Wearable Metamaterial Absorber using Screen Printed Chanel logo

Dongju Lee, Sungjoon Lim
School of Electrical and Electronic Engineering, college of Engineering, Chung-Ang University, Seoul, Republic of Korea

Abstract – **In this paper, a wearable metamaterial absorber is proposed using screen print. A unit cell of the proposed absorber is chanel logo for wearable device. It is printed on textile by screen printing method. In order to demonstrate the performance of the proposed absorber, the absorber prototype is measured with rectangular waveguides. The experimental results show that the absorptivity of the proposed achieves 93% at 11 GHz.**

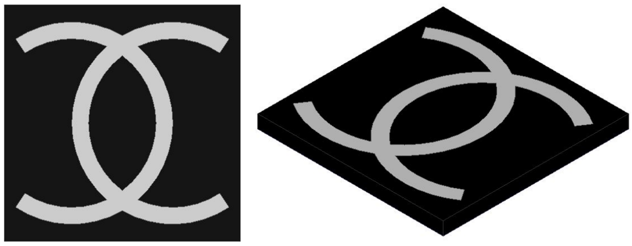
Index Terms — **Metamaterial Absorber, Wearable device, Screen print.**

1. Introduction

The metamaterial (MM) based absorber has been researched since it was introduced by Landy in 2008 [1]. Because the MM based absorber consist of infinitely periodic unit cell structure, it is easily expand to the required space. In addition, The MM based absorber can be implemented at thin substrate as compared with conventional electromagnetic (EM) wave absorber such as ferrite and wedged tapered absorber. Although its thinness, the MM based absorber shows almost perfect absorptivity[2]. Nowadays, the MM based absorber is researched for a variety of applications on flexible substrate as well as PCB substrate. These absorbers have been proposed using a polydimethylsiloxane (PDMS) substrate [3], flexible MM film [4] and polyimide substrate [5]. Furthermore, with the development of science, there are number of study about wearable device such as antenna and sensor in textile in order to improve the convenient of life [6], [7].

The screen printing method is in additive process like inkjet and gravure printing method. Compared with the subtractive etching process, the additive process is much simpler and faster. Also, additive technology is an eco-friendly process, because it doesn't generate chemical waste. Among them, the screen printing method is available to screen on textile, because of its easily printing procedure. In addition, the screen printing enables the mass-product.

In this paper, the wearable metamaterial based absorber is proposed using screen printing method on ordinary textile. The shape of unit cell is the chanel logo which is printed using silver nano-particle ink. The bottom of unit cell is printed same ink fully. The performance of the proposed absorber is analyzed with a full-wave simulation and experimental measurement. This work is a first step for integrating the wearable technology with MM based absorber. Through the results, this work confirmed the possibility.

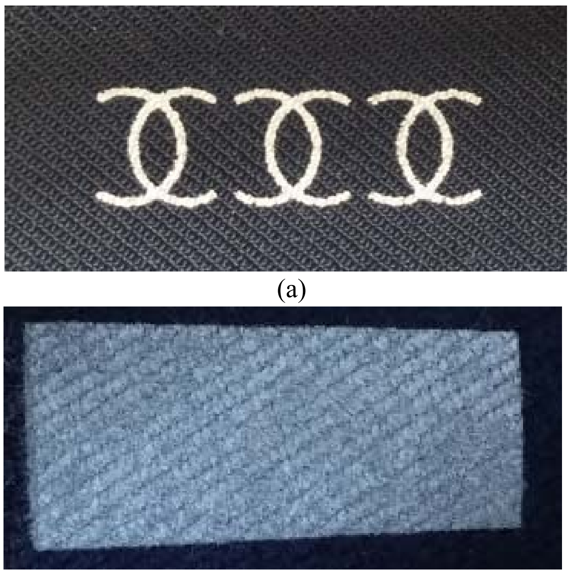


(a) (b)

Fig. 1. (a) Top view and (b) perspective view of the proposed absorber.

2. Design and Fabrication

The proposed absorber is implemented by screen printing method using silver nano-particle ink on ordinary textile. The unit cell is demonstrated in Fig. 1. The top layer of the unit cell is chanel logo, while bottom layer is fully printed. The chanel logo on top layer consists of capacitance which is gap between adjacent unit cell and inductance which is conductive patterns. As a result, the patterns generate electric resonance, because of its LC. When EM wave incidence to the absorber, there is not transmitted wave, because of its fully printed ink on bottom layer. In addition, the magnetic resonance is generated, because the top and bottom conductive patterns generate an anti-parallel current.



(a)

(b)

Fig. 2. Fabricated proposed absorber prototype (a) top and (b) bottom layer.

To experimentally demonstrate the performance of the proposed absorber, the prototype sample is fabricated in Fig. 2. The prototype consist of 3 unit cells in same column in order to fit to aperture of WR-90 waveguide which size is 22.86 mm × 10.16 mm for experimental measurement. After the silver nano-particle ink is printed on ordinary textile by screen printing, the thermal sintering process is progressed for 10 minutes at 150 ˚C in oven [8]. The conductivity is improved through this sintering process, because the impurities such as polymers, a dispersant and surfactants to facilitate smooth printing are burnt off.

3. Simulation and Measurement Results

In order to verify the performance of the proposed absorber, full-wave simulation and experimental measurement are accomplished. The absorptivity of the proposed absorber is tested by waveguide mode method using vector network analyzer (VNA) and two WR-90 waveguides which operate from 8.2 GHz to 12.4 GHz. Figure 3 shows the simulation and measurement absorptivity of the proposed absorber. In waveguide mode method measurement, the absorption frequency and absorptivity of the proposed absorber are 11 GHz and 93%, respectively.

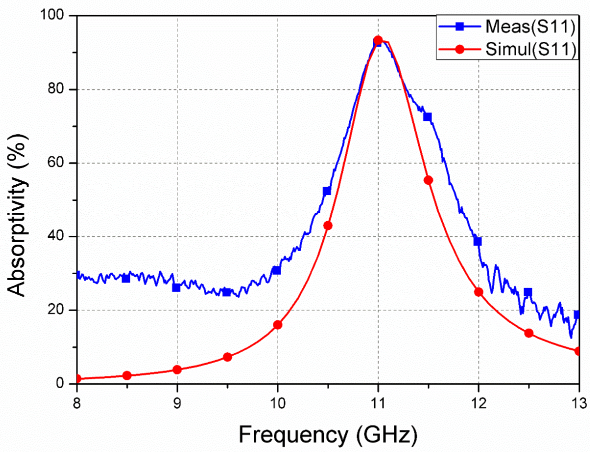


Fig. 3. The simulated and measured absorptivity of the proposed absorber.

4. Conclusion

In this paper, metamaterial based absorber is proposed on ordinary textile for wearable device. The proposed absorber is implemented by screen printing method, because of its easily printing procedure and mass-product. A full-wave simulation is performed to design and analyze the proposed absorber. To demonstrate the performance of the proposed absorber, the prototype is fabricated using silver nano-particle ink. After printing on textile, the thermal sintering process is progressed in order to improve the conductivity of the silver nano-particle ink. We use a VNA and two WR-90 waveguide for experimental measurement, to verify the performance of the proposed absorber. The proposed absorber operates at 11 GHz and its absorptivity is 93%. Therefore, we demonstrate the possibility for integrating the wearable technology with MM based absorber.

Acknowledgment

This work was supported by the Low Observable Technology Research Center program of Defense Acquisition Program Administration and Agency for Defense Development.

References

[1] N. I. Landy, S. Sajuyigbe, J. J. Mock, D. R. Smith, and W. J. Padilla, "Perfect metamaterial absorber," *Phys. Rev. Lett.*, vol. 100, no. 20, pp. 1–4, 2008.

[2] B. Lee and B. Kim, "Design of Metamaterial-Inspired Wideband Absorber at X-Band Adopting Trumpet Structures," *J. Elecromagnetic Eng. Sci.*, vol. 14, no. 3, pp. 314–316, 2014.

[3] K. Ling, K. Kim, and S. Lim, "Flexible liquid metal-filled metamaterial absorber on polydimethylsiloxane (PDMS)," vol. 23, no. 16, pp. 21375–21383, 2015.

[4] K. Iwaszczuk, A. C. Strikwerda, K. Fan, X. Zhang, R. D. Averitt, and P. U. Jepsen, "Flexible metamaterial absorbers for stealth applications at terahertz frequencies," *Opt. Express*, vol. 20, no. 1, p. 635, 2012.

[5] P. K. Singh, K. A. Korolev, M. N. Afsar, and S. Sonkusale, "Single and dual band 77/95/110 GHz metamaterial absorbers on flexible polyimide substrate," *Appl. Phys. Lett.*, vol. 99, no. 26, pp. 1–5, 2011.

[6] T. Kaufmann, T. Kaufmann, C. Fumeaux, and S. Member, "Integrated Cavity Antenna Using Embroidered Wearable Textile Half-Mode Substrate-Integrated Cavity Antenna Using Embroidered Vias," no. May 2016, 2013.

[7] W. Gao, S. Emaminejad, H. Yin, Y. Nyein, S. Challa, K. Chen, A. Peck, H. M. Fahad, H. Ota, H. Shiraki, D. Kiriya, D. Lien, and G. A. Brooks, "Fully integrated wearable sensor arrays for multiplexed in situ perspiration analysis," *Nature*, vol. 529, no. 7587, pp. 509–514, 2016.

[8] B. S. Cook and A. Shamim, "Inkjet printing of novel wideband and high gain antennas on low-cost paper substrate," *IEEE Trans. Antennas Propag.*, vol. 60, no. 9, pp. 4148–4156, 2012.