An Investigation into Printing Processes and Feasibility Study for RFID Tag Antennas

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Abstract: This paper will explain a study of several printing processes (screen printing, flexography, gravure and ink jet printing) for RFID antennas transponder. The potential of each process will also be investigated. A current sample of RFID is selected, and the antenna processes have been identified, and the comparison of antenna read range will be exhibited.

1. Introduction

RFID system consists of three basic components which a tag, reader and back office data processing equipment. RFID tag is containing an integrated circuit chip and an antenna and has an ability to respond to radio waves transmitted from RFID reader in order to send, process and store information [1]. The reader transmits a modulated signal to the tag and the tag backscatters a signal with identification data to reader at the same time. In order to store identification data, the tag have an antenna and RF(Radio frequency) chip. Many potential applications in different areas, such as item identification and retail management purposes [2]. According to Merimlampi et al [3] RFID conductive tag antenna normally manufactured by etching process which contains many processes, phases and uses different chemicals, therefore this is not environmentally friendly and very costly. Furthermore with traditional electronic manufacturing techniques the integration may not be technically and economically competitive in mass production. Etched copper or aluminium is normally used for RFID tag antenna which produced chemical waste during the etching process. An environmental friendly manufacturing process by printing silver paste has become popular and highlighted by Bo and Yuen [2]. Printing methods are the most common additive methods applied in RFID tag antenna fabrication and they are currently under wide research [3]. For the mass production enables, printing is simple and a fast method. Compared with etching, the material loss and the usage of different chemicals are considerably lesser. Author found there are a lack of study about the tag material and the performance of printed tag antenna. Therefore the study is vital. Recently, different printing techniques have been adapted for electronics manufacturing. For example, screen printing, gravure printing, flexography, and ink jet printing seem to be promising techniques for printable electronics [4], [5], [6] and [7].

2. Potential of Printing Processes for RFID

The fastest printing process in the market today is Gravure printing. Researchers such as Pudas [8], Makela [9], Leppavuori [10] have attempted to use it to print with functional materials. However, this printing technique have been confined to low resolution devices and
Furthermore the imaging technology leads to stepped line features when their direction in neither circumferential nor transverse to the cylinder. Therefore these will impact on electrical properties when printing fine feature and highly cost and rigid design. Currently, screen printing is the most widely used in printing with functional materials, because the ability to deposit thick ink film in one passed onto wide array of substrates, ease and economical turn-around of small quantities using low cost equipment. But it is a slow reproducibility printing technique though having the advantage of very close print to print consistency. In fact, it has been used in medical device fields for diabetic applications of glucose levels measurement sensors [11], [12], [13] and [14].

In lithography, printing and non printing elements are at the same planographic level which has also been explored [15]. Lithography uses high viscosity inks with long inking trains that is hard to stabilise. Furthermore it has also been found to be poor at reproducing fine features due to suffering from lateral distortions [16]. Ink-jet as a digital printing has gained growing interest as a method for depositing functional materials. It has been used for fabricating antennas and solar cells. Low-cost, easily changeable digital print patterns and low material consumption are the advantages of ink-jet printing. However, it has limited printing speed and other problems such as clogging, especially when small nozzles are used[17], unless the ink properties were properly tuned to a low viscosity (below 15mPa.s) and low evaporation rate.

Flexography is the newest printing method evolving from the letterpress printing technique [18]. It is a simple process compared to others printing processes such as gravure, screen printing, lithography [15]. Flexography transfers the image onto substrate using a plate as an image carrier. The plate is inked using an anilox roller that picks up the ink within its cells from the ink bath and it is metered using a doctor blade. It then inks the relief image on the printing plate where finally it transfers the inked image on to the substrates. However it have a unique advantage which capable of printing fine features. Fundamentally, printing is simply described as a process or technique of transferring ink onto a substrate. The principles of these processes are depending on the type of image carrier it uses as shown in figure 1, where depend to their application and purposes [15].

As a summary, table-1 shows the currently known capabilities of traditional printing to the fabrication of electronic in terms of ink film thickness and each application [16]. All the printing technique has advantages, disadvantages and problems which should be countered to
verify the capabilities to be used for electronic printing. These is a challenge we working
toward base previous researcher was done.

<table>
<thead>
<tr>
<th>Printing Process</th>
<th>Smallest Printable Feature</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravure Offset</td>
<td>50 μm</td>
<td>• Conductor lines on ceramic substrates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pattern thin-film transistors for low-cost displays</td>
</tr>
<tr>
<td>Offset Lithography</td>
<td>25 μm</td>
<td>• Fabrication of capacitors using printed lines</td>
</tr>
<tr>
<td>Electrophotography</td>
<td>Not Available</td>
<td>• Pattern transistors and conductors on dielectric materials</td>
</tr>
<tr>
<td>Screen Printing</td>
<td>50-75 μm</td>
<td>• Commercial printed circuit boards</td>
</tr>
<tr>
<td>Inkjet</td>
<td>10-30 μm</td>
<td>• Presently the dominant experimental method</td>
</tr>
</tbody>
</table>

Table-1: Application of Traditional Printing to the Fabrication of Electronic [16]

3. Methodology and Experimental

Flexography and screen printing method has been selected since the method have most potential as RFID antenna printing compared to others such as gravure, lithography or ink-jet. Firstly, in this study as seen in Figure 2, a PASSIVE RFID: Read and Display V2010 where the antenna made from etched cooper embedded in the tag was selected as a bench marking. We confirmed that the antenna has been done by etching process as shown in figure 2. The read range between the tag and the reader has also been measured and the results are shown in figure 3 which is 97.5mm in average.

![RFID: Read and Display V2010](image1)

![RFID Tag (with etching copper antenna: embedded in card)](image2)

Figure 2: Investigation on RFID card

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Read Range (mm)</th>
<th>Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td><strong>Average Value</strong></td>
<td><strong>97.5</strong></td>
<td></td>
</tr>
</tbody>
</table>

![Antenna Read Range Graph](image3)
A preliminary research of the same pattern and size of V2010 product (circle with 35mm inner diameter and 3mm thickness antenna) has been printed by flexography and screen printing and the read range were compared using silver inks. As shown in figure 3 of Antenna Read Range Graph, when these alternatives process are selected the current results are inconclusive which may better or worse as prediction 1 and 2 respectively due to many other printing factors which need to be addressed in the future.

4. Discussion and Conclusion

In order to produce electronic component like RFID in an efficient and cost effective way, this preliminary study shows that printing processes may be chosen as an alternative process. Printed passive components are crucial for the development of low cost, flexible and printed systems like RFID. Going forward, a remaining challenge is to improve the conductivity of printed patterns for antenna fabrication. For an optimum performance it is needed to conduct further research. In this article author presented and demonstrated that flexography and screen printing technology may capable of processing antennas for RFID.

References


