Pharmaceutical Packaging and ID Cards with Printed Antennas of RFID Tags

Urška Kavčič[1], Miloje Đokić[2], Marijan Maček[3], Vasa Radonić[4] and Tadeja Muck[2]
[1]Valkarton Rakek d.o.o., Rakek, Slovenia
[2]University of Ljubljana, Faculty of Natural Sciences and Engineering, Ljubljana, Slovenia
[3]University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia
[4]University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia

Abstract: *The integration of RFID tags in different applications is important in order to gain greater functionality in products. Upon packaging, box tracking in logistics or in the supply chain can easily be achieved [1]. High manufacturing costs have led to the search for alternative manufacturing methods at an ultra-low cost and various printing processes have been considered such as inkjet, gravure, flexo, offset and screen printing. Currently, investigations are focused on the use of these printing technologies for the mass production of RFID directly on different printing materials such as papers, cardboards and foils [2–12].*

This paper is an upgrade of our preliminary research [13] focused on antenna design and optimization of printing conditions. The analysis of the readability of UHF RFID tags, which were printed on real pharmaceutical packaging (of tablets) and on ID cards with printed and multi-layered laminated plastic cards were done.

Two different antenna designs were printed. The first one on a packaging box and the second one on a foil layer which was then laminated with seven different foil layers. For printing thermal drying silver conductive printing ink was used. The NXP plastic strap chips were integrated with printed antennas using conductive glue.

We found that printed antennas of UHF RFID tags and inline chip integration can swap the RFID tag label on packaging and RFID tag inlays in ID cards with printed ones. Preliminary results are promising, but to achieve better performance significant improvements have to be made in the near future.

Keywords: *UHF RFID antenna, screen printing, packaging, ID cards*

Introduction

Radio frequency identification (RFID) is an automatic identification technology that is already incorporated in ID cards and is more and more used in packaging. An RFID tag consists of an antenna and a chip (IC) and can be applied to products as a label or can be directly printed on them. As conventionally manufactured tags incorporated in labels have not matched the forecasts for growth in usage because of high production costs and environmental unfriendliness, the printing industry began to research the possibility of printing RFID antennas and chips [14]. Printed RFID antennas can be manufactured more economically and with a better environmental record, since the additive printing process consumes less raw material and limits waste products [15].

In order to improve the functionality of products, the integration of RFID tags in different applications is important. Upon packaging, box tracking in logistics or in the supply chain can easily be achieved [1] and different printing technologies such as inkjet, gravure, flexo, offset and screen printing offer the possibility of mass production of RFID directly on different printing materials, such as papers, cardboards and foils [2–12].

Since the printing technologies offer so many opportunities, the RFID antennas were directly printed onto the cardboard and onto foil. Two different antenna designs were used. The first one on cardboard packaging and the second one on a foil layer which was then laminated with seven different foil layers. For printing, thermal drying silver conductive printing ink was used. The NXP plastic strap chips were integrated with printed antennas using conductive glue.

At the end the analyses of UHF RFID tags readability printed on real pharmaceutical packaging (with tablets inside) and tag inlays inside ID cards were done.

Materials and Methods

The investigation (Figure 1) was divided into two parts. In the first part (1) the UHF RFID antennas were printed on cardboard which was then cut and folded into pharmaceutical packages and in the second part (2) the UHF RFID antennas were printed on one of the foil layers that was later laminated for making finished ID cards.

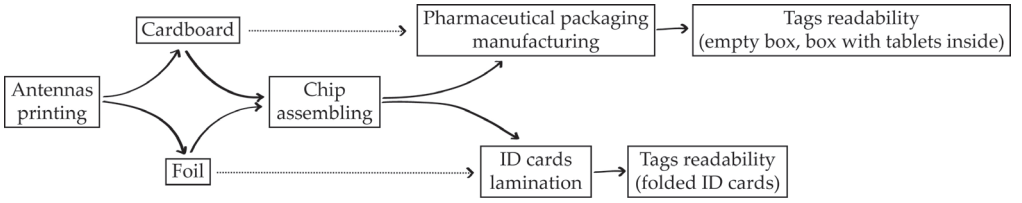

Figure 1: Process of analysis

UHF RFID Antenna

Two different UHF RFID antennas were printed, each on different printing material and for a different purpose. Figure 2 shows two antenna designs, the first for packaging (a) and the second for ID cards (b).

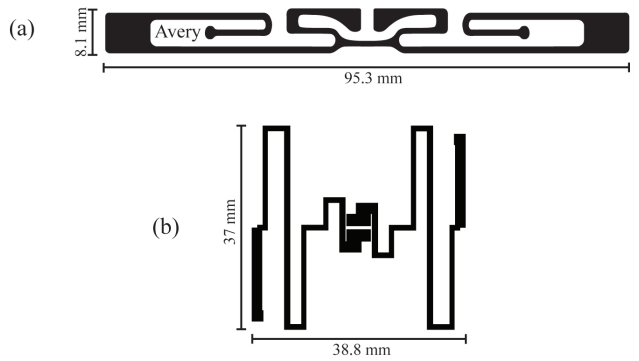

Figure 2: Designs of UHF RFID antennas: (a) antenna for packaging, (b) antenna for ID cards

Printing

In the study two different printing materials were used: (1) coated cardboard – 245 g/m^2 (Metsä Board, Finland) for packaging and (2) white polycarbonate foil – 120 g/m^2 (SABIC) for ID card manufacturing.

The designed UHF RFID antennas were printed using a semi-automatic screen printing machine. Conductive lines were printed using thermal drying silver conductive ink (SunChemical, USA) with screen mesh density 120 l/cm (theoretical ink volume 16.3 cm^3/m^2). After printing, the NXP strap chips were manually assembled to the antennas using isotropic electro-conductive adhesive with silver particles (Bison, Netherlands).

Analyses

When the final products were prepared, the analyses of the RFID tags' performances were evaluated. The readability of printed RFID tags on different applications was determined in a real environment using an IDS-R902 reader with a Patch A0025 antenna (Poynting GmbH, Germany) that also measures the strength of the modulated signal backscattered from the tag.

The received power strength was measured on each cm for the pharmaceutical packaging that was empty and on packaging with tablets inside the packaging.

The readability of the tags' inlays before lamination (unfolded) and after lamination (unfolded and folded cards) was determined. The received power strength was measured every two cm.

Results and Discussion

Previous research [16, 17] indicated that the reading range of tags applied on empty cardboard boxes is much greater than the reading range of tags applied to boxes with an aluminium plate on the inner side of box. In those cases the aluminium plate was ideally positioned for the thickness of cardboard away from the tag. Similar results were measured in this study, where the tags were applied to real pharmaceutical packaging with tablets in blister packaging inside (Al foil). According to Figure 3, the reading range of tags on empty boxes is almost twice that of tags applied to packaging with tablets inside. There is a significant difference as well between the received signal strength (power), where a difference of more than 10 dBm can be seen between both samples. Metals in the vicinity of UHF RFID tags reflect the incident radio frequency wave, which causes lower signal strength and consequently a shorter reading range.

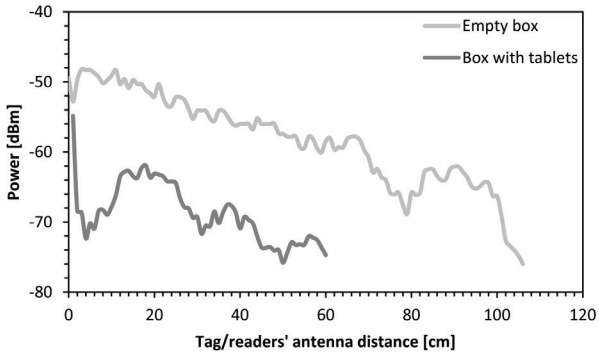

Figure 3: Power of the backscattered signal from the empty pharmaceutical packaging and from the box with tablets inside

In Figure 4 it is possible to see a tendency of behaviour of non-laminated printed antennas (unfolded) and laminated (unfolded and folded) RFID ID cards. The reading range of non-laminated printed antennas is less than half the reading range of laminated ID cards (unfolded and folded). The received signal strength (power) for non-laminated printed antennas at the beginning had greater power than with laminated cards, but with increasing distance the signal strength had tended to decrease. That tendency is steeper than the tendency of decreasing for

laminated cards. The received signal strength (power) is very similar for folded and unfolded laminated ID cards. Differences in the distance and power between non-laminated antennas and laminated cards are a consequence of the laminating process. The lamination process used elevated temperature and pressure to improve the strength and stability of composite material. It also led to better contact between the chip and antenna, as well as to better drying of conductive ink and glue.

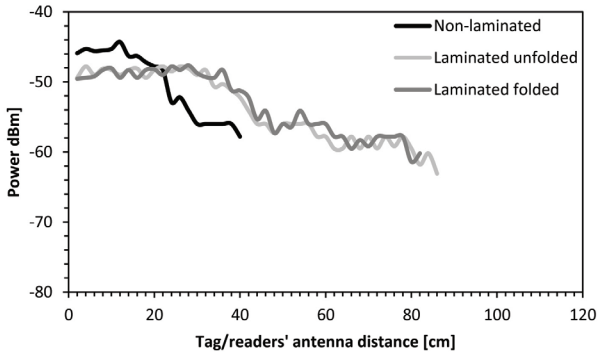

Figure 4: Power of the backscattered signal from the non-laminated and laminated (unfolded and folded) ID cards

Conclusion

In this study the readability of UHF RFID tags printed on pharmaceutical packaging and ID cards was tested. The difference between readability of printed tags on empty pharmaceutical packaging and on packaging with tablets in blister packaging was presented. It can be concluded that the received signal strength and reading range is much lower/shorter when the metal blister packaging is inside the packaging. The readability of non-laminated printed tags and tags laminated into ID cards was also studied. We found that there is almost no difference between laminated folded and laminated unfolded cards' readability, but there is a significant difference between non-laminated and laminated cards in received signal strength and reading range. Reading range is more than half for non-laminated printed antennas, and the received signal strength has a steeper tendency to decrease for non-laminated antennas compared to laminated ID cards. All of that is apparently the impact of the lamination process.

Acknowledgements

Urška Kavčič acknowledges assistance from the European Social Fund ("Operation part-financed by the European Union, European Social Fund") and to the Avery Dennison Corporation for permission to use their antenna design.

References

1. RFID Handbook : *Applications, Technology, Security, and Privacy*, ed. S. Ahson and M. Ilyas. Boca Raton, London, New York: CRC Press. 689. ISBN: 978-1-4200-5499-6.
2. Merilampi, S.L., et al., *The effect of conductive ink layer thickness on the functioning of printed UHF RFID antennas*. Proceedings of the IEEE, 2010. 98(9): p. 1610-1619. ISSN: 0018-9219.
3. Blayo, A. and Pineaux, B. *Printing processes and their potential for RFID printing. Joint Conference on Smart Objects and Ambient Intelligence: Innovative context-Aware Services: Usage and Technologies*. 2005. Grenoble.

4. Futera, K., Jakubowska, M., and Kozioł, G. *Printed electronic on flexible and glass substrates*. SPIE. 2010. Wilga, Poland.
5. Jakubowska, M., Sloma, M., and Mlozniak, A., *Printed transparent electrodes containing carbon nanotubes for elastic circuits applications with enhanced electrical durability under severe conditions*. Materials Science and Engineering B-Advanced Functional Solid-State Materials, 2011. 176(4): p. 358-362. ISSN: 0921-5107.
6. Janeczek, K., et al. *Screen printed UHF antennas on flexible substrats. SPIE Conference.* 2010. Vilga, Poland.
7. Nikitin, P.V., Lam, S., and Rao, K.V.S. *Low cost silver ink RFID tag antennas. IEEE Antennas and Propagation Society International Symposium.* 2005.
8. Pudas, M., et al., *Gravure printing of conductive particulate polymer inks on flexible substrates*. Progress in Organic Coatings, 2005. 54(4): p. 310-316. ISSN: 0300-9440.
9. Rida, A., et al. *Design and integration of inkjet-printed paper-based UHF components for RFID and ubiquitous sensing applications. 37th European Microwave Conference*. 2007. Munich, Germany.
10. Shin, D.Y., Lee, Y., and Kim, C.H., *Performance characterization of screen printed radio frequency identification antennas with silver nanopaste*. Thin Solid Films, 2009. 517(21): p. 6112-6118. ISSN: 0040-6090.
11. Sloma, M., et al., *Investigations on printed elastic resistors containing carbon nanotubes*. Journal of Materials Science-Materials in Electronics, 2011. 22(9): p. 1321-1329. ISSN: 0957-4522.
12. Syed, A., Demarest, K., and Deavours, D.D. *Effects of antenna material on the performance of UHF RFID tags. International Conference on RFID*. 2007. Grapevine.
13. Muck, T., et al., *Printed HF and UHF RFID antenna directly on cardboard and recycled paper*. LOPE-C: p. 398-401. ISSN: 978-3-00-038122-5.
14. *PolyIC*. Available from: www.polyic.com.
15. Sure, P. *The silver ink printed antenna*. Global IDentification, 2005. 70-72.
16. Bogataj, U., Macek, M., and Muck, T., *Impact study of disturbance on readability of two similar UHF RFID tags*. Informacije Midem-Journal of Microelectronics Electronic Components and Materials, 2011. 41(3): p. 197-201. ISSN: 0352-9045.
17. Bogataj, U., et al., *Readability and Modulated Signal Strength of Two Different Ultra-high Frequency Radio Frequency Identification Tags on Different Packaging*. Packaging Technology and Science, 2012. 25(7): p. 373-384. ISSN: 1099-1522.