Development of New Multi-Purpose Heating Head

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Abstract

We developed a new multi-purpose heating head. It resembles the traditional thermal printhead which has the resistive heating element on the ceramic substrate. Some differences are that it has a continuous resistive element while the printhead has an array of individual independent resistive element heating dots. Consequently, the methods to energize two devices are different. The most significant difference is that it has the heating element on the back side of the ceramic substrate and the media contact is on the front side of the substrate. This unique structure solves many problems which have been difficult and costly to deal with in the traditional structure. Heating element abrasion is no longer a problem as the media is not in contact with the heating element side. The heating element protective over-coating layer is not needed. Other benefits are the even temperature distribution throughout the heating head and easiness of manipulating the heating characteristics of the heating element. A family of heating heads using this idea has been made from small to large format. The new concept product is suitable for thermal rewritable printer erase head, thermal re-transfer printer heating head, pre/post-printing process of printing media and electrophotographic printer toner fuser.

Introduction

Heating devices in imaging field go back to the beginning of the thermal printing technologies started in the mid-60s. Thermal printheads, as they have been referred to, started as the dot matrix type which moved back and forth over the length of the thermal sensitive media and called "serial-type printhead". When the fax (short for facsimile) market moved to the thermal technology in the late 70s / early 80s, stationary printhead "line-type printhead" became a high demand product. Line-type printheads kept evolving and improving as the new applications emerged which required higher print speed, higher print density, lower cost and smaller size to name a few.

Specialized heating head came to the market when the thermal rewritable media became available for erasing purposes in the beginning of 2000[1]. Since it was critically important that the erasing temperature be controlled within the specified range while the erasing process was taken place, we developed a new type of heating head which was capable of monitoring the real-time temperature of heating head while the media was in contact with the head.

We made an improvement on our heating head so that it would be more durable and easier to manufacture. We believe that the improved head can be used for various purposes which are beyond the original rewritable media erasing application.

We will discuss our original heating head which was specifically designed as an erasing head and the new improved heating head for multi-purpose usage.

Our Original Erase Head [2]

The heating head we developed originally had a unique capability of monitoring the real-time temperature of the head substrate or heating element while the print media was in place.

The temperature monitoring ability comes from the resistive material used for the sensor and heating element for the heating head. The substrate of head structure is as shown below:

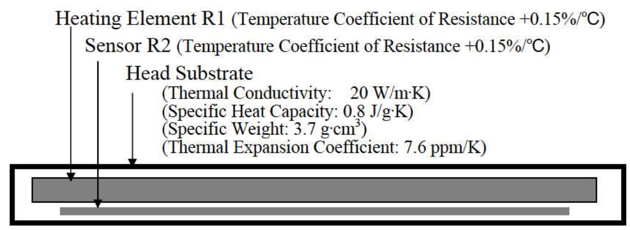

Fig. 1
Substrate structure of original erase head
(Top view)

The temperature sensing using the sensor (or the heating element) is accomplished by the following process [3].

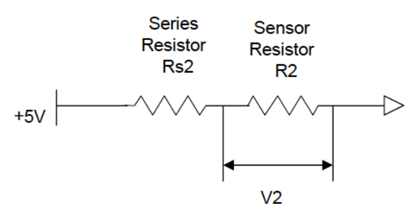

Fig. 2
Temperature measurement

Temperature measurement can be done either using the sensor R2 or the heating element itself, though the sensor usage will be easier to implement.

+ The sensor R2 has a temperature coefficient of plus 0.15% / degree Celsius.
+ Add a series resistor Rs2 with high precision (+/- 1%) and temperature coefficient of +/- 25 or 50 ppm (parts per million) / degree Celsius.
+ Since the sensor resistance R2 at a given time can be defined as R2 = Rs2 x V2 / (5 – V2), the temperature change can be calculated as the change from the original resistance value at 20 degrees C.
+ Temperature change is found as the ratio of the percentage change of sensor R2 to the temperature coefficient (0.15)
+ The heating element temperature change can be calculated a similar way, although the series resistor will have be larger wattage.

Existing head configuration and construction

The existing heating head including our own has the configuration of heating element facing to the thermal media as shown below:

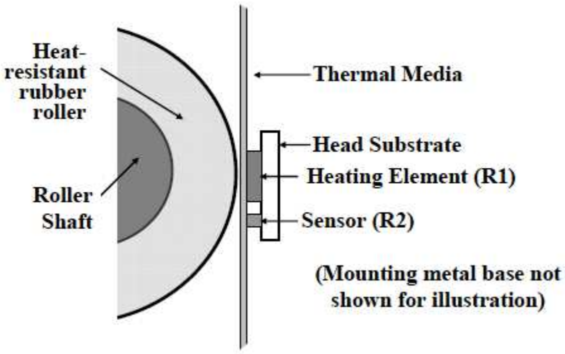

Fig. 3
Existing heating head configuration
(Side view)

There is an abrasion issue of heating element by the thermal media and it has been the constant challenge for the heating head (and thermal printhead) manufacturers to improve the abrasion life. The over-coating materials have been improved over the years from thick-film "glass" overcoat to more exotic thin-film substance like "DLC" (diamond-like carbon). The new materials are effective to protect the heating element, still there is a finite abrasion life which is expressed by actual length of media much like the automobile tires.

Studying of head temperature distribution

We studied the temperature distribution through the heating head and we discovered that the temperature differential between the front and back side of the heating head substrate was very slight. The heat distribution through the various materials is shown on Fig. 4 where the heating element is energized at 100 W of power. The temperature goes from 150 of the front side of ceramic substrate to 148.5 of the back side, then down to 50 after the insulation layer and aluminum heatsink. So the temperature drop is only 1% from front to back of the ceramic Al_2O_3 substrate. The thickness and thermal resistivity of materials are also shown.

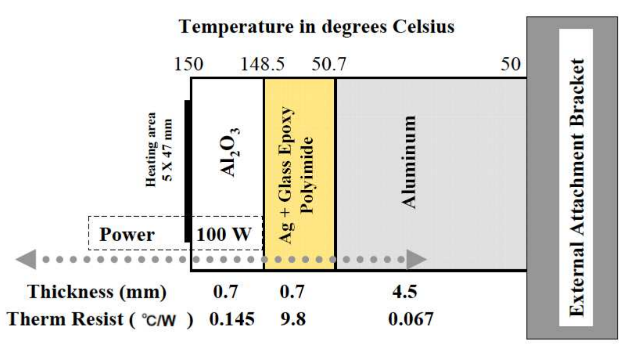

Fig. 4
Temperature distribution of existing heating head
(Side view)

New head configuration and construction

Based on the finding, we designed the new heating head which would heat the thermal media from the "back side" of the ceramic substrate. The simplified side view is shown on Fig. 5 in order to illustrate the difference between the new and existing heating heads.

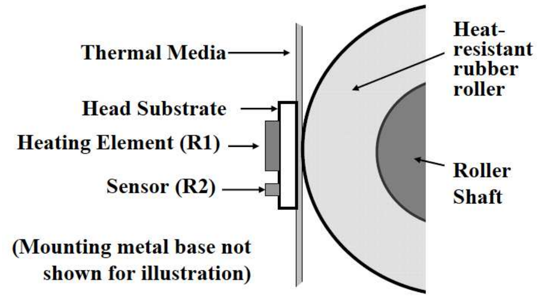

Fig. 5
New heating head configuration
(Side view)

Benefit of the new configuration

There are numerous benefits of the new configuration compared with the existing heads. Some of them are:

+ Thermal media does not contact the heat element which eliminates abrasion issues and increases durability
+ Even if there is an irregularity on the heating element surface, it will not affect the contacting ability to the media and it will not degrade the performance or reliability of the head
+ Anti-abrasion heating element protective over-coating layer which is a basic necessity for the existing head is not required
+ Local temperature variation become less as the heat is coming through the ceramic substrate and heat is spread more evenly
+ Heating element can be adjusted fairly easily and inexpensively using such technology as laser trimming to achieve better resistance uniformity
+ Since the over-coat layer forming process is not required, heating head substrate manufacturing process can be simplified which benefits production cost and yield
+ Even if there is a burnt residual material or "*kogation*" on the media-side surface of the heating head, it can be removed by mechanical means unlike the existing head whose surface can be easily damaged
+ The chemicals which may be present in the media will not react with or attack the heating element since the ceramic substrate works as the "protective layer"
+ The head can be used for the purposes which are not directly related to printing – such as heating chemical solutions or heat-curing process at a specific temperature
+ Due to unique structure of this design, several potential configurations are possible in various applications as shown on the following section
+ The new areas of applications are thermal retransfer, electrophotography toner fusing, thermal curing, pre/post printing process, lamination, non-printing heating, etc.

"Orthodox" way of new head implementation

Implementation of the new heating head fabrication can be done several ways, but the conventional or "orthodox" way is shown on Fig. 6. The head substrate is mounted on the metal base with air cavity so that the conduction heat loss to the base will be minimized. Also, roller shown has the air cavity for low heat loss purpose as well. This will be the most thermally efficient configuration.

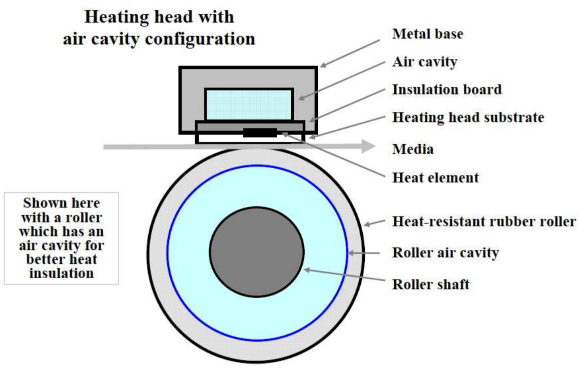

Fig. 6
"Orthodox" way of new head implementation
(Side view)

High-power "sandwich" configuration

When there is a need for more power for high speed processing, two heating head substrates can be put together in a sandwiched fashion (two heating elements placed face-to-face) to increase the power capability.

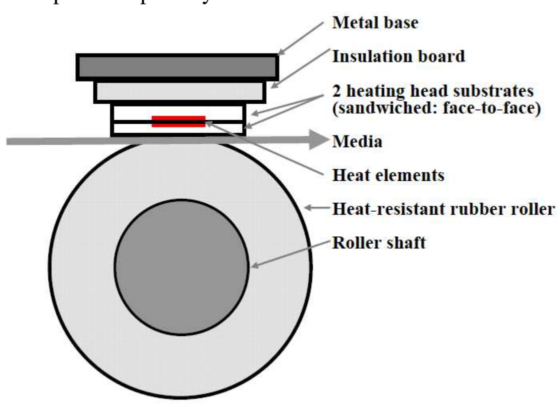

Fig. 7
Two substrates "sandwiched" for higher power application
(Side view)

"True-edge" configuration

Another type of substrate configuration is so-called "true-edge". As the name implies, the heating process is done at the edge of the substrate.

The merit of this configuration is that it is easier to obtain high heating head pressure as the media contact area is smaller than the other configurations. Also, if heating head placement space is an issue, the "true-edge" configuration may solve the problem as the heating head foot print is substantially smaller than others.

There will be an extra process step to make the substrate edge straight and smooth which will add the production cost and yield issue. So, there is a trade off of the benefit and cost which have to be considered for this type of heating head.

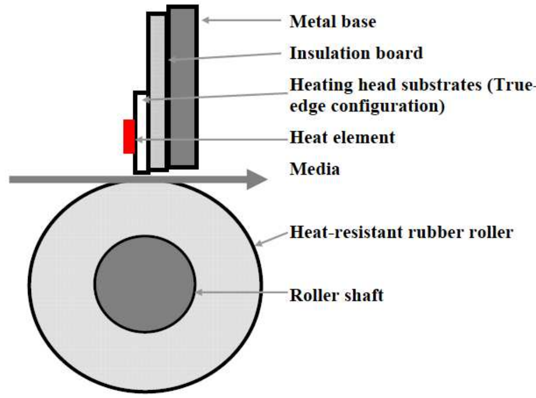

Fig. 8
"True-edge" configuration
(Side view)

"Double-header" parallel-usage configuration

This is the case when the roller is heated first and the media become heated indirectly. Some application may require pressure and heat for the process, such as the toner fusing for the electrophotographic printing. Two of the "orthodox" heating heads can be used for this configuration.

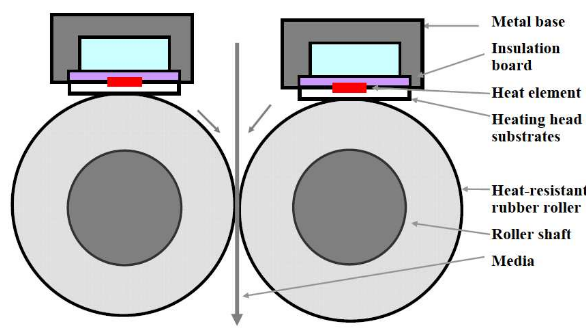

Fig. 9
Parallel-use configuration
(Side view)

Conclusion

The original heating head was designed only to work as an erase head for thermal rewritable media. With the new development, we extended the usage to different areas beyond the thermal rewritable purpose. Since this paper is written from the heating head point of view, the detailed application discussion is not included. However, it is our opinion that this heating head and its' variation will go beyond the conventional printing industry usage and applications.

References

[1] J. Oi & H. Taniguchi, New erase head for thermal rewritable media, Proceeding 2006 IS&T's NIP22 pg. 306

[2] H. Taniguchi & J. Oi, New erase head for kanban card size thermal rewritable media, Proceeding 2008 IS&T's NIP24 pg. 833

[3] U.S. Patent # 7206009 B2

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.

Shigemasa Sunada joined HIT Devices Ltd., in 2007 and has been working in various heating head projects for design and development. Prior to his current work, he worked for ROHM Co., Ltd. in Kyoto as a design and development engineer for such products as LEDs and various diodes. He graduated in mechanical engineering at Rakuyo Technical High School in Kyoto

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