FULLY R2R GRAVURE PRINTED SMART TAGS AND RELATED WEB HANDLING CHALLENGES

By

Gyoujin Cho
Sunchon National University
KOREA

ABSTRACT

Although a smart tag which can communicate with a smart phone *via* NFC (Near Field Communication) has been considered as a core tool for bringing up the ubiquitous society, the difficulties in integrating 13.56 MHz RFID (Radio Frequency Identification), sensors and signage altogether on plastic foils with extremely low cost (< 0.5 $) nullify its role for the realization of the ubiquitous society. In this presentation, three key issues of R2R gravure such as overlay printing registration, web tension control and surface roughness of printed layers will be introduced as challenges to be overcome in the production of inexpensive smart tags on flexible plastic foils. The integration of those devices (RFID, sensors and signage) on the plastic foils will be successfully demonstrated using fully gravure printed 96 bit RFID tag, RF-QR tag and RF-Sensors. Those tags contains printed key device units such as 13.56 MHz modulating TFT, digital logic gates, 96 bit memory, cyclic voltammetry, electrochromic display, and rectifier for the wireless power transmission *via* NFC (13.56 MHz). The detail specifications of R2R gravure and printed key device units for the printed smart tags will be presented as well.

INTRODUCTION

Printed electronics based on roll to roll (R2R) gravure is an emerging field in which the printer and inks are fully utilized to fabricate electronic devices on flexible substrates. In other words, as like printing a newspaper, magazine and poster on various substrates, electronic devices could be printed on the substrates with high throughput. Therefore, the R2R gravure has a lot of advantages over current Si based photolithography especially for producing low cost, disposable and flexible electronic devices [1],[2]. In fact, flexible signage with a large area and costless smart tags such as RFID tags are two of the most promising fields in utilizing the R2R gravure as a tool for manufacturing active electronic devices. The advantage of R2R gravure technology over the Si based photolithography is obvious for producing a large area and flexible signage. However, in the field of RFID tag, the advantage of using R2R gravure printing techniques over current Si based one

needs to compare closely since the cost of Si chip itself for RFID tag can be lowered up to the point of a penny. For comparing the costs between the printed RFID tags and Si based current RFID tags, we first analyze how the cost of manufacturing RFID tags can be lowered using R2R gravure based on the assumption of the comparable function and reliability of printed RFID tags to the Si based one. Conventional Si based RFID tags have been produced by bonding Si based transponder chips, produced by the photolithography, onto antenna, etched Cu or Al films, and then labeling and tagging. Therefore, the conventional RFID tags have an intrinsic limit to reduce the costs in the chip bonding, labeling and tagging. However, this intrinsic cost limit can be easily overcome if R2R gravure printing process is employed to print antenna, transponder chip and then continuously integrate with package printing as shown in Figure 1. This advantage of integrating with the package printing process will create the new IT field, called smart tags where sensors and signage are integrated for the ubiquitous society. However, current Si based IT cannot be directly applied for the realization of ubiquitous society due to the cost limit and flexibility.

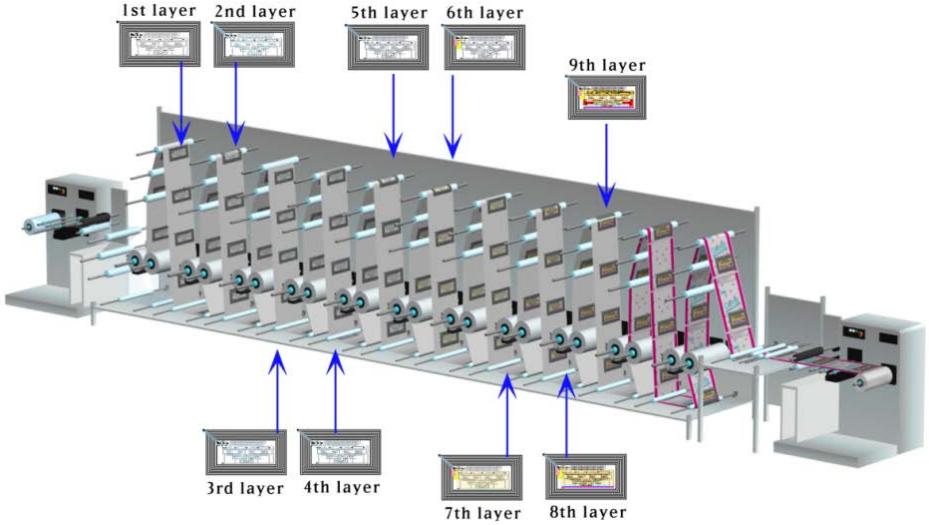

Figure 1 – Schematic description of roll-to-roll gravure process for printing RFID tags with the integration to a package printing process. At the 1st printing unit, print antenna, wires and electrodes, and consecutively print dielectric layers, drain-source electrodes, active layers for TFTs, active layers for diodes, top electrodes of diodes, wires to connect and then, passive layers. At the 9th printing unit, print laminating layers, and then finally, complete color packaging printing process.

DISCUSSION

For the realization of Figure 1 in manufacturing RFID tags, first of all, fully printed basic building block of RFID tag should be available. In other words, antenna, wires, diodes, capacitors and thin film transistors (TFTs) should be gravure printable on plastic foils and then scalable *via* R2R gravure. As a consequence of developing fully R2R gravure printed RFID tags, Figure 2 shows the operation of 96 bit RFID tags, fully printed using R2R and roll to plate (R2P) hybrid gravure on plastic foils. To attain those integrate ability and scalability using R2R and R2P gravure, all of inks including metal,

semiconductor and dielectric should be orthogonal to each other and curable in less than 5 sec under 150 ºC to maintain the printing speed of at least 12 m/min. Since those inks are not fully reported yet, I would like to present how those inks were designed and prepared and then, how we utilized them in printing RFID tags on PET (polyethylene phthalate) foils using the R2R and R2P gravure in this presentation. Especially, the overlay registration accuracy of ± 20 μm was controlled by developing our own servomechanism where web tension, pressure of impression roller and doctor blade angle of R2R gravure were controlled as well (Figure 3). Those results will be used as a milestone to practically develop inexpensive and disposable smart tags where RFID, sensors and signage are integrated.

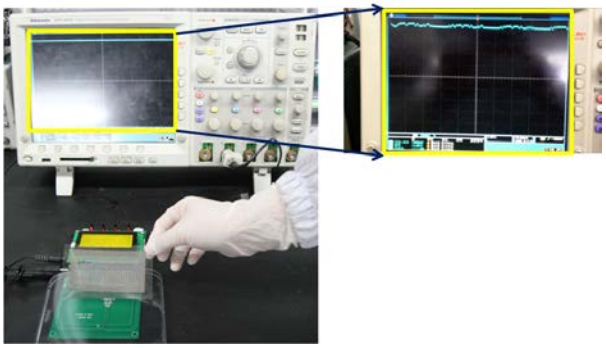

Figure 2 – Image of all gravure printed 13.56 MHz passive RFID tag with 13.56 MHz reader and oscilloscope to wirelessly readout 96 bit information.

Figure 3 – Data for showing the overlay registration accuracy of R2R gravure used for printing electronic devices.

ACKNOWLEDGEMENTS

This work was supported by Paru Co. and RIC in Sunchon National University.

REFERENCES

1. Noh, J., Jung, K. H., Kim, J. S., Kim, S. H., Cho, S. H., and Cho, G., "Fully gravure-Printed Flexible Full Adder Using SWNT-Based TFTs," IEEE Electron Devices Letters, Vol. 33, Nov. 2012, pp. 1574-1576.
2. Park, H., Kang, H. W., Lee, Y., Park, Y. S., Noh, N., and Cho, G., "Fully Roll-to-Roll Gravure Printed Rectenna on Plastic Foils for Wireless Power Transmission at 13.56 MHz," Nanotechnology, Vol. 23, Aug. 2012, pp. 34406-344012.