Conductive Microwire Patterning Using Laser Thermal Transfer Method

Katsuhiro Yoshida, General Technology Co., Ltd, Shiga, Japan

Abstract

Laser thermal transfer method,or LT2M was performed on PET and glass substrates with Cu,ITO(Indium Tin Oxide),using microwire conductive patterning. PET substrate Cu 1.5 µm was printed with a line width of 75 µm, and also a thickness of Cu 0.6 µm was printed with a line width of 50 µm. On the glass substrate, ITO 0.25 µm thickness was printed with a line width of 30 µm.

Introduction

In recent years, as the use of the personal computer and the cellular telephone have increased dramatically, and the need for the electronic circuit board and flat panel displays (FPD) have risen rapidly, the trend toward the manufacture of miniaturized, high definition products has continued apace. The products which have been produced in job shop type manufacturing facilities have become main stream, with a need for large production output. There are many methods for making circuit boards, but the main method of construction is photo lithography, which is a complex process used for most products.

Furthermore, because a wet process is required, a large quantity of developing solution and etching liquid is needed, and these waste liquids create a significant environmental burden. Compared to photo lithography, screen printing is a more simple process, but the ink paste used in printing also produces waste ink that also causes a negative environmental impact. In addition, in both manufacturing methods, circuit printing techniques (photo mask or screen printing) must be employed. From now on, to improve the efficiency of job shop type production and to minimize the environmental risks, it will be necessary to develop dry process manufacturing methods for circuit boards. At this juncture, we propose the use of laser thermal transfer method (LT2M). The advantages of this technique stem from the ability to print directly and with excellent quality while minimizing environmental risks to meet the needs of job shop type production.

Schematic of LT2M

The laser thermal transfer apparatus (Figure 1) is controlled by the Nd:YAG laser oscillator (wavelength of 532 nm, continuous wave oscillation) and a personal computer to create movement from two axis stage. In the case of Cu type transcription film, the laser apparatus emits light, then that exposed light transcribes onto the surface of the film absorbing the heat, and subsequently the PET substrate surface is fused with the image; and the Cu layer is printed (Figure 2).

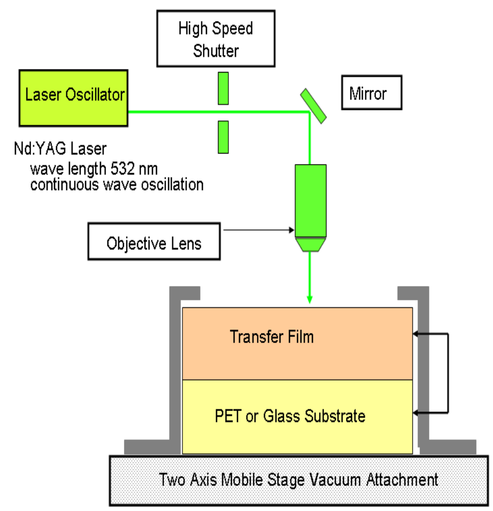

Figure 1. Laser Thermal Transfer Apparatus Schematic.

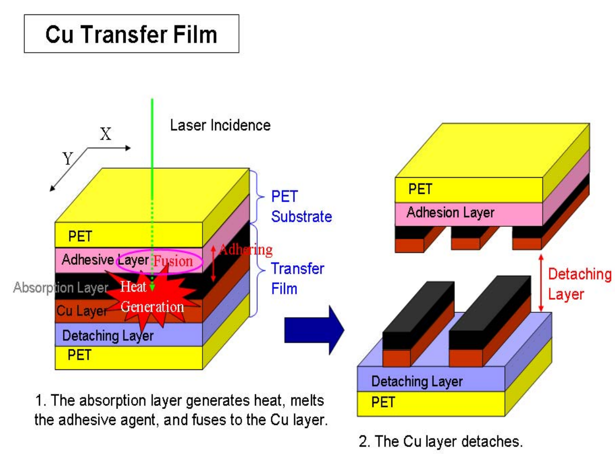

Figure 2.Schematic of laser thermal transfer(Cu transfer film).

Due to the light that the laser oscillator exposes, the transfer film for ITO generates heat in the absorptive layer between the PET and ITO layers, transferring heat to the ITO layer, generating a heat and mass transfer, creating fusion and bond strength, and causing transfer onto the ITO layer (Figure 3). The detaching layer of the transfer film is the support for the Cu layer which then easily transfers to the PET substrate, and then the absorptive layer takes in the laser beam (wavelength 532 nm), performing the function of transforming light to heat. For the Cu transcription film, the laser beam goes in through the PET layer, but for the ITO transcription film layer, the direction of entry is different.

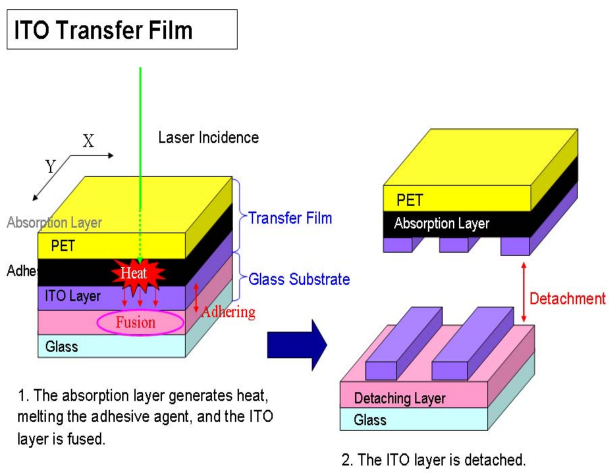

Figure 3.Schematic of laser thermal transfer(ITO transfer film.

Results of Laser Thermal Transfer Experiments

Experiment Conditions 1

Laser Oscillator：Spectra-Physics Corporation, Millennia Pro (Wavelength 532 nm continuous wave oscillation)

Incident Power(P)：0.3 W
Scan Speed(v)：10 mm/s
Objective lens：Magnification 20 times NA 0.46
Cu Transfer Film：Cu thickness 0.6 µm or 1.5 µm
PET Substrate：PET (100 µm), Adhesive layer 1 µm

P=0.3 W, v=10mm/s, Cu (0.6 µm) requirement with 1mm sq. transferred is pictured in the optical microscope photograph in Figure 4(a), and the enlargement is shown in Figure 4(b).With these conditions, the 50 µm line width was achieved.

In addition, in the same way, the conditions of 1 mm sq. ,P=0.3 W, v=10 mm/s, Cu (1.5 µm) is pictured in the optical microscope photograph in Figure 5(a), and the enlargement is shown in Figure 5 (b).

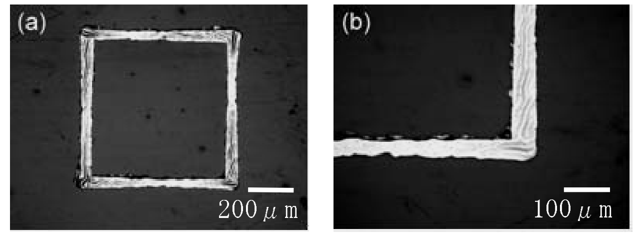

Figure 4.Transferred Cu line(Cu0.6µm).

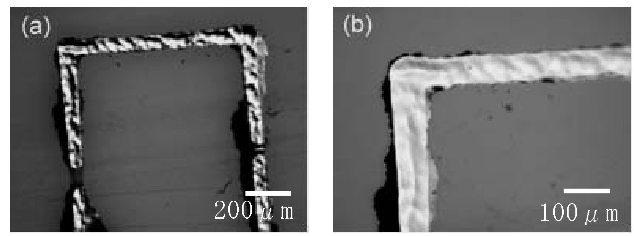

Figure 5.Transferred Cu line(Cu1.5µm).

This photograph verifies that a 75 µm line can be transferred.

Experiment Conditions 2

Laser Oscillator：Spectra-Physics Corporation, Millennia Pro (Wavelength 532 nm continuous wave oscillation)

Incident Power(P)：0.07W
Scan Speed(v)：10 mm/s
Objective lens：Magnification 5 times NA 0.13
ITO Transfer Film：ITO thickness 0.25 µm
Glass Substrate：Glass(1.1mm), Adhesive layer 1 µm

The SEM photograph depicting the conditions above is presented in Figure 6.

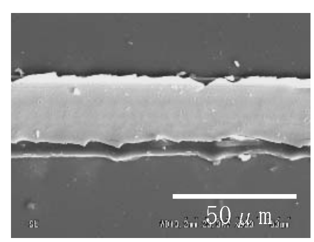

Figure 6.Transferred ITO line.

With these conditions, a line width of 30 µm was transferred as is visible here.

Experiment Conditions 3

Laser Oscillator：Spectra-Physics Corporation, Millennia Pro (Wavelength 532 nm continuous wave oscillation)

Incident Power(P)：0.6 W
Scan Speed(v)：50 mm/s

Objective lens：Magnification 5 times NA 0.13
Cu Transfer Film：Cu thickness 1.0 μm
PET Substrate：PET (100 μm), Adhesive layer 1 μm

In the conditions above, as is seen in Figure 7, a dipole antenna has been transferred (1mm width x 85 mm length). The resistance of the antenna that was transferred is 2 Ω, and the resistivity became 2.4 x 10^{-6} Ω cm. In addition, when the corresponding characteristics (953 MHz) were evaluated, the corresponding range was verified as 1.5 m.

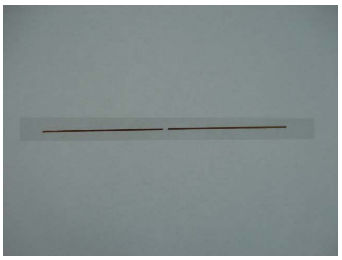

Figure 7.Transferred dipole antenna.

Application

We would like to focus on the many characteristics of the flawless laser thermal transfer method which can be developed and used in the design stage of new systems for job shop type production lines. For example, these possibilities include the RFID field, the printing of RF tags (in particular custom tags), the ever increasing engineering developments expected in the fields of FPD technology, liquid-crystal displays, organic electroluminescence displays, electronic papers,touch panels, and transparent electrodes. (Figure. 8)

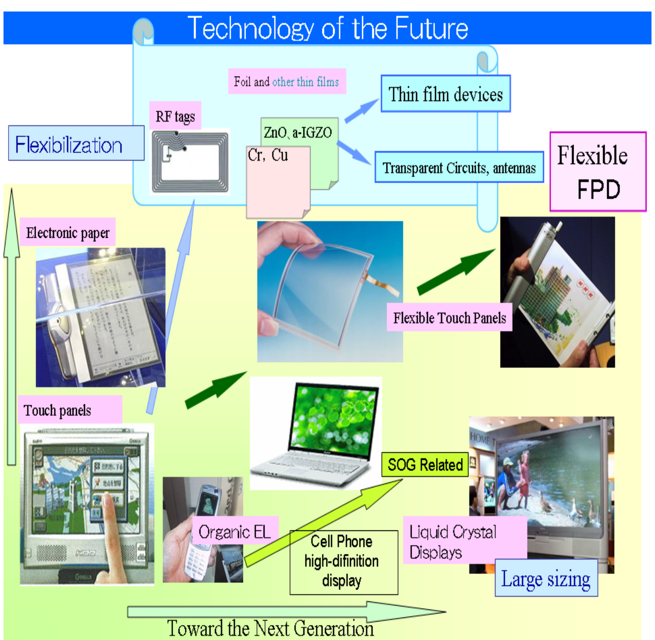

Figure 8. Toward the Next Generation

Conclusion

We were able to successfully print a line of 75 μm on a Cu thickness of 1.5 μm on PET substrate using the laser thermal transfer method, as well as a line of 50 μm on a Cu thickness of 0.6 μm. For glass substrate, we were able to transfer a line of 30 μm onto an ITO film thickness of 0.25 μm. In addition, with this construction of the dipole antenna, with a resistivity of 2.4 x 10^{-6} Ω cm we were able to achieve superior results with the range of transmission up to 1.5m, proving the high efficiency of the antenna.

Acknowledgement

The development of the Laser Thermal Transfer Method was made possible through joint collaboration with Tomokazu Sano, Assistant Professor at Osaka Universiy, Katsura Sumio of Nippon Denki Kagaku Company, and Akira Nakayama of Osaka Science&Technology Center, and I wish to express my most sincere thanks to these colleagues. Also, regarding the antenna evaluation, my deepest gratitude goes to Seigo Zaima of TDK for his cooperation.

References

[1] Kenji Takahata, Tomokazu Sano, Akio Hirose, Sumio Katsura, Akira Nakayama, Katsuhiro Yoshida, 13th Symposium on Microjoining and Assembly Technology in Electronics(Mate2007), pg.157－160
[2] Shogo Iwasaki, Tomokazu Sano, Kenji Takahata, Sumio katsura , katsuhiro Yoshida, Akira Nakayama, Akio Hirose, 14th Symposium on Microjoining and Assembly Technology in Electronics(Mate2008), pg.395－398

Author Biography

Katsuhiro Yoshida received his BE in chemistry from Doshisha University (1987). His career as an engineer started from Fujicopian Co., Ltd. Since 2002, he has been working in the R&D Department at General Technology Co., Ltd. He has focused on thermal transfer ribbons in his career, especially interested in the possibility of specialty use, or wider application of thermal transfer ribbons.