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Printed Graphene For Chipless RFID Applications

Abstract

This paper presents screen printed graphene for chipless RFID applications. The highly conductive ink consists of multi-layer graphene nanoflakes and has been formulated specially for screen printing printed electronics. The frequency selective surfaces (FSS) periodic arrays are screen-printed on normal paper and attached onto FR4 for measurement. The measurement results show that the simple structure can encode 2 bits, indicating that screen printed graphene can be a viable solution to low-cost chipless RFID applications. In recent years, researchers have been trying to develop chipless RFID tags, often involving not printable patterns and complex decoding mechanisms [1]. The costs of the tags are mainly dependent on the cost of the IC chips as the mass production of transponder antennas is relatively cheaper. Additionally, the assembling implementation processes of the chips onto the tag antennas and the additional transportation add more cost down the production line. Hence, efforts have been put in developing chipless RFID tags without ICs, which means that the main cost of the tag can be removed.

The tagging of extremely low cost paper/plastic based items demands a fully passive and printable chipless tag as a low-cost, robust solution for simple applications. The primary potential benefit of the chipless tags is their capability to be directly printed on inventory items for a lower cost, providing a good alternative for traditional RFID tags with IC chips. For many applications, such as small business company applications and identifying classes of objects, a large ID string is not necessary.

The screen printed graphene technique has been reported in [2-4]. Different to antennas, printed graphene FSS arrays for chipless RFID applications are presented in this work. Frequency selective surfaces (FSS) are periodic structures that function as filters for microwave frequency waves. The resonating nature of these periodic structures at specific frequencies has been used as frequency selective filters and electromagnetic interference (EMI) shielding applications. Each data bit can be associated with the presence or absence of a resonant peak at a predetermined frequency in the spectrum by adding or reducing the resonating structures [5]. These tags have the advantage of extremely low fabrication costs benefiting from printed graphene technology and the chipless structure. The periodic FSS structure consists of concentric rings of different radius as multiple resonances are created. The ring structure has the advantage of its small length in terms of wavelength [6]. For the circular element, its length should be a multiple of half wavelength for resonance [7]. The resonance frequency is a function of the equivalent inductance L_{eq} and equivalent capacitance C_{eq} of the concentric rings. It should be noted that L_{eq} and C_{eq} are related to the radii and width of the rings, and the distance between the rings [8]. The structure of the samples prepared are shown in Fig.1(a). The sizes of the concentric rings are chosen to respond to the measurement range 2.6 to 3.95 GHz. Fig. 2(b) shows the Scanning Electron Microscope(SEM(image of the highly conductive printed graphene sample, showing the compact structure after compression.

A pair of identical standard gain horn antennas (2.95 – 3.95 GHz) are connected to measure the transmission(%) from antenna 1 to antenna 2 using a vector network analyzer (VNA), (FieldFox N9918A). A TRL (Thru-Reflect-Line) calibration was made for the cables to ensure the accuracy of the measurement. The measurement was first made without the printed graphene sample (DUT, device under test), then the DUT was pasted onto FR4 board (thickness:1.6 mm) to measure the transmission coefficients. When DUTs is absent, the

transmission is firstly measured from 2 to 5 GHz. This data is saved as reference. The measured transmission from antenna 1 to antenna 2 for different configurations then are normalized using the reference data to extract the response when the DUT is present. Fig. 1(c) shows the calculated transmission for different configurations. It can be seen that when the ring responsible for bit 1 is present, a resonance peak appears, same as the bit 2 ring, revealing the data bits can be encoded by adding or reducing the resonating structures. A 70% transmission can serve as a guidance line to observe the resonance as shown in Fig.1(c).
However, the resonant peak for bit 2 is relatively low due to the thin printed ring. The prepared sample's sheet resistance is measured to be 3 Ohms/sq. The small ring's resistivity is too high to resonate hence the lower resonant peak. This should be further addressed in future designs.

These results have proven that the screen printed graphene can provide bit encoding by its printed periodic structures. This is useful for chipless RFID applications in small business.

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Figures

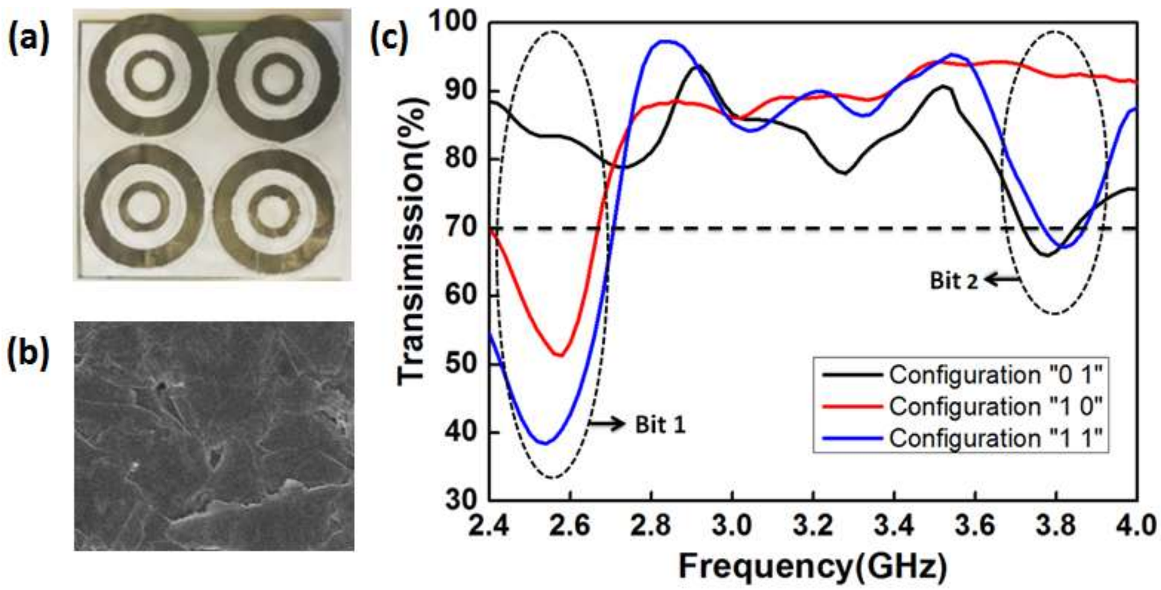

Figure 1: Printed Graphene For Chipless RFID Applications (a) Prepared screen printed graphene chipless RFID prototype tag (b) SEM image of the compact surface of highly conductive printed graphene sample (c) Measured transmission (%) from antenna 1 to antenna 2 for different configurations.