Development of Durable and High efficiency Thermal printhead

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Abstract

In recent years, applications with a thermal print system have been rapidly expanding to emerging countries. Under the circumstances, a lot of direct thermal paper is being developed locally by many companies leaving the end-users little to no choice but to use the local paper supplier.

Unfortunately, some of this newly developed local direct thermal paper cause significant abrasions on the printheads forcing the users to replace the printheads frequently.

Considering the situation, ROHM has developed a durable thermal printhead which can achieve three times longer life compared to conventional printheads, even with such severe locally manufactured medias. In addition, the new printhead has 15% improved energy-efficiency and contributes to the ability of accepting a low-sensitivity direct thermal paper.

We have also developed AST (Anti Sticking Treatment) technology to prevent a sticking problem which causes a poor print-quality. The treatment also reduces paper residue build-up on the surface of printheads and keeps a good print-quality for continuous printing.

1. Background

The method of thermal printing has diversified over the years and it's used for a wide variety of applications such as POS, cash-register, ATM, Kiosk, and Barcode printers. In addition, these applications where thermal printers are used have been expanding into emerging countries.

Along with the expansion, a large variety of direct-thermal paper has been developed and manufactured in each of these markets due to high transportation costs of the paper rolls. Unfortunately, it turns out that some of newly developed local paper shortens a printhead life-time due to a severe abrasion and there are signs of degraded print-quality due to the papers low sensitivity.

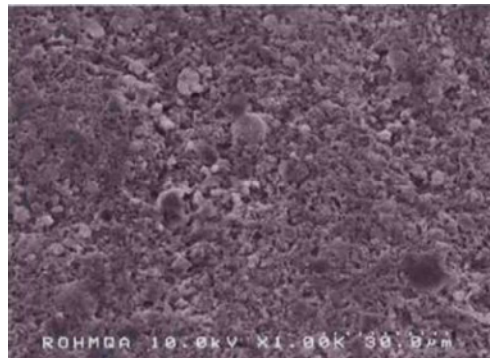
In addition, a sticking problem is present which can be caused by some of the new paper, especially when printing in a low-temperature condition.

So it is expected that we develop new printheads which are resistant to high-abrasion and are energy efficient.

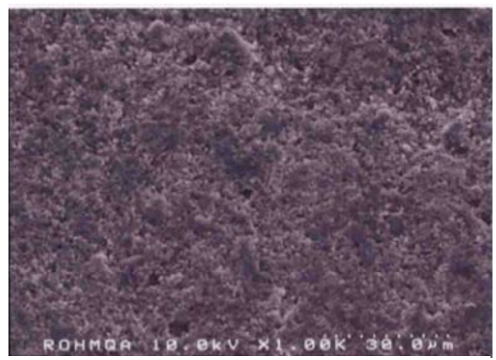
2. Development of Durable printhead

2.1. Analysis of Emerging DT paper

In considering how to improve the life of printhead even with those emerging direct-thermal papers, we analyzed various paper surface conditions and their contained components. Figure 1 shows two magnified photo examples of DT paper surfaces. We compared the condition of DT paper that we got in an emerging



(a) Surface of New local paper



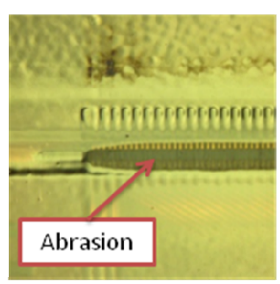
(b) Surface of Existing standard paper

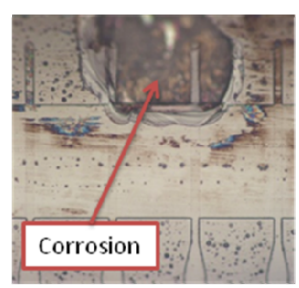
Figure 1. Magnified photo of the surface paper by SEM

country (a) with the one which is commonly used in Japan (b). The new local paper looks coarser. Such a rough condition could cause severe abrasion on the printheads. In addition, it may cause physical damage as well.

Also, we did the componential analysis both paper surfaces. We found that some new developed paper have a lot of ionic components. In general, ionic constituents could cause corrosion failure of the printheads.

The below photos are examples of failed printheads due to severe abrasion and corrosion.





2.2. Improvement of Printhead life

Generally, there are thick-film and thin-film printheads, but our focus was on improving the life of thick-film printheads this time since it's the more common technology used in emerging countries.

Figure 2 shows the schematic cross-section of a general thick-film printhead. The abrasion life of printhead is mostly related to the protective layer over the heat-elements.

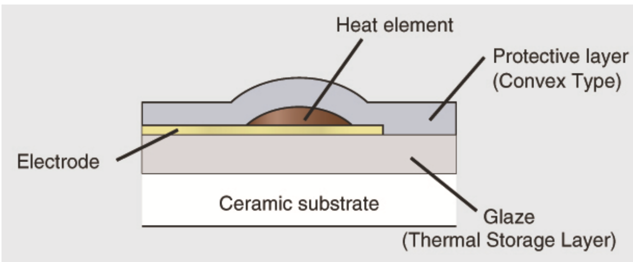


Figure 2. Schematic cross-section of Thick-film PH

Currently, a silicon dioxide (SiO_2) based material is used for the protective coating. To extend the abrasion life, we have added a hard material, Aluminum oxide (Al_2O_3), into the SiO2-based paste before the screen-printing process of the protective layer. Then we evaluated the effect by doing the following accelerated test with lapping film sheets. (Figure 3)

- Test conditions;
  - Print speed: 12IPS
  - Print media: Lapping film sheet (#8000)
  - Platen pressure: 2.5kg/head
  - Print duty: 12.5%

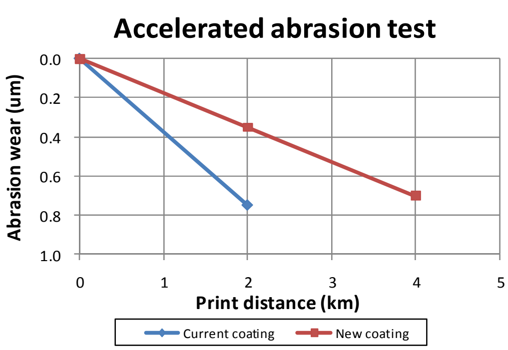


Figure 3. Accelerated abrasion test results

Comparing at 2km print distance, the abrasion wear of the new coating was just one-half of the current coating.

However, we also found that printheads with this new coating are less resistant to electrical energy supplied to the heat-element. Therefore, we tried several conditions of doped Al_2O_3 and selected the best one to resolve it. After that improvement, we did actual abrasion life-tests with existing standard and new local developed papers. Figure 4 shows the comparison results of the abrasion life between the current and new coating with both existing standard DT and newly developed local severe DT papers. The new coating

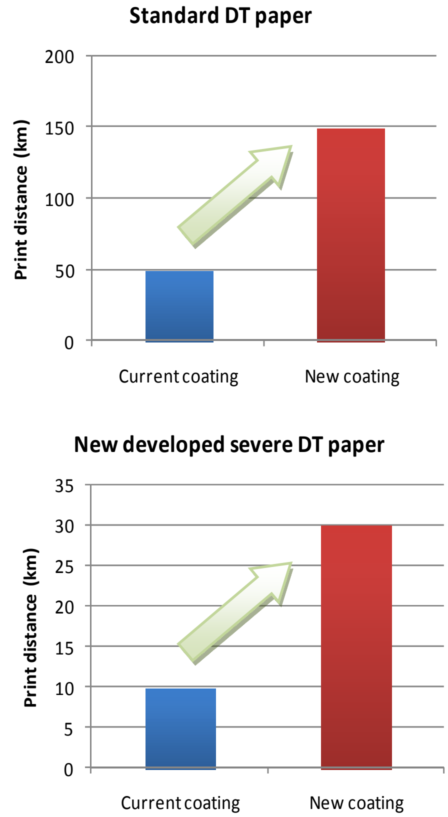


Figure 4. Abrasion life comparison

with hard material has three times longer abrasion life than the current coating with both standard and new abrasive papers. We believe the doped hard material contributes to the results. Of course, the result depends on print conditions and we have experienced that printheads with the new coating had no failures even after 250km printing with one of the most popular DT paper available.

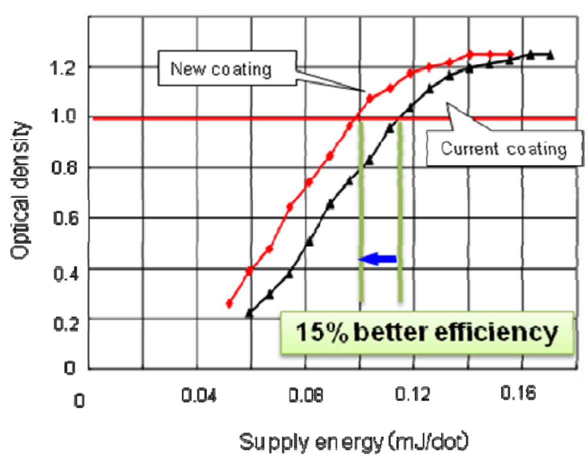


Figure 5. Energy efficiency comparison

2.3. Improvement of Energy-efficiency

We also changed the SiO_2-based material when we develop the new coating. The purpose was to obtain better heat conductivity. It is very important to enhance the ability of transferring heat generated at heat-elements to print-media. Figure 5 shows the comparison test results of print-energy vs print-density between the current and new coating.

- Test conditions;

- Print speed: 12IPS
- Print media: PD150R (OJI)
- Platen pressure: 2.0kg/head

We found that the new coating has a 15% better energy efficiency which obviously contributes to get the better print-quality with a low-sensitive DT paper.

2.4. Overall

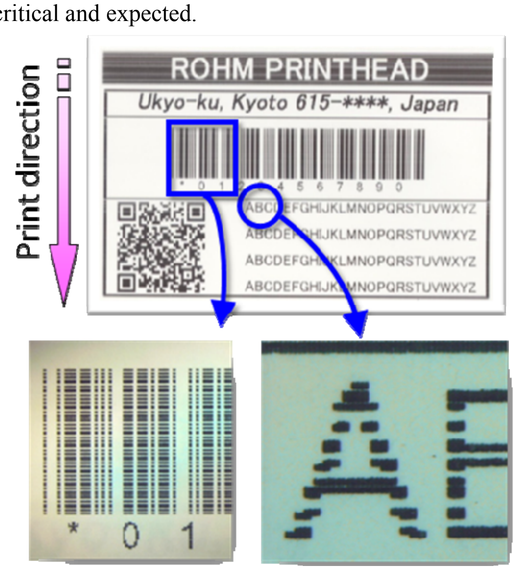
We developed the new protective coating for printheads which is tougher and has improved energy-efficiency (high thermal conductivity) characteristics than the current coating. It's expected to be extremely helpful for those who are forced to use the newly developed low-quality DT papers.

3. Development of AST

3.1. Sticking problem

With the expansion of the area where thermal printers are used, people sometimes need to print at a very low temperature. In that case, the sticking problem may occur. Figure 6 is the example photo of a print-result where sticking occurred.

It obviously makes print-quality worse, so resolution is critical and expected.



6. Example of Sticking problem Figure

3.1. Reduction of COF

In order to improve this issue, we focused our attention on Coefficient of Friction (COF) and developed AST (Anti Sticking Treatment) which is a surface treatment technology designed to reduce COF on the surface of printheads. Figure 7 shows the equipment that we used to measure COF which is calculated by the following formula.

$\mu = F/P$

- μ: COF
- F: Friction force
- P: Weight of Ball

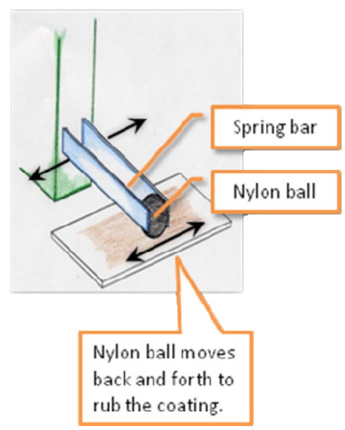


Figure 7. COF measurement equipment

Figure 8 shows the comparison results of COF, with and without AST during the test.

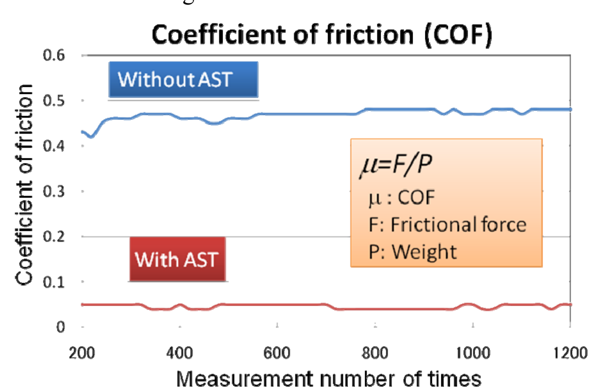


Figure 8. Comparison results of COF

It turns out that the COF of printhead with AST is nearly 1/10 of the one without AST. We then did some print-tests comparing with and without AST.

- Test conditions;

- Print speed: 2IPS
- Ambient temperature: -5 degree C
- Platen pressure: 2.5kg/head

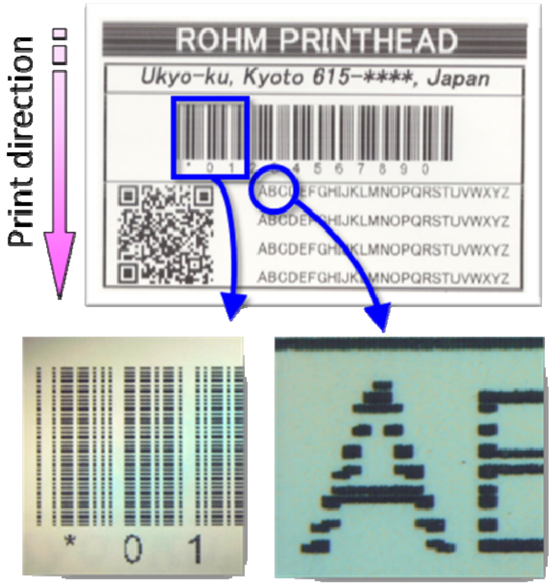


Figure 9 (a). Print example without AST

Figure 9 (b). Print example with AST

Figure 9 shows the results. As you can see, in the examples without AST, the rotated barcode and characters are intermittent due to the sticking problem under such a severe print conditions (low print-speed and low-temperature). However, those print problems were resolved by applying AST even at the same print condition.

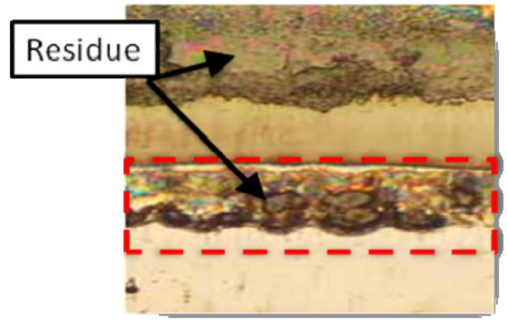


Figure 10 (a). Printhead without AST

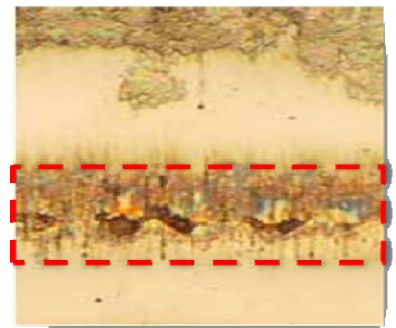


Figure 10 (b). Printhead with AST

We also found that the AST technology improves any paper residue build-up, especially with linerless DT labels. In view of Eco-friendly ideas, linerless labels are getting popular, but those special labels sometimes cause too much residue on and around heat-elements of printhead and can cause a print-failure like a white-line or so. Figure 10 shows the comparison results of with and without AST regarding the surface condition of printheads after continuous 6,000 labels print. As a result, the printhead applied with AST had much less residue build-up due to a much lower COF.

Author Biography

Tadashi Yamamoto received his B.A. in engineering from the Osaka University (1998) and his M.A. in applied material engineering from Osaka University (2000). Since then, he had worked in the Printhead Division at ROHM CO., LTD in Kyoto, Japan. Then, he transferred to ROHM Semiconductor U.S.A., LLC in San Diego, CA, USA. His work has focused on the development of thermal print heads and marketing activities.