

Laser Marking Characteristics of Thermo-Rewritable Marking Media

Takashi Kitamura, Satoshi Arai
Image Science Department, Faculty of Engineering, Chiba University
Chiba, Japan

Abstract

We are studying a laser thermal recording on thermo-rewritable marking media. In this recording method, a laser is used as a heat source instead of a thermal print head. The thermo-rewritable media is composed of low-molecular-weight organic compound and binder polymer. This media have two states at room temperature such as opaque and transparent states corresponding to high and low temperature of recording area. A high definition thermo-rewritable image can be obtained by a laser thermal recording. The effect of layer structure on the optical contrast of image was discussed in this report. The thermo-sensitivity of media with the light-heat conversion layer coated on the thermo-rewritable layer is higher than that with thermo-rewritable layer coated on the light-heat conversion layer.

Introduction

Image can be printed and erased easily on thermo-rewritable marking media by selecting a high and low temperature of image area, respectively. This thermo-rewritable media is composed of low-molecular-weight organic compound and binder polymer. This media have two states at room temperature such as opaque and transparent states corresponding to high and low temperature of thermal recording head. This media is used for a visible information display on a plastic card. [1), 2)] We are investigating a laser thermal recording on thermo-rewritable media. By employing a laser light instead of a thermal print head, the media is printed in non-contact with heat source and a high resolution image can be obtained.[3)] In this paper, the recording characteristics and an effect of layer structure upon the image contrast for thermal-rewritable media are discussed.

Experimental

Principle of Laser Thermal Marking on Thermo-rewritable Media

The principle of laser thermal recording on the thermo-rewritable media is shown in Figure 1. The media is composed of the laser absorbing layer and thermo-rewritable layer. The laser light that is focused by a lens is irradiated to the laser light absorbing layer, and then the laser light energy is converted into heat energy and heats the thermo-rewritable layer. By this process, the layer is changed from transparent to opaque state.

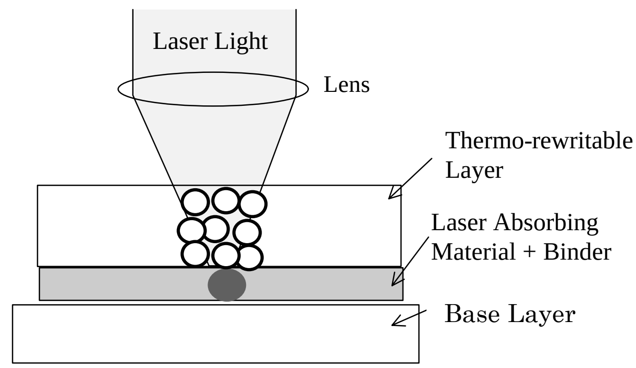

Figure 1. The principle of laser thermal Recording on Thermo-rewritable media.

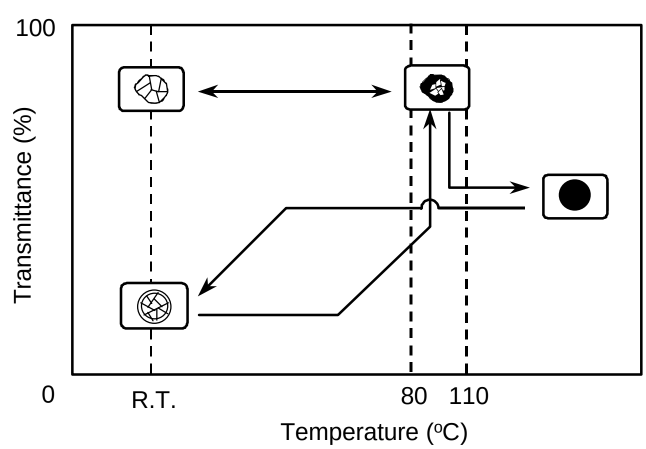

Figure 2. Structure Change of Thermo-rewritable media.

Figure 2 shows the mechanism of color change in the thermo-rewritable media by heating. In transparent state, the particles of fatty acids are so close with the binder polymer that there is no air void between particles and polymer in the thermo-rewritable layer. Therefore, the light is not scattered and thermo-rewritable layer is transparent. In the opaque state, there are some air void at the interface between the fatty acid crystals and polymer. Therefore, the light is reflected at surface of particles and crystal boundaries and is scattered, so that the media appears to be a white opaque color.

Preparation of Double-layered Thermo-rewritable Media

A structure of a double-layered thermo-rewritable sheet[4] is shown in Figure 3. A mixture of IR pigment and polycarbonate polymer was coated on transparent polymer film by a wire bar coating. Titanyl Phthalocyanine pigment was used for IR light absorbing material. Thickness of IR pigment layer is 0.6µm. In the next, a mixture of higher fatty acids and binder polymer was coated on a laser absorbing layer by wire bar coating. Higher fatty acids are behenic acid, tetracosanoic acid and eicosanedioic acid. Vinyl chloride-vinyl acetate copolymer is used for binder polymer. The thickness of thermo-rewritable layer is 10µm.

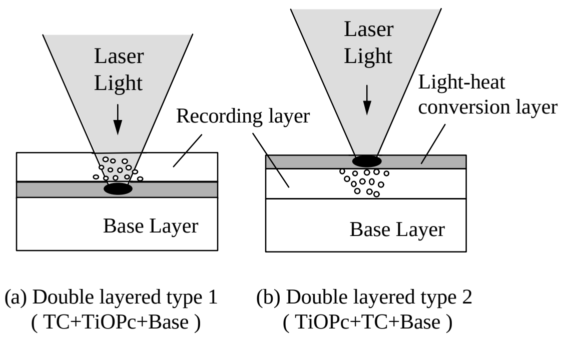

Figure 3. The construction of the double-layered thermo-rewritable sheet.

Laser Thermal Recording System

A schematic diagram of laser thermal recording system is shown in Figure 4. There are three main sections: an optical head which includes the laser diode (wavelength is 825nm, and laser power is 100mW), a recording drum which performs the main scanning, and a sub-scanning section which moves the optical head using a micro-stage. The laser diode is operated according to the image signals, and the drum rotation and micro-stage movement are controlled by a microcomputer.

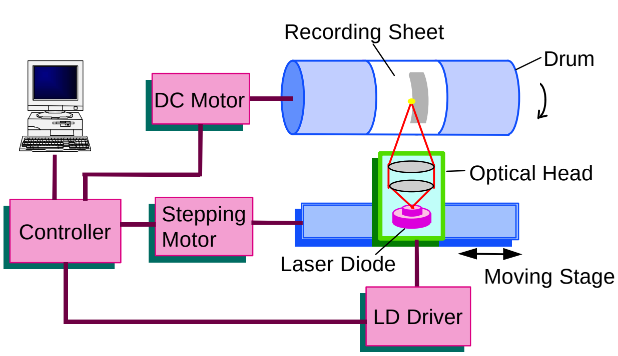

Figure 4. Schematic diagram of experimental recording system.

A spot size of laser light on the recording medium can be changed by controlling of a distance between the optical head and the recording drum by hand. Though a possible minimum spot size was 3.0µm at this recording system, a spot size was decided on 25µm in order to flatten irradiating energy density in this experiment.

Measurement of Optical Density

The optical reflection densities of image and non-image areas on the sample upon the aluminum reflection layer were measured using optical densitometer. The optical contrast of image was calculated using Equation 1.

$$C = (D_{base} - D_{image})/(D_{base} + D_{image}) \qquad (1)$$

Results and Discussion

Laser Recording Characteristics of Double-layered Thermo-rewritable Media

Figure 5 shows the relationship between the reflection density of image area and light power of laser at surface of the double layered thermo-rewritable sheet.[4] The image area shows white color and non-image area transparent. The laser powers for recording are 8 mW and 3 mW for TC/IR/Base and IR/TC/Base samples, respectively. The IR/TC/Base sample exhibits higher thermo-sensitivity than TC/IR/Base sample. The heat generated by laser heating were effective to change the thermo-rewritable layer white color. The heat generated in the IR layer at the interface between thermo-rewritable layer and base layer for the TC/IR/Base sample was conducted to both layers of thermo-rewritable layer and base layer, but heat was conducted only to thermo-rewritable layer for IR/TC/Base sample.

The other hand, the reflection density of image area for TC/IR/Base sample is lower than that for IR/TC/Base sample at the power of 35 mW. The image area for TC/IR/Base sample looks more white than for IR/TC/Base sample.

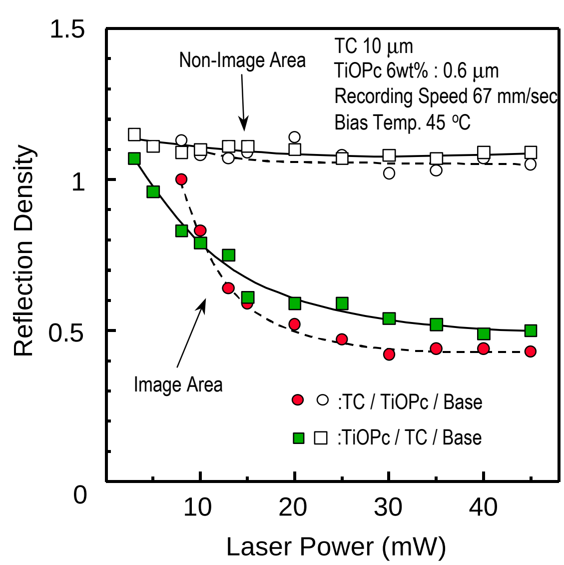

Figure 5. Relationship between reflection density and laser power for the double-layered thermo-rewritable sheet.

Figure 6 shows the optical contrast between the image density and base density. The contrast for IR/TC/Base sample is higher than that of TC/IR sample at low power range but the maximum contrast of TC/IR sample is higher than that of IR/TC sample. The contrast of the sample having IR layer at the top of sample is low. This cause is that the IR layer, TiOPc, shows light blue color and absorbs visible light. The IR layer at the top of sample absorbs a light to do lighting of a sample and scattering light in the layer.

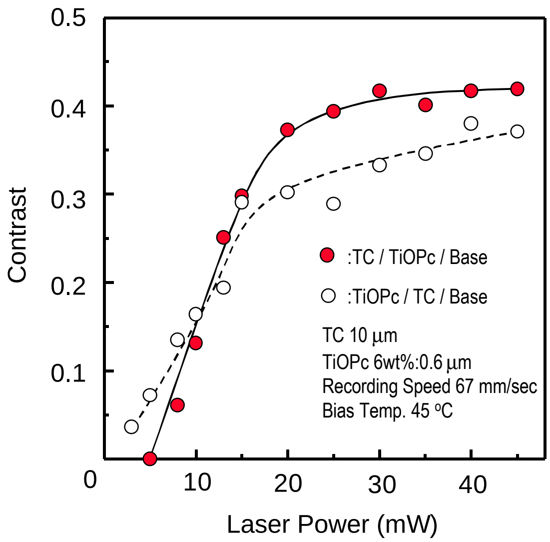

Figure 6. Relationship between an optical reflection contrast and laser power for the double-layered thermo-rewritable sheet.

Printed Samples

Figure 7 shows the microscope photographs of printed samples. The TC/IR/Base sample was exposed to a laser light modulated by image data. The power of light at surface of sample was 25 mW and printing speed was 67mm/sec. The image with the resolution of 1524 dpi and screen ruling of 180 lpi was obtained.

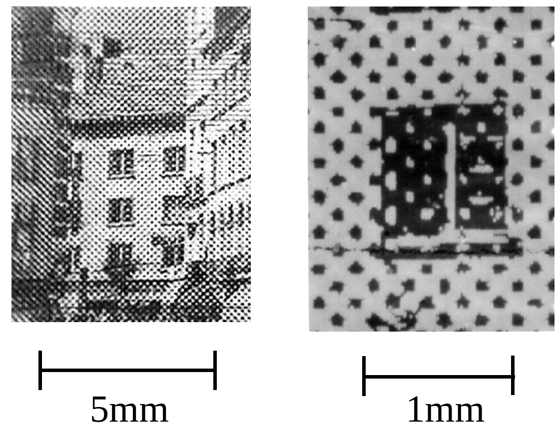

Figure 7. Microphotographs of printed samples. Image resolution:1524dpi, Half Tone:180lines/inch, Laser Power:25mW, Recording Speed:67mm/sec, Laser pulse width:249µs, Bias temp.:45°C.

Conclusions

We studied on the printing characteristics of thermo-rewritable media by laser heating. The thermo-sensitivity of layer with a light-heat conversion layer coated on the thermo-rewritable layer is higher than thermo-rewritable layer coated on the light-heat conversion layer. The optical contrast between image area and non-image area for thermo-rewritable layer coated on the laser light absorbing layer is high.

References

1. Y. Hotta, K. Morohoshi, K. Tsutsui and T. Yamaoka, *Proceedings of 9th International Congress on Advances in Non-Impact Printing Technologies,* 405 (1993)
2. Y. Hotta, T. Yamaoka, K. Morohoshi, T. Amano and K. Tsutsumi, *Chem. Matter*. 7, 1793 (1995)
3. Y. Hotta, A. Suzuki, T. Kitamura and T. Yamaoka, *J. Electrophotography of Japan*, 35, 168 (1996)
4. S. Arai, Y. Hotta, A. Suzuki and T. Kitamura, *Proceedings of Japan Hardcopy 97*, 193 (1997)