New erase head for kanban card size thermal rewritable media

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Abstract

The benefits of thermal rewritable technology can be seen in working for traditional conservation situations – the idea of saving trees, reducing CO_2 gas emission and cutting down waste material and reducing the print material cost over time. They can also be found on more application specific situations such as a data security conscious world -- since the print media is reused, there is no need for the internal information leaking out and documentation shredding is not required.

Advantages of thermal rewritable printing over conventional printing can be fully exploited in a closed system environment like commercial or industrial applications where the rewritable media can be recovered at the end of processes. Physical distribution within manufacturing cycle such as parts supply of assembly plant, for example, will be an ideal situation to take advantage of this technology in order to increase productivity and efficiency.

Highly publicized and successful application is an adaptation of rewritable technology in "just-in-time" *kanban* system. In order to meet the demand of better erasing device, the new erase head which is one of the key components for the technology was developed. The HDA-2310 has erase width of 210 mm which will accommodate the kanban card size and erase speed of 100 mm/sec which is on par with the high speed thermal printhead used for rewritable application.

Introduction

The society in general is getting more conscientious about ecology, global warming, saving energy & natural resources and reducing waste in recent years.

In the US personal and business world, there is a tremendous concern about leakage and misuse of individual's or corporation's information/data. A lot of document and data-storage media shredding equipment is available on the market and shredding business is thriving.

With this climate, the idea of recycle or reuse of print media has been revisited. Although there have been some success in other technologies such as removal of toner from the printed media with electro-photographic process, they are still an experimental level. Only commercially viable technology is thermal at this time.

Thermal rewritable technology is around over a decade and it has been used primarily for card applications such as the loyalty cards, hotel door access key cards and transportation related cards.

The newer usage applications emerged in larger-than credit-card size formats in recent years. The sizes (widths) vary based on the applications from 4 inches to 8.5 inches, in comparison to the card size of 2 inches.

Typically, those new applications are for the industrial / commercial usages and not for consumer purposes. Recovering or retrieving the rewritable media is very difficult for the consumer product environment whereas it is easier to do so in manufacturing or warehousing routine since those are operating in the "controlled" environment.

The newer usage of thermal rewritable technology is working very well with RFID applications also. One of the drawbacks of RFID is the high cost of media such as tags/labels which are printed. When the media can be rewritten and reused over several hundred times, the cost issue disappears. Although the topic of rewritable RFID tag is a separate category and it is not discussed further in this paper, such applications as Kanban cards or in-house production traveler sheets with RFID capability are becoming popular in Japan. If thermal rewritable technology is used in conjunction of RFID to print the electronic data of the IC content, it can be used for data verification.

Thermal writable technology, if used in a proper environment, can prevent the information/data leakage and promote re-use/recycle -- champion of eco-friendly operations.

Thermal Rewritable Technology Information

From a printing point of view, thermal rewritable technology is similar to direct thermal printing where the media which contains chemical is heated with the printhead and a permanent image forms. The difference is the thermal rewritable media. It is made with a different type of material and it forms an image when heated, but the image goes away when it is reheated with different heating profile. Print/erase cycles can be repeated several hundred times.

From a function point of view, the major difference between the regular direct thermal printer and rewritable printer is the erasing process. There are various ways to erase the rewritable media. They can be separate devices such as hot roller and thermal erase head. Printhead itself can be used to erase the image on the media. There are several key attribute criteria to determine the best way to erase for a given situation:

- "Erasablity" -- How well can the device erase the media?
- Erasing on demand – Does the device require "warm-up" time before erasing?
- Selective area erasing – Can the device erase part of the media selectively?
- Durability – How durable is the device over usage?
- Responsiveness – How well does the device respond to the temperature control?
- Safety – How safe is the device if someone touches even if it is not operating?
- Energy saving – Is the device capable of using the energy mainly for erasing without heating the surroundings?
- Erasing speed – How fast can the device run the erasing process?
- Cost of device and the final printer – How much is the device and what is the printer total cost?

There are pros and cons of various ways to erase the rewritable media, although some method might have specific feature which was suitable for a specific application – for example, usage of printhead would eliminate a need for separate device, but erase speed and erase quality may be sacrificed. After evaluating all of the factors, our conclusion is that the thermal erase head is the best choice for general purpose usage.

Rewritable Media

The thermo-chemical process on the rewritable print media (leuco dye type) is shown graphically on Figure 1.

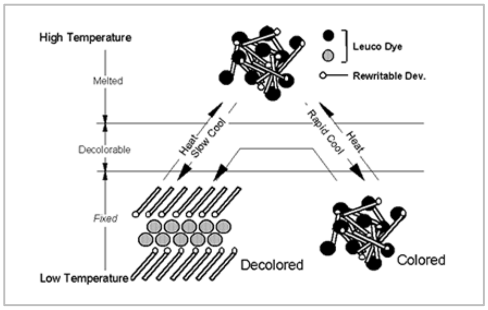

Figure 1
Thermo-chemical Process on the Rewritable Media
(Courtesy of Mitsubishi Paper Mills Limited)

In essence, the printing (coloring) profile needs to be heated and cooled in short duration while erasing (de-coloring) requires slow cooling within a narrow window of temperature range. Currently, the thermal rewritable media in production quantity are available from two companies – Ricoh[1] and Mitsubishi[2]

Although various rewritable media from both companies are similar, there are some minor differences among their products and types. Because the erase head has to work on both companies' media, it was necessary to evaluate the media with the same testing conditions. The test consisted of subjecting the media to a heating block at a various temperature and measuring the optical density. The test results were tabulated and shown in graph form on Figure 2.

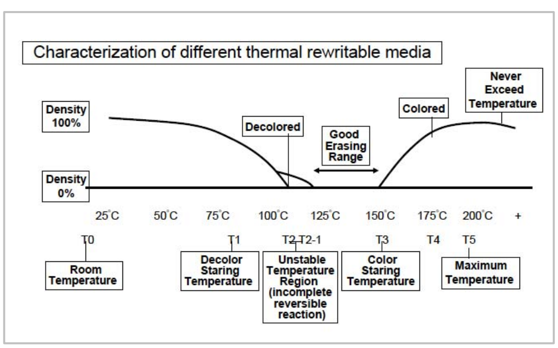

Figure 2
Rewritable media evaluation result

The results indicate that the best erasing result can be obtained between temperature T2 and T3. However, we found that there is an unstable region between T2 and T2-1 for some versions of the rewritable media. If the erase head is a "universal" device, then the erasing temperature needs to be maintained between T2-1 and T3. As seen from the graph, the "window of erasing" is rather narrow – in case of this example, within 30 °C. Ability to monitor, control and maintain a correct erasing temperature of the media is extremely important for thermal rewritable process. If the temperature is not within the erasing temperature window, good erasing results will not be obtained. The rewritable media can be damaged irreversibly if the temperature becomes too high.

Development of Erase Head

The erase head was developed in order to meet the very stringent temperature requirements by utilizing the following factors and properties.

(1) ***Incorporation of heater and sensor on substrate***

The temperature sensor element is placed in parallel with and right next to the heating element as shown on Figure 3. This makes the sensing of erase head ceramic substrate temperature more accurate than a discrete thermistor placed on the heat-sink as seen on existing erase heads on the market.

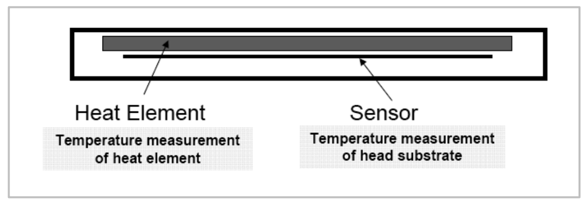

Figure 3
Top view of erase head (heat element and sensor location)

(2) ***Temperature measurement ability***

The heating element and temperature sensor element are made of the resistive material which has a positive Temperature Coefficient of Resistance (TCR) of 1500 parts per million per degree Celsius (ppm/°C). This enables the real-time temperature monitoring of the heating element and sensor while the media is attached to the erase head. This ability is very unique and other erasing devices on the market today do not have this capability. The illustration below is for the temperature measurement using the sensor element.

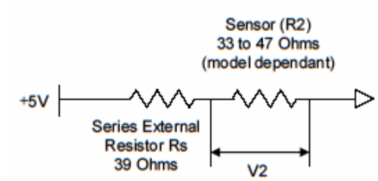

Figure 4
Temperature measurement using the Sensor

- Sensor resistor R2 has a TCR of + 1500 ppm / °C.
- The external series resistor Rs is a high precision (+/- 1%) and TCR of +/- 25 ppm / °C.
- The sensor temperature is found by measuring the V2 as follows:
  Formula $R2 = 39 \times V2 / (5 - V2)$
  Temperature change in °C = % change of R2 / 0.15

The heat element temperature can be also determined by using the same method with different external resistor value.

(3) ***Self-limiting temperature characteristics***

Because the heating element is made of the resistive material which has a TCR of 1500 ppm/°C, it has the self-limiting characteristics. The temperature affects the resistance value proportionally which limits the current as seen on Figure 5. This prevents the erase head from catastrophic thermal runaway even if the driving control circuit malfunctions.

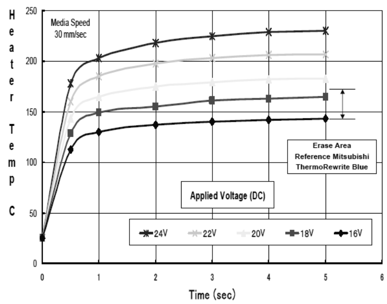

Figure 5
Self-limiting temperature characteristics

Making Erasing Speed Faster

In order to be used for industrial/commercial applications and to achieve higher erasing speed with wider format, the following steps were also taken when the new erase head was developed:

(1) ***Larger thermal capacity***

In order to maintain sufficient thermal energy supply, the heat element is made with larger wattage for higher power dissipation capability.

(2) ***Faster thermal transfer***

The erase head ceramic substrate is made without glass under-glaze insulation layer so that the substrate can act as the thermal reservoir. The heat from the resistive element is stored in the substrate and it can be retransmitted to the rewritable media quickly at the time of high speed erasing.

(3) ***Structure to withstand the thermal stress due to localized fast heating and cooling***

The new requirement for erase head to be used with the Kanban and FA system is up to A4 media size. Increasing the head width from card size (54 mm) to 210 mm presents a new type of challenge due to thermal expansion coefficient differences of materials. The length deference between the ceramic substrate and heat-sink, for example, is about 0.5 mm going from room temperature up to 150 °C on the A4 size. If the materials are bonded rigidly, then they will result bimetal-effect and the erase head will warp. The head structure was designed to accommodate the lateral dimensional fluctuations as shown on Figure 6 by incorporating intermediary layer. The ceramic substrate "floats" on the intermediary board and eliminates the mechanical stress due to the difference of thermal expansion. The flexible circuit board (FCB) which interfaces the connector and the ceramic substrate also faces the elongation and shrinkage issue, but it was solved by making several slots on the FCB in order to prevent the accumulation of head-wise longitudinal elongation.

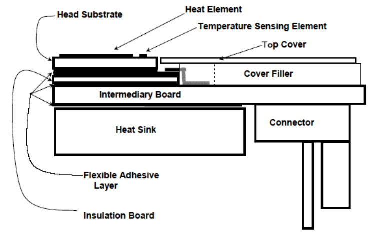

Figure 6
Cross-sectional View of A4-size Erase Head

(4) ***Energy-saving head structure***

The intermediary board employed for the wide-format erase head acts as the additional insulator. As a result, it provides energy-saving effect for the erase head. Since the wider erase head dissipates a large amount of thermal energy, this is a very welcomed effect.

Conclusion

The new erase head shown on Figure 7 (HDA-2310) was developed successfully with the following accomplishments:

- Possible to measure actual erasing temperature in real-time with the rewritable media in place.
- The A-4 size (210 mm) erasing width which is compatible with rewritable Kanban and FA system cards. Some cards are used in conjunction with RFID capability.
- Erasing speed of 100 mm/sec (or 4 ips)
- Continuous operation with localized high temperature repeatedly

Figure 7
A4-size Erase Head HDA-2310

References

[1] Ricoh Company Ltd., Tokyo, Japan

[2] Mitsubishi Paper Mills Ltd, Tokyo, Japan

Author Biography

Before founding HIT Devices Ltd., in Kyoto, Japan, Hideo Taniguchi worked for ROHM Co., Ltd. for over 40 years where he was responsible for the products including items relevant to printing industry like thermal printheads (printhead with partial glaze layer, development / implementation of driver ICs on substrate for printhead) and development/mass-production of LED printhead. He received his BS from Ritsumeikan University in Kyoto (in the field of Applied Chemistry) with additional study in Electrical Engineering.

Jiro Oi works for HIT Devices Ltd., a Kyoto-based electronic component manufacturer. Native of Hokkaido, Japan now he resides in Brentwood, Tennessee. Prior to joining HIT Devices, he had been with Rohm Co. Ltd. for more than 15 years in the field of thermal printheads and other electronic components. He received his BSEE from California Polytechnic State University in San Luis Obispo, California and MBA from Thunderbird School of Global Management in Glendale, Arizona.