidly. The commercialization of inkjet method has advanced in the low cost field, and that of toner method has advanced in the field of high-speed printing on plain paper. Because of these rival technologies, the application of the thermal transfer printing has been confined to a specific field.

In spite of this general trend, half tone printing characteristic of thermal transfer printing has been remarkably improved by using paper with porous layer. On one hand color printing quality on plain paper was remarkably improved by using 600 dpi head. On the other hand, dye sublimation printing which can vary density gradation boasts it's superiority in gradation and reproduction to inkjet method or toner method. It has steadily secured the market which requires high quality printing. Recently, dye sublimation printing has been introduced to passports' and driving licenses' application.

Also, TA method, announced by Fuji Photo Film Co., Ltd. in 1994, showed possibility of density gradation and put color direct thermal printing into practical use. It seems that this technology has the potential to present new possibility to thermal color printing technology.

I believe that 600 dpi serial thermal transfer printing method that we developed eradicate issues of thermal transfer printing including running cost and has the potential to achieve print quality close to offset printing. MD-2000, which I will introduce here, is a serial high precision color thermal printer based on Micro Dry™ technology, and I will present the Micro Dry™ technology.

High Precision Full Color Printer, MD-2000

MD-2000 in the Figure 1 and Figure 2 can execute 600 dpi printing resolution, not only dot pitch but also dot size by using the 600 dpi head with 240 dots and using dry ink which might not be blurred on paper. This machine was developed to print crisp characters and full color printing on plain paper. Even it's high performance, the price of this machine is still kept low. It provides color printing of true 600 dpi resolution and monochrome printing of 600x1200 dpi resolution on not only dedicated paper but also wide range of paper such as copy paper, postcard, recycled paper and transparency.

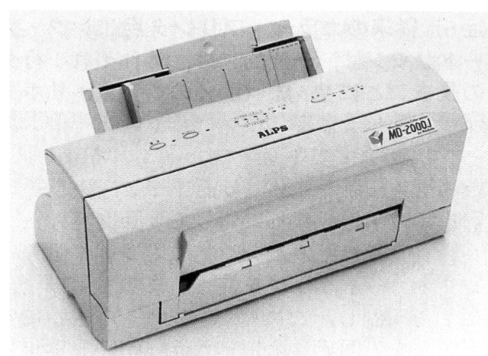

Figure 1: MD-2000, Appearance

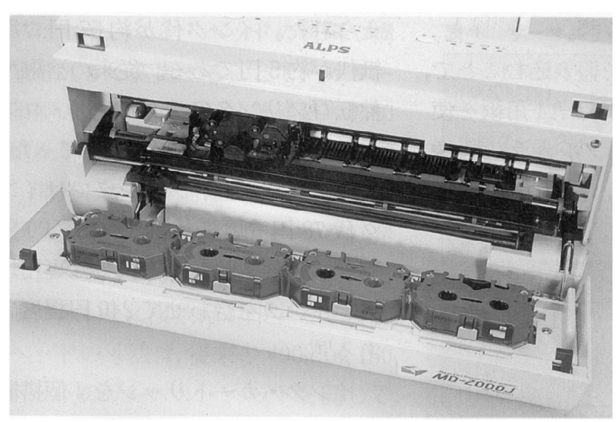

Figure 2: MD-*2000, Inside*

Metallic printing is also available by using special ink composed of metallic foil covered with pigments.

This machine consists of the following basic devices:

1. Micro Dry Ink (Figure 4)
2. Micro DOS Head (Figure 3)
3. Micro Energy Controller

And this machine achieves the following performance which we have pursued:

- Clear black
- Crisp and true 600 dpi character printing (Fig. 5)
- Near-photo realistic color printing (Figure 6)
- Printable on any media
- Excellent water-proof/light-resistance (Figure 7)

Micro DOS Head

The thermal head used in this machine achieves many demands, which are assumed to be indispensable for executing high precision printing such as high-speed thermal response, high cooling efficiency, high thermal endurance, low deviation of resistance value and so on by greatly changing conventional material and the structure. The developed head is serial type and its resolution is 600 dpi. This is what is called a multiline head having 240 dots of heating elements. These elements are arranged in a straight line with a pitch of approximately 40µm that allows multiline printing at a time. The dimension of the head substrate forming the heating element is 18mm X 8.5mm X 0.8mm. The terminals are arranged with a pitch of 70µm in order to arrange them for 240 heating elements in the width of 18mm. This head is connected to the film carrier mounted with a head driver by soldering. Monocrystal silicon is used for head substrate.

Glazed layer is low density columnar structure of SiO_2, approximately 20µm thickness. There are pores, which diameter ranges from a few µm to tens of µm, on the surface of conventional glazed alumina substrates. These pores will be the cause for short circuits and disconnection's and make the interconnections in terms of 600 dpi difficult.

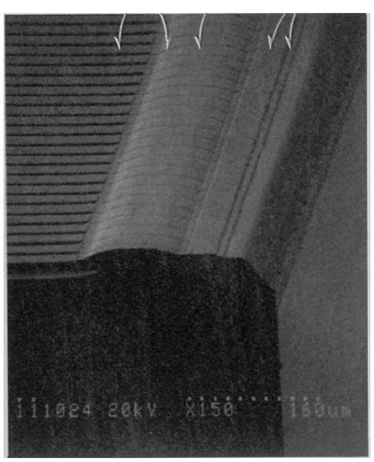

Figure 3: New thermal head appearance

Also, because the thermal diffusion rate of alumna substrate is low, we have had a problem with the heat accumulation in the substrate when we drive the thermal head at high speed and high duty. This will result in the difficulty of thermal control. However, we have solved this problem by using monocrystal silicon substrate as a head substrate.

It is known that ink transfer characteristic (releasing characteristic of ink ribbon) is easily affected by head edge distance which is from head heating element to the edge. However, the Micro DOS head can control tolerance approximately down to 5µm for edge distance of approximately 100µm by using precise processing characteristic of silicon monocrystal.

Use of silicon monocrystal as a substrate and sputtering of porous SiO_2 enabled projecting structure of the heating element, optimized thermal retaining property, optimized cooling efficiency and optimized ink transfer characteristics.

Micro Dry Ink

The ink used for the Micro Dry^{TM} technology uses the same pigments as that of offset printing in order to obtain extremely close printing quality to offset printing. And we aim at ink thickness of 1µm or less which is also close to that of offset printing. Dot reproduction of 600 dpi is required in order to achieve high quality character and image printing and high efficient thermal conductivity is required for that.

Ink ribbon thickness was thinned to half of conventional ink ribbon by improving ink the dispersion of high viscosity ink material and ink coating technology. The base film for the ink ribbon is 2.5µm thick polyester. When thermal response of ink ribbon becomes sharp, defects caused by thermal control error tend to be magnified. In the Micro Dry^{TM} technology, the Micro DOS head and the Micro energy controller execute thermal control to suppress these defects. Thermal efficiency was improved by approximately 15% compared with the case using 3.5µm material.

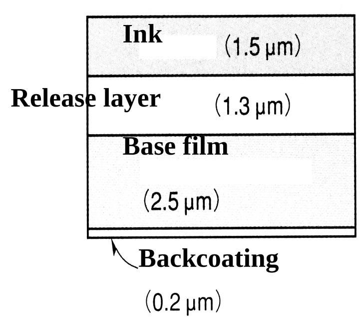

Figure 4: Cross-section of the new ink ribbon

When heated ink is pressurized or cooled, the ink is fixed firmly on the surface of the paper. Ink release and transfer characteristic is greatly affected by cooling temperature. This cooling temperature is concerned with the above-mentioned head edge distance. There is an optimum value in the edge distance, and it is set at approximately 100µm in the Micro Dry™ technology.

Micro Energy Controller

In order to achieve ideal ink transfer, precise head thermal control suited for the above-mentioned head is required. The Micro DOS head cannot attain sufficient performance without thermal correction. If there is approximately 3% of error in printing density, it is recognized as density deviation by naked eyes. Therefore, density error must be corrected.

The heat accumulation of the head depends upon number of heated dots and printing interval. In the Micro Dry™ technology, a thermistor detects temperature nearby the head and the controller corrects energizing pulse width in accordance with its temperature and according to head on/off history of approximately 150 dots which are located near each heated dot.

The energizing pulse width for 240 dots is calculated by this controller within 1 cycle (energizing cycle for heating element), 167µs. Dispersion of heating temperature has been reduced to less than 3% from approximately 10% by using this correction circuit.

Micro Dry Inkjet Toner

Figure 5: Enlarged picture

Laser paper *Copy paper*

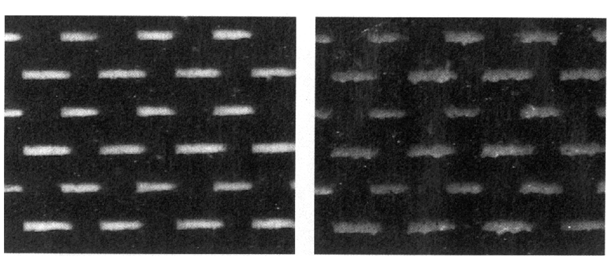

Figure 6: High-duty printing enlarged picture

Before After being left in the sun for one month

Figure 7: Micro Dry™ printing, light-resistance

Conclusion

The possibility to achieve printing quality close to offset printing was obtained by using dry ink, 600 dpi head, and precise thermal control.
That is:

- Printable on the same paper
- Almost the same pigment
- Almost the same weather resistance
- Half-tone image forming method which is close to offset printing
- Clear character printing

At present, image is formed by binary pattern. I think that true offset printing quality will be achieved when gradation of dot diameter is achieved.

The print quality of MDP is very close to that of offset printing. I think that in near future, MDP will achieve the comparable print quality of offset printing along with the advances of relevant technologies.

References

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2. Y. Tokunaga, R. Takano, *J. Appl. Photographic Engineering*, **7**, 1, 10, 1981.